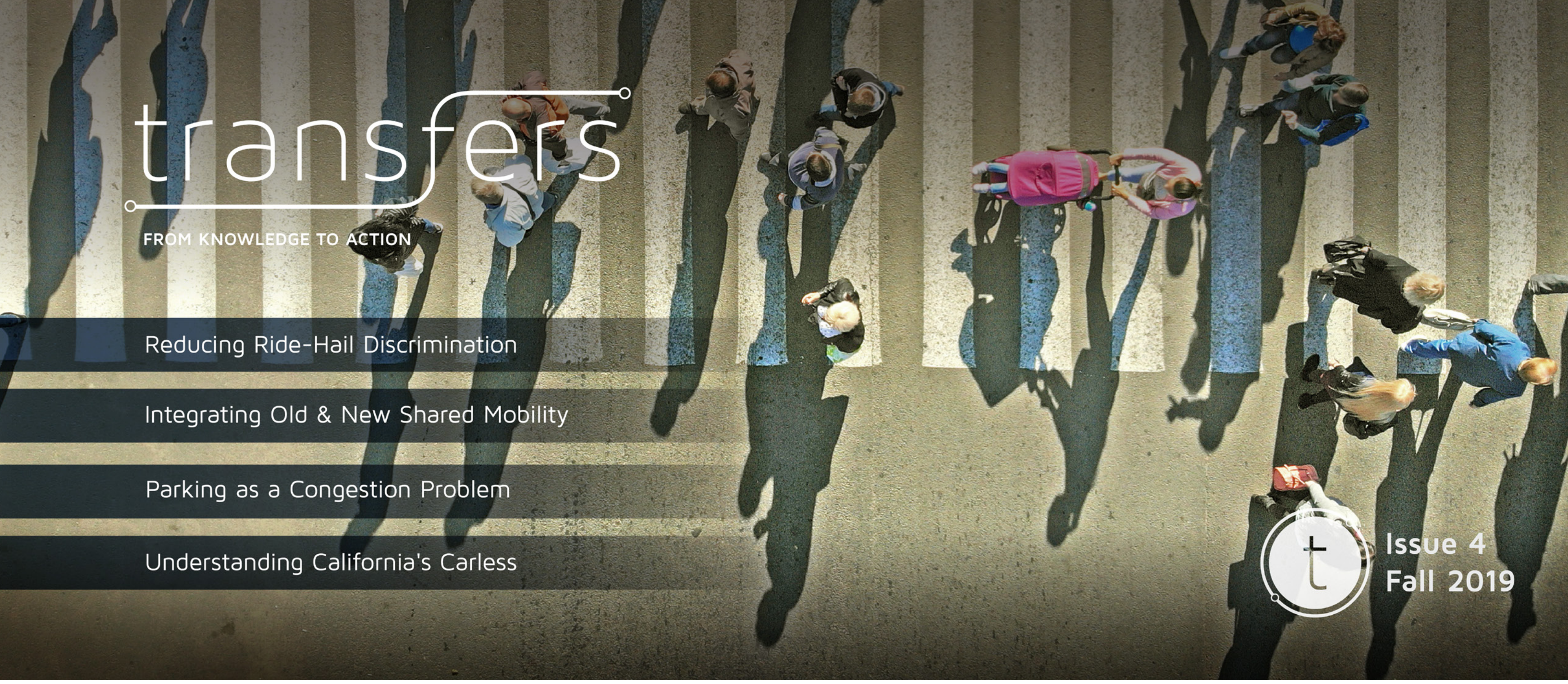

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The Equalizer: Could Ride-Hailing Extend Equitable Car Access?

Anne Brown

Ride-hail services like Uber and Lyft upend the historic link between car access and ownership by connecting riders to drivers through smartphones. The meteoric rise of these services has captivated investors, riders, planners, and policymakers alike. However, despite its high-tech luster, we do not yet know how ride-hailing serves different neighborhoods and travelers, or who, if anyone, is left behind.

The closest historical analog to these new ride-hail services is the taxi industry, which has a history of discrimination, particularly against black riders. Previous studies, mostly observing street-hail taxis, have found that taxis are far more likely to drive past or refuse service to black riders. Does ride-hailing perpetuate the inequitable status quo? Or could it represent a new chapter in on-demand car access?

Ride-hailing discrimination could harm travelers on both an individual and neighborhood scale. Addressing both is therefore critical to ensuring equitable access. Drivers refusing to pick up or drop off travelers in certain neighborhoods can impede the mobility of whole communities. If drivers refuse to pick up individuals based on race, ethnicity, or gender, then ride-hail services offer little value to many travelers, despite operating in their general vicinities.

To understand equitable access at these two scales — the individual and the neighborhood — I conducted a two-part study of ride-hail travel and equity in Los Angeles, and examined the following questions: Do ride-hail services serve neighborhoods differently based on resident characteristics? How frequently do individuals who have been historically marginalized by transportation systems use ride-hail services? Is there evidence of racial or gender discrimination against individual travelers using ride-hail services?

Measuring ride-hail access

One of the greatest challenges to understanding how ride-hailing serves neighborhoods and travelers is the dearth of fine-grain data. To begin to address this knowledge gap, I obtained a complete dataset of every Lyft trip taken to, from, and within Los Angeles County between September and November 2016 — more than 6.3 million trips in total. Each trip record included a unique rider identification number, and contained details such as the origin and destination census tracts, the time of day, the day of the week, the price, the distance, and whether the rider used Lyft or Lyft Line (now called Lyft Shared), the company's shared ride-hailing service.

Combining this information with neighborhood-level data reflecting the local built environment and population characteristics, I examined the factors associated with ride-hail travel in neighborhoods. Specifically, I sought to discover whether Lyft drivers, like taxi drivers before them, tended to avoid low-income neighborhoods or communities of color, and which neighborhood characteristics were associated with more or less Lyft service.

In addition to determining *where* Lyft traveled, it was equally important to find out *who* was making these trips. Since it would be possible for Lyft to serve a neighborhood without serving its residents, distinguishing where Lyft goes from whom it accommodates is critical. For example, many trips could begin or end in a low-income neighborhood with plentiful nightlife destinations, exclusively serving nightlife patrons rather than area residents.

While the Lyft data offered unparalleled insight into questions of Lyft travel and usage, the data did not include any personally identifying information, and therefore offered no insight into the final question: Is there evidence that ride-hail services, like taxis before them, discriminate against individuals based on race, ethnicity, or gender? To answer this, I conducted an audit study of Lyft, Uber, and taxis in Los Angeles. Audits are field experiments designed specifically to identify discrimination by sending study participants into actual social or economic settings to measure how otherwise similar people are treated, in this case based on their race, ethnicity, or gender. Specifically, I was interested in measuring whether service qualities (wait times and cancellation rates) varied by passenger characteristics, and if so, how.

To test this, I sent 18 UCLA undergraduate and graduate students out to collect data. The students identified as either male or female, and as one of four general racial/ethnic categories: Asian, black, Hispanic, or white. To control for other factors that might influence driver behavior, the students were matched as closely as possible across other individual characteristics that were not measured, including age, ride-hail star ratings, and dress. All riders were between 20 and 30 years old and had 4.5-star ratings or higher (drivers rate riders on a scale from one (worst) to five (best) after completing trips). When collecting data, riders wore plain, non-flashy clothing, such as jeans and plain T-shirts. Each rider also uploaded a new profile photo to their ride-hail account — a headshot against a white backdrop. Lyft drivers see a rider's name, photo, and star rating before accepting a trip request. Uber drivers see a rider's star rating before accepting a trip request, and the rider's name after accepting a request. Uber drivers never see a rider's photo, even if a rider uploads one.

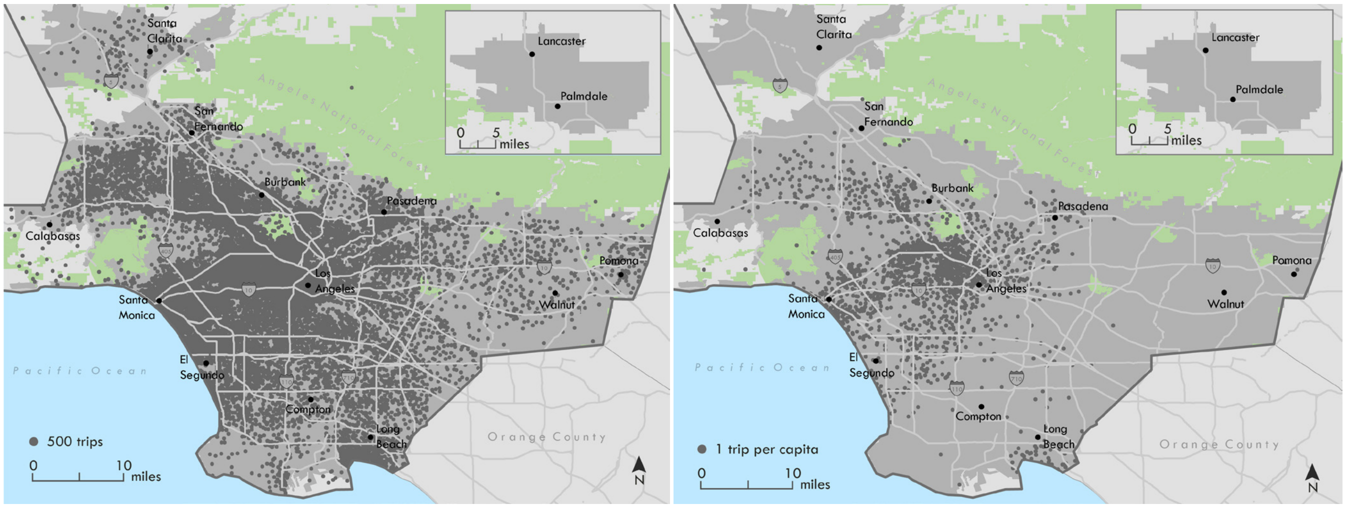
The UCLA student riders hailed Uber, Lyft, and taxi rides at two different locations — both centrally located in metropolitan Los Angeles along Metro's Expo light rail line — and collected data every day (excluding holidays) between 9 a.m. and 9 p.m., seven days a week for nine weeks between October and December 2017. They hailed Uber and Lyft via the companies' respective mobile apps, and hailed taxis via phone dispatchers. For each trip, riders recorded the following: wait time, cancellation (yes/no), and the rider's perceptions of the driver's race/ethnicity, gender, and age. In sum, auditors hailed more than 1,700 Uber, Lyft, and taxi trips.

Does ride-hailing extend equitable access to neighborhoods and individuals? The results of this research suggest that at both the neighborhood and individual level, the answer is yes.

Expanding car access to underserved neighborhoods

The 2016 data provided by Lyft show that between September and November of that year, the ride-hail company served nearly every neighborhood in Los Angeles County, reaching census tracts home to 99.8 percent of the county's population. Figure 1 shows the spatial distribution of those Lyft trips, both in total trip numbers and trips per-capita (workers plus residents), to account for the uneven distribution of jobs and residents across Los Angeles County.

Figure 1. Spatial distribution of Lyft trips and trips per capita

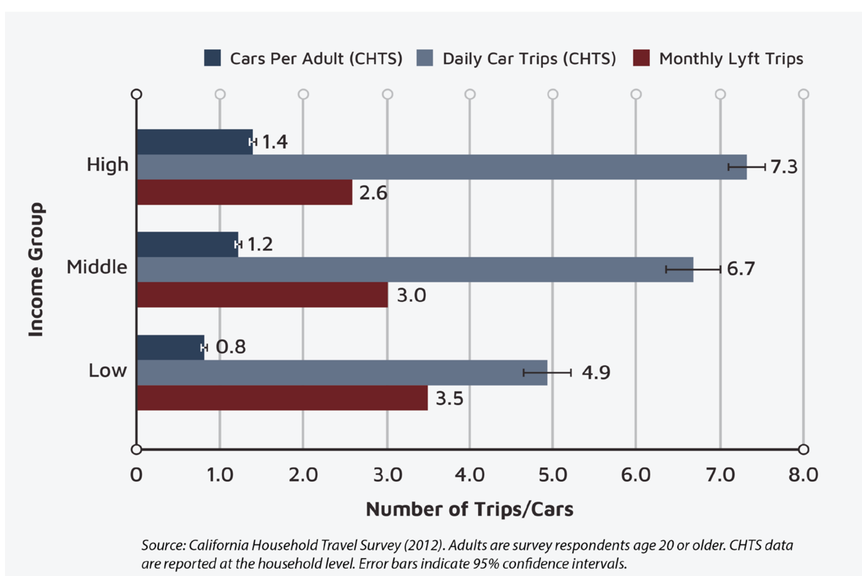


Lyft trips and trip-making are associated with the built environment. Generally speaking, more Lyft trips begin and end in high-density neighborhoods, and people take Lyft more often when they live in dense neighborhoods.

Strikingly, after controlling for neighborhood characteristics, I found no evidence that Lyft provided less service in neighborhoods based on neighborhood income or racial/ethnic majority. In fact, travelers living in low-income and majority-black neighborhoods — neighborhoods historically eschewed by taxis — took *more* Lyft trips per person.

The strongest variable associated with the number of Lyft trips an individual made was neither neighborhood racial/ethnic composition nor income, but rather local car ownership. Every 10 percent increase in the share of households *without* a car in a given neighborhood is associated with a 7 percent increase in the number of Lyft trips a user makes. This association is inverse to the one typically observed in personal car travel. For example, the California Household Travel Survey data show that carless households in Los Angeles make just one car trip per day, compared to the average of seven daily trips made by car-owning households. Figure 2

Figure 2. Predicted number of Lyft vs. car trips and vehicle ownership across incomes



shows that personal car access and travel increase with income, a pattern also inverse to Lyft trip-making. The contrasting patterns between Lyft usage and personal car access suggest that people use Lyft in areas where its ready substitute — the household car — is scarcest.

However, not all data present a rosy picture of ubiquitous access to ride-hail services, and barriers to ride-hailing remain. On average, riders living in majority-Asian and majority-Hispanic neighborhoods take significantly fewer trips per person compared to residents of majority-white and majority-black neighborhoods. Possible explanations for this include barriers to ride-hailing, such as a lack of bank accounts or smartphones, and cultural differences in car use and carpooling across groups. These potential factors and barriers require additional study.

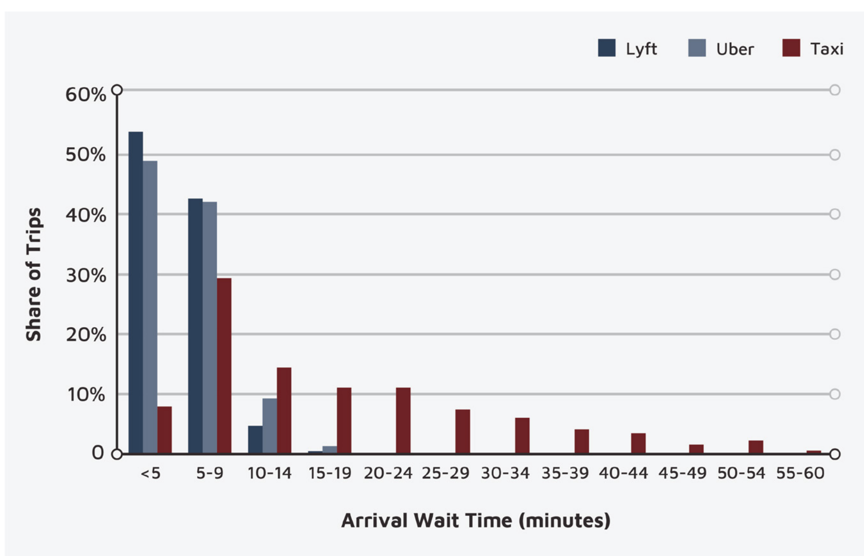
Upending the status quo: Increasing equity in individual car access

The audit study revealed two stark findings. First, it showed that ride-hailing is remarkably more reliable than taxi use in terms of securing a ride and reducing wait times. Second, it demonstrated that ride-hailing dramatically narrows — but does not entirely erase — racial/ethnic-based service gaps among riders. None of the results varied based on driver characteristics, meaning that the results discussed below are consistent no matter the age, race/ethnicity, or gender of the driver.

Lyft and Uber provided consistently shorter wait times than taxis. On average, ride-hail travelers waited 5.6 minutes between requesting a ride and the driver's arrival. By contrast, taxi riders waited 24.3 minutes (four times longer) for the average cab to arrive, and more than one in 10 taxis (11 percent) failed to arrive within an hour. The highly variable taxi wait time distribution (shown in Figure 3) underscores the general unreliability of taxi services observed in this study.

Wait times did not differ appreciably between men and women, nor among white, Asian, and Hispanic riders. Wait times were, however, significantly longer for black riders than for white riders, who experienced the shortest wait times. Differences in service for black riders and white riders using Lyft, Uber, and taxis are statistically significant, and therefore unlikely due to chance. On average, black riders waited one minute and four seconds longer than white riders for Lyft, and 52 seconds longer than white riders for Uber. The starkest — and most meaningful — differences by rider race/ethnicity applied to taxis. Black taxi riders waited 10 minutes and 30 seconds longer than white riders. On average, black taxi riders waited 52 percent longer than white taxi riders.

Figure 3. Arrival time reliability across services



Nearly 20 percent of taxi riders did not receive rides because the taxi dispatcher did not pick up the phone, a taxi did not arrive within an hour, no taxis were available, or a taxi refused to provide a ride upon arrival. By contrast, just four out of 1,271 (0.3 percent) ride-hail trip requests in the study were not completed.

Cancellations translate into different rider experiences across services. For Lyft and Uber, cancellations are associated with somewhat longer wait times. However, in 99.7 percent of "canceled" Uber and Lyft trips, riders were assigned to new drivers and still reached their destinations. By contrast, taxi cancellations resulted in riders not being picked up and impeded mobility.

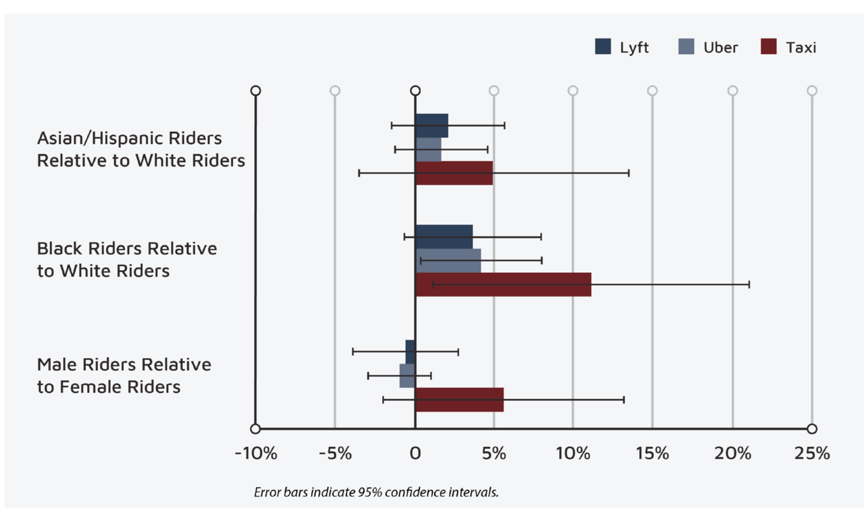
In addition to stark variation across services, cancellation rates also vary by rider race and ethnicity. Across all services, cancellation rates were lowest for white riders, moderate for Asian and Hispanic riders, and highest for black riders. Figure 4 shows the change in the probability of a Lyft, Uber, or taxi canceling on a rider of a particular racial/ethnic or gender group relative to members of other groups. No significant differences existed among Asian, Hispanic, or white riders. Black taxi riders, however, were 73 percent (or 11 percentage points) more likely to have a driver cancel compared to white riders. More than a quarter of taxis hailed by black riders were canceled, compared to about 15 percent of trips hailed by white riders. For both Lyft and Uber, the difference in the probability of a trip being canceled is far smaller. Cancellations for black riders are 4 percentage points higher than for white riders.

A role for policymakers

Ride-hailing dramatically extends car access to neighborhoods previously underserved by taxis, and appears to fill an important mobility gap by providing rides in neighborhoods where residents have the least access to personal cars. At the individual level, ride-hailing narrows, but does not erase, the service gaps associated with taxis. Each of the analyses briefly summarized here yields lessons for policymakers as they consider how to facilitate equitable access to ride-hailing and future modes of technology-enabled transportation. While equity gains can likely be achieved by mobility platforms themselves by tracking discriminatory cancellations by drivers and enforcing consequences, among other methods, I focus the remainder of this discussion on the role that policymakers can play in ensuring access to ride-hail service for all.

While I found no evidence that ride-hailing excludes neighborhoods based on resident income or racial/ethnic characteristics, as taxis have historically done, my findings do suggest that ride-hailing exclusion may occur along

Figure 4. Percentage point change in probability of cancellation by rider characteristics



a digital divide. Lower Lyft use in majority-Asian and majority-Hispanic neighborhoods may be partially explained by lack of access to technology. The Federal Deposit Insurance Corp. reports that Hispanic and Spanish-speaking households, in particular, are less likely to own smartphones or have bank accounts. Overcoming technological barriers and ensuring access to new mobility services, including ride-hailing, are imperative as cities and public transit agencies enter partnerships with new mobility companies to, for example, provide first/last-mile access to transit stations, or replace lightly patronized transit services in outlying areas. Without efforts to bridge this technological divide, the gap between mobility haves and have-nots may well expand. Efforts to provide access to travelers without smartphones and bank accounts already abound in bikeshare systems. For example, a San Francisco Bay Area bike program does not require a credit card, is compatible with the regional transit fare card, and allows people to sign up in-person rather than using a smartphone.

Ride-hailing represents but one of a multitude of new modes — and future mobility possibilities — enabled by technology. To ensure equitable access, no matter what comes next, planners should adopt equity-first goals and performance metrics. These equity-first metrics should show both mobility opportunities and outcomes. Opportunity metrics should reflect whether service is available, and if so, *how much*, by capturing, for example, the number of vehicles per capita or per mile across neighborhoods. Outcome metrics measure *how well* modes of transportation serve particular neighborhoods by measuring wait times and other factors. Metrics should reflect access at both the individual and neighborhood scale, given that services may vary or exclude travelers at each level. In addition to measuring who uses new mobility services, cities should adopt a metric that reflects *non-users* — for example, the number of users per capita in a neighborhood — to understand who may be excluded from new mobility services.

Finally, cities should use these equity-based metrics to define the data requests (or requirements) of new mobility companies. Of course, data alone will not eliminate discrimination, nor will it guarantee equitable service across urban areas. Such data can, however, help to answer policy questions more reliably than we can today, and advance equitable access to ride-hailing and other new and future mobility services.

This article is adapted from Brown, A.E. (2018). *Ridehail revolution: Ridehail travel and equity in Los Angeles*. Los Angeles, CA: UCLA. https://escholarship.org/uc/item/4r22m57k

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About the Author

Anne Brown is an assistant professor in the School of Planning, Public Policy, Management at the University of Oregon. Her research examines the intersection of equity, shared and innovative mobility, travel behavior, and transportation finance.

Positioning Transit for the 21st Century

Steven E. Polzin and Daniel Sperling

Traditional fixed-route, fixed-schedule public transit faces both challenges and opportunities from the latest wave of mobility services and new technologies. U.S. public transit ended 2018 with a fourth consecutive year of declining ridership. Multiple factors, including competition from Lyft and Uber, help explain the decline. However, public transit operators can incorporate the many information and communication technologies private mobility companies employ to improve service and reduce costs; and can partner with them to increase accessibility for many more travelers at a lower cost. But this will require technical innovations, improvements in public financing, and changes in transit priorities and management.

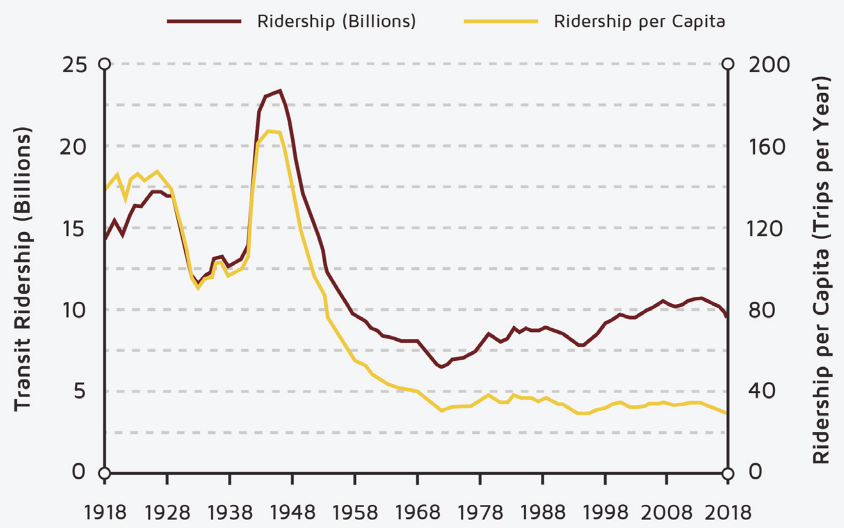
The long decline of public transit

Mass transit plays a valuable role in society. But more than a century of automobile use has contributed to sprawling urban development, undermining the efficacy and economics of bus and rail travel. Transit now accounts for about 2 percent of passenger trips in the United States and about 1 percent of passenger miles. The long-anticipated renaissance in public transit, supported by substantial public investment over the past five decades, remains elusive even as the country becomes more urban and populous.

Ever since the first Ford Model T was introduced, U.S. public transit per capita patronage has faltered. The only exception was during World War II when gasoline was rationed and new cars unavailable. After the war, transit ridership fell from 114 trips per capita in 1950 to an all-time low of 30 in 1995, where it stands today (see Figure 1) — even as overall travel has continued to increase. Even transit's mainstay, commuting in urban areas, dropped from 12.5 percent of all work trips in 1960 to 8.5 percent in 1970, 6.2 percent in 1980, and about 5 percent since 1990.

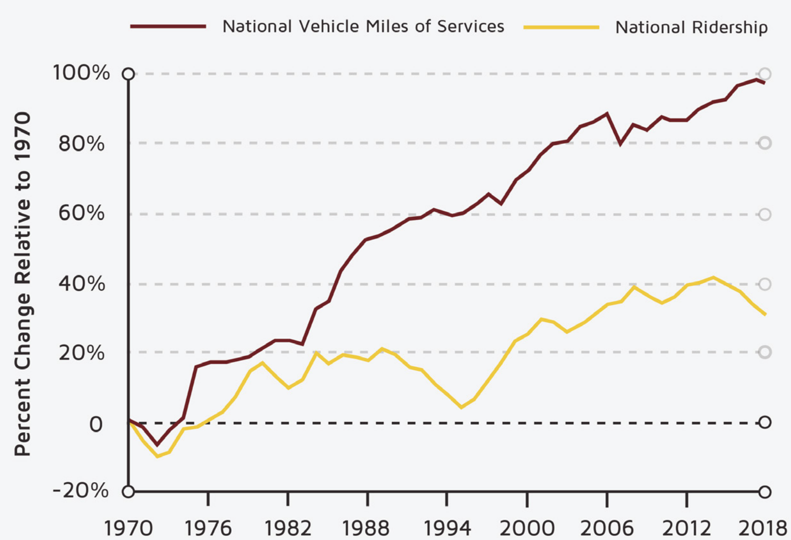
These losses have come despite growing transit investment. Total vehicle miles of transit service have grown dramatically, nearly doubling since 1970, while the change in ridership is less than half of that (see Figure 2).

Today, the average operating cost of providing bus service — excluding capital costs — is well over $4 per trip. The cost of expanding service to attract more riders tends to be much higher, especially in suburban areas. Urban bus passengers in the United States pay only about 20 percent of the full operating and capital cost of service (rail riders pay 30 percent). The rest is covered by government subsidies. Total local, state, and federal subsidies doubled (controlling for inflation) between 1988 and 2010. Even so, transit agencies are challenged to ask for even higher subsidies in light of stagnant or falling



Source: Compiled from APTA Public Transportation Fact Books, National Transit Data and U.S. Census.

Figure 1. U.S. transit ridership trends



Source: Compiled from APTA Public Transportation Fact Books, National Transit Data and U.S. Census.

Figure 2. Change in ridership and vehicle miles of service relative to 1970

ridership; the result is deferred maintenance, fare increases, service cuts, and underfunded pensions. These could commence a downward spiral in which lower productivity and lower fare revenues lead to service cuts that lead to even lower ridership.

Despite these struggles, public support for transit investment endures. Since 2000, voters in more than 200 American cities have voted to raise their own taxes to finance transportation improvements — usually including public transit — with an almost automatic presumption that "more" is better. Not only because more transit will serve disadvantaged travelers, but probably more so in the hope it will clear cars from the road, reduce traffic congestion, and garner environmental benefits. This broad political support has not, however, translated into higher ridership or greater efficiency and effectiveness.

The challenge of change

To survive, public transportation will have to adapt to the boom in new services and technologies competing for customers — on-demand ride-hailing and van services (known as transportation network companies or TNCs), dockless scooters, and eventually, automated vehicles.

Studies indicate that Lyft and Uber are indeed undermining transit ridership, especially in dense cities, even though they are delivering some travelers to transit stations. The diversion in New York City and San Francisco appears to be substantial — with 10 to 30 percent of Lyft and Uber riders switching from transit. Should these services siphon off more and more influential higher-income customers, it could jeopardize political support for public transportation spending.

Still, the future of these new mobility services is increasingly clouded by slowing growth and problems with driver retention and compensation. Automation may change that and exacerbate the risks to transit. Shared automated cars and vans could provide quality mobility at reduced prices, possibly as low as (currently subsidized) transit fares, and especially in suburban and other markets where transit service is not time-competitive, routes are circuitous, or transit is not convenient or comfortable. Although the arrival of driverless vehicles is still years away due to technological and logistical issues, the start of real-world testing is adding color to visions of how vehicle automation and new mobility business models will influence travel behavior, the economy, environment, and other aspects of daily life.

Despite the uncertainty, moving forward is less risky than standing still. Until now, criticism of transit has been muted, even as subsidies have mounted and ridership has stagnated. Data on energy, cost, and environmental performance of public transit receive little attention, while proponents focus on other potential benefits, such as shaping land use, economic development, and urban livability. The primary reason, however, for the lack of attention is that until recently no good travel alternatives have existed. Now that new mobility services are rapidly emerging, criticism of transit may gain traction.

Meeting the challenge of the mobility revolution means re-envisioning transit for the 21st century. This will require integrating and leveraging these new technologies and developing new service models to reach markets currently not well served by traditional public transportation. Transit agencies may resist, but the cost of doing so could be marginalization and even extinction.

Integrating innovative technologies

While vehicle automation attracts the most attention these days, there are many other promising innovations — in-vehicle camera security systems, remote vehicle operation monitoring, various driver-assist technologies and safety systems, ride-hailing and customer service tools, and electrification — that could make transit more competitive.

Public transit can benefit from web- and mobile-based apps to give travelers convenient access to information about travel options, as well as real-time updates and convenient fare payment to help them plan trips using different modes, even in unfamiliar places. For example, OneBusAway is an open-source platform for real-time transit information developed by the University of Washington and currently available in cities across the globe. RideTap software from Moovel makes it easier for transit agencies to integrate their services with other shared mobility providers. The Dallas Area Rapid Transit GoPass app helps riders plan and pay for "complete trips" using Uber to access DART.

Ride-hailing tools can also improve paratransit, the specialized transportation services for travelers with disabilities, by helping to coordinate service across more providers and agencies with vehicles capable of handling wheelchairs and mobility aids.

The use of electric buses is on the rise, especially in China, which has 421,000 in operation, but also increasingly in the United States. Some cities, led by Shenzhen (with a population of more than 15 million) have converted every bus to battery-electric propulsion. California has followed suit, mandating in late 2018 that all transit buses in the state operate on electricity by 2040 (meaning essentially all new bus purchases must be electric by 2028). Many other American cities from Seattle to Tallahassee, Florida, are accelerating their purchases of electric buses, encouraged by dramatic improvements in battery cost and capability.

But the most tantalizing opportunity to increase transit's competitiveness is automation, in part because of the high cost of employing bus operators. Information drawn from the National Transit Database indicates that bus operators account for 42 percent of bus operating expenses. Automating transit buses and vans will mean a massive restructuring of public transportation services, but companies already have well-established operational protocols and insurance, high vehicle-utilization enabling the rapid accumulation of service time, professional maintenance staff, high public exposure, and established fleet facilities, all of which can facilitate the transition. Also, they operate on fixed routes, providing a defined physical environment for autonomous operation. Instead of running a few large buses (to lower labor costs by carrying more passengers per vehicle) transit agencies could run smaller driverless vehicles at higher frequencies and thereby provide more frequent, less crowded service. All these factors make buses an attractive laboratory for an early application of safety-enhancing, cost-reducing vehicle automation technologies. The potential to improve performance and safety help justify the policy, investment, and regulatory changes needed to deploy these new technologies broadly.

Automation also provides an opportunity to reduce costly investments in expanded rights-of-way for exclusive lanes for bus rapid transit and grade-separated rail lines that restrict high-speed transit to a limited number of high-volume locations. In a fully automated and managed transportation network, with computers and sensors guiding vehicles, public transit could travel along congestion-free lanes without requiring expensive new infrastructure.

New service models to bolster transit

Ultimately, shared-ride vehicle services, automated or not, can reach far-flung people and places, transport persons with disabilities, plug first/last-mile gaps, and feed into public transport operating along major corridors. Transit agencies around the globe are already launching demonstration and pilot projects, including partnerships with Lyft and Uber, real-time rideshare-matching services, short-term car and scooter rental, and bikeshare services. Several transit agencies in the United States and Canada are subsidizing TNCs or microtransit providers in less dense, suburban areas where traditional transit service is especially expensive.

Pilot projects provide experiences that can lead to planning better public transit connections and services. Of particular interest is how first/last-mile services can increase ridership for fixed-route services. Ultimately, transportation providers will need to understand how the cost, performance, and environmental impacts of investing in complementary services compare to such traditional ridership-enhancing strategies as reduced fares, park-and-ride lots, increased frequency, more routes, and expanded hours of operation.

Going forward, the transit industry — and local leaders — will have to assess the ability of ride-hailing and other new mobility companies to be good partners and to provide reliable service, adequate capacity, and stable pricing. Among the many questions is their ability to scale up, given the limited number of drivers available at the low compensation levels now offered.

While the case for new transit partnerships and a new vision for public transportation is compelling, and the opportunities they present are enticing, they are also fraught with political land mines. Transit services employ union labor, offer low fares to serve low-income riders, and often extend routes into low-density suburbs, at high cost, to better serve the community. Changing these practices would inevitably affect their stakeholders. If they reduce or withdraw service, or partner with non-union private entities, they become vulnerable to political backlash that could further threaten the support public transit currently enjoys.

Helping public transportation flourish

Public transportation is on the cusp of dramatic change. New transformational technologies and service models are already having profound effects on transit. Current methods of delivering and managing transit must change if the mode is to remain viable. More traveler choice and better service are possible, but by no means assured. A multiplicity of stakeholders, limited funding streams, the needs of carless travelers, and the economic vitality and livability of cities frame these challenges.

Policy will play a crucial role in shaping the future of public transportation if the path forward is not left solely to the pace of technological evolution and market forces. Some things are clear. First, financial support must be adequate to sustain transit infrastructure and services in high-volume locations where large vehicles and trains are uniquely suited.

Second, the government must provide a social safety net of affordable mobility for low-income urban travelers and ensure door-to-door assisted services for travelers with mobility limitations. Alternative mobility options that undermine these obligations should be eschewed; those that can better serve riders with disabilities at less cost should be pursued.

Third, as private companies begin to play a larger role, local government oversight will be needed to ensure equitable access for all and to protect the public from abusive practices all the while without stifling innovation or hindering private sector competition.

Fourth, transit policymakers will have to address the labor implications of automation on the 200,000 bus-operating employees for fixed-route services and 100,000 employees for demand-responsive services. Managing fare collection, monitoring customer behavior, and providing customer information without an onboard operator will surely prove a challenge for public transportation going forward.

Fifth, one of the most critical issues facing transit stakeholders is long-range planning and capital investment decision-making, in light of the long lifespan and high cost of many fixed-infrastructure commitments. For example, today's new rail projects might come on line just when new automated vehicles appear, cutting into anticipated business. New mobility options could also influence urban development patterns, further altering travel demand. Meeting these challenges in a responsible fashion will be key to retaining credibility with the public.

The future of transportation is highly uncertain. What is certain is that travelers will have more choices from an array of new mobility options varying in cost, speed, convenience, flexibility, safety, reliability, comfort, and environmental impact. The path forward requires tearing down silos among transport modes, perhaps more quickly and deliberately than ever before. Affected groups — users, local governments, taxpayers, operators, advocates — need to begin organizing around the mobility needs of various market segments and quality-of-life objectives, rather than around existing modes, technologies, or governance structures. Progress will require leveraging the entrepreneurial private sector in such a way that it can complement the purposes that have sustained the historic public investment in transit.

This article is an abridged and updated paper based on a chapter from Three Revolutions: Steering Automated, Shared, and Electric Vehicles to a Better Future.

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Dan Sperling is founding director of the UC Davis Institute of Transportation Studies and distinguished professor of civil engineering and environmental science and policy. He also is a member of the California Air Resources Board and lead author of *Three Revolutions: Steering Automated, Shared and Electric Vehicles to a Better Future*.

How Much Traffic is Cruising for Parking?

Robert Hampshire and Donald Shoup

On a congested city street where all the curb spaces are occupied, some of the traffic is probably searching for curbside parking. This cruising for parking creates a moving queue of cars waiting for vacancies but it is difficult to know how many cars are in the queue because the cruisers are mixed in with other cars that are traveling to destinations.

Cruising for parking stems from underpriced curb spaces. If prices are too low and no curb spaces are vacant, drivers searching for parking congest traffic, waste fuel, and pollute the air. Conversely, if prices are too high and many curb spaces are vacant, businesses lose customers, employees lose jobs, and cities lose tax revenue. Consequently, pricing for curb parking should follow the Goldilocks principle. The right price is the lowest price that keeps one or two spaces open for convenient access on every block so that any driver willing to pay will find a place to park.

Measuring cruising

How much traffic stems from cruising for parking? Table 1 summarizes the results of 22 studies of cruising in 15 cities on four continents, dating back to 1927. According to these findings, cruising for parking accounted for between 8 and 74 percent of traffic in the areas studied, and the average time to find a curb space ranged between 3.5 and 15.4 minutes. On average, 34 percent of cars were cruising, and the average time it took to find a space was eight minutes. However, these results do not represent all city streets because researchers tend to study cruising only where they expect to find it: on downtown streets where traffic is congested and all the curb spaces are occupied. Despite this selection bias, these studies do show that searching for curb parking has wasted time and fuel for decades.

These averages do not suggest that a third of *all* traffic is cruising for parking. On streets with plentiful open curb spaces, no cars are likely to be cruising. The share of traffic that is cruising can also change from one minute to the next, just as traffic volumes shift throughout the day. Cruising is a variable, not a constant. For example, a study of traffic in central Zurich found that the share of cars cruising varied between 20 and 70 percent from 11 a.m. to 4 p.m. There may be an average share of cruising traffic on a particular street throughout the day, but that average does not predict cruising at any particular time or location, and it certainly does not apply to a whole city.

Understanding how much traffic is caused by cruising for curb parking is important because new demands are overloading the curb. The growth of e-commerce has increased the demand for loading zones. Uber and Lyft have increased the demand for curb space to pick up and drop off passengers. Traffic congestion has increased the demand for dedicated bus lanes.

Table 1. Cruising for parking

Year	City	Share of traffic cruising	Average search time (minutes)
1927	Detroit (1)	19%	
1927	Detroit (2)	34%	
1933	Washington		8.0
1960	New Haven	17%	
1965	London (1)		6.1
1965	London (2)		3.5
1965	London (3)		3.6
1977	Freiburg	74%	6.0
1984	Jerusalem		9.0
1985	Cambridge	30%	11.5
1993	Cape Town		12.2
1993	New York (1)	8%	7.9
1993	New York (2)		10.2
1993	New York (3)		13.9
1997	San Francisco		6.5
2001	Sydney		6.5
2005	Los Angeles	68%	3.3
2006	New York (4)	28%	
2007	New York (5)	45%	
2008	New York (6)		3.8
2011	Barcelona	18%	
2015	Brisbane		15.4
Average		**34%**	**8.0**

Cyclists want bike lanes and pedestrians want wider sidewalks. The curb is the new urban frontier, and parking may no longer be the most productive use of this space.

A new way to estimate cruising traffic

The studies in Table 1 used three main methods to study cruising for parking. They either observed cars in the traffic flow (Detroit, Freiburg, Los Angeles), interviewed drivers who had parked at curbs or were stopped at traffic lights (Barcelona, Brisbane, Cape Town, Los Angeles, New Haven, New York), or conducted park-and-visit tests (Cambridge, London, New York). Unfortunately, these research methods are labor-intensive, time-consuming, expensive, and hard to replicate.

We propose a simpler way to estimate the share of traffic that is cruising for parking on a congested street where all of the curb spaces are occupied. We do this by observing how many cars pass a newly vacated space until a driver parks in it. If, for example, the first or second driver who approaches a newly vacated curb space always parks, it suggests that most of the traffic is cruising for parking. But if many cars pass by before one takes the vacated space, we can assume that most of the traffic is not cruising.

To determine the amount cruising for parking using this method, we employ a probability distribution where each observation of cars in traffic has only two possible outcomes: parking or passing. In a large sample, if the first driver who approaches a newly vacated space always takes it, all of the traffic is probably cruising. If an average of three cars pass the space before a car takes it, then about a third of the traffic is probably cruising. And if an average of 10 cars pass before a car takes it, then 10 percent of cars are probably cruising.

An example

Suppose we have 20 separate observations of how many cars pass a newly vacated parking space before a car takes it and find:

- In 10 of the tests, the first car to approach the open space takes it.
- In five of the tests, the second car to approach the open space takes it.
- In the remaining five tests, the third car to approach the open space takes it.

To estimate the share of cars cruising we divide the number of cars passing the vacant spaces (35 total across all observations) by the number of observations (20); in this case, 57 percent of the traffic is cruising for parking.

A German case study

Video sensors can be used to monitor traffic and measure the number of empty and occupied parking spaces on a block. The cameras are mounted on lamp poles or traffic signals between 20 and 40 feet above the ground, and can observe up to 30 parking spaces each. The cameras have onboard data-processing capabilities that calculate the share of vacant curb spaces every two or three seconds with the goal of providing real-time measures of the availability of open curb spaces throughout the day. A fortunate byproduct of these new camera systems is that the video sensors also record the traffic and parking occupancy on each street throughout the day. We were able to analyze these video measurements through Cleverciti, a firm that provides sophisticated camera-based analyses of parking occupancy in many cities. We then applied our formula to the data to estimate how many cars in a given area are cruising for parking.

In September 2017, Cleverciti analyzed the video records of parking and traffic on 12 streets in central Stuttgart, Germany, from 9 a.m. to 6:30 p.m. Whenever a camera detected a new open parking space, it counted the number of cars that passed before another car occupied it. Over the course of the study's two days, there were 876 instances of newly vacated parking spaces.

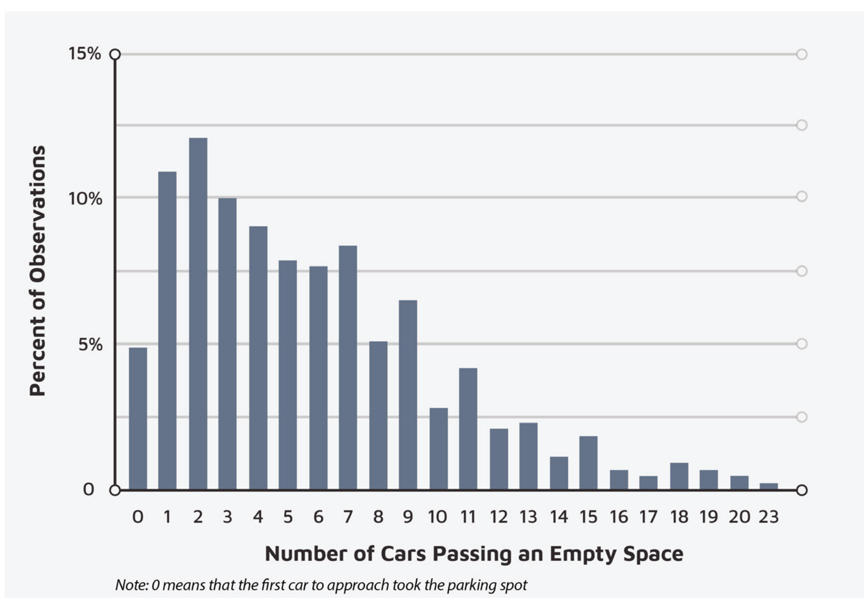
Figure 1 shows that few or no cars often passed by a curb parking vacancy without parking in it. On the first day's observations, we estimated that 15 percent of the drivers in traffic were cruising for parking. On the second day's observations (not shown here), we estimated that 16 percent of those cars in the traffic flow were cruising for parking.

Traffic congestion is a nonlinear phenomenon, meaning that small additions to or reductions in traffic can have outsized effects on vehicle flow, so removing 15 percent of the cars in traffic could greatly reduce congestion. And because a car waiting in traffic while another driver is leaving (or preparing to leave) a space is effectively double-parked, reducing cruising could substantially reduce congestion.
We also estimated the share of traffic cruising during each hour during the day. Figure 2 shows that cruising varied surprisingly little during the day (the observations started and ended earlier on Saturday).

Reducing cruising

Setting the right price for curb parking is the simplest, quickest, and cheapest way to reduce time spent cruising for parking. The benefits of

Figure 1. Often, few cars approach an open parking spot without taking it



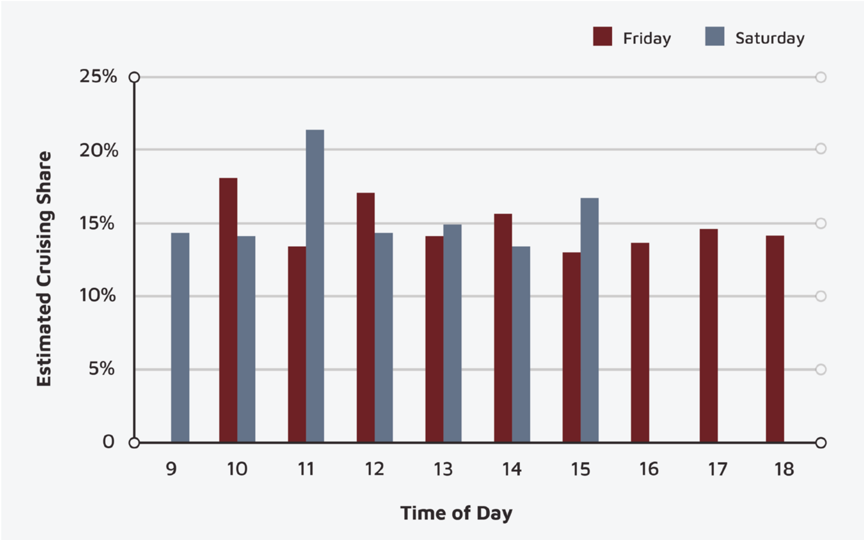


Figure 2. Share of traffic that is cruising for parking in Stuttgart, Sept. 1-2, 2017

reducing cruising are substantial — saving time and fuel, reducing traffic congestion and air pollution, and preventing traffic injuries. Cities will also raise public revenue from the curb parking.

The technology used to measure parking occupancy and adjust parking prices is rapidly improving. Better and cheaper technology will allow more cities to adjust parking prices according to demand, and thus reduce the harm that cruising causes. Developing a simple way to estimate the share of traffic that is cruising for parking will ultimately help to increase political support for demand-based parking pricing. If measurements show where large shares of traffic are cruising for parking, elected officials may be more willing to adopt demand-based pricing for curb parking to reduce cruising and ease traffic.

Conclusion

Previous measurements of cruising for parking have been expensive, time-consuming, and potentially misleading. But as camera-based parking analysis improves and spreads across cities, counting how many cars pass a vacant parking space before one parks is becoming cheaper and easier. With the appropriate algorithms, cities can begin to measure cruising in real time. This new information will reveal the cruising problem to transportation planners, stakeholders, and elected officials who can use the data to improve their cities' curb management. Carefully looking at traffic to measure cruising for parking can yield substantial benefits for cities, the economy, and the environment.

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Carless in California: What the Carless Can Tell Us About Shifting Behaviors and Improving Mobility

Jean-Daniel Saphores and Suman K. Mitra

About 7 percent of California households do not own motor vehicles. Unfortunately, families without cars, trucks, vans, SUVs, or motorbikes are rarely the focus of transportation research and policies, which typically center more on predicting and managing motor vehicle traffic.

Widespread automobile ownership has shaped our society by enhancing mobility for most, but these benefits have come at the cost of frequent collisions, heavy traffic congestion, substantial carbon emissions, and widespread noise pollution. In 2015, California Gov. Jerry Brown signed an executive order requiring the state to reduce greenhouse gas emissions to 40 percent below 1990 levels by 2030, accelerating goals previously set by Assembly Bill 32 and Senate Bill 375. While these laws and executive orders have turned reducing vehicle-miles traveled into a prominent policy goal, the path away from an auto-dependent society is far from clear. Accordingly, researchers and policymakers can learn a great deal from the households who live without motor vehicles. To do this, we must first distinguish between "voluntarily carless households," who have chosen to not own motor vehicles, and "involuntarily carless households," who are carless by necessity.

Understanding the characteristics and the travel behavior of households who voluntarily forgo cars can inform policies that aim to reduce our dependence on motor vehicles. At the same time, it is equally important to take into account the characteristics of involuntarily carless households, as they are at risk of social exclusion due to impaired mobility.

Involuntary carlessness has been associated with poverty, which in turn, links it to race, ethnicity, place of birth, and for immigrants, time since arrival in the United States. Some studies show that car ownership is more important to finding employment than even education or job training. Motor vehicle access is also strongly associated with important health-related factors, like doctor's visits and prenatal care. Because car ownership is so valuable in the United States, some studies show that carlessness is often temporary and ends when families are able to acquire vehicles. Not surprisingly, research shows that walking, cycling, transit use, and getting car rides from others are more prevalent in carless households than in motorized households. When they do travel in motor vehicles, members of carless households most frequently travel for work or personal business, followed by social/recreational and religious activities. New mobility options, such as car and bike sharing programs, appear to be particularly promising for involuntarily carless people, and could facilitate more voluntary carlessness since they provide substitutes for family cars.

Unfortunately, we don't know a lot about carless households and their travel behavior. To fill this gap, we analyzed data from the 2012 California Household Travel Survey (CHTS). We characterized carless households in California, and assessed the effects of socioeconomic and built environment factors on the likelihood that a household is carless. California is a good place to study carlessness because its diverse population lives in many different types of built environments — rural, urban, and suburban — from the San Francisco Bay Area, where comprehensive transit service is widespread, to Southern California suburbs, where transit is scarce and cars are indispensable.

Understanding the carless

Most results reported in this paper come from analyzing data from the 2012 CHTS, which gathered geographically specific travel information from households in all of California's 58 counties. The data were collected using diaries, computer-assisted telephone interviews, a website, and global positioning system devices. A total of 42,431 households recorded their travel for a pre-assigned 24-hour period, and provided detailed socioeconomic characteristics, locations, and household car ownership status.

To understand whether carless households chose to live without cars voluntarily, we analyzed the CHTS question that asks reasons for not owning a motor vehicle. Respondents who selected either "want to be without a car" or "concerned about [cars'] impact on [the] environment" (items 1 and 2 in Table 1) were assumed to have chosen voluntarily to forgo vehicles, provided they did not select any other answer suggesting that their choice was constrained (e.g., "for monetary, medical, or age reasons"). Conversely, households who could not afford vehicles, could not get insurance, or who had health- or age-related constraints, were deemed involuntarily carless, provided that they did not also give reasons that characterize voluntarily carless households. All other households were deemed "unclassifiable."

Following published car ownership studies, we investigated characteristic patterns of both households (income, education level, household composition, and dwelling type) and household heads (Hispanic or Latino status, other ethnicity indicators, age, gender, and immigration status). Since the built environment is an important determinant of car ownership, we also examined factors related to home area population density, land use diversity, and urban design. The nearby availability of public transit was estimated by measuring the share of the regional population that could be reached within 45 minutes via public transit and/or walking. Finally, residential self-selection — the likelihood that carless families choose to live in areas conducive to walking, bicycling, or riding transit — was statistically accounted for as well.

Who are California's carless?

Households are more likely to be carless if they are African American, less educated, immigrated to California fewer than five years ago, or have many household members. Conversely, households are less likely to be carless if they have higher incomes, belong to the "Silent Generation" (born between 1920 and 1940), or live in a single-family house. Not surprisingly, compared to households with vehicles, carless households tend to live in denser, more land-use diverse, and more walkable areas with better transit service.

Similar factors are associated with households who voluntarily forgo their cars, with a few notable differences. Those with male heads of household are more likely to be voluntarily carless, but neither the age of householders nor the jobs-housing balance in their communities affects the likelihood of voluntary carlessness. Compared to involuntarily carless households, voluntarily carless households are also more affluent and live in more walkable, land-use diverse areas with better transit service. These differences between voluntary and involuntary carlessness suggest that the long-held practice of interpreting not having a car as an indicator of disadvantage without accounting for the fact that some people choose not to own cars may

Table 1: Classification of carless households

Item number	Reasons and combinations of reasons given by respondents for not having a motor vehicle	Authors' Classification
1	"Do not need a car - can do what I need and want to without a motor vehicle"	Voluntary
2	"Concerned about impact on environment"	Voluntary
3	"Can't drive" and (1 or 2)	Voluntary
4	"No driver's license" and (1 or 2)	Voluntary
5	"Get rides from other people" and (1 or 2)	Voluntary
6	"Use public transit" and (1 or 2)	Voluntary
7	"Too expensive to buy"	Involuntary
8	"Too expensive to maintain (gas/insurance/repairs)"	Involuntary
9	"Health/age related reasons"	Involuntary
10	"Cannot get insurance"	Involuntary
11	"Can't drive" and (7 or 8 or 9)	Involuntary
12	"No driver's license" and (7 or 8 or 9)	Involuntary
13	"Get rides from other people" and (7 or 8 or 9)	Involuntary
14	"Use public transit" and (7 or 8 or 9)	Involuntary
15	Other	Unclassifiable
16	Mentioned at least one reason between 1 and 6 and one reason between 7 and 14 in the list above	Unclassifiable
17	No answer	Unclassifiable

Notes:

1) This table partitions CHTS participants based on their responses to the question: "Please let us know the reasons why you/your household does not own a motor vehicle."

2) The middle column ("Reasons for not owning a motor vehicle") lists the combinations of responses given by the respondents. The rightmost column gives the corresponding authors' classification.

3) A household was assumed to be voluntarily carless if the household respondent answered either "do not need a car" or "concerned about impact on environment" or any combination of reasons given by items 3 through 6 above. These answers do not imply that their choice to be carless was constrained. We made a judgment call when we interpreted "Can't drive" and "No driver's license" in combination with (1 or 2) as a sign of voluntary carlessness.

4) Conversely, households who stated that they cannot afford a vehicle, cannot get insurance, have health/age constraints, or gave combinations of reasons, as shown by items 11 through 14 above, (which exclude the reasons that characterize voluntarily carless households) were assumed to be involuntarily carless. All other carless households were deemed "unclassifiable."

5) After an exhaustive investigation during which we removed observations with missing and questionable information, our sample had 32,781 households, of which 30,812 own at least one motor vehicle, and 1,969 own none. This includes 302 voluntarily, 830 involuntarily, and 837 unclassifiable carless households.

be distorting our understanding of household transportation decision-making.

Although its effects are relatively minor, our results also confirm the presence of residential self-selection — whereby some people choose to live in neighborhoods (such as central city areas) that make it easier to live without a car.

Finally, while we find that higher population densities foster more voluntary carlessness, research has long shown that density alone has a relatively small influence on driving, and that other factors often associated with density — such as transit service coverage, neighborhood walkability, and the diversity of local land uses — play important roles in supporting carlessness as well.

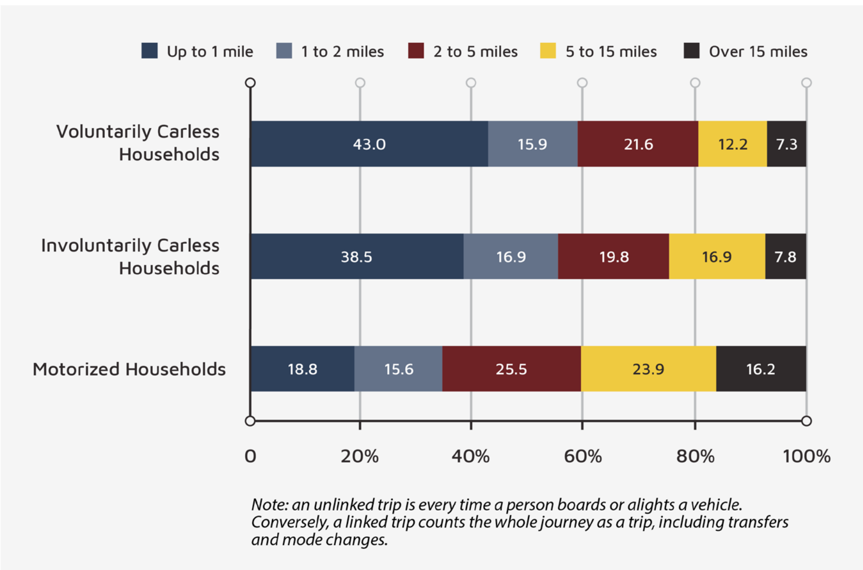

Figure 1. Linked trip frequency by distance

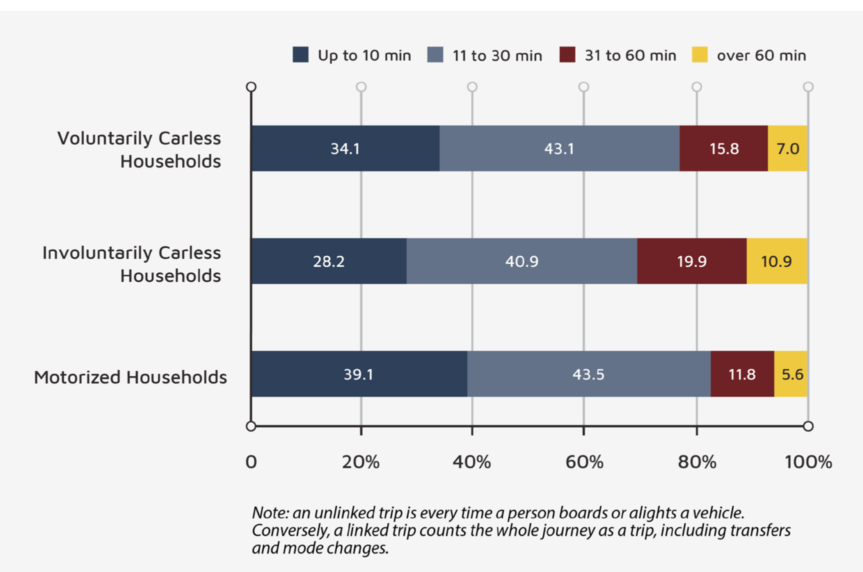

Figure 2. Linked trip frequency by duration

Travel patterns of carless households

Compared to motorized households, carless households take fewer than half as many trips on average. Their trips are also consistently shorter; median trip distances are less than half as long, with a higher proportion of trips under a mile (Figure 1). Conversely, median travel times tend to be longer for involuntarily carless households than for either voluntary carless households or, especially, motorized households, as walking, getting rides from others, or taking public transit are typically slower than driving (Figure 2). Unsurprisingly, members of carless households ride transit, walk, and bike more than motorized households.

Compared to the voluntarily carless, involuntarily carless households travel farther, albeit less frequently, even though they are slightly less affluent. This is especially the case for trips involving personal business or work, civic, recreational, religious, or social activities. This may be because voluntarily carless households can satisfy more of their needs without traveling as far as they are more likely to live in neighborhoods with mixed land uses that make walking trips easy and convenient. Overall, voluntarily carless households walk and bike more, and depend on motor vehicles and transit less than involuntarily carless households.

The more frequent use of public transit by involuntarily carless households suggests that public transit still largely serves "captive riders" (i.e., riders without good alternatives to public transit), even though recent public transit investments have tended to focus on attracting so-called "choice riders." Finally, when involuntarily carless household members do use motor vehicles, they tend to carpool more than when those in voluntarily carless households travel by car. Involuntarily carless households may have less flexibility when using motor vehicles because they are less affluent, on average, and thus have more incentive to share vehicles and rides.

Overall, involuntarily carless households appear to be less mobile than voluntarily carless households. Their trips tend to take more time and they often travel farther. These travel patterns, which planners typically interpret as symptoms of transportation disadvantage, may contribute to more social exclusion and diminished well-being among those in involuntarily carless households.

Assisting the involuntary carless and promoting voluntary carlessness

In the short term, there is no simple solution for improving the mobility of involuntarily carless households because access to motor vehicles is key to quality mobility in most of California. Financial assistance for families to acquire motor vehicles is an obvious remedy, and numerous evaluations of vehicle access assistance programs have found them to be effective for helping low-income travelers. Effective or not, such programs can prompt concerns that helping the involuntarily carless increase motor vehicle access will contribute to greenhouse gas emissions, air pollution, and traffic congestion. At the same time, restricting the poor from the auto-mobility benefits enjoyed by more affluent Californians is an inequitable way to meet important environmental objectives.

Improving transit services could make carlessness more appealing by bolstering the mobility of carless households. However, this strategy's financial viability often hinges on high population and job densities where public transit works best. Furthermore, transit improvement projects can often draw opposition from community groups, not to mention resistance to the costs of transit implementation and the potential impacts on car throughput. To maximize the effectiveness of transit, these measures could be coupled with policies that promote affordable housing in denser, mixed-use environments, which encourage walking and bicycling. As a result, carless households would not have to travel as much to fulfill their needs.

Transportation planners in California should review experiences in Europe, Japan, and Australia, where voluntary travel behavior change programs provide information, assistance, and incentives to entice people to switch to greener, more active modes. These “soft policies” often feature information campaigns about the health benefits of active modes or the negative environmental impacts of driving, along with real-time information for personal travel planning, convenient e-ticketing, and discounted or free public transportation passes. “Hard policy” alternatives include infrastructure changes, implementing road and parking pricing, as well as higher levels of vehicle taxation. In Denmark, for example, the registration tax for a new car varies between 85 and 105 percent of the purchase price. The Danish government has also consistently invested in public transit and bicycling infrastructure, in addition to implementing voluntary travel behavior change measures. As a result, approximately one third of Danes bike to work, and almost half of Danish children ages 11 to 15 bike to school. Apart from substantial environmental benefits, the health effects of these high bicycling rates have been estimated to reduce annual sick days by 1.1 million per year in Copenhagen alone. Large behavioral changes in California on the scale needed to provide equitable mobility options for carless individuals and achieve greenhouse gas reduction targets will likely require both soft and hard policies.

The development of shared transportation options, coupled with the emergence of self-driving vehicles, could also enhance the mobility of carless households, especially those who are involuntarily carless. In particular, bike sharing and affordable car sharing programs could begin to address transportation disadvantage in urban environments. Car sharing would become even more attractive if self-driving technology were to substantially cut its cost, disconnecting vehicle ownership from mobility. The timing of this potential revolution is highly uncertain, but today’s carless households could be harbingers of the future to a greater extent than they are relics of the past.

Acknowledgments

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Opinion: Mentoring the Next Generation of Transportation Professionals

Richard Willson

Transportation professionals often enter the workforce with strong motivations to make positive change. Happily, change is afoot. Transportation agencies are shifting to multimodal approaches, while new technologies and analytic methods are shaking up the field. Policy attention to sustainability, system resilience, and social equity is growing. That's good news for aspiring change agents.

The bad news is that some entry-level transportation professionals feel constrained by their workplaces. Surveys of millennials show that they want to make a meaningful impact early on, and that reforms around multimodal, active, and equitable transportation strongly resonate with them. Yet, I hear complaints from young transportation planners about their organizations, and have been surprised by how quickly they will leave positions that don't feel like an immediate fit.

However, by offering encouragement and guidance, seasoned professionals can help younger colleagues understand the value of their early career work, which can reduce dissatisfaction and turnover. Mentoring helps young professionals see the subtle and indirect ways that their work makes a difference, while making new transportation planners feel welcome and effective in their organizations. It can aid them in finding alignment with organizational culture, and offer insight into how discrete technical tasks affect project outcomes upstream and downstream. Mentoring also enhances young planners' capacity to make professional judgments pertaining to processes, methods, and ethics.

Young public sector transportation planners will sometimes describe their work setting as top-heavy and bureaucratic. They don't always find a satisfying connection between their day-to-day work and change on the ground. For example, a planner working on making service changes at a transit agency may encounter resistance from colleagues and get frustrated by slow progress. Mentoring can help young transportation professionals develop strategies to respond productively to such settings, and/or decide whether to seek a job where results are more tangible.

In consulting firms, young transportation planners can have concerns about a lack of training, insufficient manager feedback, and pressure to produce billable hours, while compartmentalized entry-level tasks can make them feel like cogs in a wheel. Mentoring can help such planners manage time pressure, understand clients' perspectives, and gain informal constructive feedback on their performance.

I have written extensively on idealists and planning in recent years, and through that work have developed some mentoring tips for transportation professionals.

Tips for young transportation professionals

1. If in-house mentoring is available, take advantage of it. If it is not available from your direct supervisor, find it where you can. If mentoring is not available within your organization, or you'd like to keep it separate from performance reviews, cultivate mentors outside of your organization.
2. Be attentive to the many forms that mentoring takes. Mentoring can include career planning, professional coaching, life coaching, and mentoring-by-doing (completing a task with an experienced transportation planner). It could be happening without you noticing.
3. Be open to different mentoring styles. Mentors can range from kind supporters to those who challenge you. Some will take you under their wings on their own initiatives, while others will respond only if asked.

Tips for mentors

1. Mentoring provides intrinsic rewards by extending the mentor's legacy through the work of others. But even from a utilitarian standpoint, mentoring can reduce employee turnover and increase engagement.
2. While storytelling is a powerful teaching tool, place the focus on the mentee's process of understanding and deciding. Rather than suggesting what the mentee might do, offer ways of thinking about the issue. Point out blind spots and offer approaches to dealing with ambiguity.
3. For mentees who are concerned with a lack of impact, provide tools to help them understand political conflict, organizational rivalries or coalitions, risks, timing, or external mandates. Share ways of processing cynical feelings if a good idea is scrapped.

New planners should take advantage of the numerous field-related organizations that offer mentoring, including the Institute of Transportation Engineers, the American Planning Association, the Women's Transportation Seminar International, the Transportation Research Board, and others. For example, the Transportation Research Board Minority Student Fellows Program empowers young transportation planners and engineers by having them write peer-reviewed papers alongside mentors. This program has led many participants to advanced degrees. Transportation planners can benefit from *ad hoc* mentors they meet through professional connections as well.

Employers also offer mentoring programs. For example, the Los Angeles Department of Transportation's in-house program pairs senior and junior transportation professionals, and LA Metro holds "lunch and learn" seminars for young employees. Employers should seek to canvas young employees about their needs, and design programs to fill them.

Perhaps the most important contribution of mentoring is helping young transportation planners master the dance of idealism and realism that is inherent in professional transportation planning practice. Personal idealism about desired changes must adapt to the work context. Mentoring can help young transportation planners develop a style of practice that is based on a realistic understanding of the prospects for change. Plus, it can keep young planners engaged in transportation professions over the long-term, so that they are ready and capable of tackling the transportation challenges of the coming decades.

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