Falling Transit Ridership:

California and Southern California

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EXECUTIVE SUMMARY

In the last ten years transit use in Southern California has fallen significantly. This report investigates that falling transit use. We define Southern California as the six counties that participate in the Southern California Association of Governments (SCAG) – Los Angeles, Orange, Riverside, San Bernardino, Ventura and Imperial. We examine patterns of transit service and patronage over time and across the region, and consider an array of explanations for falling transit use: declining transit service levels, eroding transit service quality, rising fares, falling fuel prices, the growth of Lyft and Uber, the migration of frequent transit users to outlying neighborhoods with less transit service, and rising vehicle ownership. While all of these factors probably play some role, we conclude that the most significant factor is increased motor vehicle access, particularly among low-income households that have traditionally supplied the region with its most frequent and reliable transit users.

Transit service and use trends in Southern California

Long associated with the automobile, in the last 25 years Southern California has invested heavily in public transportation. Since 1990, the SCAG region has added over 100 miles of light and heavy rail in Los Angeles County, and over 530 miles of commuter rail region-wide. These investments, however, have not been matched by increases in transit ridership. Transit ridership in the SCAG region reached its postwar peak in 1985. Through the 1990s and 2000s ridership rose and fell modestly, but never again reached its 1985 level. Figure ES-1 shows that per capita trips have been mostly declining in the SCAG region since 2007, and have fallen consistently since 2013.

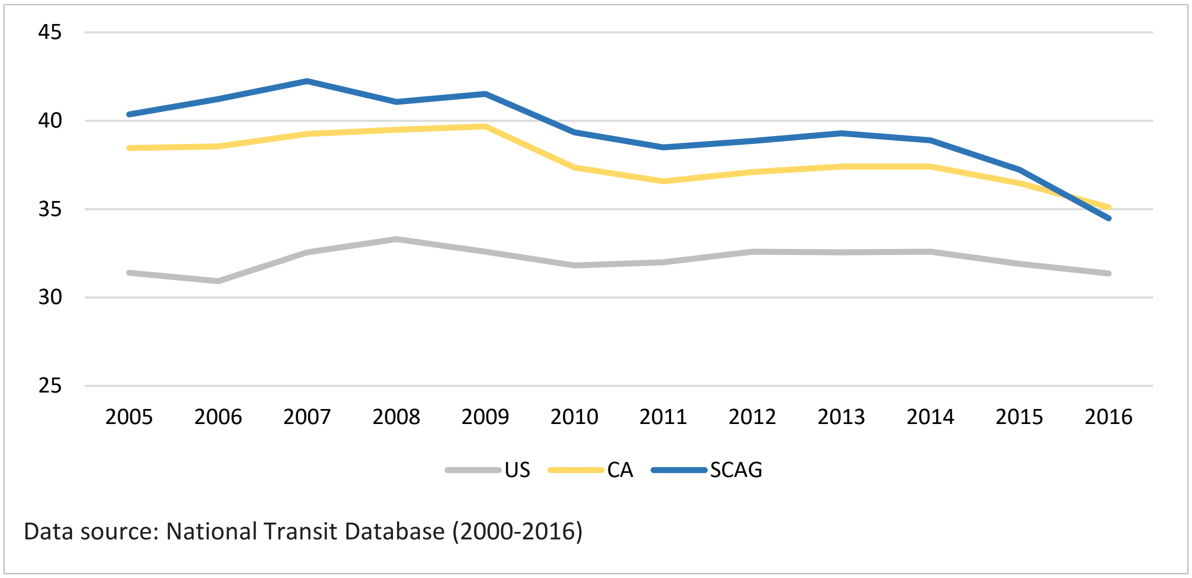


Figure ES 1. Transit trips per capita. *Relatively flat nationally, but down in California since 2009.*

This decline spans modes; it is not simply a case of bus ridership falling while rail ridership increases. Rail ridership, on net, is also down. Further, these aggregate numbers mask large asymmetries in transit service and use. Transit use in particular is heavily concentrated among a relatively small segment of the population, in a small number of the region's neighborhoods, and on a small share of the region's transit systems. As a result of these asymmetries, even small changes in these households, neighborhoods, or transit systems can have an outsized effect on regional transit use.

A few people make most of the trips

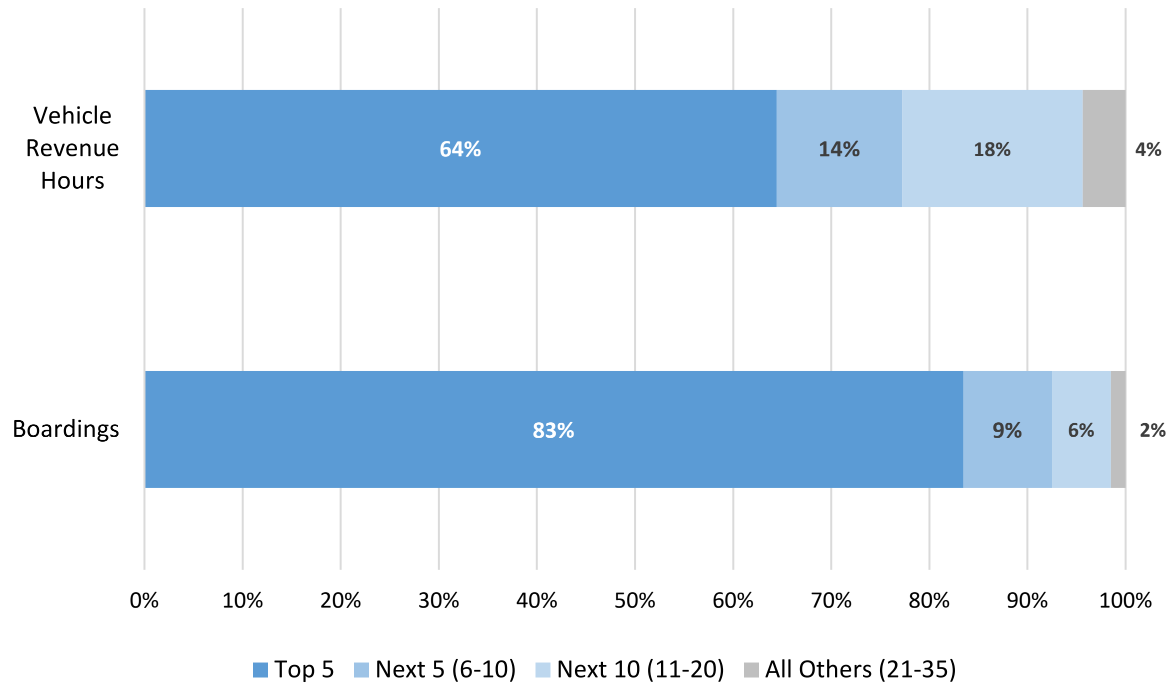
The average resident of the SCAG-region made about 35 transit trips in 2016, but the median resident made none. Only a minority of the population rides transit very frequently or even occasionally. About two percent of the population rides transit very frequently (averaging 45 trips/month), another 20 percent of the population rides transit occasionally (averaging 12 trips/month), and more than three-quarters of SCAG-region residents ride transit very little or not at all (averaging less than 1 trip/month). Heavy transit use, moreover, is concentrated among the low-income population, and especially low-income foreign born residents.

A few neighborhoods generate most of the trips

Ten percent of all of the people who commuted to and from work on transit in 2015 lived in 1.4 percent of the region's census tracts, which covered just 0.2 percent of the region's land area; the average number of transit commuters in these few tracts was almost 12 times the regional average. Fully 60 percent of the region's transit commuters lived in 21 percent of the region's census tracts, which occupied 0.9 percent of the region's land area. Overall, the most urban and transit-friendly neighborhoods in the SCAG region comprise less than one percent of the region's land area. These neighborhoods hold about 17 percent the region's population, but 45 percent of its transit commuters. So while the region's transit systems are increasingly diverse and far reaching, transit riders remain highly concentrated.

A few operators carry most of the passengers

The SCAG region has over 100 transit operators, but just a few them carry the vast majority of riders. Figure ES-2 shows that nine percent of the region's operators are responsible for 60 percent of the region's transit service and carry about 80 percent of all transit riders.



Data source: National Transit Database (2000-2016)

Figure ES 2. Key metrics by operating grouping. *14% of operators carry 83% of the trips.*

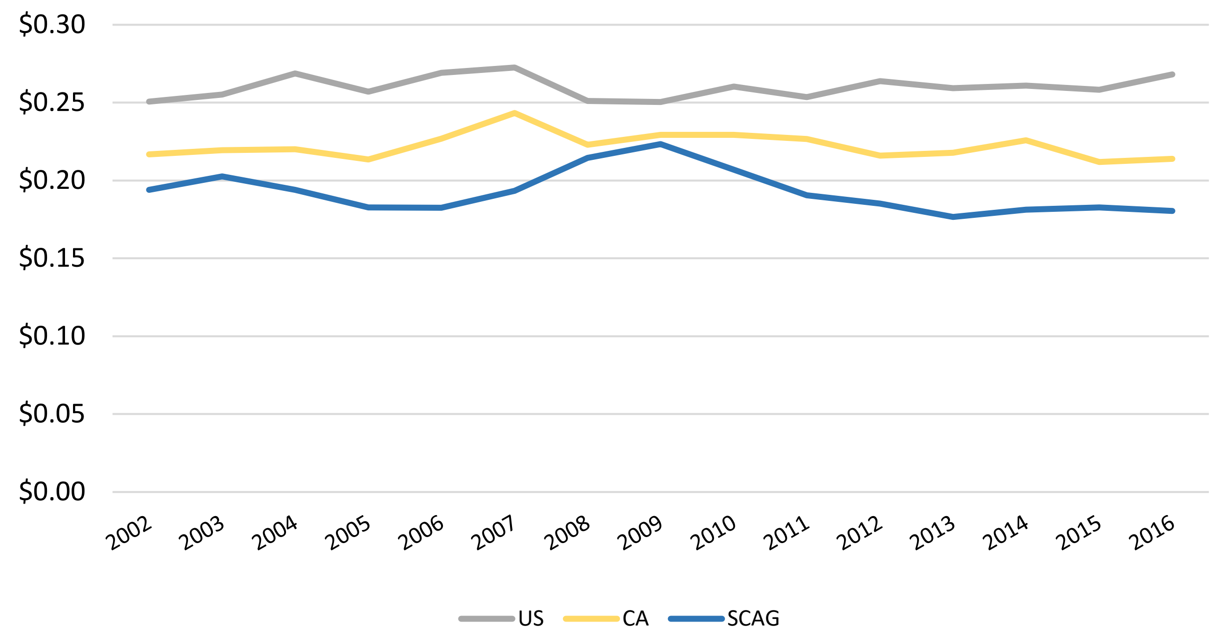
Because service and riders are concentrated on the largest systems, ridership losses are concentrated on these systems as well. Four SCAG-region operators—LA Metro, Orange County Transportation Authority (OCTA), Los Angeles Department of Transportation (LADOT), and the Santa Monica Big Blue Bus—accounted for 88 percent of the state's ridership losses between 2010 and 2016. LA Metro by itself accounted for a remarkable 72 percent of the state's losses. Because LA Metro's losses are themselves highly concentrated, a dozen *routes* in LA County account for 38 percent of all the lost ridership in California. In fact, half of California's total lost ridership is accounted for by 17 LA Metro routes (14 bus and 3 rail lines) and one OCTA route.

Possible causes of eroding transit use

Why is transit use falling? We consider a number of potential explanations, and review our findings below.

Changes in transit service and fares have mostly followed and not led falling ridership

Transit use can fall if transit becomes harder to use: if service declines, or fares rise. It does not appear, however, that these factors played a large role in the SCAG region's falling ridership. While transit fare increases are never popular, they are occasionally necessary to keep pace with rising costs. Figure ES-3 shows the inflation-adjusted trends in average fare paid per mile of transit travel between 2002 and 2016 in the U.S., California, and the SCAG region. Fares in Southern California are lower than those in the rest of the state and the country and have been remarkably flat over time.



Data source: National Transit Database (2000-2016)

Figure ES 3. Average fare per passenger mile traveled in 2015 dollars. *Average fare per PMT remained fairly consistent and even declined a little since 2009.*

These regional averages can mask significant variation among transit operators. In particular, inflation-adjusted fares per boarding for both OCTA and the Big Blue Bus increased by about 50 percent between 2002 and 2016 — to nearly $1.25 and $0.75 per boarding respectively. So while fares have probably not caused significant ridership declines across the region, they may have played a role at operators like OCTA and Big Blue.

Transit service in the SCAG region, moreover, mostly rose while ridership was falling, and ridership fell even on routes that maintained excellent on-time records. These circumstances suggest that service quantity and reliability were not large factors in falling transit use. There is some evidence, admittedly limited, that riders felt unsafe on transit vehicles in recent years, which may have contributed to the ridership decline.

Fuel prices have likely played a contributing, but not leading role

Fuel prices have been volatile since 1998, but have fallen substantially since peaking in 2012. Figure ES-4 compares trends in fuel prices and transit use in the Los Angeles metropolitan area. While there is a generally positive relationship (as fuel prices rise so too does ridership), it is a relatively weak one – fuel prices rise and fall much more dramatically than transit patronage. The timing of transit's decline, moreover, is not conducive to a fuel price explanation. Per capita transit use in Southern California has been mostly falling since 2007, and it fell between 2009 and 2011 when fuel prices were rising sharply.

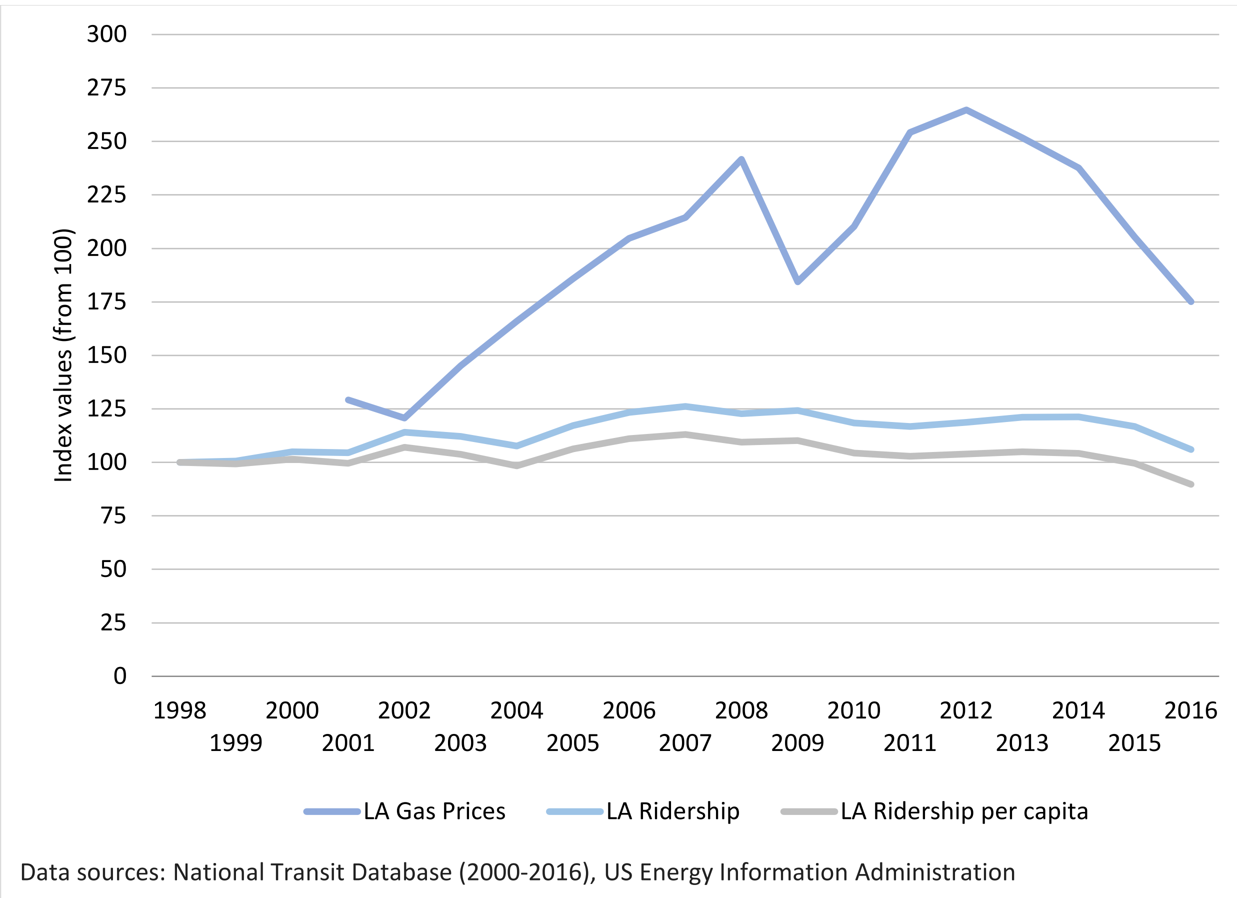


Figure ES 4. Transit ridership and gas prices in Los Angeles Metropolitan Area.

The Transportation Network Companies do not appear to have cannibalized transit

We have very little data that lets us directly measure the effect of transportation network companies (TNCs, like Lyft and Uber) on transit use. What evidence we do have suggests that most TNC trips are probably not replacing large numbers of transit trips. The typical TNC user does not resemble the typical transit rider, the typical TNC trip does not occur when and where most transit trips occur, and most TNC users report no change in their travel by other modes. However, if the pool of TNC users continues to expand, the effect of TNCs on transit use — both positive and negative — may expand as well.

Evidence about neighborhood change and migration of lower-income people is mixed, but suggestive

Transit is heavily-supplied in a small proportion of places, and heavily used by a small proportion of people. If the neighborhoods where transit quality is high change, and become less likely to hold the small group of people who use transit regularly, then transit use could fall. We find some evidence consistent with the idea that neighborhood change has been associated with less transit use. Areas that were heavily populated with transit commuters in the year 2000 became, in the next 15 years, slightly less poor, and significantly less foreign born. Perhaps most important, the share of households without vehicles in these neighborhoods fell notably. All these factors align with a narrative where a transit-using populace is replaced by people who are more likely to drive. We emphasize, however, that this relationship is not one we can measure with precision, and it would be premature to declare neighborhood change a large culprit in falling transit ridership.

Private vehicle access increased substantially from 2000 forward

A defining attribute of regular transit riders is their relative lack of private vehicle access. But between 2000 and 2015, households in the SCAG region, and especially lower-income households, dramatically increased their levels of vehicle ownership. Census data show that from 1990 to 2000 the region added 1.8 million people but only 456,000 household vehicles (or 0.25 vehicles per new resident). From 2000 to 2015, the SCAG region added 2.3 million people and 2.1 million household vehicles (or 0.95 vehicles per new resident).

The growth in vehicle access has been especially dramatic among subsets of the population that are among the heaviest users of transit. Between 2000 and 2015, the share of households in the region with no vehicles fell by 30 percent, and the share of households with fewer vehicles than adults fell 14 percent. Among foreign-born residents, zero-vehicle households were down 42 percent, and those with fewer vehicles than adults were down 22 percent. Finally, among foreign-born households from Mexico, the share of households without vehicles declined an astonishing 66 percent, while households with more adults than vehicles dropped 27 percent. Living in a household without a vehicle is perhaps the strongest single predictor of transit use; the decline of these households has powerful implications for transit in Southern California.

Vehicle ownership is not, of course, the only determinant of regional transit ridership—income, race, age, and nativity, to name a few, also matter. But vehicle access may well be the largest factor. We demonstrate the strong association between vehicle access and transit ridership by building a series of statistical models of transit ridership. The models cover the SCAG region, all of California, Los Angeles County, and the SCAG region outside of LA County. Each model compares two predicted outcomes: the change in transit use we would expect to see based on due to changes in socioeconomic attributes *other than* vehicle ownership, and the change we would expect to see if we account, in addition, for changes in vehicle access. In short, we compare a scenario where incomes, nativity, racial composition, and various other attributes change the way they did from 2000-2015, but where vehicle access is unchanged, to a scenario where vehicle access changes as well.

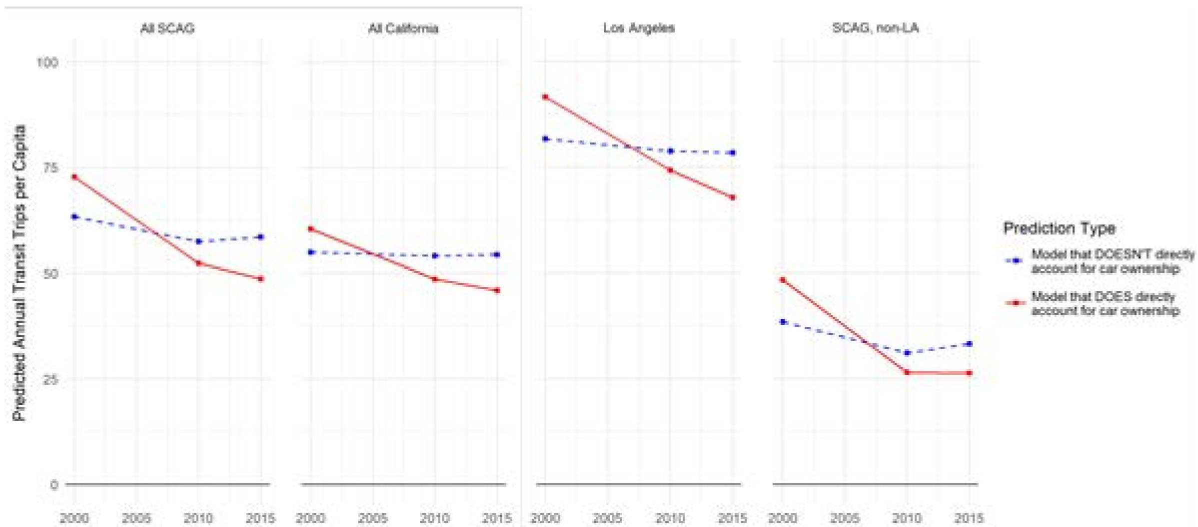


Figure ES 5. Transit use changes based on area.

Figure ES-5 shows the results of these models. The dotted blue line in each case is an estimate of transit ridership trends between 2000 and 2015 based on changes in the region's income, nativity, and so on, but assuming no change in vehicle ownership. The solid red lines represent these same models, but with the region's observed changes in vehicle access included. In all cases the blue line predicts transit use starting at a lower point and declining only modestly, while the red line shows transit use starting at a higher point and falling sharply, more in line with what we are actually observing. The models reinforce the idea that vehicle access is the decisive factor in transit use: income, age, and many other factors matter, but they matter largely because they predict the ability to access and use motor vehicles. In Southern California since 2000, that ability has increased, and transit use has fallen.

Conclusion

Public transportation is unlikely to fare well when Southern California is flooded with additional vehicles, especially when those vehicles are owned disproportionately by transit's traditional riders. Much of the region's built environment is designed to accommodate the presence of private vehicles and to punish their absence. Extensive street and freeway networks link free parking spaces at the origin and destination of most trips. Driving is relatively easy, while moving around by means other than driving is not. These circumstances give people strong economic and social incentives to acquire cars, and — once they have cars — to drive more and ride transit less.

The advantages of automobile access, which are particularly large for low-income people with limited mobility, suggest that transit agencies should not respond to falling ridership by trying to win back former riders who now travel by auto. A better approach may be to convince the vast majority of people who rarely or never use transit to begin riding occasionally instead of driving. This task is unquestionably more difficult than serving frequent-riding transit dependents, and it would likely require weakening or removing some of the state's and region's entrenched subsidies for motor vehicle use. But the opportunity is substantial. The SCAG region, between 2012 and 2016, lost 72 million transit rides annually. That number seems daunting, but the region has a population of 18.8 million, and about 77 percent of those people (roughly 14.5 million), ride transit rarely or never. If one out of every four of those people replaced a single driving trip with a transit trip once every two weeks, annual ridership would grow by 96 million — more than compensating for the losses of recent years. The future of public transit in the SCAG region, then, will be shaped less by the mobility needs of people who do not own vehicles, and more by policy decisions that encourage vehicle-owning households to drive less and use transit more.

FALLING TRANSIT RIDERSHIP: CALIFORNIA AND SOUTHERN CALIFORNIA

In the last 15 years Americans have supported public transportation more and demanded it less. California, the nation's most populous state, is in many ways emblematic of this pattern. Motivated by concerns about congestion and climate change, California's state and local governments have invested heavily in transit, often with the explicit approval of voters. This investment is particularly evident in Southern California. Since 1990, the six-county Southern California Association of Governments (SCAG) region has added over 100 miles of light and heavy rail in Los Angeles County, and over 530 miles of commuter rail region-wide. In November 2016, voters in LA County approved a $120 billion sales tax measure for transportation, with a plurality of the funding dedicated to expanding and improving transit (Measure M: Metro's Plan to Transform Transportation in LA 2016). This measure marked the third such countywide tax increase since 1990, and the fourth one overall. Other SCAG counties have also routinely passed sales tax measures for transportation and transit improvements.

Over the same period, however, California's transit use (depending on how one measures it) has varied from modest increases to relative stagnancy to—in more recent years—steep decline. Southern California is again illustrative. Despite its heavy investments in transit, in absolute terms the region's transit ridership reached its postwar peak in 1985. Through the 1990s and mid-2000s ridership rose and fell modestly, never reaching 1985 levels, and in 2012 it began declining. In per capita terms, ridership has fallen more steadily since the 1980s. Ridership per capita was flat in the early 2000s, but started trending down again in 2007. In California overall, per capita ridership was flat until 2009, when it began a decline from which it has not recovered (The National Transit Database (NTD), 2015).

Why is transit ridership falling? The question is not merely academic. The combination of rising supply and falling demand has profound fiscal implications for transit operators, since it substantially increases the public cost of moving each passenger. Increased transit supply has meant increased public investment, particularly in new rail services. Measured as a ten-year rolling average of capital and operating costs, transit investment in both the US and California rose almost 50 percent between 2000 and 2015. These rising expenditures, when combined with falling patronage, yield falling productivity. Between 2005 and 2016, transit productivity —measured as passenger boardings per vehicle revenue hour (VRH) —has fallen 5 percent in California and 14 percent in the SCAG region. Falling productivity is not sustainable; it usually ends with more subsidies or less service.

Beyond fiscal concerns, falling ridership calls into question a number of California's ambitious environmental goals. California's aggressive agenda for combatting climate change is predicated in part on many people using transit more and driving less. The carbon reduction targets set out in Senate Bill 375, California's landmark climate reduction bill of 2008, involve large mode shifts to transit and away from driving, while the California Department of Transportation's current Strategic Management Plan includes an explicit goal of doubling the state's transit mode share by 2020 (California Department of

Transportation, 2015). But transit ridership, despite heavy transit investment, is trending very much in the opposite direction.

This report assesses California's, and particularly Southern California's, recent ridership downturn. We emphasize Southern California because — as we will show — California's falling ridership is in many ways Southern California's falling ridership. Had transit use not fallen in the SCAG region through 2016, it would not have fallen statewide.

Our study considers the years from 2000 to 2015 or 2016 (depending on data availability). While widespread concern about falling transit use did not begin until ridership began falling absolutely in 2012, we focus on the per capita decline that began about five years before that. The falling absolute ridership of the last few years is important, and we do pay outsized attention to it. But we view it as a particularly acute manifestation of the longer-run per capita decline, not as a phenomenon in itself. Absolute declines in ridership are at once more noticeable and less important than per capita declines. Ridership numbers that are not adjusted for population lack context, and focusing only on absolute ridership declines can for that reason yield incomplete or misleading results.

For example, since 2012 gas prices have fallen sharply, transportation network companies (TNCs) like Lyft and Uber have expanded dramatically, undocumented immigrants have been granted drivers' licenses, and the economy has rebounded from the Great Recession. All these factors may have depressed transit use, but all of them also occurred well *after* per capita transit ridership began to decline. Thus none of them, individually or in combination, can fully explain Southern California's, or California's, transit patronage losses.

Our analysis faces data limitations common to examinations of transit. Aggregate data on transit use are widely available through the National Transit Database (NTD), but users of NTD data can never be entirely sure of the data's accuracy.[1] NTD records are compiled from the reports of individual transit operators to the federal government, and for a variety of reasons — from failure to report to mistakes in reporting to errors in correcting those mistakes— NTD data do not always match up with operator data. We have checked some of the NTD data used in this report against operator data and been satisfied that they reasonably conform, but checking all the data would be impossible. We emphasize that this problem is almost universal in transit studies: all data are imperfect, but the NTD is the nation's standard source for transit data.

A second issue is that while data on transit use are easy to find, data on transit *users* are not. Public transportation is used by a small and hard-to-track subset of the population, making riders (and especially former riders) hard to study. The U.S. Census, in its annual American Community Survey (ACS), provides detailed economic and demographic information about transit commuters, but commutes are a minority of transit trips, and commuters (as we will show) are a minority of transit riders. More detailed data on

[1] Transit operators who receive funding from the Federal Transit Administration's Urbanized Area Formula Program, or its Rural Formula program, must submit data to the NTD on the financial and operating conditions of their systems, as well as the conditions of their assets and rolling stock. Just over 660 operators receive such funding and report to the NTD. See https://www.transit.dot.gov/ntd

transit users can be found in the California Household Travel Survey (CHTS) which provides an in-depth look at travel of all types by Californians, and complements those travel data with extensive person-level socioeconomic information. But the CHTS is a one-year snapshot, only available for 2012. As a result, we have a data mismatch: excellent data for a single year, but a research question – why is transit ridership declining? – that demands data on changes over time.

A last data obstacle is that the determinants of transit use are varied, ranging from gas prices to auto ownership to the quality of transit service, and no single data set contains all of them. Some factors thought to influence transit use, like the availability of free parking, are not systematically tracked at all.

To work around these limitations, we draw on an array of spatial, person-level, and administrative data. At different points we use the U.S. Census summary files, the Integrated Public Use Microdata (IPUMS) of the Census,[2] state and national travel diary data, gas price and economic data from the Energy Information Agency and the Bureau of Labor Statistics, and data and rider surveys conducted by some of Southern California's larger transit operators. One operator—the Los Angeles County Metropolitan Transportation Authority (Metro, or LA Metro)—by itself accounts for most of the region's transit use and has ample public data available. As a result, at different points in the report when data for the entire region is lacking, we draw on data specific to LA Metro.

Largely because of these data constraints, the case we build is circumstantial; we offer no definitive proof of cause-and-effect. But the evidence is nevertheless compelling. The primary factor we identify is automobile ownership. In the last 15 years, household vehicle access in the SCAG region has grown dramatically. Vehicle ownership has grown particularly sharply among subgroups most likely to use transit, such as the low-income and the foreign born from Latin America. The steep rise in vehicle access among these groups that occurred as transit ridership began to fall is not direct proof, but it is a smoldering if not a smoking gun. Public transportation is unlikely to fare well when Southern California is flooded with additional vehicles. Much of the region's built environment is designed to accommodate the presence of private vehicles and to punish their absence. Extensive street and freeway networks link free parking spaces at the origin and destination of most trips. These circumstances give people strong incentives to acquire cars, and — once they have cars — to drive more and ride transit less.

The surge in vehicle ownership does not explain all of the transit decline. And it may well have been reinforced by falling gas prices and the rise of TNCs— though again we note that increasing vehicle ownership and declining transit use began before TNCs existed and when gas prices were still high. But increased vehicle ownership by itself probably explains much of Southern California's lost transit ridership.

Our findings accord with previous research about transit patronage. Giuliano (2005) has shown that compared to Americans at large, the poor use transit more but like it less. The typical low-income rider wants to graduate to automobiles, while the typical driver might view transit positively but have little interest in using it (Manville & Cummins, 2015). These facts, coupled with the falling ridership of recent years, raise questions about transit's future.

Transit ridership is not, by itself, a legitimate goal of public policy. Transit use is instead a means to achieve other public ends. Traditionally, transit's goals have been twofold: Providing mobility to disadvantaged people who lack it, and mitigating the social and environmental costs of private automobiles by providing

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2 The IPUMS data are from Ruggles et al (2017).

alternatives to them. The first goal has long accounted for more of transit's ridership, while the second has accounted for more of its rhetoric. Throughout the United States, and particularly in Southern California, public transportation advocates have emphasized transit's potential to manage traffic and reduce pollution. In practice, however, transit has functioned overwhelmingly as a social service for low-income people with little private mobility (Taylor & Morris, 2015).

Because transit has primarily carried low-income people, rising vehicle ownership among those people suggests a future where public transportation's core ridership could dramatically shrink. While this outcome poses a grave problem for transit operators, it is not obvious that transit operators should try to win these low-income riders back, at least not to the very high levels at which they rode transit previously. With very few exceptions, acquiring an automobile in Southern California makes life easier along multiple dimensions, dramatically increasing access to jobs, educational institutions and other opportunities (Kawabata & Shen, 2006). As a result, pulling low-income former riders out of their cars and back onto trains and buses could make transit agencies healthier but the region poorer. If transit agencies want to protect their fiscal health while also increasing social welfare, they may need to convince the vast majority of people who never use transit to begin riding occasionally instead of driving. This task is unquestionably more difficult than serving a large pool of people who have few alternatives to transit. Convincing some drivers to start using transit would likely require weakening or removing some of the state's and region's entrenched subsidies for motor vehicle use. But transit is unlikely to grow substantially, to accomplish its environmental goals, if driving remains artificially inexpensive.

THE SPATIAL AND DEMOGRAPHIC DISTRIBUTION OF AMERICAN PUBLIC TRANSPORTATION

Public transportation use in the United States is distributed unevenly across people and places. Transit accounts for about two percent of all passenger miles travelled (PMT), and about two percent of personal trips overall (NHTS 2009). These small overall numbers, however, conceal transit's outsized importance to some people in some places. The average U.S. resident made about 32 transit trips in 2016 (Neff & Dickens, 2017; U.S. Census Bureau, 2016), but the modal resident made zero trips, and a small number of people rely on transit extensively. Chu (2012) shows that 20 percent of Americans live in neighborhoods without transit, while 60 percent live in neighborhoods with transit but have not used it in the previous month. Another 11 percent uses transit less than ten times per month, while eight percent take ten or more trips monthly.

The small share of people who use transit frequently is concentrated in a handful of metropolitan areas. In 2016, 65 percent of all transit boardings occurred on the nation's ten largest transit operators; the 15 systems in the New York region by themselves account for over 40 percent of the country's transit trips (FTA, 2016). Even within these transit-heavy areas, however, most people do not use transit regularly, because most transit use occurs in the central cities, and specifically among lower-income and foreign-born people in these cities. And even within these subgroups, whose members are *more likely* to ride transit, *most* people do not use transit.

Why is transit use so rare? In the broadest terms, travelers will choose to ride transit when they believe transit has the lowest relative costs – in money, time, or risk and uncertainty – of the various transportation modes available to them. These factors help explain why so much transit use occurs in New York City. New Yorkers ride transit as much as they do not only because transit service is frequent and extensive, but also because riding a subway across Manhattan is often cheaper, faster and more reliable than driving. Manhattan's streets are clogged with unpredictable congestion and parking is scarce and expensive.[3] In most other places, driving is a faster door-to-door option, and one that people also believe is safer (Yoh, Iseki, Smart, & Taylor, 2011). Driving in these places is also more reliable: when congestion is low and transit service is sparse, riding transit might involve more time waiting at stops and transferring between vehicles, which make trips seem unpredictable, complicated and burdensome (Iseki & Taylor, 2009). For this reason, outside New York and a handful of other urban places, most transit users are people who for various reasons do not have the option of travelling by car.

The fact that so few people use transit regularly is important but often overlooked, especially in discussions about why ridership might fall. Per capita transit use can fall when current riders ride less, when the number of people who never ride grows, or both. Strictly speaking, there is no difference between these root causes. A person who rides and stops is a lost transit rider, but so is a person who moves to a transit service area and never rides. The decision to stop and the failure to start both reduce per capita transit use.

In practice, however, concerns about falling per capita ridership are rarely concerns about new residents who never start riding, and are instead concerns about current riders who leave. This dynamic is understandable, as riders who leave are easier to notice. But it is important to remember that transit riders leave transit regularly, even when ridership is stable or growing. If riders who leave are replaced by others, their departure from transit is less noticeable, and ridership might remain unchanged. For that matter, ridership can remain unchanged even when riders leave and are *not* replaced by other people. If an existing rider stops taking her daily trip and drives instead, but another frequent rider adds a daily trip, the number of riders falls but per capita ridership does not. Conversely, if two riders who take three trips a day each start taking two, the number of riders won't change but ridership will. Riders are not equivalent to ridership; stable ridership can conceal large churn among riders, and vice-versa.

The Spatial Concentration of Transit in California and Southern California

As it is in the nation at large, public transit use in California is unevenly distributed: a small share of people and places account for a large share of overall rides. Northern Californians use transit more intensively than Southern Californians, largely as a result of high ridership in San Francisco and its surrounding areas,

[3] Manhattan also has relatively few highway lane-miles, which contributes to its surface-street congestion.

but most of California's transit use occurs in Southern California, where a majority of the state's population lives (Figure 1). Transit accounts for 6 percent of all trips in the Bay Area, as opposed to 5 percent in the SCAG region, but the SCAG region – because it is so large – accounts for 52 percent of California's transit trips, while the Bay Area accounts for 28 percent. Southern California thus exerts a large influence on California's overall transit use.

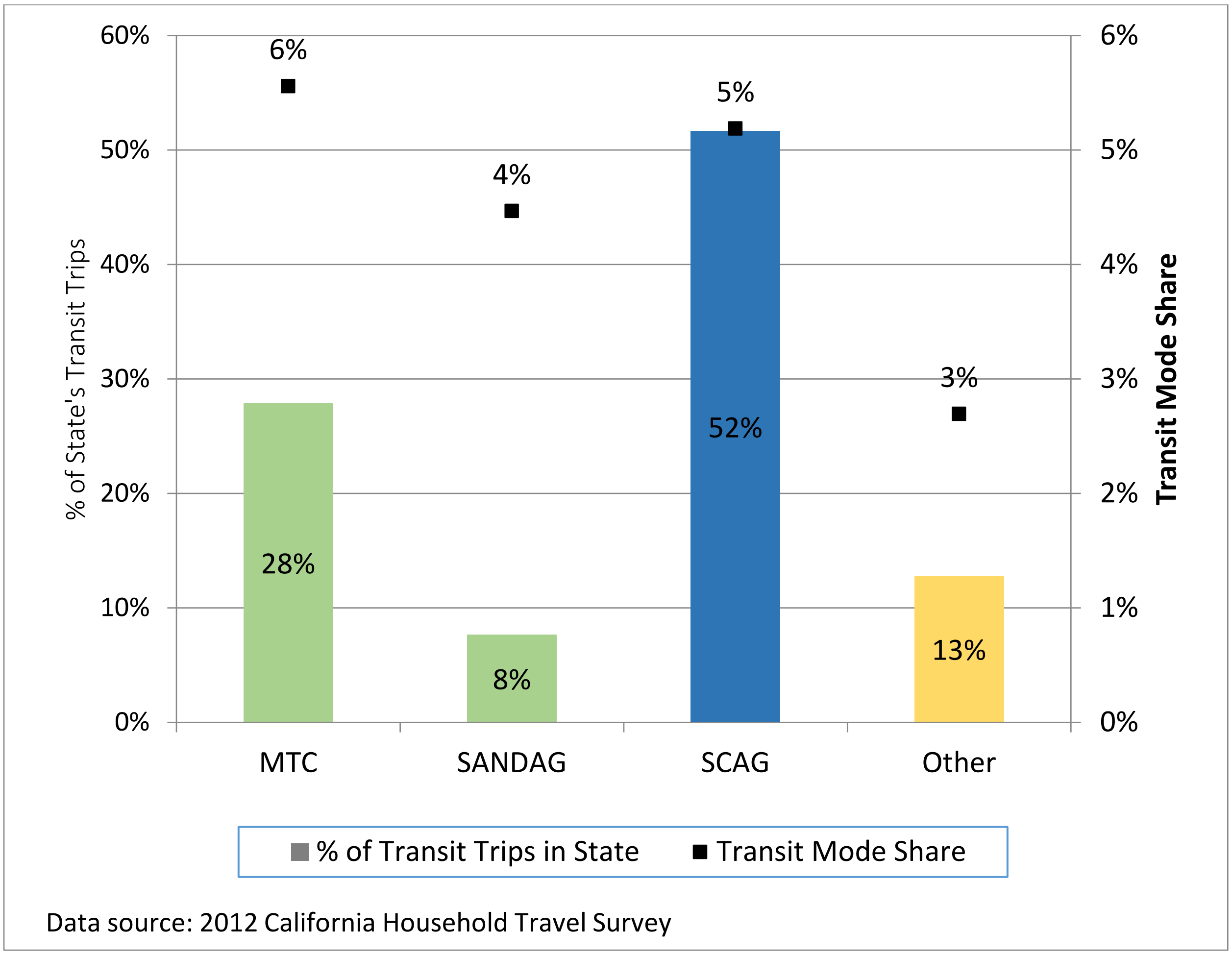


Figure 1. Transit mode share and distribution of transit trips by California region.

Figures 2 and 3 show the trend in transit boardings nationwide, in California, and the SCAG region between 2000 and 2016, first in absolute and then in relative terms. Absolute ridership was largely flat over this time in all three geographies. In relative terms ridership grew steadily between 2004 and 2007 (SCAG region), 2008 (the U.S.), and 2009 (California). This period of growth was followed by patronage losses from the start of the Great Recession through 2011, particularly in California. The recession's end brought a gradual transit patronage recovery, followed by steep declines from 2014 onward.

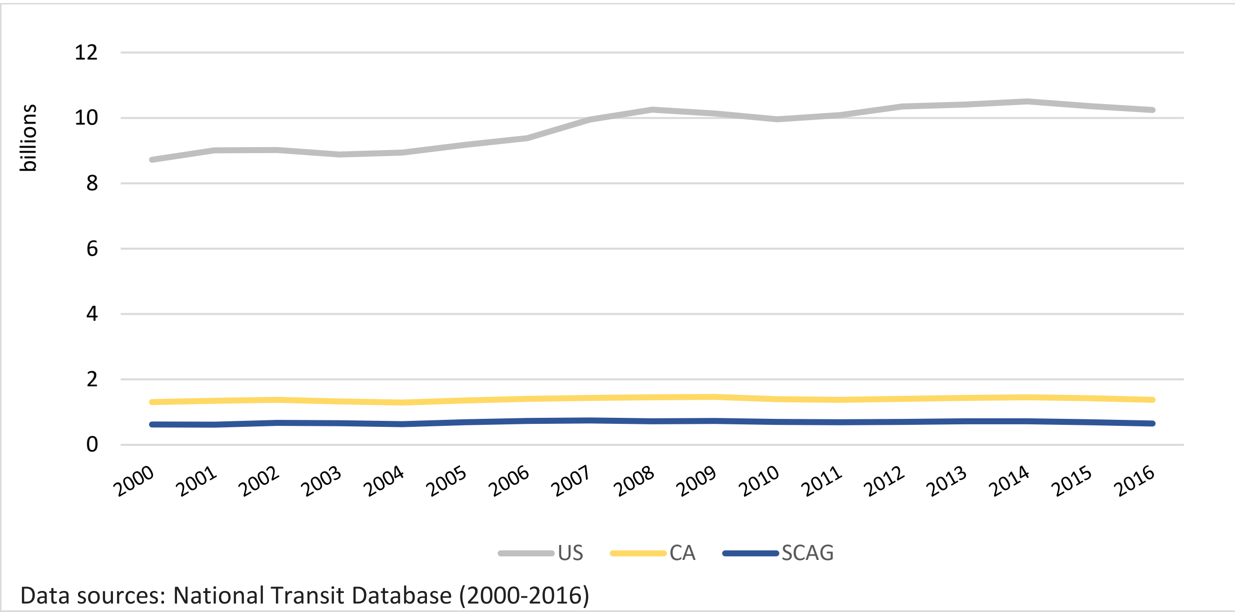


Figure 2. Boardings (unlinked passenger trips*). Growing nationwide, but relatively flat in California and SCAG.*

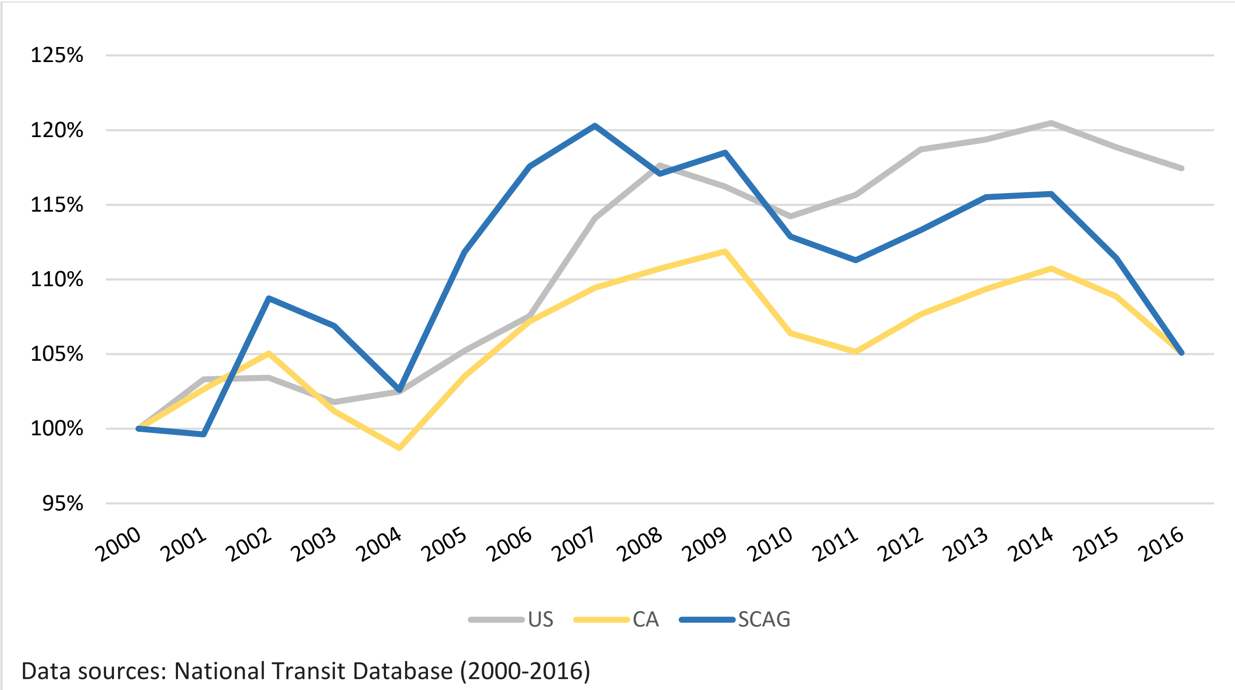
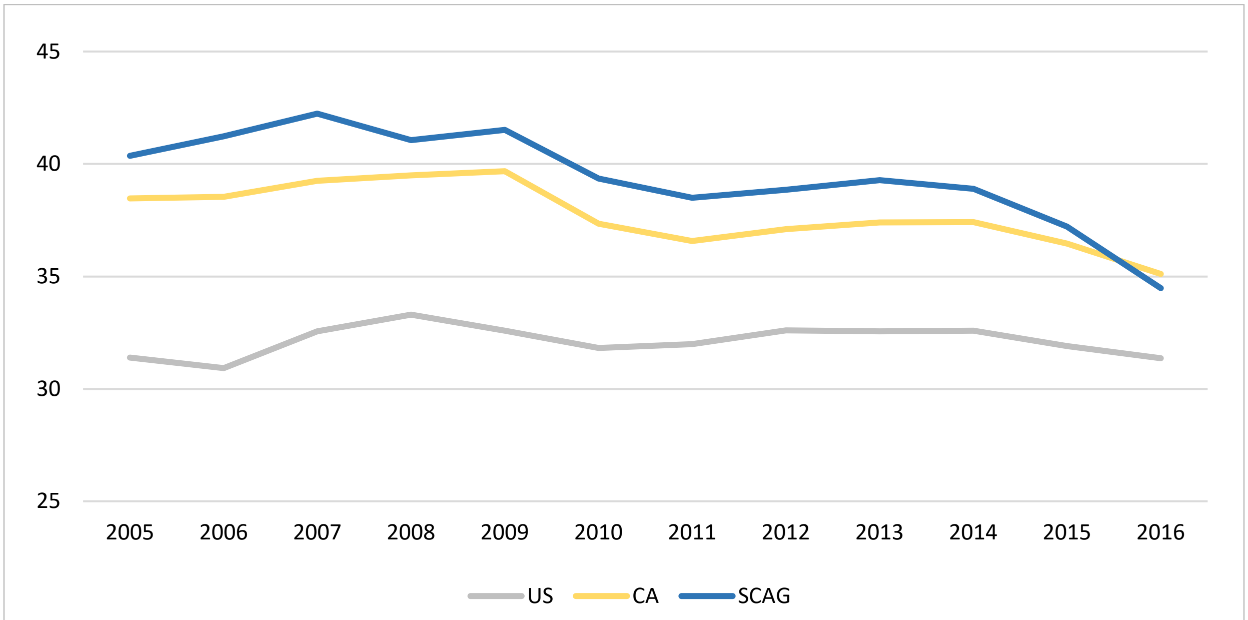


Figure 3. Indexed boardings. *Growing nationwide, but California and SCAG face steeper declines, returning to 2000 levels.*

Figure 4 expresses these ridership trends in per capita terms. Between 2005 and 2016, per capita ridership peaked in California in 2009, in the nation in 2008, and in the SCAG region in 2007. Since 2007, per capita transit use in the SCAG region has been mostly falling—before the recession, the rise of Lyft and Uber, or the post-2012 drop in fuel prices.



Data sources: National Transit Database (2000-2016)

Figure 4. Transit trips per capita. *Relatively flat nationally, but down in California since 2009.*

Because the SCAG region accounts for so much of California's ridership, and because in recent years its decline has been so steep, losses in the SCAG region from 2012 to 2016 actually account for all of California's ridership losses during that time. Figure 5 shows changes in transit ridership across California from 2012 to 2016. During this time annual transit boardings statewide fell by 62.2 million. The SCAG region, however, lost *72 million* annual rides, or 120 percent of the state's total losses. Ridership outside the SCAG region actually rose 20 percent, largely as a result of gains made by transit systems in San Francisco. The Bay Area Rapid Transit District (BART) alone accounted for 28.4 percent of the state's increased transit ridership (although by 2017 ridership on BART, and in California outside the SCAG region, had also started to fall).

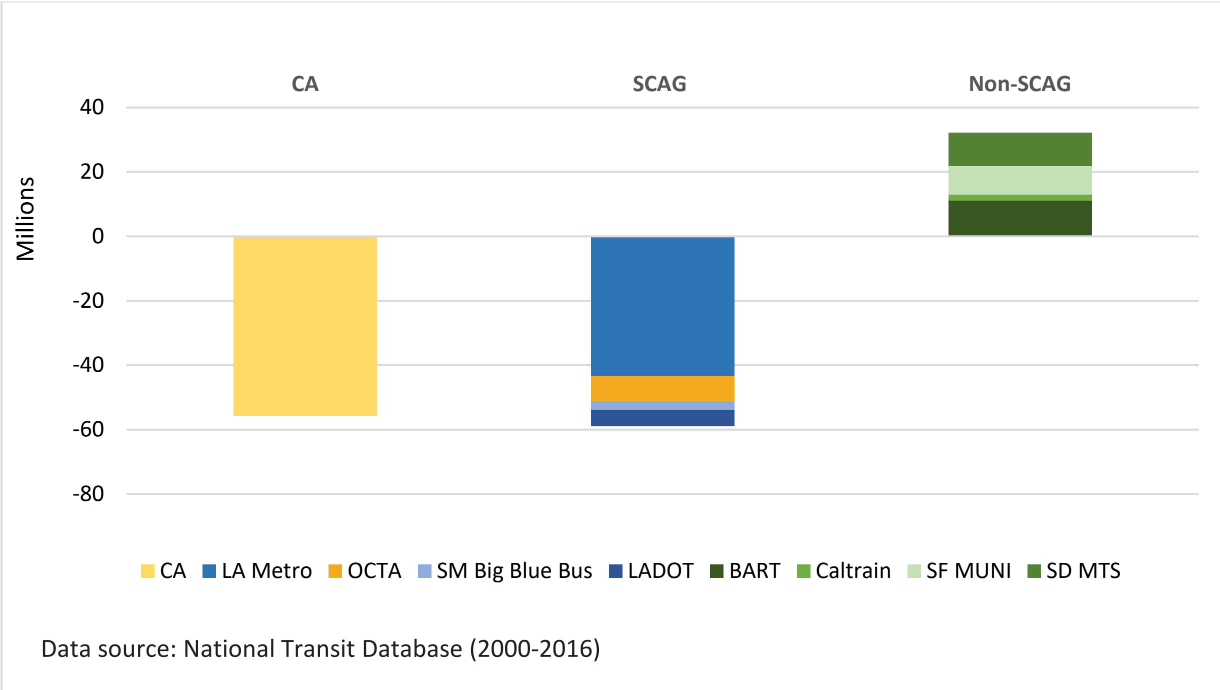


Figure 5. CA net change in ridership (2012-2016). *Losses in CA are driven by losses from the largest operators in the SCAG region, while Bay Area region saw growth in ridership.*

Within the SCAG region, transit trips (and lost trips) are similarly geographically concentrated. We can illustrate this concentration in a number of ways. For example, the CHTS shows that in 2012 82 percent of the transit trips in the SCAG region were in Los Angeles County. Another 8 percent were in Orange County, and the remaining ten percent were spread over the other four counties.

A second way to measure concentration, which allows us to examine smaller levels of geography, is to use census data and map the location of the region's transit commuters. While commuters are not the majority of transit riders, they do tend to use transit frequently and intensively, and we have high-quality data about their residential locations. Those locations are intensely concentrated. In 2000, 2010, and 2015, 60 percent of the SCAG region's transit commuters lived in 20 percent of its census tracts, which represented (depending on the year) one to three percent of the region's land area. In all three years, ten percent of the region's transit commuters lived in one percent of the region's census tracts, which accounted for two-tenths of one percent (0.2%) of the region's land area.[4] (Note that even in these tracts, *most* workers do not commute via transit – 7 out of 10 use some other means.) Unsurprisingly, these tracts are overwhelmingly located in LA County, followed by Orange County.

A third way to illustrate the concentration of transit use is to examine transit trips by operator. Figure 6 shows that the ten largest transit agencies in the SCAG region account for 60 percent of all transit service

[4] Calculated from summary file data of the Decennial Census 2000, and the 2010 and 2015 ACS.

(measured in vehicle-revenue hours), and 80 percent of all transit trips. The smallest 60 transit operators, by contrast, account for just over 6 percent of service and just over two percent of trips.

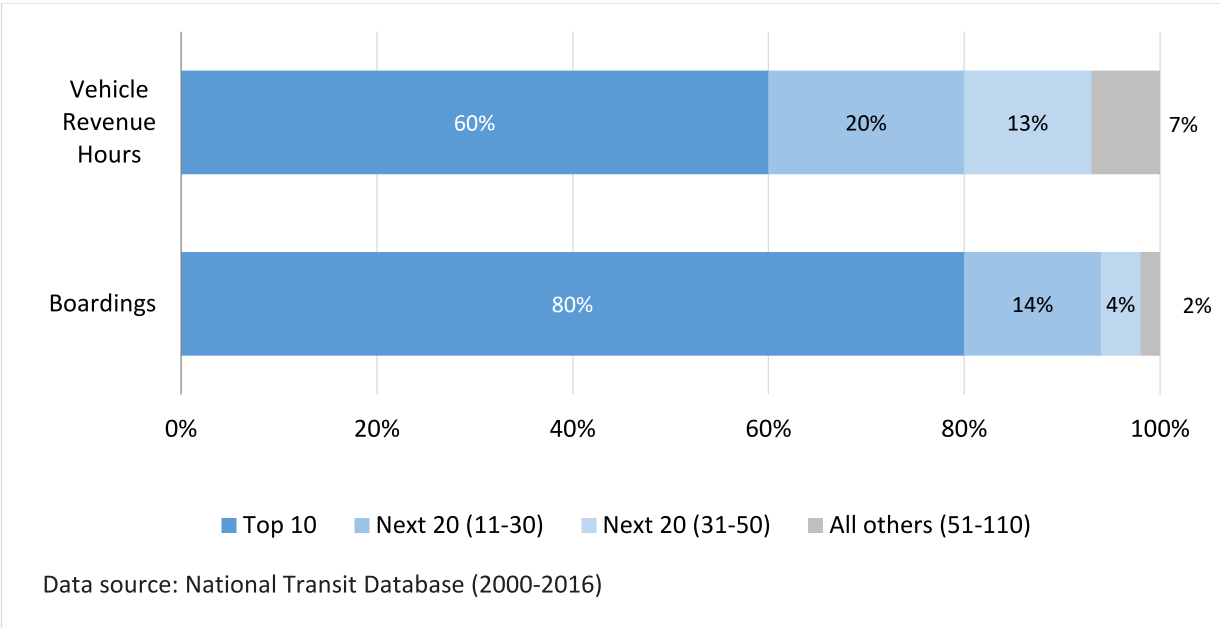


Figure 6. Key metrics by operator grouping. *9% of operators carry 80% of the trips.*

Digging still deeper, the distribution of service and trips within these large operators is also highly skewed. LA Metro accounts for most of the SCAG region's trips, and LA Metro's ridership is itself highly concentrated. The agency has over 100 transit routes, but in both 2012 and 2016 over half of its total rides took place on 20 of those routes.[5] Metro's busiest routes are also, unsurprisingly, where the agency has suffered the largest ridership declines. A dozen Metro lines accounted for 53 percent of all the agency's lost rides between 2012 and 2016.

Putting all this information together, we see that declining transit patronage through 2016 in California is essentially declining patronage in Southern California, and that Southern California's ridership declines are themselves remarkably concentrated. As a result, the state's lost ridership can be traced to a small number of Southern California transit operators. Four SCAG operators (LA Metro, the Orange County Transportation Authority (OCTA), the Los Angeles Department of Transportation (LA DOT), and the Santa Monica Big Blue Bus) accounted for 88 percent of the state's ridership losses, and LA Metro by itself accounted for a remarkable 72 percent of the state's losses. Because LA Metro's losses are themselves highly concentrated, a dozen *routes* from LA Metro account for 38 percent of all the lost ridership in California. Half of California's total lost ridership is accounted for by 17 LA Metro routes (14 bus and 3 rail lines) and one OCTA route.

[5] Calculated from Metro ridership-by-line data, 2012 and 2016.

If we examine these routes more closely (Figures 7 and 8), we see that they include both bus and rail. Transit agencies nationwide – LA Metro included – have made substantial investments in rail service, but the bus remains the workhorse of public transit in the US, the SCAG region and LA County. Bus trips are 78 percent of all transit trips in California and 86 percent of transit trips in the SCAG region.[6] Given that buses carry the most passengers, it is not surprising that they have also seen the largest ridership declines, accounting for 84 percent of the lost rides between 2012 and 2016. While some bus routes gained ridership, the bus routes that lost riders lost more than the growing routes gained. The five bus lines with the largest declines were urban routes that travel in and out of downtown LA, while the five lines that gained the most ridership ran more outlying and circumferential routes.

Two Metro rail lines, meanwhile – the Gold and Expo – opened extensions after 2012, and partly as a result their ridership grew. But Metro's remaining rail lines, most of which also travel into downtown LA, saw steep ridership losses that exceeded the Gold and Expo Line's gains. The SCAG transit decline thus spans modes; it is not a simple story of buses falling behind while rail surges. Instead major routes that run into the heart of the city – the sort of routes where transit is traditionally strongest – are losing riders precipitously.

[6] Calculated from the 2012 California Household Travel Survey.

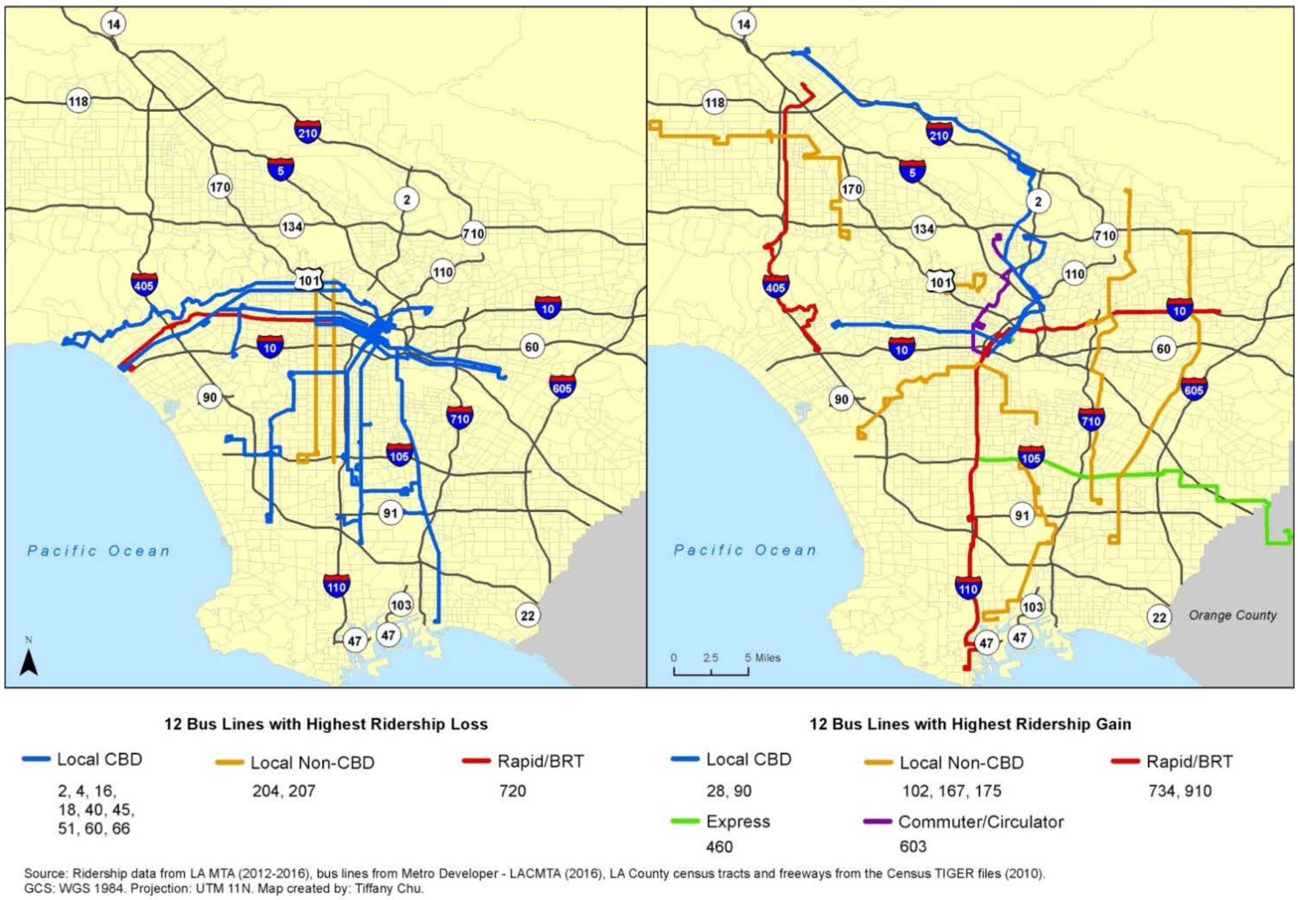


Figure 7. LA MTA: Bus lines with the most ridership change (2012-2016).

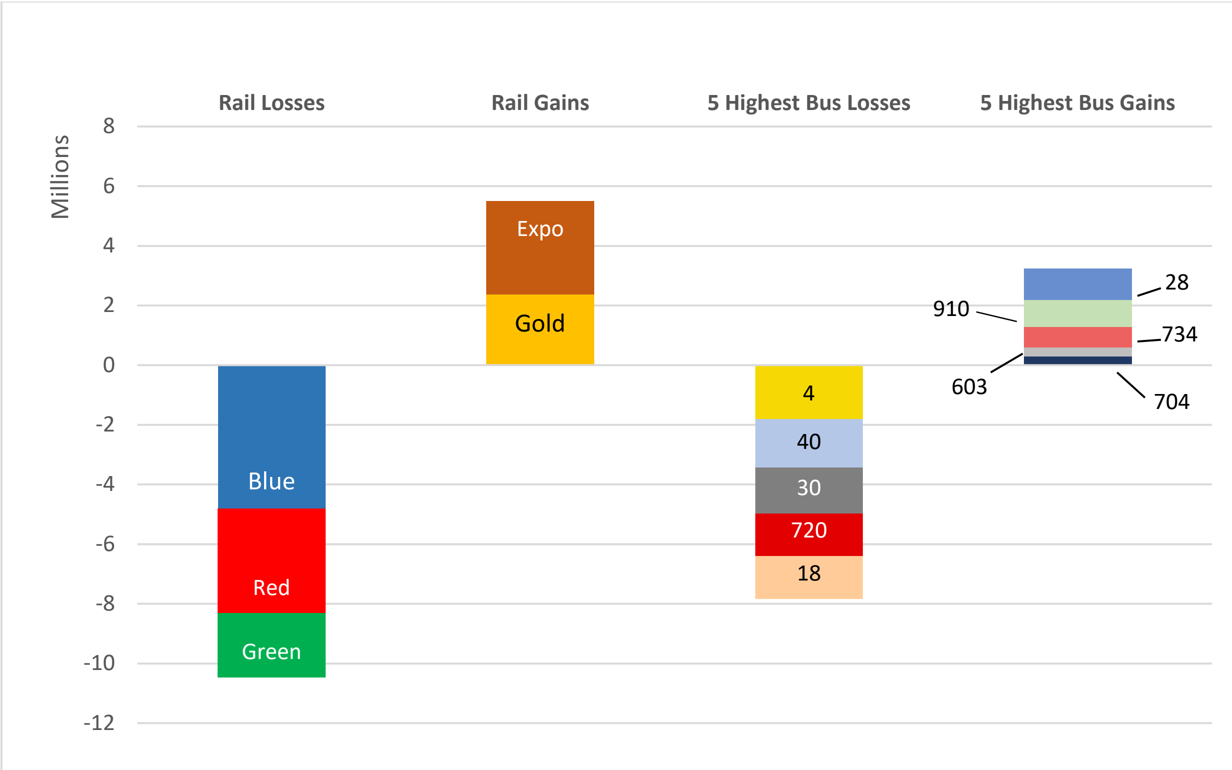


Figure 8. LA MTA: Net change in Ridership (2013-2016) by mode. *Buses made up 84% of loss and rail made up 12%.*

The Demographic Concentration of Transit Use in Southern California

Transit use in the SCAG region is concentrated among a small group of people as well as a small number of places. People ride transit for different reasons, but a common thread running through regular transit users is lack of access to a private vehicle. This trait is not universal; many commuter rail passengers, for example, could make their trips by car and choose not to, but commuter rail is a small portion of overall transit ridership. In general, transit ridership is powerfully associated with lack of vehicle access (Taylor & Fink, 2013). Note again, however, that this relationship is not symmetrical. While most regular transit users lack vehicle access, most people without vehicle access do not regularly use transit, in part because transit is unavailable in many places.

Lack of vehicle access might arise for economic reasons, for medical reasons, or out of personal preference or habit (Brown, 2017). The relationship between vehicle access and transit use could also run two ways. People might ride transit because they do not have a car (either they cannot afford a car or cannot use one for medical or legal reasons) or they may not have access to a car *because* they ride transit (they live and work near high-quality transit and so need not spend money on vehicles).[7]

Non-economic reasons for lacking a vehicle include disabilities or medical conditions that prevent driving, and legal sanctions that forbid it (e.g. losing a license as a result of traffic infractions, or being in the country illegally). In Southern California, perhaps the largest non-economic source of low vehicle access is immigration. Even controlling for income, immigrants are less likely than the native born to have vehicles, and more likely to use public transportation. Why this is so remains something of a puzzle. Scholars have proposed various explanations, including immigrants' tendency to live in dense areas; their tendency to live in close-knit communities that allow for more communal resources, including sharing of cars; a habit of not driving carried over from the native country; and – if the immigrant is undocumented – legal barriers to owning and operating automobiles (Blumenberg & Smart, 2014; Chatman & Klein, 2009, 2013; Liu & Painter, 2012). The evidence suggests, however, that driving less and riding transit more is not universal among the foreign born – immigrants from some countries, particularly Mexico and many countries in Central America, are less likely than others to drive and more likely to ride (Chatman, Klein, & DiPetrillo, 2010). There is also substantial evidence that over time immigrants assimilate and begin to travel more like the native born, with more driving and less transit use (Blumenberg & Evans, 2010). Thus transit ridership cannot be sustained by immigration alone; it requires a steady stream of new immigrants from particular countries, who will arrive with a transit habit and replace those earlier arrivals who assimilate driving.

Economic reasons for lacking vehicle access can include both low incomes and the high cost of driving. In some parts of California, such as northeastern San Francisco, a combination of heavy congestion, high tolls, and scarce and expensive parking make the price of owning and operating a vehicle high, and encourage even affluent people to ride transit (notably, the same density that makes the city congested can makes transit service more effective by putting large numbers of trip origins and destinations within steps of transit stops). Yet there are few places in Southern California where driving is challenging in this way. Congestion is severe, but parking is abundant and often inexpensive if not free, and low-to-moderate densities make transit less able to effectively link many places. As a result, income becomes the principal determining factor in vehicle access, and thus of transit use.

Figure 9 uses CHTS data to illustrate the disproportionate propensity to use transit among the low-income, the foreign-born, and households with limited vehicle access. The figure's dashed vertical line represents the overall average of daily unlinked transit trips in the SCAG region, and the circle associated with each subgroup indicates its relative size in the overall population. The figure shows, in short, that transit use is more common among smaller segments of the population. African Americans and Hispanics ride transit about three times as much as Whites and Asians. Immigrants who have been in the country less than ten years ride substantially more than both the native-born and longtime immigrants who have been in the country longer. Households earning under $25,000 per year ride more than twice as much as households earning $25,000 to $50,000, and these households in turn ride twice as much as households earning over $50,000 annually. By far the largest differences, however, are those that represent vehicle availability. Households without vehicles take almost five times as many transit trips as households with one vehicle,

[7] These reasons might interact. People who cannot afford vehicles might choose to live near transit because of their lack of vehicle access (Glaeser, Kahn, & Rappaport, 2008).

and households with one vehicle take twice as many trips as households with two. If we measure vehicles per adult, households with one vehicle for every two adults take twice as many trips as households with one vehicle per adult. Finally, people without driver's licenses take many more transit trips than licensed residents.

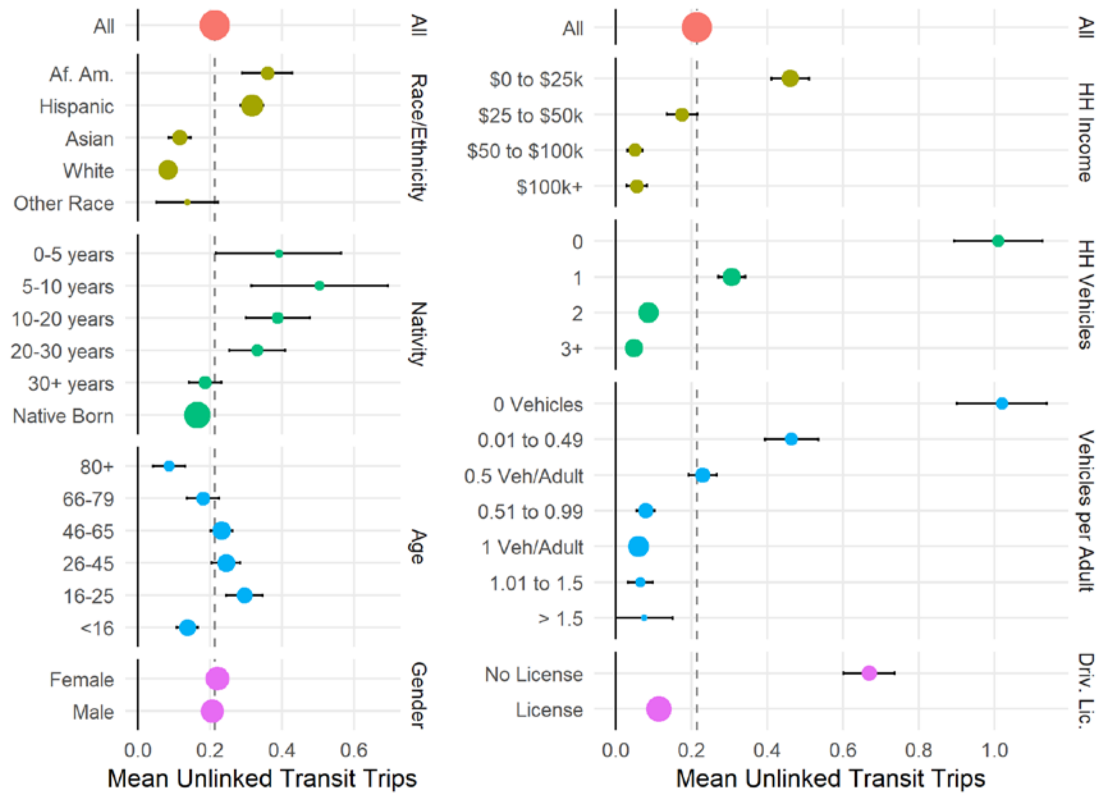


Figure 9. Mean transit trips by socio-economic characteristics and automobile access (CHTS).

The drawback of the CHTS, as we have mentioned before, is that it provides only one year of data. Table 1 uses LA Metro's annual rider surveys to show that the prevalence of people with low incomes and limited vehicle access on transit extends across years. We examine the 2005 survey (the earliest available) and then annual surveys from 2010 to 2016. Across both bus and rail riders, at least 69 percent of transit users (and often closer to 80%) report not having a vehicle available to make their trip. These proportions are higher for bus riders than rail riders, but even among rail riders between 58 and 65 percent (depending on the year) report not having a vehicle. The share of riders reporting not having a vehicle, furthermore, has grown over time.

In addition to limited vehicle access, Metro riders generally have low incomes and are strongly dependent on transit. Close to half of all surveyed LA Metro riders in each year have household incomes under $15,000. The median household income of riders hovers near $16,000, and the average income barely exceeds $25,000 in most years. In most years a strong majority of riders are habitual (riding over 4 days a week) and a majority are longtime users (riding over 5 years). The riders are also overwhelmingly nonwhite.

All these characteristics make Metro riders – who are, again, most of SCAG's transit users – strikingly different from the population at large. The CHTS shows that in 2012, 73 percent of LA County residents took transit only occasionally or never, and the 2016 Census ACS shows that LA County residents are 26 percent non-Hispanic white, and that county median household income is $62,000. Only 5 percent of the county's households earn less than $15,000 per year. Thus SCAG's largest transit operator has for over a decade been dominated by low-income, nonwhite people with little vehicle access, people who live and move very differently from the typical Southern Californian.

	2005	2010	2012	2013	2014	2015
Share No Vehicle Available (%)	69	75	81	79	69	78
Bus Only	73	76	82	80	70	82
Rail Only	50	64	63	63	58	65
Share Earning Under $15k/Year			51	45	47	47
Median Household Income ($)			14,706	16,316	15,910	15,918
Mean Household Income ($)			26,025	25,540	23,223	25,747
Share White		8	9	10	9	9
Share Riding 5+ Days/Week		56	67	67	67	68
Share Riding 5+ Years		49	53	52	59	57

Source: Metro Rider Surveys. Not all questions asked every year. Dollars are nominal. "No vehicle" indicates that respondents lack access to a vehicle for the current trip.

Table 1. Characteristics of LA Metro riders, 2005-2015.

The importance of vehicle access is reinforced by evidence from other transit operators. A small operator in the SCAG region, the Montebello Bus Lines, surveyed residents (not just riders) in 2016. Most respondents did not ride transit, and 55 percent of non-riders said they would only ride if they lost access to their car. Most people who did ride did not have access to a vehicle (Diversified Transportation Solutions 2015). In 2016, the OCTA also surveyed Orange County residents about their travel behavior. The results were similar. Only three percent of people who always had vehicle access listed transit as their primary travel mode, compared to 33 percent of people who never had a vehicle (True North Research 2015).[8]

The OCTA survey also stands out for usefully disaggregating "lack of vehicle access," and demonstrating that vehicle access is not the same as vehicle ownership. Over 70 percent of OCTA transit users had a car in their household, but the car was not available to them. In most instances it was being used by someone else, but 19 percent of current riders were unable to drive, and another eight percent reported having a vehicle that was not working (True North Research 2015). People in households with vehicles can still lack

[8] Note that 2/3 of people without vehicle access still did not use transit regularly.

vehicle access. If a household has more adults than vehicles, and if most adults move around on most days, then someone is without a car, and the odds of using public transportation rise.

We emphasize again, however, that most people simply do not use public transportation very often. The four panels of Figure 10 use 2012 CHTS data to divide the California, Southern California, and LA County populations into three groups: *Transit Commuters* (respondents who use transit for the journey to work); *Transit Non-Commuters* (respondents who used transit in the week prior to the survey but do not use transit for the journey to work); and *Infrequent Transit Users* (respondents who do not use transit for the journey to work and did not use it in the previous week).

In general, and unsurprisingly, transit use is more intensive in the SCAG region than in California, and more intensive in LA County than in the SCAG region. Beyond this difference, the patterns relating to these three types of users are generally consistent across the three geographies. *Transit Commuters*, who garner perhaps the most attention from public officials and transit planners, ride most frequently (44 to 49 trips per month), but are a very small share (2% to 3%) of the population; as a result, they account for just 25 percent to 30 percent of all transit trips taken, despite their frequent use. *Transit Non-Commuters* ride transit less frequently (11 to 16 trips per month) than *Transit Commuters,* but account for a much larger share (20% to 23%) of the population, and as a result they actually account for over half (54% to 57%) of all transit trips. Finally, *Infrequent Transit Users* ride little or not at all, averaging only 0.9 to 1.5 trips per month across the three geographies. This group, however, comprises about three-quarters (73% to 78%) of the population, and because of this large base, *Infrequent Transit Users* account for better than one in seven (16% to 18%) of all transit trips.

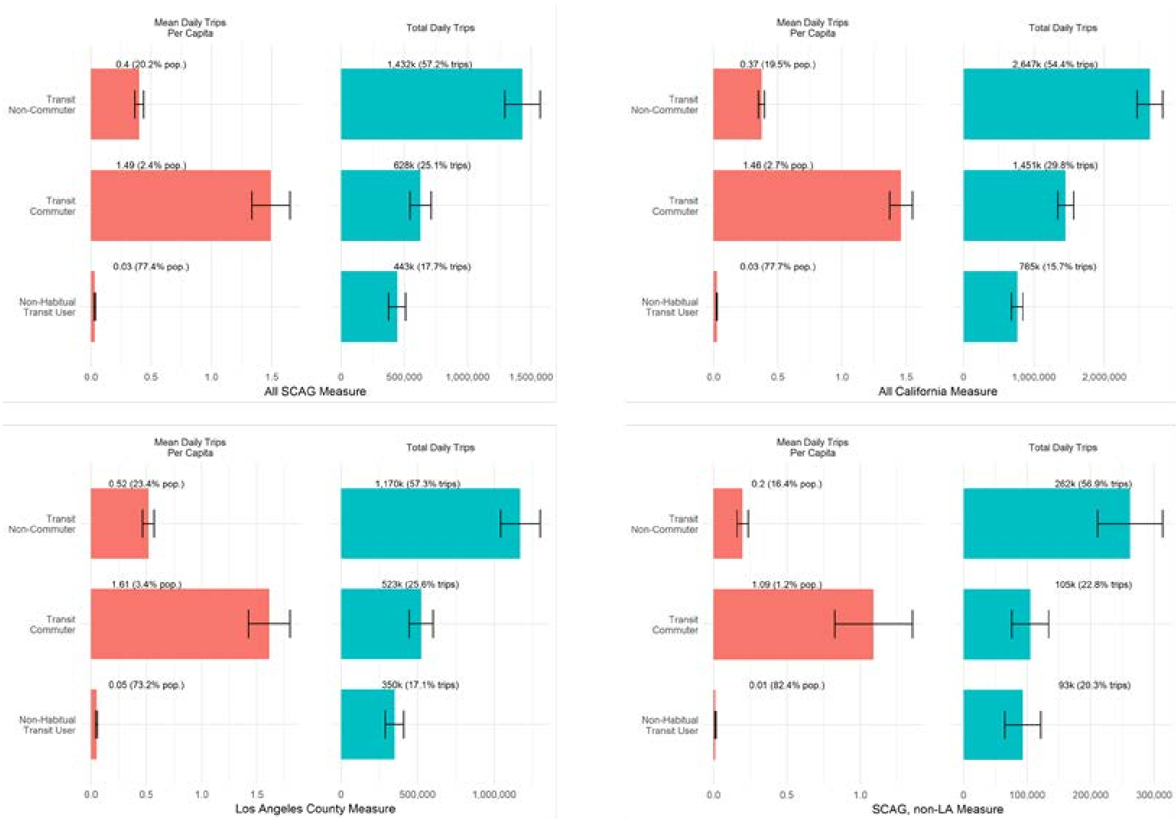


Figure 10. Mean and total daily trips by transit user group for the SCAG region, California, Los Angeles County, and non-Los Angeles SCAG region.

This snapshot of transit users is a picture of asymmetry, and this asymmetry suggests how transit ridership can fall dramatically and seemingly suddenly. The people who ride transit regularly are a narrow segment of the population. They come disproportionately from households with two or more adults per available vehicle, and especially from households with no vehicles. They have lower incomes, on average, and are more likely immigrants, young adults, and African-American or Latino. Many of them do *not* ride transit to or from work; transit commuters are just three percent of the population, and 13 percent of regular transit riders. The transit industry is thus heavily-dependent on a small subset of people, and very sensitive to even small changes in how those people choose to move around.

EXAMINING SOUTHERN CALIFORNIA'S DECLINE IN TRANSIT USE

Transit ridership can fall for multiple reasons. For convenience we divide these reasons into two categories: factors that transit operators (funding permitting) can control, and factors they cannot. We take these up in turn.

Factors Within Transit Operators' Control

The Quantity and Quality of Transit Service

People will ride transit less if service is slow, infrequent, or unreliable, and/or if rides are difficult or dangerous to take. As the quantity or quality of service falls, ridership should fall as well.

The Quantity of Transit Service

Some observers contend that recent drops in transit ridership can be tied directly to declining service quantity. For example, Hertz (2015) ties falling transit ridership to cuts in bus service, and articles in both the Wall Street Journal (Harrison, 2017) and New York Times(Rosenthal, Fitzsimmons, & LaForgia, 2017) make similar arguments. Freemark (2017) argues that LA's declining bus ridership is a function of Metro's falling service levels, and observes that average bus speeds fell 13 percent between 2005 and 2013.

Service levels certainly have a strong influence on ridership, even controlling for reverse causality – the fact that places with more riders often add more service (Alam, Nixon, & Zhang, 2015; Taylor, Miller, Iseki, & Fink, 2009). But service levels can be measured in many ways; two of the most common metrics are vehicle revenue miles (VRMs) and vehicle revenue hours (VRHs). VRM measures the distance transit vehicles cover while in service, while VRH measures the amount of time vehicles are in service. Both Hertz (2015) and Harrison (2017), in relating falling ridership to service declines, measure service using VRM. VRM alone, however, can be a problematic measure of transit service. In practical terms, VRM differentiates faster, longer-distance commuter services from lower speed local service. VRH, in contrast, measures the supply of different kinds of services (local bus service, bus rapid transit, rail transit, express bus, commuter rail, etc.) more similarly. VRH differentiates less among modes and service area types because the time between stops often varies far less than the distance travelled between them. A dozen stops spaced far apart in uncongested outlying suburbs can take a similar amount of time to serve as a dozen closely-spaced stops in a congested urban environment. The miles covered on the two routes will vary greatly, but the time required to serve them may not.

As a result, falling VRM *can* indicate service cuts, but can also reflect transit vehicles operating in higher levels of congestion, or agencies increasing local service rather than express service, or agencies redirecting service from outlying areas to central areas.

For example, if a transit agency shifts service from outlying suburban routes that travel longer distances at higher speeds to shorter, slower urban routes, VRM would almost certainly fall, as would average speed. But VRH may not change. Vehicles moved to dense areas typically cover less ground, but also move more slowly, stop more frequently, and dwell longer at each stop to allow more people to board and alight. In this case a "cut" in VRM would not necessarily be associated with a cut in VRH, and could actually deliver more service to more people.

In short, falling VRM is hard to interpret without also examining VRH. If VRM and VRH fall at roughly the same rate, then service is likely falling absolutely. But VRM falling substantially more than VRH suggests a change in service deployment or operating conditions (such as worsening congestion), rather than a service cut.

With this as background, we can consider the SCAG region's recent trends in VRM and VRH; we will show that rates of change in VRM and VRH have generally not been in concert. Figure 11 shows the relative trends in total VRM for the US, California, the SCAG region, and the SCAG region excluding LA Metro or OCTA between 2000 and 2016.

While VRM has increased across all four geographies, it has grown faster in the SCAG region than the U.S. or California as a whole, and faster still among SCAG's smaller transit operators – suggesting a relative shift in service delivery from LA Metro and OCTA to the smaller operators.

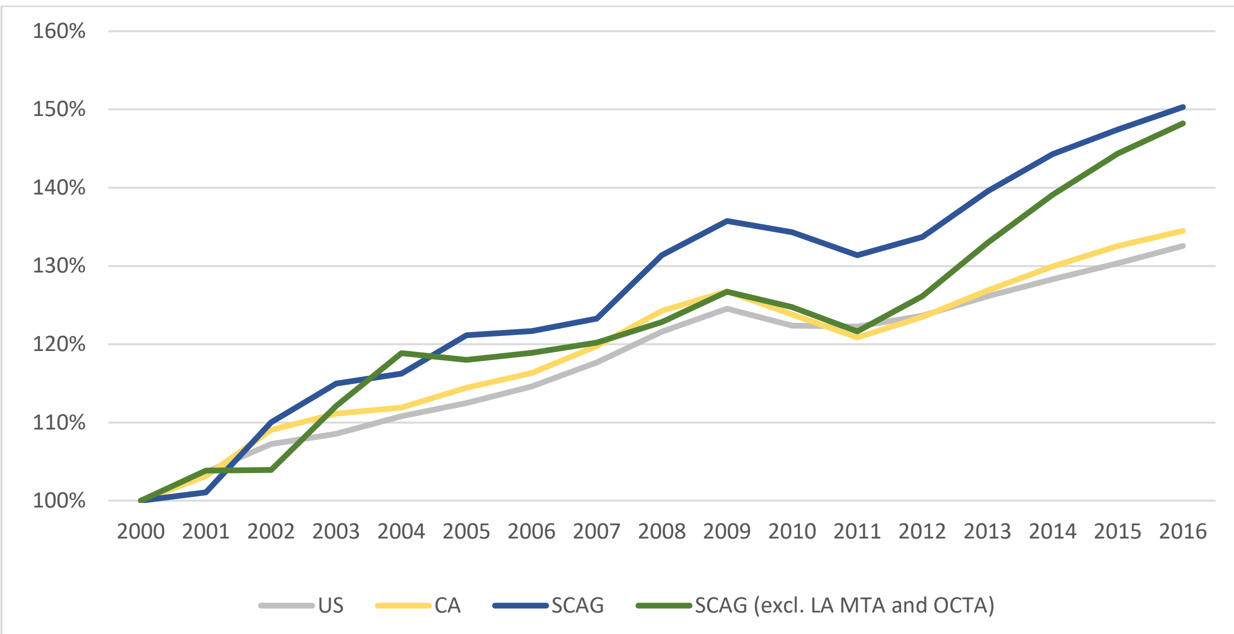


Figure 11. Indexed vehicle revenue miles. *Growth in service in the SCAG region outpaces national and state trends; within the SCAG region, all other operators have collectively added service at a faster rate than LA MTA or OCTA.*

This pattern is confirmed if we examine absolute VRM trends in the SCAG region separately for LA Metro, OCTA, and the remaining SCAG operators (Figure 12). Overall transit VRM has been growing for all three groups, but growing faster at the smaller operators.

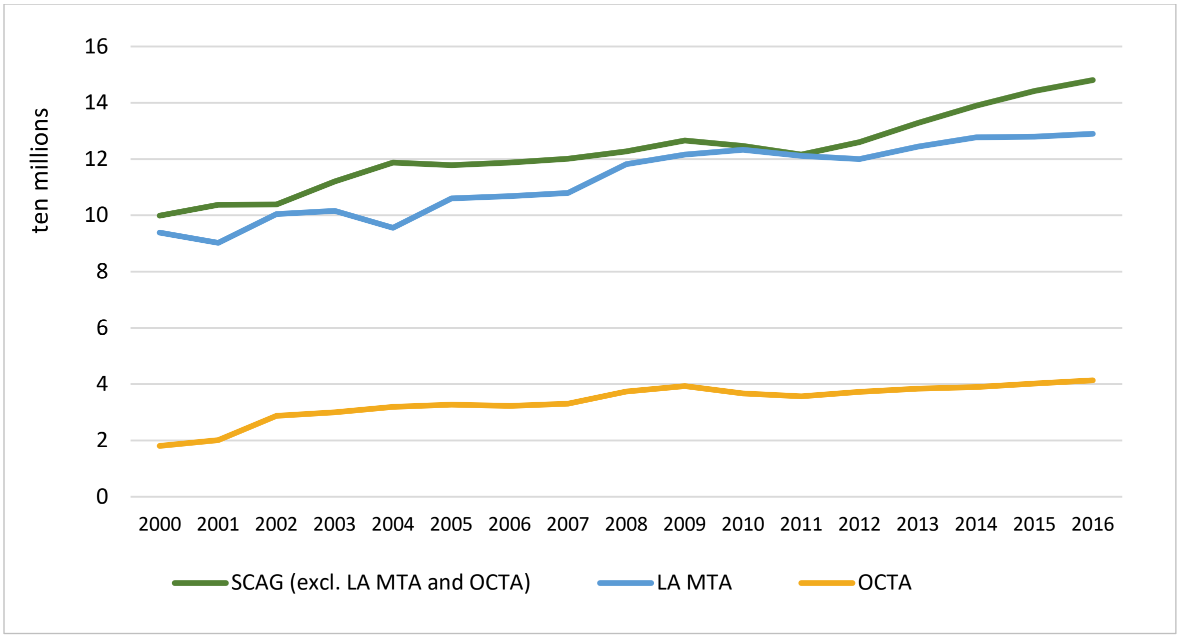


Figure 12. Vehicle revenue miles. *Service levels for LA MTA matches aggregate service provision for all other operators in the region (minus OCTA). Service is growing faster in the SCAG area excluding LA MTA and OCTA than at LA MTA or OCTA.*

While VRM rose in the aggregate from 2000 and 2016, it has not been climbing for all modes. Figure 13 shows the roller coaster that has been the VRM trend for local bus service over this period: Significant growth between 2000 and 2005, little change between 2005 and 2009, a steep drop between 2009 and 2013, and slow growth from 2014 to 2016. Rail service, in contrast, has been steadily rising, especially light rail (Figure 14).

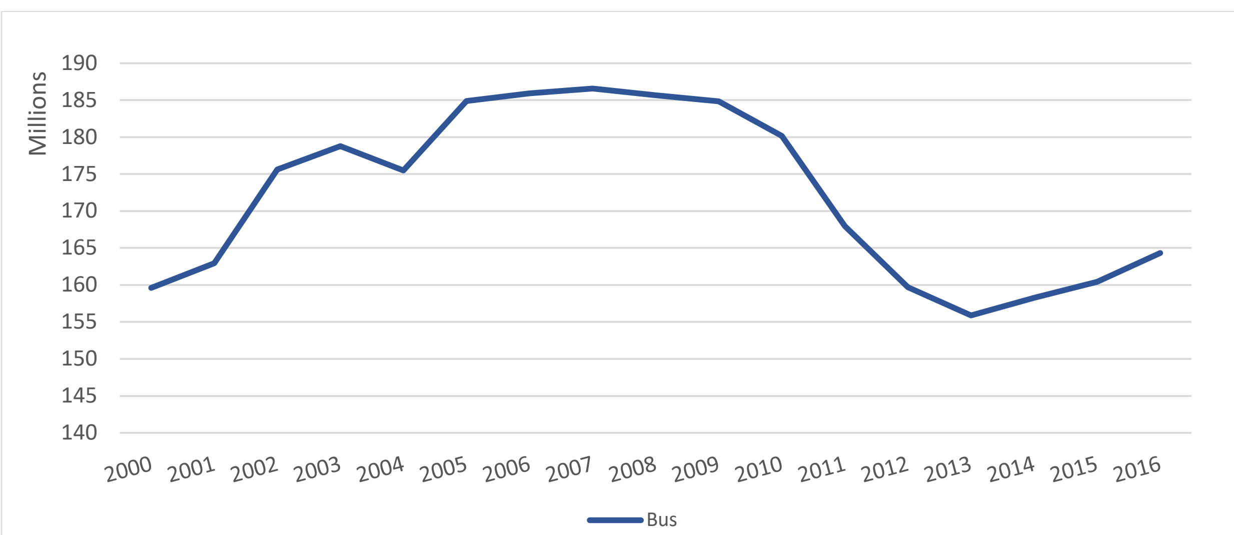


Figure 13. SCAG region: VRM for bus. *Service in miles traveled dropped by 15% between 2007 and 2013. Service has increased since. Hours of service has also declined, but not as rapidly as miles of service, indicating that service is cut on suburban bus lines.*

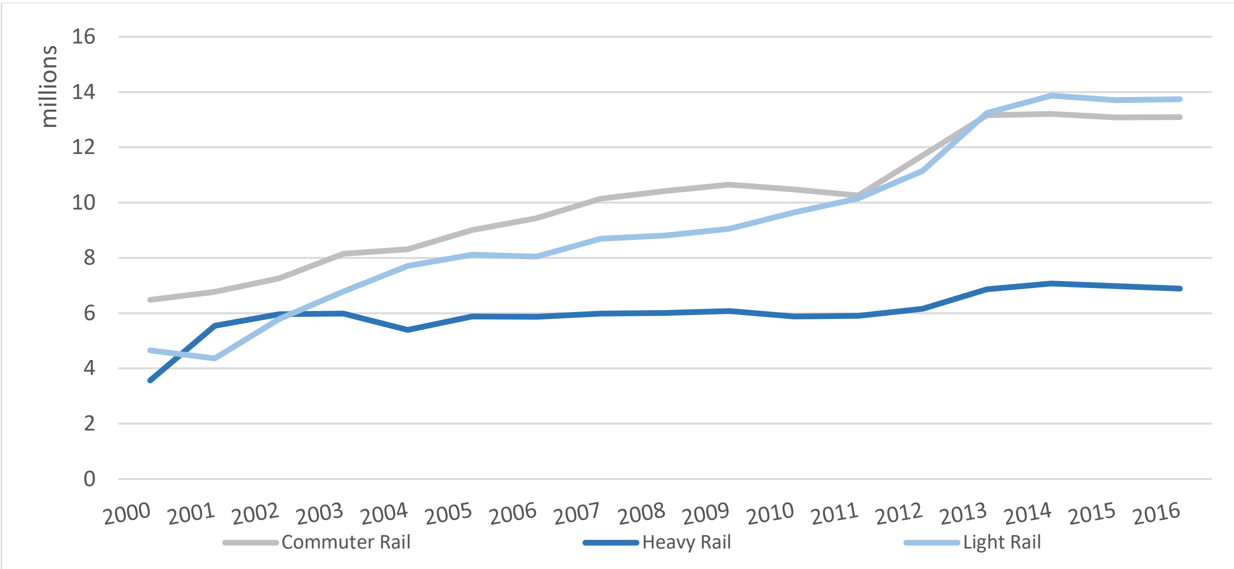


Figure 14. SCAG region: VRM for rail. *Substantial service increases for all commuter and light rail since 2000.*

If we examine service hours (VRH), we see similar aggregate trends. VRH rose from 2000 to 2009 in the US, California, and the SCAG region, fell from 2009 to 2011 during the Great Recession, and then climbed again across all three geographies through 2016 (Figure 15).

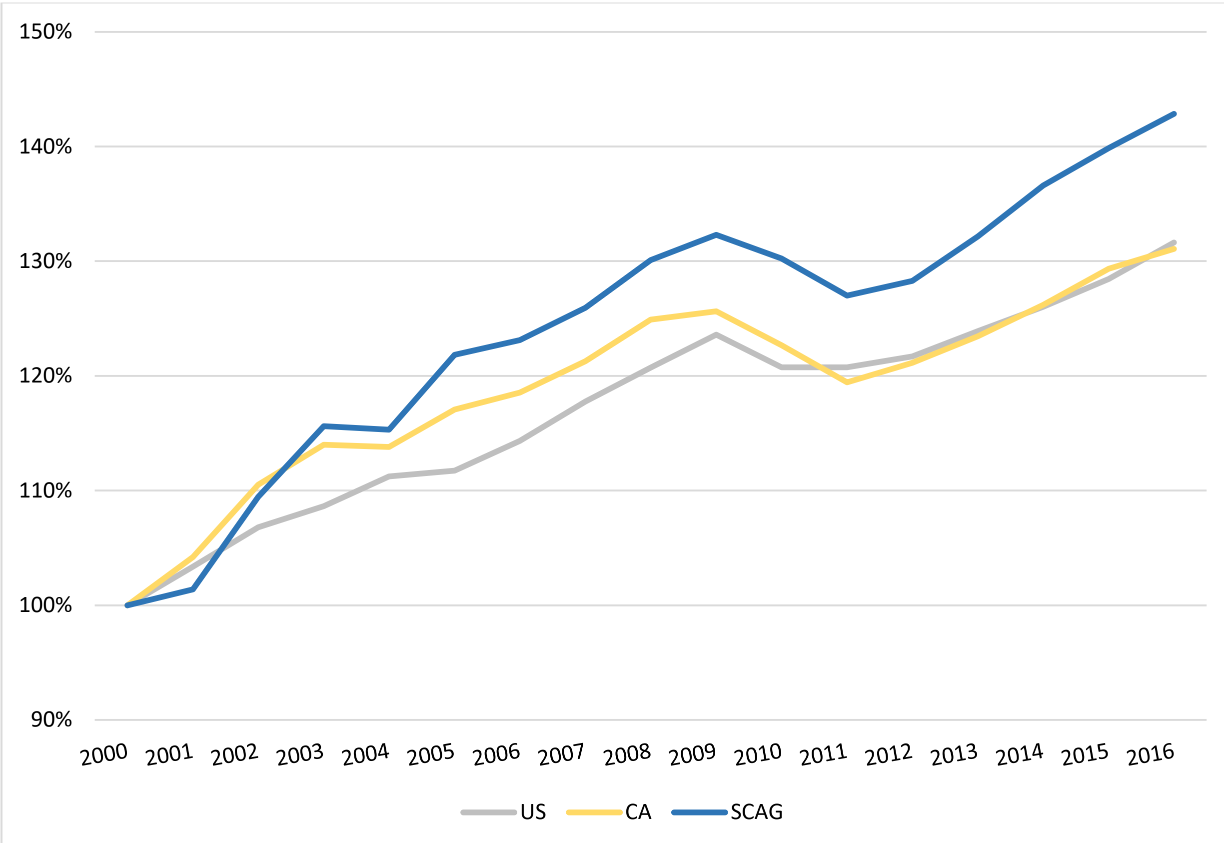


Figure 15. Indexed vehicle revenue hours. *Growth in service in the SCAG region outpaces national and state trends.*

Figure 16 shows the percent change in vehicle revenue hours over two time periods – 2005 to 2016 and 2010 to 2016 – across three geographies (US, California, SCAG region) and across four types of SCAG-region transit operators (Largest, Large, Medium, and Small). The figure shows that VRH increased during both time periods across all three geographies and all four operator types. It also shows, however, that VRH grew least among the largest operators that have lost the most riders, while it increased much more among the smaller operators.

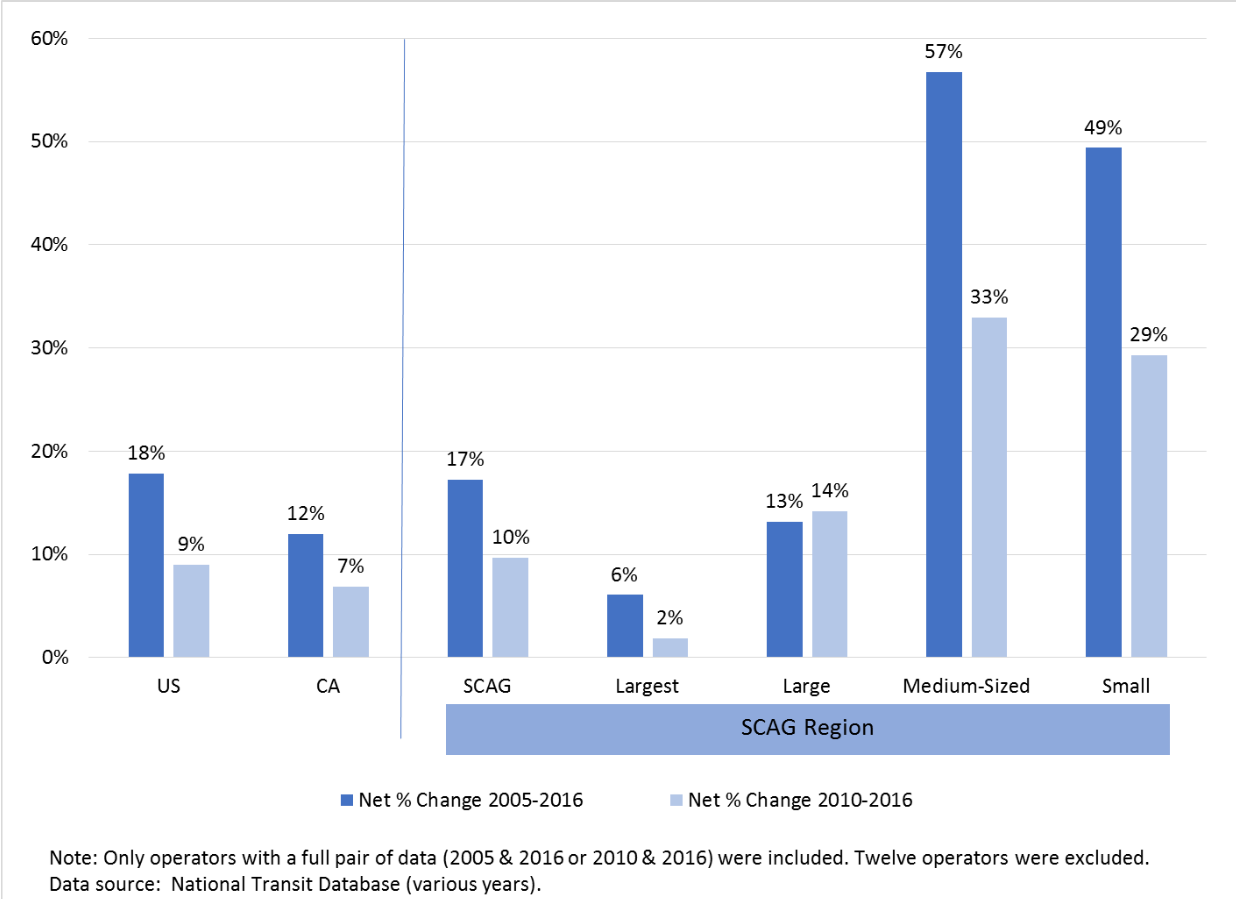


Figure 16. Changes in indexed vehicle revenue hours by region and SCAG transit operator size: 2005-2016 & 2010-2016. *Service growth among the largest SCAG operators was lower than national, state, or regional averages, and much small than smaller SCAG-region operators.*

Finally, Figures 17 and 18 show the absolute and relative changes in VRM and VRH by mode between 2010 and 2016.[9] The figures show substantial overall shifts in service among modes, with local bus, rapid bus and demand response taxi service declining, while rail, commuter bus, and vanpool service increased. In absolute terms, local and rapid bus service declined most, while commuter bus and vanpool grew most; in relative terms, rail transit grew most while demand response fell most.

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[9] Note that because Figure 17 shows absolute changes in both VRM and VRH on the same Y-axis, the VRM changes appear to be substantially larger than the proportional differences shown in Figure 16. These apparently large differences are mostly an artifact of transit service moving anywhere from about 6 (for the slowest urban bus service) to 40 (for the fastest commuter rail service) miles per hour, on average. This means that, for example, a one million VRH increase might be expected to have a corresponding 10 million or more VRM increase.

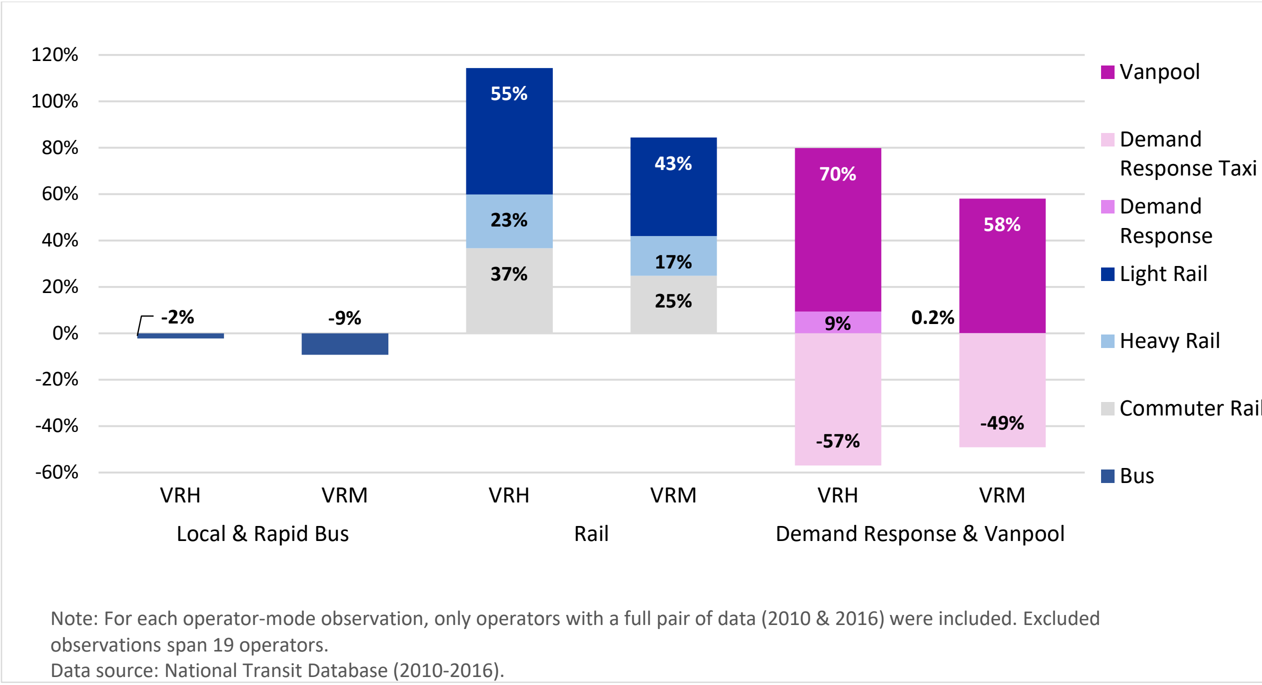

Figure 17. Percent change in service (hours and miles) by mode: SCAG region 2010-2016. *Rail and vanpool have largest % gains, and service is added in the urban core, rather than to outlying areas. Bus service hours were slightly reduced, and came from outlying areas.*

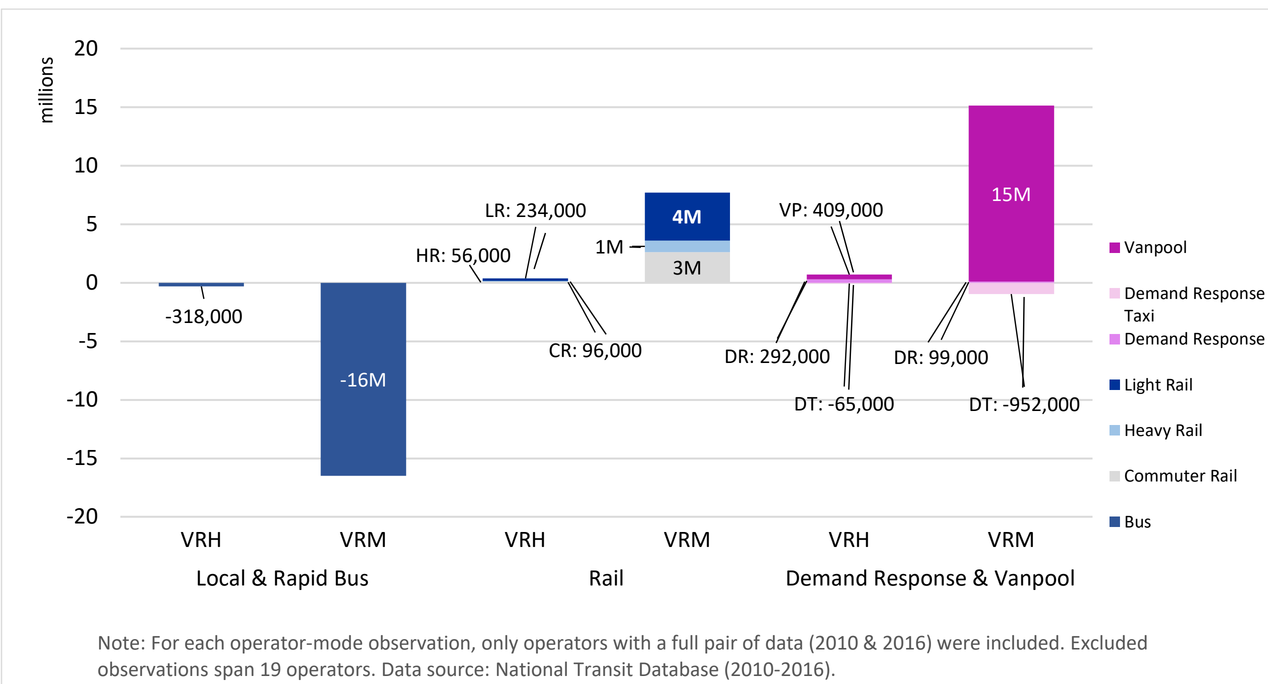

Figure 18. Change in service (hours and miles) by mode: SCAG region 2010-2016. *A 9% reduction in bus service miles is equivalent to 16.5 million bus service miles cut. Vanpool had the most service miles added, reflecting the longer commutes that vanpool serves.*

Overall, these shifts in service provision reflect both the choices and mandates of public policy. For better than three decades Southern California, and Los Angeles County in particular, has chosen to invest heavily in new rail services. As these new services have come on line, they account for a growing share of the region's transit service. Second, federal civil rights legislation, in the form of the Americans with Disabilities Act, has mandated the delivery of both accessible and demand-response transportation services to a growing and aging population. In combination, these choices and mandates have shifted transit service away from buses and toward rail and van services.[10]

What do these changes in transit service supply mean for transit patronage? First, Figure 19 shows the trends per capita VRH and per capita transit boardings over the past quarter century in the SCAG region. Transit service supply has been mostly climbing in the SCAG region for better than a quarter century, while transit use has never reached the 1991 levels. Given this, there is no *prima facie* case that faltering transit service supply is driving down patronage.

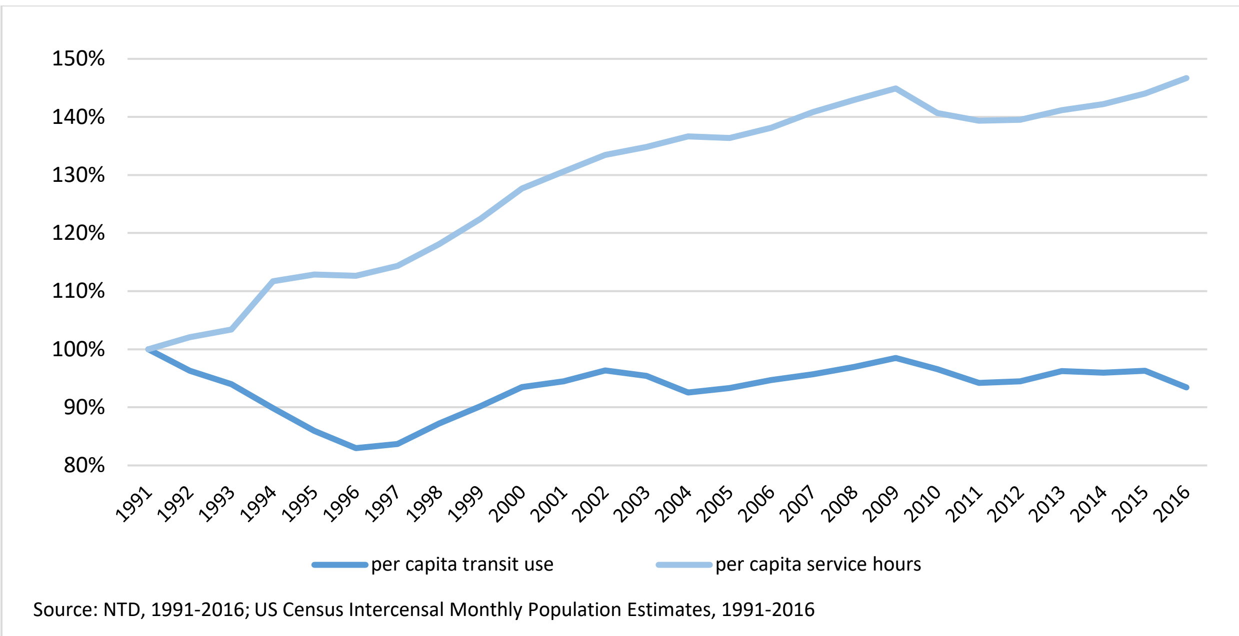

Figure 19. Transit trips and transit supply (1991-2016). *Per capita transit supply has increased 34% since 1991, while per capita transit use has not changed much.*

As a final way to examine the relationship between service levels and ridership, we examine the shifts between modes that occurred within the region's largest transit operator, LA Metro. Doing so allows us

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[10] Though not directly relevant to our question, these shifts have significant budgetary implications beyond just the deployment of various services (Taylor, Garrett, & Iseki, 2000). Local bus and bus rapid transit services (with the exception of those operating in exclusive rights-of-way) tend to be the cheapest to deliver and require the smallest per passenger subsidies. By contrast, the annualized capital plus operating expenses of rail transit tend to be substantially greater per passenger, while the per passenger subsidies for ADA demand response services tend to be the highest of all.

to address the possibility that aggregate increases in services are masking drops in those types of services— such as buses— that most transit riders rely on. The figures below show the indexed trends in boardings, service (VRH), and productivity (boardings/VRH) for LA Metro bus (Figure 20) and rail (Figure 21) service from 2000 to 2016, and demand response service (Figure 22) since 2008. For local bus and BRT service, transit service supply has tended to follow, rather than lead, changes in ridership — at least through 2014. Beginning in 2014, bus service rose slightly while boardings plunged. Rail service, not surprisingly, has increased more than 150 percent since 2000, and ridership has increased as well, though more slowly. Both service and patronage have tailed off since 2014, but largely in concert— there is no obvious sign of one leading the other. Finally, demand response and van service supply has grown steadily since 2008; boardings increased steadily, albeit more slowly than service, through 2015. Over the past year, service continued to gradually climb, while patronage began to fall.

Collectively, these data offer little evidence that service cuts are driving away customers. Instead service expansion has been accompanied by less ridership, with the main result being lost productivity, particularly for rapidly expanding rail and van services. Rail and van productivity (measured as boardings per VRH) has eroded steadily since 2009, while the service effectiveness of local bus and BRT service began dropping later (and more precipitously) in 2014. Falling service does not seem to be the culprit for falling ridership; falling ridership, in concert with expanding service, is the culprit for falling productivity.

Figure 20. LA MTA: Indexed bus and BRT boardings, service, and productivity. *Declining ridership since 2007, with services' slow growth in the post-recession period leading to declining productivity.*

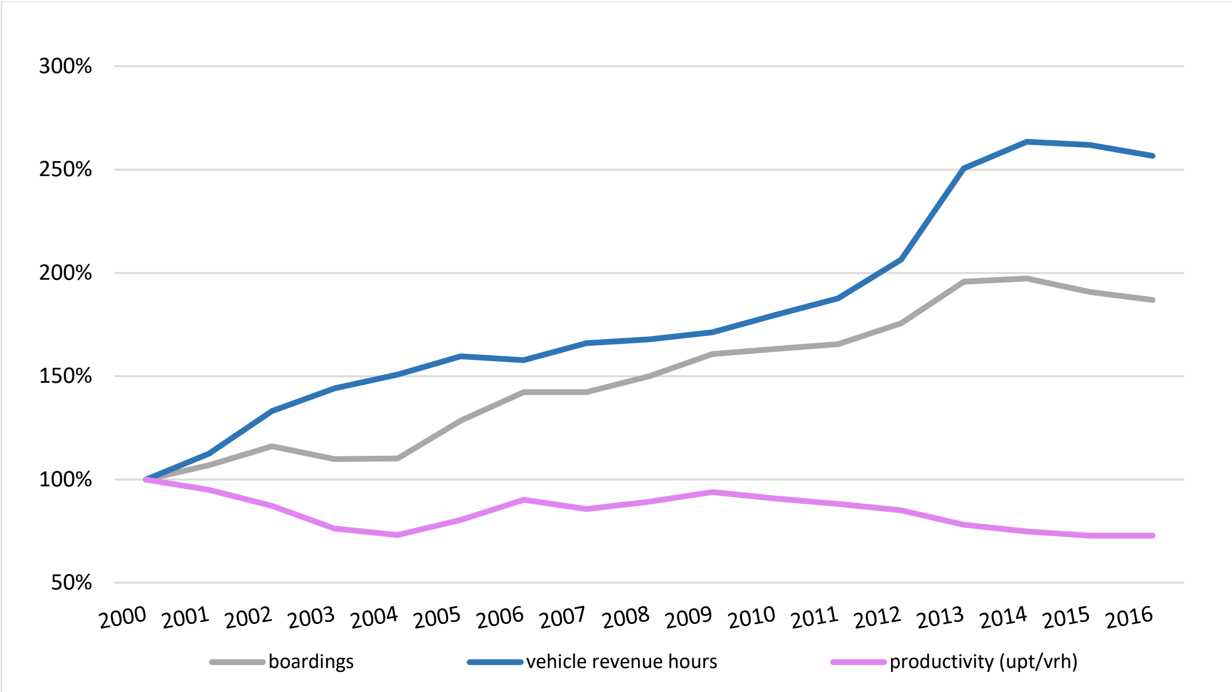

Figure 21. LA MTA: Indexed rail boardings, service, and productivity. *Light rail service doubles with the opening of the Expo Line. Boardings do increase, but slower than the amount of service added.*

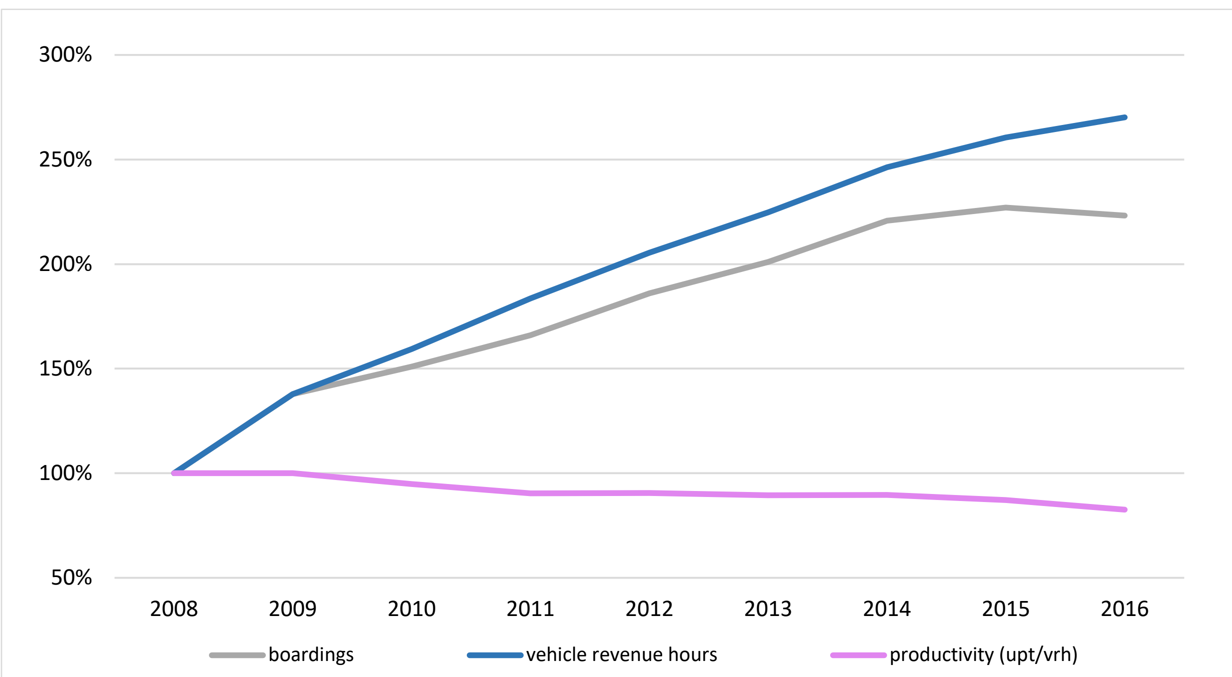

Figure 22. LA MTA: Indexed demand response boardings, service, productivity. *Ridership more than doubled, while service increased by 2.8x.*

The Quality of Transit Service

Even if transit quantity does not change, transit quality might. Transit quality has no specific definition, but we can divide it into speed, reliability, and experience. Speed measures how quickly transit vehicles move throughout the region. Reliability is a measure of on-time performance: Do vehicles arrive and depart when they are supposed to? Experience is a measure of how safe or comfortable people feeling during their transit journey, including the time they spend waiting for and transferring among their buses and trains.

Local bus and BRT service in the SCAG region has been slowing down over time. This slowdown is likely a result of many factors, including worsening congestion, shifts from faster suburban to slower urban service, shorter stop spacing, and longer stop "dwell" times to load and unload passengers. Whatever the underlying causes, region-wide bus vehicle speeds declined five percent between 2000 and 2010, and another eight percent between 2010 and 2016, for a total drop in speed of nearly 13 percent over 16 years. By comparison, rail transit speeds were down only two percent between 2000 and 2016.

Falling speeds slow travel times, and if operators do not counteract falling speed by adding more vehicles, then headways (the time between vehicle arrivals at a stop) will rise. Rising headways make transit less attractive by increasing average wait times at stops and lengthening the times of transfers among vehicles. Research has shown that transit passengers find waiting for busses and trains to be especially burdensome, so increased headways can undermine the quality of transit service even if the quantity (in terms of vehicle revenue hours of service) stays unchanged (Iseki & Taylor, 2009).

The SCAG region has 41 transit agencies that operate fixed-route general public service, and on-time performance naturally varies across them.[11] Measuring reliability for all or even most of these operators is therefore beyond the scope of this report. We can, however, examine reliability for LA Metro, which again accounts for the lion's share of the SCAG region's transit trips and lost trips.

Historically, Metro has been unreliable relative to other large transit agencies. A 2008 study by the agency showed that compared to 9 peer operators, Metro had both a lower on-time target and a lower on-time percentage (a vehicle is considered "on-time" if it is less than 5 minutes late). Metro aimed to have 70 percent of its vehicles arrive on time, and attained a rate of 63 percent. In comparison, New York attempted an 83 percent on-time rate and attained an 82 percent rate (Flowers & Snoble, 2008). Metro's reliability problems occur almost entirely on buses, which can easily become trapped in congestion (and which, of course, can also exacerbate congestion).

In the intervening years, however, Metro's on-time performance appears to have improved substantially. An analysis of Metro data by local reporters (Mendelson, 2015) suggests that from 2010 to 2015 Metro rail maintained a 99 percent on-time rate (with subways being late 1 stop out of 200, and light rail 1 stop out of 50), while the buses improved their on-time rate to 81 percent. We say "appears" because this discussion comes with an important caveat: Reliability is a function of the conditions in which buses and trains operate, the efficacy of the bus and train operations, and the schedule that sets the performance expectations. Controlling for conditions or operations, schedules that assume few traffic disruptions and

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[11] With another 69 systems operating demand-response and other types of transit services, for a total of 110 regional transit service providers.

little layover or recovery times can be difficult to meet, while those that assume slower speeds and provide generous layover and recovery times at the ends of routes are easier to meet.

As a result, transit operators can improve measured reliability in two ways. The first involves steps like better field supervision, quicker boarding and alighting procedures that reduce dwell times, and giving buses their own lanes in chronically congested districts. All these steps can change operations, and lower the variability of travel times. But the second way to improve reliability is to change the schedule, by factoring in more slack. Doing so is not necessarily disingenuous, and may simply reflect the challenges of operating in heavy congestion. Adding slack to schedules can allow vehicles to maintain performance even in the face of disruptions (severe congestion, crashes, crowds of people boarding or alighting at particular stops, and so on). The downside to this approach, however, is that too much slack in the schedule might increase reliability on paper but manifest as poorer-quality service in the eyes of riders. As slack increases average vehicle speeds fall, headways rise, and so do timepoint holds (instances where vehicles wait at stops so as not to run ahead of schedule). A service that is on-time because its schedule makes it less frequent is not a high-quality service.

We could not, with the data and time available to us, determine if Metro's schedule adherence improved because its buses met the existing schedule more often, or because schedules themselves were changed. If bus performance improved on the street as opposed to on paper, then we would have little reason to think service reliability was a large factor in falling ridership – bus ridership would have fallen even as schedule adherence increased. But we cannot say for certain that this occurred. We do know, however, that rail ridership fell even as rail maintained a near-perfect on-time record. So we have some reason to think that service reliability did not play a large role in the ridership downturn.

We should also note that the advent of mobile apps that track transit vehicles in real time may have diminished the problems caused by unreliable buses. Unreliability is a larger problem when it strands people at stops with little idea of when a vehicle will arrive. To the extent people can follow vehicles in real time and adjust their departures to minimize waiting, some of the worst aspects of irregular transit vehicle arrivals can be mitigated (Yoh et al., 2011). LA Metro has next bus and next train information at its rail stations and BRT stops, and real time information about local and express buses is available on multiple smartphone applications. Metro's 2016 rider survey shows that 51 percent of bus riders have a smartphone, and that 66 percent of these riders use the phone "very often" or "occasionally" to get information about Metro rides.

A transit vehicle that arrives on time can still have poor service quality, if the experience of using the vehicle – which includes walking to the stop, waiting at the stop, and riding – is unpleasant. Specifically, if people using transit feel unsafe or uncomfortable, ridership could fall (Delbosc & Currie, 2012; Iseki & Taylor, 2009). Safety perceptions are often gendered (Loukaitou-Sideris, 2015), and a slight majority of transit users in the SCAG region are women. Note that perceptions of safety are different from, and probably more important than, safety itself. Many behaviors that are not crimes, and that do not directly threaten other people, may nevertheless disturb people nearby, and can discourage them from using transit (Ellickson, 1996; Fink, 2012).

There is some reason to think that transit vehicles, stations, and stops in the SCAG region – and particularly along LA Metro routes – came to feel less safe to riders in recent years. In 2016, LA Metro surveyed former riders, and 28 percent said that the primary reason they stopped riding transit was that they felt either unsafe or uncomfortable. Unfortunately, this survey is not conclusive. Former transit riders are a hard group to reach, and there are responses in the survey that suggest that the overall sample may not have been representative. As a result, we cannot be certain that safety actually loomed so large for former riders. At the same time, even if the survey inflated safety concerns by a factor of two, a nontrivial share of former riders (14 percent) report leaving transit because they felt unsafe. And considerable anecdotal evidence suggests that in recent years transit users started to feel less safe — such reports prompted Metro to completely revamp its security procedures in 2017.

What might explain riders' perceptions that transit is less safe? Possibly some riders have *always* felt unsafe, and what changed was not conditions on transit but the option to leave (if people got access to vehicles or TNCs, for example). We do not discount this possibility, but will take it up later in this report. If we assume that perceptions of safety really did decline in recent years, one potential (and admittedly speculative) reason involves LA County's dramatic increase in homelessness after 2010. Table 2 shows changes in the LA County homeless population from 2005 to 2017, based on homeless counts done by the Los Angeles County Housing Services Administration. Homeless counts, and especially counts of the unsheltered homeless, are for obvious reasons prone to error. Nevertheless, the table suggests that homelessness, while not as severe today as it was in 2005, has in recent years both risen sharply and changed in composition. The unsheltered chronic homeless (people who are not just homeless but also have some sort of disabling condition) became a larger proportion of the homeless overall.

Year	All Homeless		Share	Chronic Homeless		Share
	Total	Unsheltered	Unsheltered	Total	Unsheltered	Unsheltered
2005	65,287	53,429	81.8%			
2007	59,956	39,168	74.0%			
2009	38,602	21,073	54.6%			
2011	39,153	20,157	52.4%			
2013	39,463	25,136	63.7%	7,475	6,652	89.0%
2015	44,359	31,025	69.9%	13,356	nd	nd
2016	46,874	34,701	74.0%	14,644	13,746	93.9%
2017	57,794	42,828	74.1%	17,531	13,321	93.1%
Pct Change, 2005-2017	-13.0%	-24.8%	-10.4%			
Pct Change, 2009-2017	33.2%	50.8%	26.3%			
Pct Change, 2013-2017	46.5%	70.4%	16.3%	57.4%	59.2%	4.4%

Source: Los Angeles Homeless Counts, Los Angeles Almanac
https://www.lahsa.org/homeless-count/reports
http://www.laalmanac.com/social/so14.php

Table 2. Changes in LA County homeless population, 2005-2017.

Homelessness— the simple condition of people being without housing— often arises from high housing prices that push some people out of the housing market (O'Flaherty, 1998). Chronic homelessness, however, which tends to be much more visible (in part because the chronic homeless are less likely to be sheltered) often has different underlying causes related to addiction or mental illness. In conversations with transit operators during the writing of this report, some mentioned the impact of California's prison realignment program, which led to many inmates being released from prisons and jails. The state's carceral institutions have traditionally held many mentally ill persons, and discharging them without any corresponding increase in other social services may have increased the number of people with addictions and disabilities living on the streets. No government entity tracks prison realignment's impact on homelessness, but some advocates estimate that up to 20 percent of the state prisoners discharged, and up to 10 percent of county jail inmates, have now become homeless(Holland, 2015). There is also small body of evidence, some academic and some journalistic, suggesting that the unsheltered homeless gather disproportionately around transit facilities. Transit vehicles can provide shelter and protection, while transit stops can provide a roof or even just a bench (Emmons, 2013; National Academies of Sciences, Engineering, and Medicine, Transportation Research Board, Transit Cooperative Research Program, & Boyle, 2016; Trevor, n.d.; Voorhees Center for Neighborhood and Community Improvement, 2016). To the extent some of these people use transit stops and transit vehicles as ad hoc shelters, and to the extent their presence or behavior disturbs others, realignment may have played a role in making transit seem less safe, and reducing ridership. We emphasize again that this line of thinking is quite speculative and warrants further research.

Transit Fares

Potential transit riders weigh the quality of a ride against its price. Like most goods, transit, even at constant quality, will become less attractive if its price rises, and more attractive if the price falls. The postwar high-water mark for transit in Los Angeles County occurred during a three-year program that cut bus fares in half from 1982 to 1985. When this program ended and bus fares returned to their previous levels, transit ridership fell substantially (Southern California Rapid Transit District, 1986).

The inverse relationship between fares and use, however, is complicated by two factors. First, the people who use transit the most – lower-income people with limited or no vehicle access – are generally more price sensitive in that they have less income, but *less* price sensitive in that they have few viable alternatives to transit. As a result, many transit riders are less sensitive to fare increases than one might expect given their incomes. Second, although every transit operator has a posted one-way fare, relatively few riders actually pay that rate, because agencies offer a variety of discounts and bulk payment mechanisms, including daily, weekly or monthly passes, youth and elderly discount passes, and so on that offer substantial discounts to particular classes of riders, including those who ride frequently (Yoh, Taylor, & Gahbauer, 2016). Heavy users who buy monthly passes will typically pay a per-ride rate much lower than the advertised fare. LA Metro's 2016 rider survey showed nearly half (49%) used a daily, weekly, or monthly pass, while about 25 percent paid a discounted fare.

Further complicating this issue is that transit fares can be calculated on a per-trip or per-mile basis. Arguably the most intuitive way to think about fare increases is per-trip: How much does a person pay to get aboard a vehicle? But once a passenger is on board, what follows might be a local bus trip of two blocks or a light rail trip of 22 miles. With the exception of commuter rail and some express bus routes, transit fares generally do not change with distance travelled. If the average fare to board a vehicle rises less quickly than the average distance of a trip, the per-mile fare could fall more than the per-trip fare rises, and transit may in a real sense become less expensive. For our purposes, the fare per trip is probably more relevant, as it is likely more salient to potential riders, but it remains worthwhile to consider both.

This wide array of payment methods and rates, and ways of considering these rates, makes calculating the actual fare paid by different classes of users beyond the scope of this report. We can, however, easily determine the average fare paid per boarding for a given system and the SCAG region, by simply dividing total fare revenues collected by either total boardings or passenger miles. While these metrics will fail to capture some of the nuances of fare payment among different types of users (they cannot completely control, for instance, the bulk discounts for heavy users of different lines) they are a measure of the fare payments actually made by people when they ride.

Figure 23 below displays the average inflation-adjusted fare paid per boarding across all transit systems in the US, California, and the SCAG region between 2002 and 2015. The figure shows, first, that the average transit fare paid is lower in the SCAG region than for California as a whole, which in turn is lower than the average transit fare paid nationwide. Second, the figure shows that the average inflation-adjusted fare paid per boarding in California began creeping up in 2012, and to a lesser extent in the US since 2013 and the SCAG region since 2015. Overall, however, the average inflation-adjusted fare per boarding in the SCAG region has been remarkably flat since 2002.

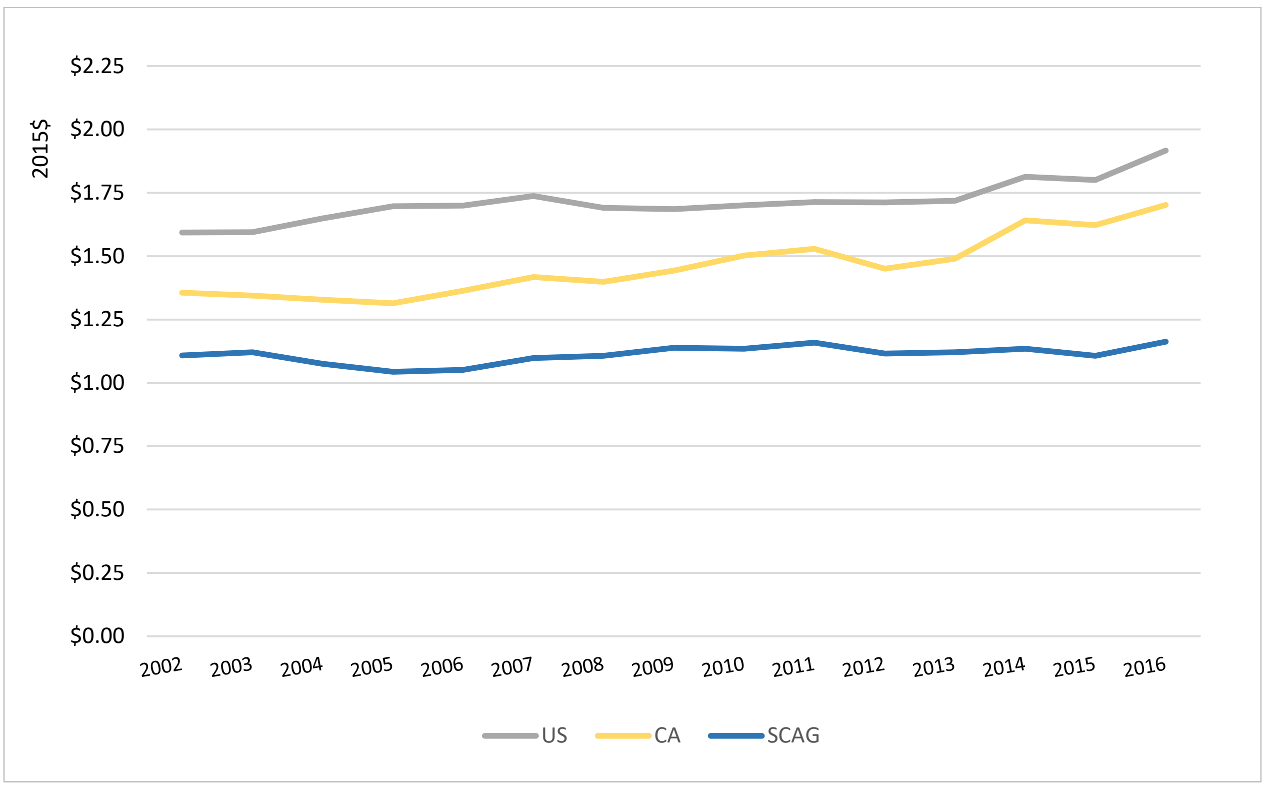


Figure 23. Average fare per boarding in 2015 dollars. *Average fare per boarding has stayed relatively constant in the SCAG region.*

National, state, and regional averages, of course, can mask considerable variation in fares paid across transit systems, services, and riders. Figure 24 shows the same inflation-adjusted trend in fares paid per boarding since 2002 for each of the six largest transit operators in the SCAG region. Focusing on these larger operators tells a different story. With the exception of Long Beach Transit, inflation-adjusted fare payments have been increasing over time on these operators. In particular, inflation-adjusted fares per boarding at both OCTA and the Big Blue Bus increased by about 50 percent between 2002 and 2016 — to nearly $1.25 and $0.75 per boarding respectively. Foothill transit had (in 2016) the highest average fares paid (at $1.25 per boarding), followed in order by OCTA, LA MTA, the Big Blue Bus and Long Beach Transit, while LA DOT had the lowest average fare paid (at just over $0.50 per boarding).

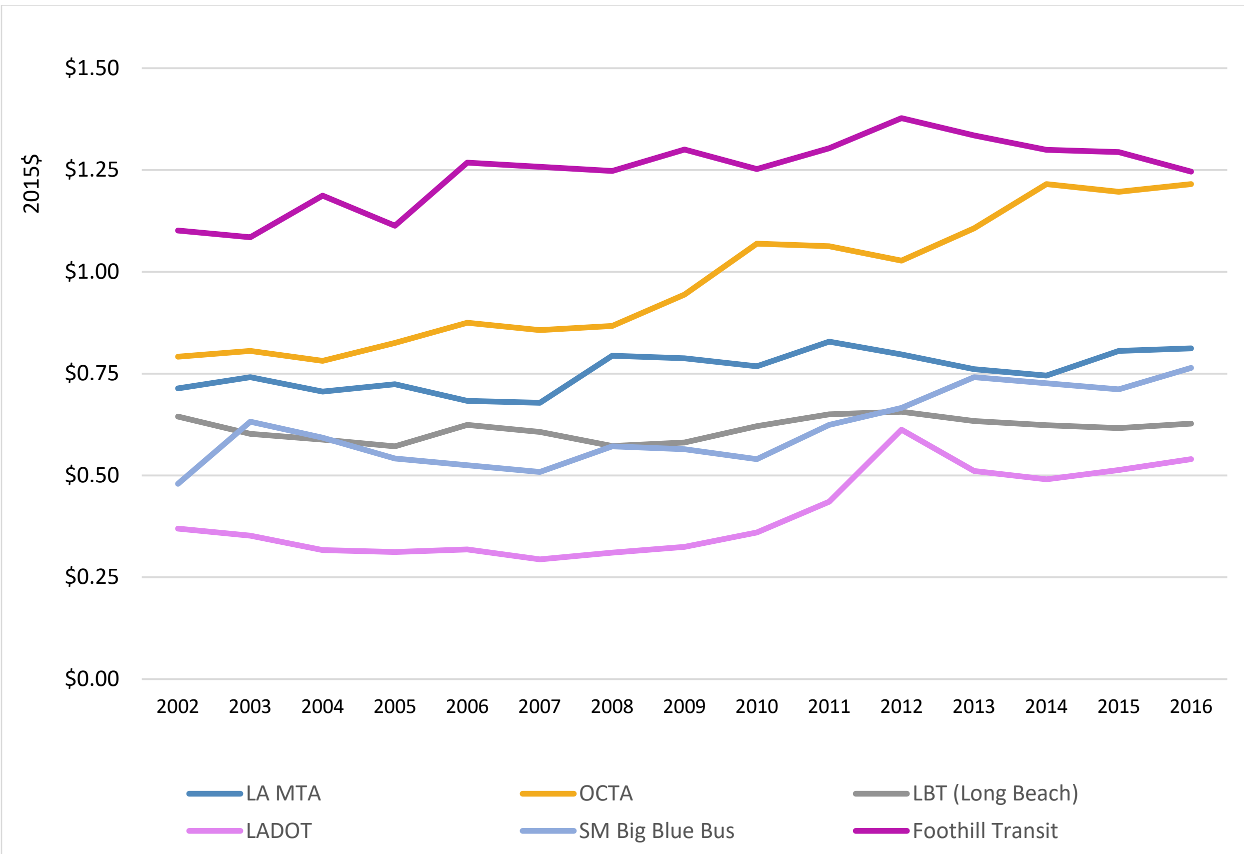


Figure 24. SCAG: Average fare per boarding for largest operators in 2015 dollars.
Inflation-adjusted average fares per boarding have increased the most rapidly for OCTA and LADOT.

Figure 25 shows the 14-year trend in real average fare paid per mile for the nation, California, and the SCAG region. Here we see that average fares paid per mile have remained largely unchanged in the U.S. and California, and in the SCAG region they have actually fallen. Despite being lower than average per mile fares in the state and nation, average per mile fares in the SCAG region have declined about 20 percent since 2009.

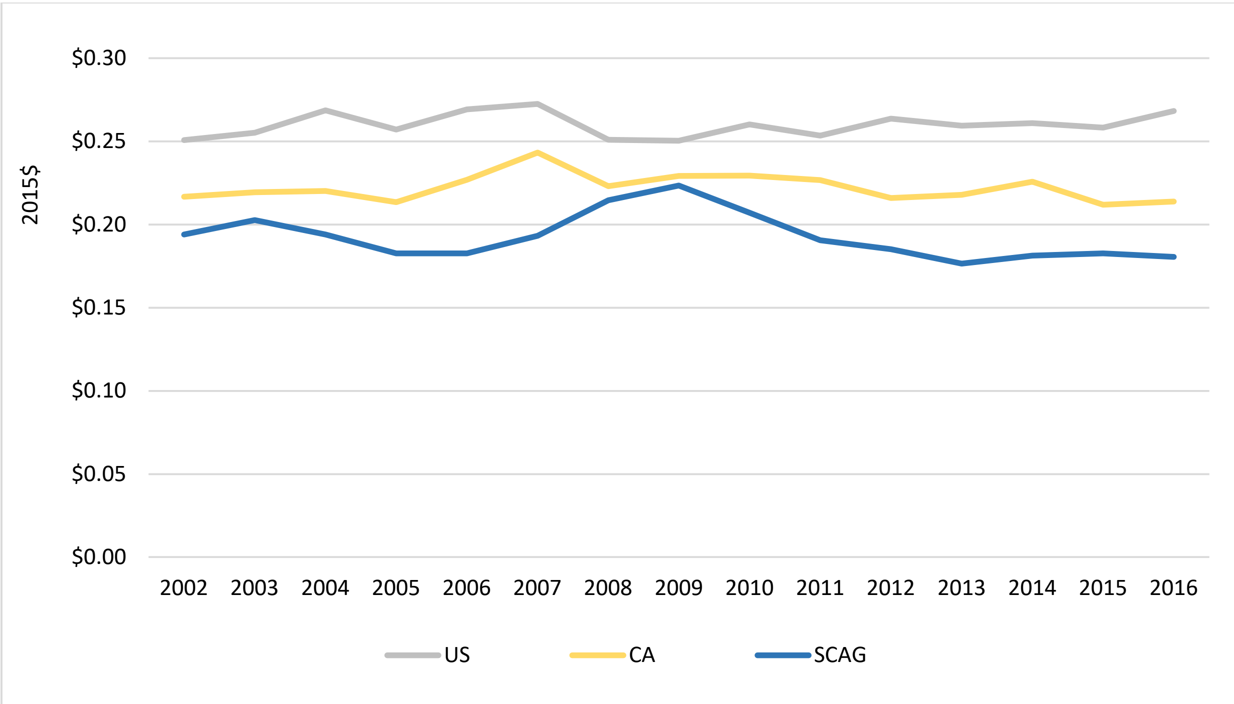


Figure 25. Average fare per passenger mile traveled in 2015 dollars. *Average fare per PMT remained fairly constant, and even declined a little since 2009.*

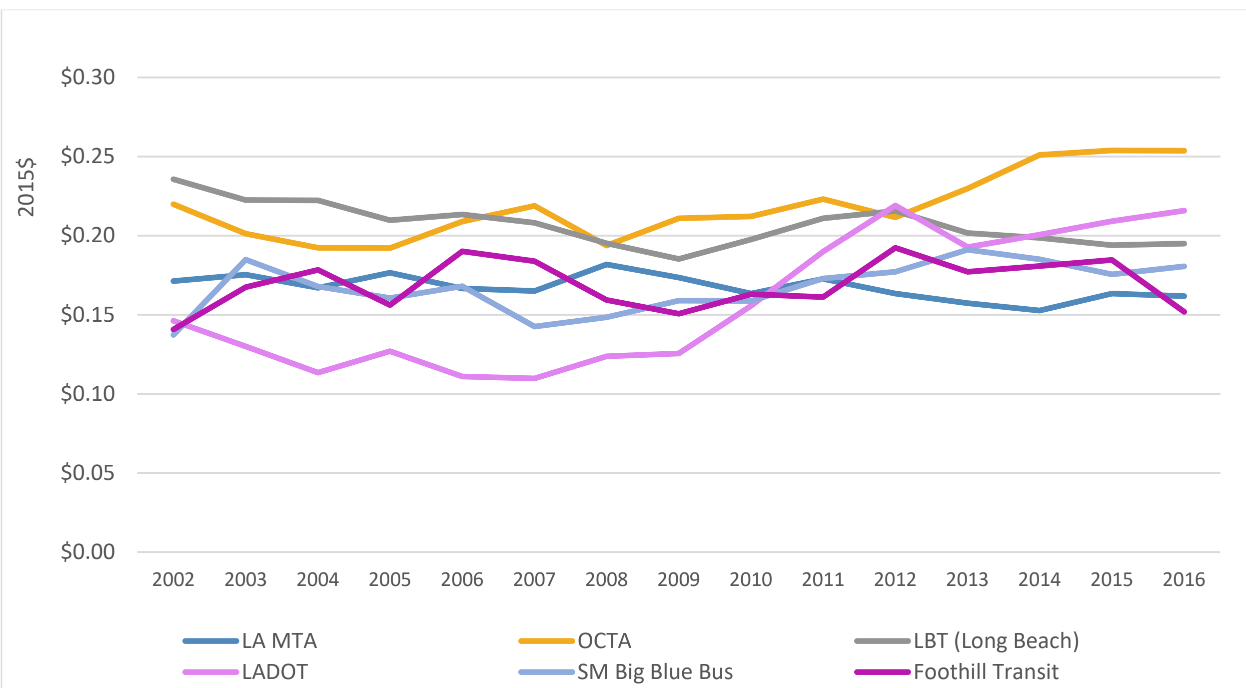


Figure 26. SCAG: Average fare per PMT for largest operators in 2015 dollars. *Average fare per PMT increased the most rapidly (about $0.07 per mile) for LADOT and slightly for OCTA ($0.04 per mile).*

If we zoom in on the six largest transit operators in the SCAG region, we see that inflation-adjusted fares per mile rose notably at two systems — LA DOT (+$0.07/mile) and OCTA (+$0.04/mile). On the Big Blue Bus and Foothill Transit per mile fares rose modestly, and at Long Beach Transit and LA Metro they fell (despite Metro's 2014 fare increase).

The most notable attribute of the figures above is the steep increase in fares for OCTA. OCTA's fares have risen over 50 percent since 2002, and OCTA is also the transit operator that has suffered the sharpest decline in ridership (about 35% since 2007). The transit industry's rule of thumb (sometimes called the Simpson-Curtin rule) suggests that a 10 percent increase in fares will be associated with about a 3 percent reduction in ridership. By this heuristic, OCTA's fare increases should have resulted in a 17 percent ridership decline.

To help isolate the association between fare increases and transit use, we estimated a multivariate regression statistical model using data for each transit operator in the SCAG region for each year between 2002 and 2016. Full details of this model are in the Appendix, but we used fixed effects to control for the panel nature of the data, and controlled for the level of service each operator provided, the average time between each bus or train arrival, and the density, size and population of the service area.

We find, after controlling for these factors, that higher fares are indeed associated with lower ridership, but by less than industry rules of thumb might suggest. Across the SCAG region over this time period, a 10 percent fare increase was associated with a roughly 1.6 percent decrease in ridership. This relationship is relatively "inelastic" (i.e. it suggests people are not very sensitive to prices) though it falls within the range of findings from other studies of how fare increases influence ridership (Cervero, 1990; Linsalata & Pham, 1991). Based on these results, we would expect OCTA patronage to have fallen about 8 percent since 2002, as a result of its fare increases.

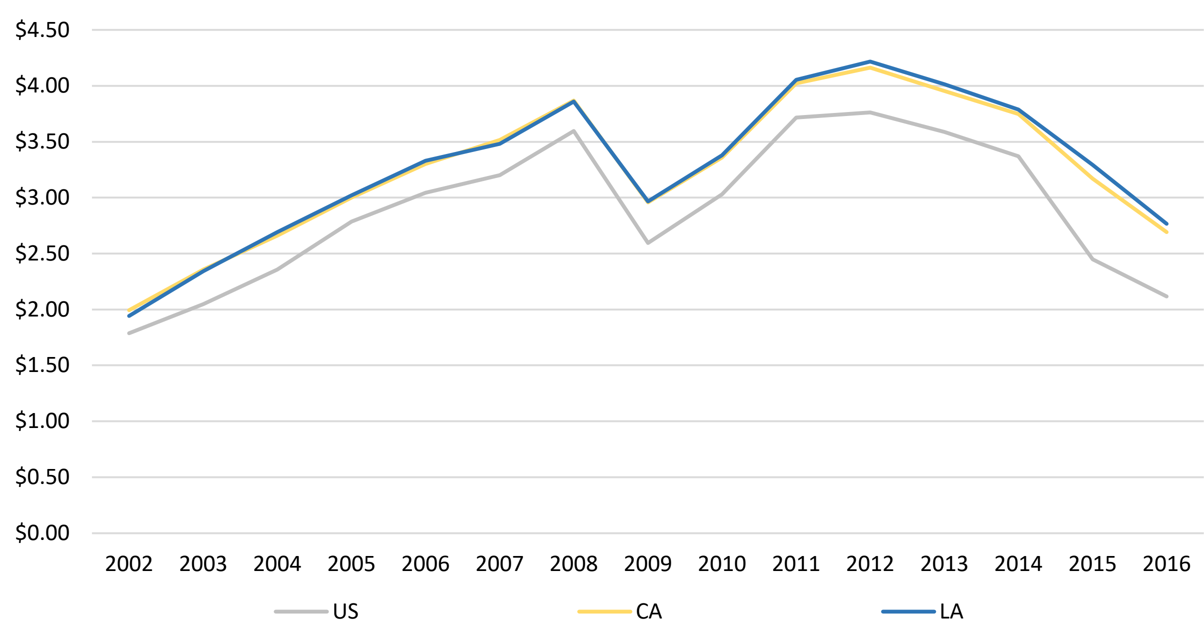
It seems plausible, in light of these data, to suggest that fare increases played some role in OCTA's lost transit trips. But OCTA's losses, as large as they are, account for a small fraction of the SCAG region's total losses. The bulk of those losses were from LA Metro, and it is harder to suggest that fare increases played a big role in Metro's ridership decline.

Factors Outside Transit Operators' Control

Fuel Prices

Fuel prices are a large and highly salient operating cost of driving. As fuel prices rise people drive less, and as they fall people drive more. In general, a ten percent increase in the price of gasoline is associated with a long-run (5 year) one to three percent reduction in vehicle travel (Goodwin, Dargay, & Hanly, 2004). Driving more, however, is not the same as using transit less, since (again) the typical driver almost never uses transit. People who drive less when gas prices are high often walk, carpool, stay home, or drive to nearer destinations (e.g. a restaurant that is 2 miles away instead of 10). Similarly, for many regular transit riders changes in the price of gasoline are immaterial, because many transit users do not have access to private vehicles. As a result of these factors, much of the adjustment to fluctuating fuel gas prices that occurs in the U.S. has no bearing on transit use, and the relationship between fuel prices and transit ridership tends to be weaker than the relationship between fuel prices and driving.

"Weaker," however, is not "nonexistent," and in both Southern California and nationwide, fuel prices rose and fell sharply from the late 1990s through 2015. Prices increased at a record pace from 1998 to 2008, declined, and then rose sharply again until 2013, after which they plunged (Figure 27). Transit ridership also fell steeply from 2013 to 2016. It is reasonable to think that falling gas prices could contribute to falling transit ridership. A steep drop in gas prices could have lured some of the minority of transit riders who do have vehicles away from transit use. Even among riders without vehicles available, falling fuel prices could have an indirect impact. When fuel is cheap rides in cars become more available: Friends or family members who become more likely to drive, and people who might otherwise have used transit might start carpooling for some trips.

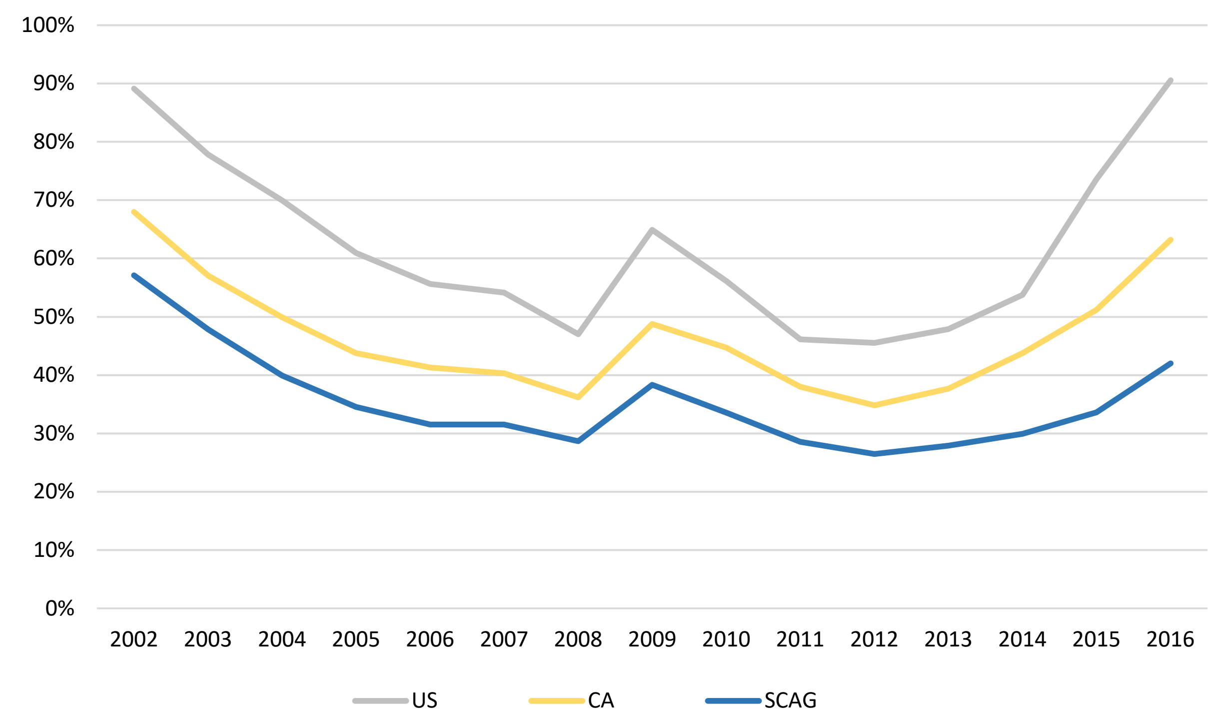


Source: EIA Average Gas Price (retail regular gasoline for US, California, Los Angeles), 2002-2016

Figure 27. Average gas per gallon in 2015 dollars.

As to how much a steep drop in fuel prices might undermine transit use: the research literature reports a fairly wide array of elasticities (estimates of transit's sensitivity to gas price changes). These range from relatively large effects for commuter rail (0.37, when gasoline costs more than $3 per gallon) (Nowak & Savage, 2013) to much lower average estimates for bus ridership that range from -0.05 to 0.22 (Blanchard, 2009; Iseki & Ali, 2014; Mattson, 2008). Blanchard (2009) used gas price changes in LA County to estimate a bus ridership elasticity of 0.092, a subway elasticity of 0.011, a commuter rail elasticity of 0.126, and light rail elasticity of 0.071. Lane (2010), also studying LA, found similar results. All these estimates suggest that a 10 percent change in fuel prices is associated with about a half-percent change in transit use in the near term, and a 1 to 1.8 percent change in the longer-term. Gas prices fell 30 percent from 2012 to 2016, which would imply a 3 percent reduction in bus ridership, and larger losses in rail and commuter rail, all else equal.

One way to consider this relationship of fuels prices to fares is to compare the ratio of average fare paid per boarding with the average price of gasoline in the SCAG region over this period (Figure 28). As with fares generally, we see that this fares-to-gas ratio is lower in the SCAG region than in California as a whole, and lower in California than the nation as a whole. Further, while the price of a transit trip relative to a gallon of gas has been climbing across all three geographies since about 2012, the ratio in the SCAG region today remains substantially lower than it was in 2002.



Source: NTD, 2002-2016; EIA Average Gas Price (retail regular gasoline), 2002-2016.
Note: Average LA gas prices are used for the SCAG region.

Figure 28. Average fare as a percent of region's average gas per gallon. *Average fare is consistently less than the cost of a gallon of gas, even as gas prices have been falling since 2014.*

Figure 29 plots the trend in gas prices against the trend in absolute and per capita transit ridership in the SCAG region (we use the Los Angeles Metropolitan Statistical Area average gas prices). The graph suggests a real but fairly modest relationship: Transit use does rise and fall with fuel prices, with a small lag. The response does not appear to be large, however, especially for ridership per capita. But with only one data point per year, we can only say so much about the role of gasoline prices. It would be surprising if falling gas prices did not contribute to the decline in transit ridership, but it is difficult to quantify their precise role. Overall, we consider falling fuel prices to be a real but probably minor driver in falling transit use.

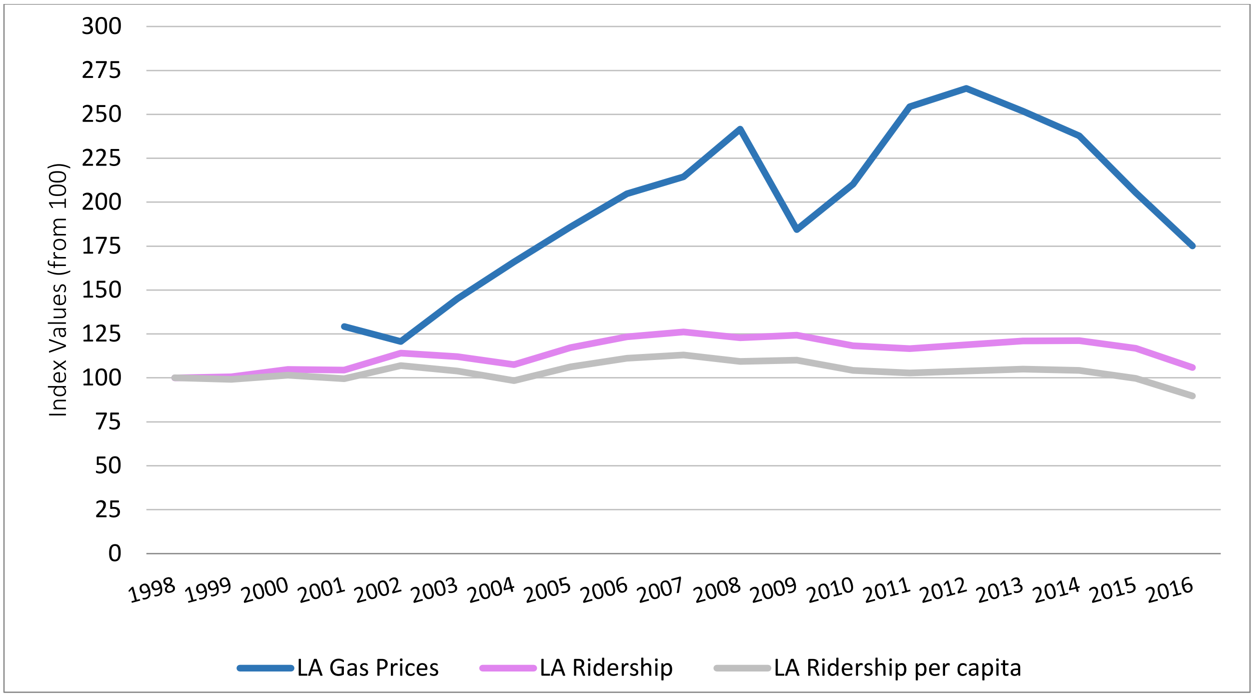


Figure 29. Transit ridership and gas prices in Los Angeles.

The Transportation Network Companies

The large absolute decline in transit ridership coincided not just with falling gas prices but also with the rise of Transportation Network Companies (TNC) like Lyft and Uber. TNCs are a plausible culprit in transit's decline. TNCs can offer the convenience of automobile travel to people who do not own automobiles, and could therefore become viable substitutes for public transportation. Any explanation for falling transit use that hinges on TNCs, however, faces a timing problem: TNCs began operating in Southern California in 2009, and did not begin serving people in large numbers until 2012. Per capita transit ridership began falling in 2007. So while the TNCs may affect transit use, they cannot by themselves explain transit's recent patronage decline.

Moreover, TNCs' influence on mode choice is theoretically ambiguous. On the one hand, TNCs let people purchase vehicle trips *a la carte*. If those trips are inexpensive, then TNCs can be a faster, more direct, less-crowded, and more comfortable substitute for transit. While some TNC trips are substantially more expensive than transit fares, the TNC shared ride services, like Lyft Line and Uber Pool, have sometimes seen fares fall low enough to be competitive with one-way transit fares. Given the speed and convenience these services offer, they could draw some riders away from transit, provided those riders have smartphones and credit cards.

On the other hand, TNCs could also *increase* transit use. TNCs could help solve first-mile/last mile problems, and get people to transit stops that are beyond walking distance. TNCs could also provide transit riders a form of insurance – if some people don't take transit because they worry an emergency might arise where they need a car (for instance, getting a sick child home from school) the option of calling a TNC during one of those emergencies can lower the perceived risk of taking public transportation, and make it more attractive.

Finally, since most people in most regions do not use transit or even consider doing so, the average TNC trip may have little impact on transit ridership. If the typical Uber passenger has never used a bus and never considered doing so, Uber's growth cannot be blamed for transit's decline.

Because TNCs provide almost no operating data to the public, we do not have sufficient evidence to adjudicate between these scenarios. We do not know even basic information — such as the total number of TNC trips in the SCAG region year over year, or the general areas where those trips originate — that could cast light on the relationship between TNCs and public transportation (Transportation Research Board, & National Academies of Sciences, Engineering, and Medicine, 2016).[12]

What little evidence we do have suggests that most TNC trips do not replace transit trips. Surveys done by independent researchers and organizations suggest that the typical TNC user does not resemble the typical transit rider (TNC users are disproportionately college-educated and affluent), and that the most common times and places for TNC rides are Friday and Saturday nights in popular commercial districts, and trips to airports (Clewlow & Mishra, 2017; Feigon & Murphy, 2016; Rayle, Dai, Chan, Cervero, & Shaheen, 2016). Large surveys by Clewlow and Mishra (2017) and APTA (Murphy 2016) suggest that most TNC trips occur between 10 p.m. and 4 a.m., when transit runs infrequently and carries few riders. Clewlow and Mishra (2017) find that the majority of TNC users report no change in their use of other modes. All this evidence suggests little impact on transit.

The caveat attached to these findings, however, is that the subgroups most likely to take transit – low-income racial and ethnic minorities – are also difficult to survey. Even very large, well-funded surveys often struggle to get adequate coverage of poorer households. As such, we cannot rule out the possibility that actual TNC use in some poorer neighborhoods is higher than the current data suggest.

Moreover, as the pool of TNC users continues to expand, the TNCs' effect on transit use – both positive and negative – may well increase. These amplified effects will be still more likely if TNC prices fall, and TNC use grows disproportionately in dense, high transit ridership areas populated by residents with relatively low levels of household motor vehicle access. For this reason, the relationship between TNCs and transit should be monitored, and there may well be a public interest in letting transit agencies see at least basic data about the location and volume of TNC trips. But relatively little evidence suggests that TNCs are a big player in the current transit decline. The timing, again, does not match up well.

Neighborhood Change and Migration

Transit is heavily-supplied in a small proportion of places, and heavily used by a small proportion of people. This situation creates a potential matching problem. If the small group of people who use transit

[12] TNCs are required under California law to report a host of data on rides given, disability access, and drivers to the California Public Utilities Commission. Unlike transit data in the NTD, however, these TNC data are not public. The CPUC cannot easily turn those data over to the public or public agencies. Such conditions are common throughout the United States. For more - http://www.cpuc.ca.gov/General.aspx?id=3989

a lot becomes less likely to live in the small number of places that offers a lot of service, transit use could fall. Such a mismatch could occur for a number of reasons. The highest-profile explanation is gentrification-driven displacement. If gentrification pushes transit-riding lower-income households away from transit-rich neighborhoods, and replaces them with higher-income residents, transit use may fall. The new higher-income residents may use transit more than they did previously, but less than the lower-income residents they replace (Dominie, 2012).[13]

Gentrification and displacement, however, account for only a small portion of moves by poor and immigrant households. Most moves by such households are by choice, or for reasons unrelated to in-migration by the affluent—for example, a low-income resident might lose a job and be forced to move (either to find new work, or to find a place with lower rent), even if neighborhood rents are not rising (Freeman 2005; Freeman and Braconi 2004; Newman and Wyly 2006; Vigdor 2002). The relevant fact is that in recent years many poor households, when they move for whatever reason, relocate to the suburbs. As poor households suburbanize, they move farther from transit on average (Farrell, 2016; Kneebone, 2014; Kneebone & Garr, 2010; Singer, 2011; Zimmerman, Restrepo, Kates, & Joseph, 2015). Upon arriving in the suburbs, low-income people may well use transit more than other suburbanites, but less than they had used it when they lived in central-city neighborhoods. If they are not replaced in central-city neighborhoods by other people who ride at high rates, then as a result of their migration overall transit use could fall.

Ideally we could examine the extent to which migration influences transit use by following low-income households and their travel behavior over time and across neighborhoods. Unfortunately, the data that would allow us do this do not exist. What we can do instead is use census-tract level data to examine changes in the spatial location of transit commuters and in the characteristics of residents living in high-transit commuting neighborhoods. We approach this task in two ways: identifying tracts with transit-friendly built environments and seeing how they change over time, and identifying tracts with high levels of transit commuting, and examining change within those places over time. These approaches have limits, as we will explain, but in combination they show a decline in the number of transit commuters in many high-transit use neighborhoods in 2010 and 2015, a decline in transit mode share in these neighborhoods (particularly from 2000 to 2010), and a shift in the characteristics of neighborhood residents in ways that help to explain declining transit use.

We have two methods available to identify areas that are highly conducive to transit use. These are areas that, regardless of who lives in them, are transit-friendly, either because of their levels of transit service or attributes of their built environment. Our first measure of transit-conduciveness is SCAG's High Quality Transit Area designation. SCAG defines a High Quality Transit Area as an area within one-half mile of a fixed guideway transit stop or a bus transit corridor where buses arrive at a frequency of every 15 minutes or less during peak commuting hours. SCAG last identified existing High Quality Transit Areas using data for 2012. These High Quality Transit Areas are located in 762 census tracts—about 45 percent of the region's total Census tracts.

Our second measure of transit-conduciveness comes from a typology of neighborhoods developed at the UCLA Institute of Transportation Studies for the US Federal Highway Administration (Voulgaris, Taylor,

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[13] This outcome could well result in lower transit ridership but also lower VMT and GHG, because the higher income in-migrants are more likely to replace driving with their transit trips (see Chapple et al. 2016, Chapter 4).

Blumenberg, Brown, & Ralph, 2016), using data from 2010-2013 (Ramsey & Bell, 2014; Voulgaris et al., 2016). This typology characterizes neighborhoods based on their built environment and transportation system characteristics (e.g. density, land use mix, age of housing stock, resident turnover, street network characteristics, and transit supply), but not on the characteristics of the people living in these neighborhoods. In this way the typology can capture how transit-friendly a neighborhood's built environment is. We focus in particular on one neighborhood type called "Old Urban," which indicates very-high density neighborhoods with high-levels of transit supply. Old Urban neighborhoods are much less common than SCAG High Quality Transit Areas—in 2010 there were 719 Old Urban neighborhoods in the region.

For our purposes, the limitations of both the SCAG designation and the Old Urban designation are that the data used to construct them are from 2010 or after. As a result, we can track changes in these neighborhoods from 2010-2015, but we do not have a good measure of tract-level transit supply or transit-conduciveness from 2000 to 2010, the time period when transit use in the SCAG region began to fall.

To examine changes from 2000 forward, we examine the clustering of transit commuters. This method is imperfect, since as we have shown commuters are a minority of transit users, but we assume for this exercise that as regular transit users, commuters tend to cluster in areas conducive to transit use. This assumption is contestable, but we have no other Census tract-level data on transit use that stretches back to 2000. We identify high-transit commuter neighborhoods with data on transit commuters by Census tract from the 2000 Decennial Census, and the 2010 and 2015 ACS.[14] For each year, we rank order tracts by the number of transit commuters in them. As we discussed earlier, transit commuters are highly concentrated in a very small fraction of the SCAG region's land area; eighty percent of transit commuters live on less than five percent of the land area and in less than 40 percent of census tracts. This distribution changed very little from 2000 to 2015.

We examine changes over time using the rank-ordered transit commuting data from the 2000 Census. We identified the census tracts that most intensively host transit commuters; these tracts, which are 1.43 percent of all census tracts in the region and 0.02 percent of the region's land area, hold ten percent of the region's transit commuters. We call these "10% Tracts." The mean number of transit commuters in these tracts is almost 12 times the regional average. For comparison, we also extracted data on the tracts where the top 60 percent of transit commuters live; these neighborhoods comprise 20.6 percent of all census tracts and 0.86 percent of the land area. We call these "60% Tracts." The mean number of transit commuters in these neighborhoods is 4.5 times the regional average. The number of ten percent tracts is extremely small: in 2000, just 48. The number of tracts that hold 60 percent of the commuters, in contrast, is 743—roughly the same number as are in the Old Urban designation.

The tracts in the 10% and 60% designations in 2000 strongly overlap with the SCAG High Quality Transit Area and Old Urban designations. If we take the 10% Tracts in 2000 and follow them forward, we see that about 85 percent are Old Urban tracts, and all of them are SCAG High Quality Transit tracts. Similarly, of the tracts in the 60% designation in 2000, in 2010 55 percent of them are Old Urban, and 85 percent are

[14] Because we are using tract-level data, the ACS data are from the 5-year samples. The 2010 data are from the 2006-2010 ACS, and the 2015 data are from the 2011-2015 ACS.

High Quality Transit. As such, following the trajectory of the 10% and especially the 60% Tracts may be a rough-but-reasonable proxy for following the trajectory of transit-rich areas.

As a first step, we follow three of these four tract designations – 60% Tracts, Old Urban, and High Quality Transit – over time, to the extent we can. For the latter two designations, this means only tracking changes from 2000 to 2015. We follow the year 2000 60% Tracts from 2000 to 2010, and then to 2015. (We use the 60% Tracts, rather than the 10% Tracts, because their numbers are more comparable to the Old Urban tracts).

Figure 30 summarizes the results. Essentially, the 60% Tracts saw substantial changes between 2000 and 2010, and these changes are consistent with the idea that the people most likely to use transit migrated away from transit-rich areas. From 2000 to 2010, the poverty rate in these tracts fell by four percentage points, the share foreign born fell from 48 percentto 45 percent, and the share of households without vehicles fell from 23 percent to 17 percent. From 2010 to 2015, in contrast, relatively little changed, and that same pattern holds if we examine Old Urban tracts and SCAG High Quality Transit Areas. Across all three neighborhood typologies, poverty rose slightly, the share of foreign born fell slightly, and – perhaps most important, given the importance of vehicle access to transit use – the share of households without vehicles stayed at the point it had fallen to. (The same general pattern holds for the 10% Tracts, although to conserve space these are not shown in the figure).

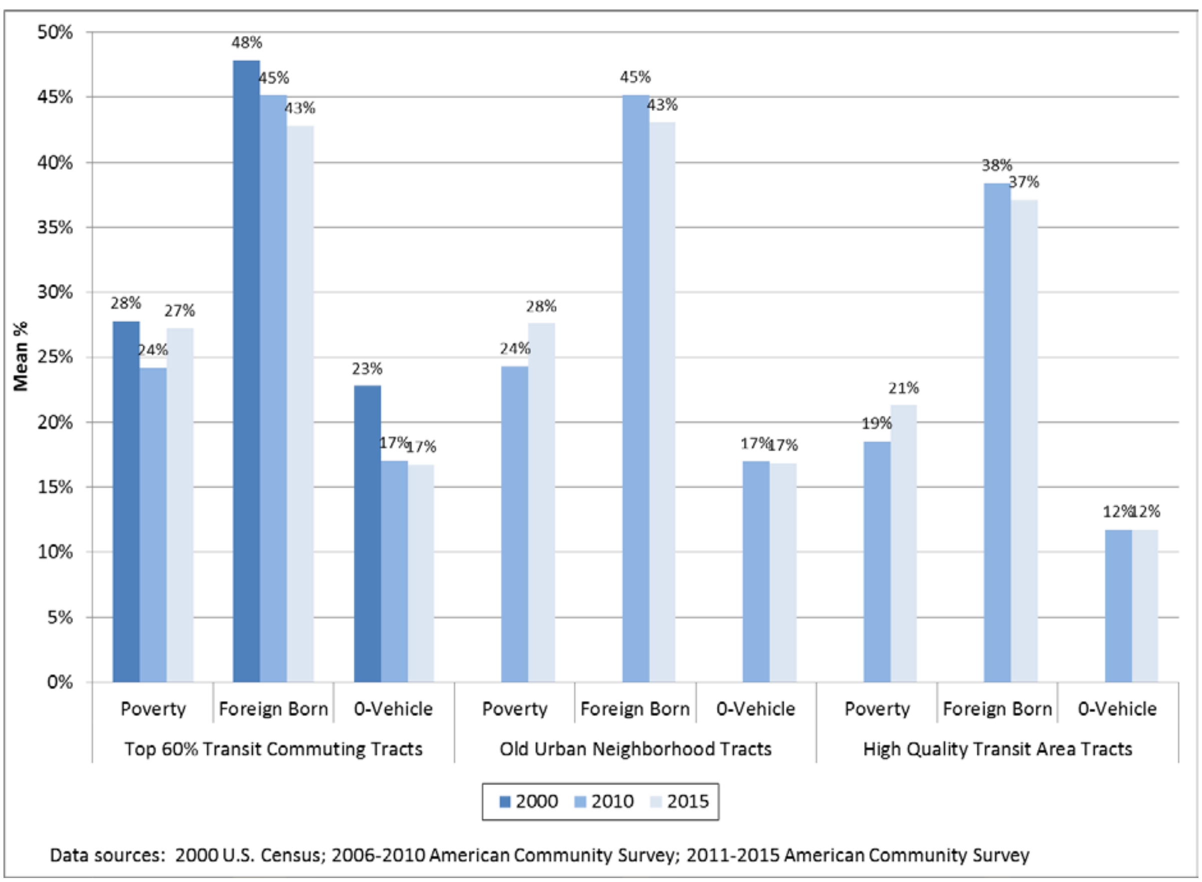

Figure 30. Characteristics of high-transit areas, 2000, 2010, and 2015 (2000 Census tracts over time)

Some additional data also suggest neighborhoods changing in ways not conducive to transit use. Figure 31, for example, shows that in both the 10% and 60% Tracts the transit commute mode share fell between 2000 and 2015 (with most of the decline occurring between 2000 and 2010.) Although not shown graphically, Census data also indicate that in these tracts, both the number of workers and overall earnings for workers rose, but earnings did *not* rise for those commuters using transit to get to work.

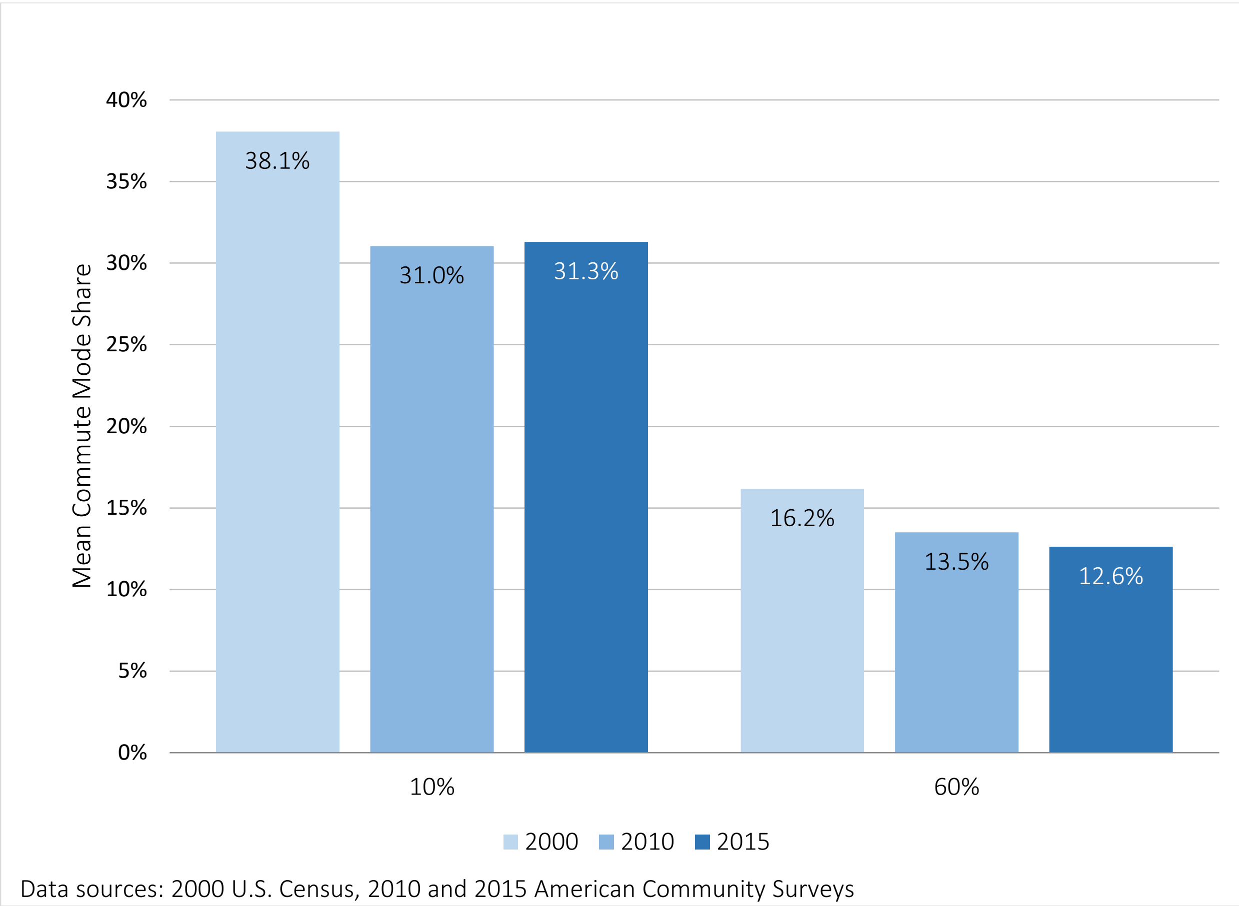

Figure 31. Mean transit commute mode share in high-transit neighborhoods, SCAG Region by year.

In summary, then, we observe changes in census tracts that in the year 2000 were most heavily-populated by transit commuters. These tracts, in turn, overlap substantially with tracts that we know in 2010 were rich in transit supply and/or had transit-friendly built environments, letting us infer (albeit with some uncertainty) that these neighborhoods were transit-rich in 2000 as well. Particularly between 2000 and 2010, in these neighborhoods we see falling transit commuting, falling population, a falling share of immigrants, falling poverty, more vehicle ownership, and higher earnings for workers overall but not those workers who commute via transit. All of this evidence is consonant with these neighborhoods becoming more affluent, with that affluence being associated with less transit use, and with people left out of that affluence remaining on transit.

We emphasize that this story is far from conclusive. For the reasons we discussed above, the relationship between neighborhood change and transit use is very hard to measure. The data we have are consistent with neighborhood changes in the most transit-friendly SCAG-region neighborhoods contributing to falling transit use, but they are not conclusive. This is an area that warrants substantial further research.

Rising Vehicle Ownership

The defining attribute of regular transit riders is often a lack of vehicle access. Between 2000 and 2015, vehicle access in the SCAG region became much more common. Households in the SCAG region, and especially lower-income households, dramatically increased their levels of vehicle ownership. Census summary file data show that from 2000 to 2015, the SCAG region added 2.3 million people and 2.1 million household vehicles (or 0.95 vehicles per new resident). To put that growth in perspective, from 1990 to 2000 the region added 1.8 million people but only 456,000 household vehicles (0.25 vehicles per new resident). The growth of household vehicles in the last 15 years has been astonishing.

There are strong reasons to believe that this surge in vehicle ownership is largely responsible for the decline in transit use. A back of the envelope calculation can illustrate the magnitude of the problem this vehicle surge could pose for transit operators. Data from the US Consumer Expenditure Survey show that from 2000 to 2015, the average expenditure per household vehicle in LA County was about $3,729.[15] Since SCAG residents added 2.1 million vehicles in this time, a midrange estimate of private expenditures on household vehicle growth is $7.8 billion. Over the same period of time, LA Metro and Metrolink combined to spend about $6.4 billion opening new rail service, and about $7.4 billion on combined rail and Bus Rapid Transit service. Thus even a conservative estimate of private investment in vehicle growth shows it easily outpacing public investment in fixed-route, dedicated right-of-way transit— the type of transit that is supposed to be most competitive with driving. This level of increased vehicle ownership is in many ways incommensurate with robust transit use.

To be sure, much of this vehicle growth would not influence transit use. Because most SCAG residents had never used transit, increased vehicle ownership in most SCAG households would not contribute to transit's decline. The 2000s were when the Millennials, a demographically large cohort, reached ages when many would buy automobiles. Millennial car-buying could help explain the bulge in vehicle acquisition, but unless those Millennials would otherwise be on transit these additional vehicles would not necessarily explain falling transit use.

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[15] The Consumer Expenditure Survey tracks the average net outlay per vehicle purchased. Data are not available for the other SCAG counties, but the average net outlays are probably similar across Southern California. Moreover, the $3,729 figure is the average of each annual average. Since more vehicles were purchased in the early to mid-2000s, and at higher prices, this figure likely underestimates the true average. See https://www.bls.gov/cex/csxmsa.htm

Some additional evidence, however, suggests that vehicle ownership did play a role in reducing ridership. When the OCTA surveyed its former riders in 2015, for example, 70 percent reported leaving transit because they had acquired a car (True North Research 2015).

Moreover, we have reason to think that the increase in vehicle ownership occurred disproportionately among populations that are more likely to take transit. Census data show that vehicle access increased most among lower-income households (we return to this point below, in Figure 40). Vehicle access also rose disproportionately among the foreign born. Table 4 shows changes in both zero-vehicle households and those with a vehicle "deficit" (that is, fewer vehicles than adults). Across the entire SCAG region, the share of households without vehicles fell 30 percent between 2000 and 2015, while the share of households with a vehicle deficit fell 14 percent. Among foreign-born households, these percent declines were larger — 42 percent and 22 percent — and among the foreign born from Mexico they were larger still. Among the foreign born from Mexico, the share of households without vehicles fell by two-thirds between 2000 and 2015, and the share with a vehicle deficit fell 28 percent. Thus car ownership rose across-the-board, but rose fastest among subgroups with a high propensity to ride transit. And these changes largely occurred between 2000 and 2010, which aligns with the timing of the transit downturn that began in 2007.

	All SCAG Share Households With:		Foreign Born Share Households With:		Mexican Foreign Born Share Households With:	
	No Vehicles	Vehicle Deficit	No Vehicles	Vehicle Deficit	No Vehicles	Vehicle Deficit
2000	10.2	30.1	14.1	47.1	15.7	57.2
2010	7.7	26.1	9.4	38.9	7.0	46.0
2015	7.1	25.9	8.2	36.6	5.4	41.6
Pct Change	-0.30	-0.14	-0.42	-0.22	-0.66	-0.27

Table 4. Vehicle ownership trends, SCAG region (US Census, Census IPUMs).

To refine our understanding of the association between vehicle ownership and transit use, we estimated a multivariate regression model. As a result of the data constraints we discussed earlier, this process involved two steps. Recall that our fundamental data obstacle was a mismatch between the availability of detailed, person-level information about travel behavior and our need to answer a question about changes over time. The CHTS provides detailed travel behavior, as well as demographic and socioeconomic data, but only for the year 2012. The Census provides detailed annual data, but for almost every category *except* travel behavior and transit use.

We resolve this problem by first using the CHTS to build a model that predicts total unlinked trips as a function of different demographic, socioeconomic, and neighborhood attributes. Importantly, all of these attributes – such as sex, nativity, income, vehicle ownership, and so on – are also tracked in 2000, 2010 and 2015 Census IPUMS microdata. This symmetry allows us to take the parameters of the CHTS model and apply them to time-series data from the Census. We use the CHTS, in short, to estimate the relationship between transit use and different social and economic characteristics, and then use the

Census to track how those characteristics have changed. Once we have measured that change in the Census, we can use the CHTS results to estimate how transit use would have changed as a result.

A core assumption of this approach is that the relationships between transit use and the socioeconomic and demographic attributes, which we can only measure in 2012, are relatively constant across time. We assume that changes in transit use from 2000 to 2015 are driven primarily by changes in the composition of the population, and not by changes in the propensity to use transit by people in different population groups. Our approach is more valid, for example, if transit use changes because there are more or fewer people in poverty, or with vehicles, and not because poor people or people with vehicles become more or less likely to use transit. The latter scenario is possible, but we cannot measure it.

We constructed models for California, the SCAG region, Los Angeles, and the SCAG region outside of Los Angeles. Figure 38 shows results from the first stage of our analysis: the major predictors of transit trips in in the SCAG region. Unsurprisingly, transit trips are highly associated with automobile ownership and access, even accounting for other potential determinants of transit use. Beyond automobile access, transit use is associated with lack of a driver's license, being nonwhite, and being foreign-born — especially being foreign-born and a new arrival.[16]

[16] While we experimented with different functional forms for the regression, we settled on a zero-inflated negative binomial regression. A negative binomial regression is a standard tool for analyzing overdispersed count data, and the zero-inflation corrects for bias that might otherwise be introduced when the value of the dependent variable is frequently zero, as it is with personal transit trips.

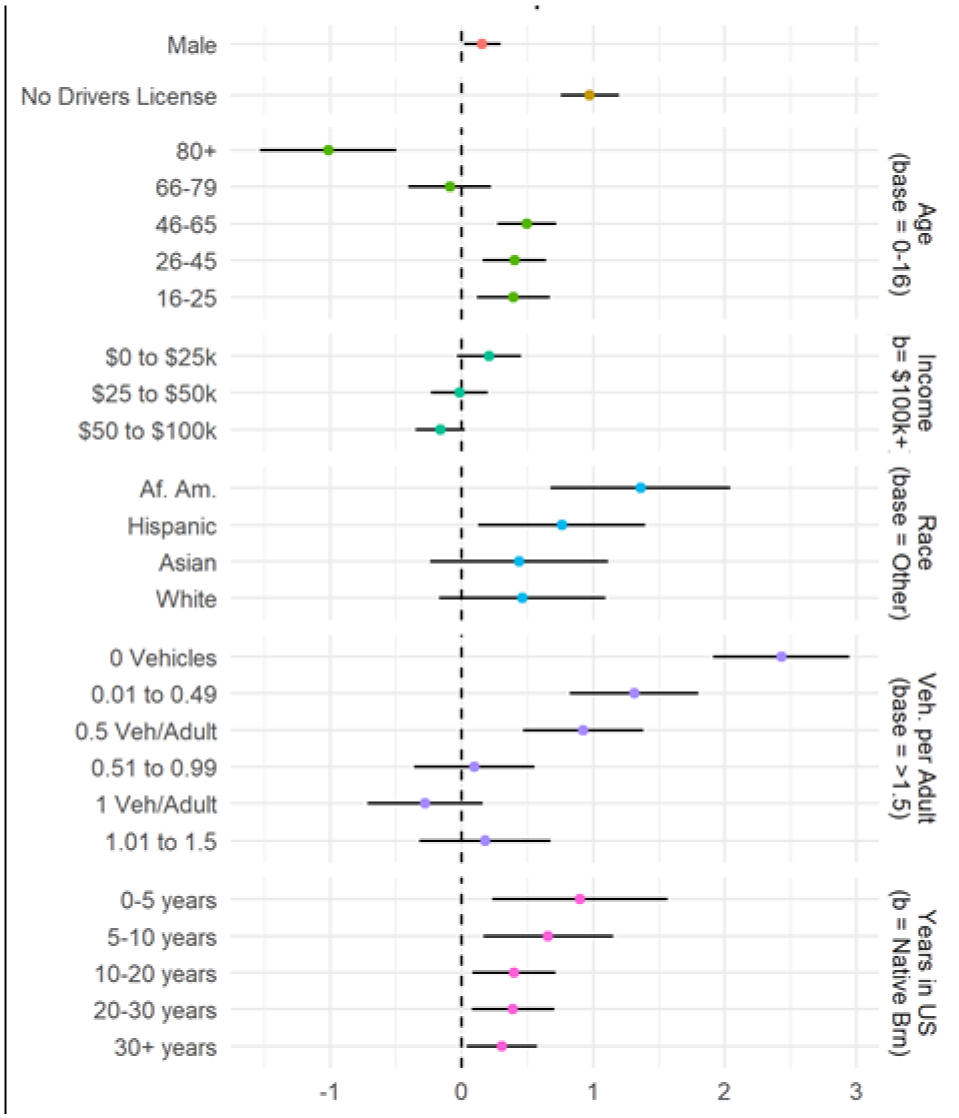

Figure 32. All SCAG unlinked trip predictors (CHTS).

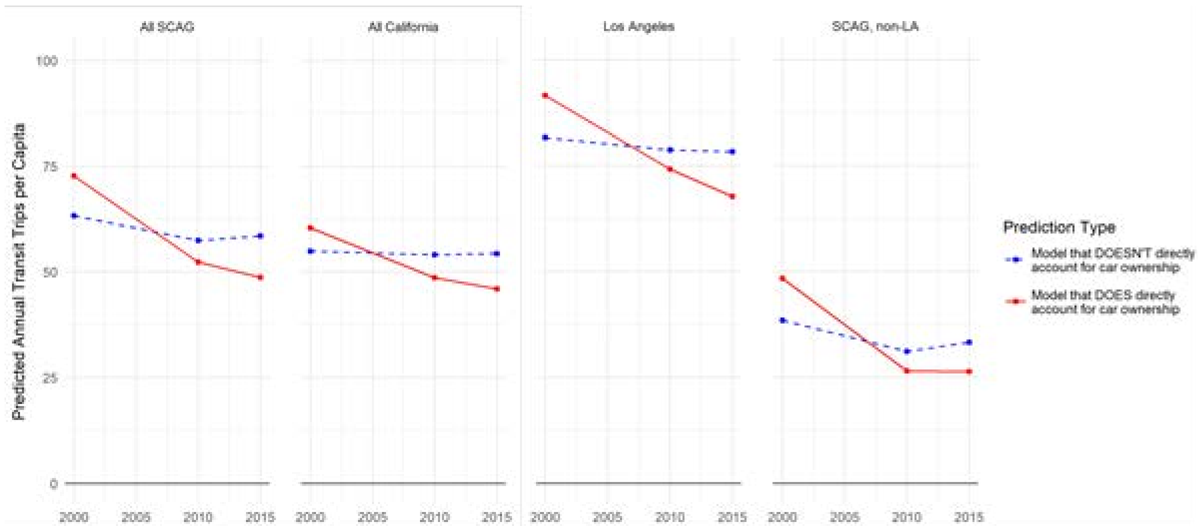

Figure 33. Relationship between increased vehicle ownership and falling transit trips (CHTS and US Census Bureau).

When we apply these parameters to Census IPUMS data from 2000, 2010 and 2015,[17] we see a powerful association between rising household vehicle access and falling transit trips. Figure 39 illustrates this relationship by graphing the results of two models. The first model, represented by the dashed line, predicts the change in county transit trips based on changes in all factors *except* vehicle access. In the SCAG region, the line has a mild negative slope from 2000 to 2010 and then a small positive slope from 2010 to 2015, suggesting that changes in these demographic, economic, and geographic factors would be associated with a small decline in transit use since 2000, albeit with a modest uptick between 2010 and 2015. The graphs for Los Angeles County and the SCAG region outside LA County suggest that this predicted modest uptick (which did not actually occur) would have taken place in SCAG's outlying counties. In Los Angeles County, transit trips were predicted to keep declining through 2015.

The second model, represented by the solid line, is identical to the first model but includes changes in automobile access. The difference in results is dramatic. This line starts at a higher point and falls sharply to a lower point, both of which suggest the important role automobile access has in influencing transit use. An absence of automobiles is associated with much more use, and the acquisition of automobiles is associated with much less. The line also suggests that many socioeconomic attributes play an essentially the intermediary role in mode choice. Income, nativity, age, location within the region, and many other factors can influence transit use, but they do so primarily by predicting people's access to private cars. Income alone, for example, does not take people off buses. Income helps people buy automobiles, and it is auto access that fuels an exodus from transit.[18]

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[17] A natural concern is that the CHTS might measure nativity, income, etc. differently than the Census. We validated our approach by first using the Census independent variables to replicate the CHTS estimates, suggesting this is not a problem.

[18] We should note that these models are *not* predictive models – their purpose is not to yield output that precisely matches the observed transit ridership in the SCAG region (and in fact our predictions do not match observed

Why did vehicle ownership rise so much? We cannot answer this question definitively, but as we discussed earlier in this report, vehicle ownership has both economic and non-economic determinants. The non-economic determinants include the growth or decline of immigrant groups who are less likely to acquire vehicles, and changes in licensure laws or other laws that surround owning and operating vehicles. The economic reasons can themselves be divided into two categories: changes in personal spending power, and changes in the price of vehicles themselves.

Since the foreign-born, and particularly the recently-arrived foreign-born, are less likely than the native-born to own vehicles, one possibility is that number or composition of immigrants changed. In absolute terms, the foreign-born population in the SCAG region grew between 2000 and 2015. However, it did not grow as fast as the overall population, so the region's share of foreign-born fell, albeit modestly (from 31% to just over 30%). This proportional decline occurred entirely within LA County, which has the most transit service. Every other SCAG county saw its share of foreign-born rise.

	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	All SCAG
2000	32.2%	36.2%	29.9%	19.0%	18.6%	20.7%	31.0%
2010	31.9%	35.6%	30.5%	22.4%	21.6%	22.9%	31.0%
2015	32.6%	34.7%	30.5%	22.0%	21.3%	22.8%	30.4%
% Change	1.2%	-4.3%	2.0%	13.7%	12.6%	9.2%	-2.0%

Table 5. Share foreign born residents, Southern California counties (2000-2015)**.** US Census.

The *composition* of immigrants, however, changed more dramatically. Table 6 shows that between 2000 and 2015 (and especially between 2000 and 2010), the share of the foreign-born from Asia rose 23 percent, while the share from Central America fell ten percent, and the share from Mexico fell over 13 percent. In 2000, 48 percent of SCAG immigrants were from Mexico, while by 2015 only 41 percent were. Because existing evidence suggests that immigrants from Mexico and Central America are less likely to have automobiles and drive than immigrants from other origin countries, this shift could contribute to rising auto use, especially among the foreign born (US Census ACS 2015).

ridership). We do not build a predictive model for two reasons. First, we are not using the correct data to do so. Regional ridership counts come from annual reporting to the NTD. Because we need person-level data that includes socioeconomic attributes, we are using one-day travel diary data from the 2012 CHTS, and then matching that to person-level data from three Census years. Second and more important, the goal of the regressions is to test a particular hypothesis – that vehicle access is the decisive factor in transit use – not to predict transit ridership. Our output thus yields an estimate of the relative magnitude of the importance of auto access, *not* a precise measure of how many trips each additional increment of auto access actually cost the SCAG region.

	2000	2010	2015	Change
Asia	28.7%	33.9%	35.3%	23.0%
Americas	63.7%	59.1%	57.7%	-9.4%
Latin America	62.4%	58.0%	56.5%	-9.5%
Central America	58.8%	54.5%	53.0%	-9.9%
Mexico	47.7%	42.4%	41.3%	-13.4%
South America	2.6%	2.7%	2.7%	3.8%

Source: US Census Summary File Data. US Census Bureau classifies Mexico as part of Central America. Data on Caribbean Americas omitted.

Table 6. Composition of SCAG immigrants (2010-2015).

Moreover, among both the foreign-born overall and the foreign-born from Mexico, in data from the US Census IPUMs we see both an assimilation effect and a cohort effect reinforcing the trend toward more vehicles. More recent waves of immigrants are more likely to have vehicles shortly after arrival, and those who do not are faster to acquire them as time goes on.

In the year 2000, for example, 31 percent of the foreign-born households in the SCAG region that had emigrated from Mexico between 1990 and 1999 had no household vehicle, and 74 percent had a vehicle deficit. By 2010, just 9.3 percent of this same cohort of immigrant households had no vehicle, and only 51 percent had a vehicle deficit. By 2015, these figures were 7 percent and 41 percent. This is the assimilation effect; as time passes, immigrants begin to behave more like the native -born.

The cohort effect, however, is more notable. The more recent waves of immigrants to Southern California are more likely to own vehicles shortly after arrival, and as such they have not fully replenish the stock of zero-vehicle households that shrank as existing immigrants assimilated toward cars. In 2010, only 17 percent of the Mexican immigrant households in the SCAG region that had arrived in the US between 2000 and 2009 had no vehicles, compared to 31 percent for those that arrived between 1990 and 1999 in the year 2000. Similarly, only 62 percent of these 2000-2010 arrivals had a vehicle deficit in 2010; in 2000, 74 percent of Mexican immigrants who had arrived since 1990 had a vehicle deficit. By 2015 the share of zero-vehicle households in thepost-2000 cohort was down to 10 percent, and the share with vehicle deficits down to 49 percent. And by in 2015, only 11 percent of Mexican immigrant households that had arrived in 2010 or after did not have a vehicle. A similar pattern holds for the foreign-born overall. More recent waves of immigrants acquired more vehicles more quickly, meaning that as previous waves of immigrants acquired cars, the ranks of the carless were shrinking rather than being replenished.

In sum, immigrants overall are now a slightly smaller share of the population, but also more likely to own vehicles, and to own them earlier after arrival. Mexican immigrants, who are a mainstay of transit ridership in Southern California, remain more likely than the foreign-born overall to live in households without vehicles, but since 2000 they have both added household vehicles and become a smaller share of total immigrants.

It is not clear *why* the foreign-born began adding more cars. In 2015, California began issuing driver's licenses to undocumented immigrants. While licensure may have increased vehicle ownership, for a variety of reasons we do not think it played a large role. First, a license makes a vehicle more useful, but not more affordable; if the barrier to acquiring a vehicle is price, a license does little to overcome that. One might argue in response that legality and not price was the actual barrier, but existing evidence suggests this is simply not the case: many undocumented immigrants, even without licenses, were already driving (Lovejoy & Handy, 2008). Indeed, the prevalence of undocumented driving was the primary motivation for the law that authorized licensure. The decision to issue licenses was justified primarily on safety, not mobility, grounds – there were concerns, for example, that unlicensed undocumented drivers would flee the scene of accidents. It is possible that undocumented immigrants drove *less* – and took transit more – before being licensed, and that licensing did help depress transit use. Even this scenario, however, has its limits. A law that took effect in 2015 cannot explain a per capita ridership decline that began in 2007 or an explosion in vehicle ownership that began in the early 2000s.

Ruling out legal changes brings us to possible economic factors for increased vehicle ownership: Perhaps immigrants (and others) began acquiring more cars because they had more money. A small but persuasive literature on personal consumption shows that poorer people tend to convert even small increases in income into vehicle purchases – a testament to how valuable vehicle access can be (Aaronson, Agarwal, & French, 2012; Adams, Einav, & Levin, 2009; Leininger, Levy, & Schanzenbach, 2010; Parker, Souleles, Johnson, & McClelland, 2013; Souleles, 1999).

The 2000-2015 period was volatile economically, as the economy grew steadily before cratering during the Great Recession. During most of this time, furthermore, median wages and incomes were stagnant. Median household income in LA County, for example, was about $59,000 in both 2000 and 2015, and was slightly lower during the recession in 2010. The Census suggests that newer waves of immigrants are if anything slightly poorer than the cohorts that came before them: In 2000 average incomes of immigrants that had arrived since 1990 was slightly higher than the average income of immigrants in 2010 who had arrived after 2000. Finally, we can see in Figure 40 that vehicle growth occurred across all income groups, for both the foreign-born and the native-born. In 2000 just under 40 percent of households earning less than $25,000 per year had a vehicle-deficit, as did 60 percent of immigrant households in the same income bracket. In 2015 less than 30 percent of native-born households in the same income bracket had a vehicle-deficit, as did just over 50 percent of immigrant households. The pattern holds for households earning $25,000 to $50,000, and for more affluent households.

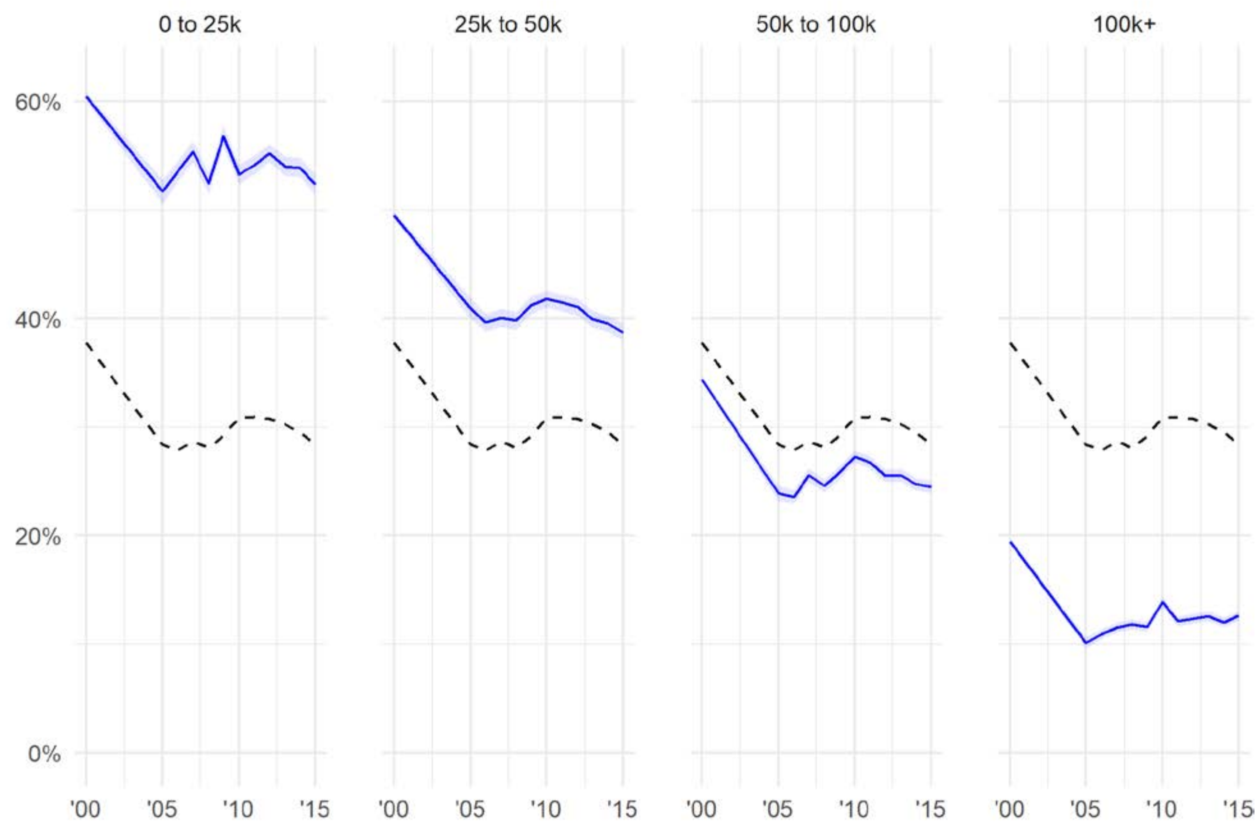

Figure 34. Share of households with vehicle deficits, by income and nativity, 2000-2015, US Census (solid line = foreign born, dashed line = native born).

It is therefore not obvious that rising incomes played a large role in rising vehicle ownership. Certainly the macro-economy played some role in changing levels of transit use. Transit use contracted during the Great Recession: A robust economy puts more people to work, which increases both commuting and discretionary travel. A faltering economy does the reverse. But these same economic trends do not appear to explain why people acquired so many more vehicles than they had in previous periods.

Even at constant incomes, households can acquire more vehicles if the effective price of those vehicles falls. The effective price reflects not the sticker price, but the actual outlay required of a consumer to drive the vehicle home. A large part of this outlay is often a down payment, meaning that vehicles can become more affordable not just if their price declines, but also if financing that price becomes easier.

Some evidence does suggest that vehicle finance became easier during this time. Although lost somewhat in the shadow of easy home-lending credit, automobile credit also surged in the run-up to the Great Recession. And unlike home lending, which tightened considerably after the crash, automobile lending has remained relatively loose. Consumers with good credit scores (typically above 700) can find auto loans with low- and sometimes even zero-interest rates. Since the recession, the share of SCAG-region residents with credit scores below 660 (considered subprime) has fallen (Figure 41), suggesting that consumers have gotten better access over time to low-interest loans (Federal Reserve Bank of New York and Equifax, various). Subprime auto loans also remain prevalent, allowing consumers with poor credit histories or low incomes to finance vehicle purchases. U.S. auto loan originations among subprime consumers increased 140 percent from 2010 to 2015 (New York Fed Consumer Credit Panel / Equifax). We do not have local-level data on vehicle debt, but inflation-adjusted per capita vehicle debt in California rose 91 percent between 2000 and 2015 (Federal Reserve Bank of New York).[19]

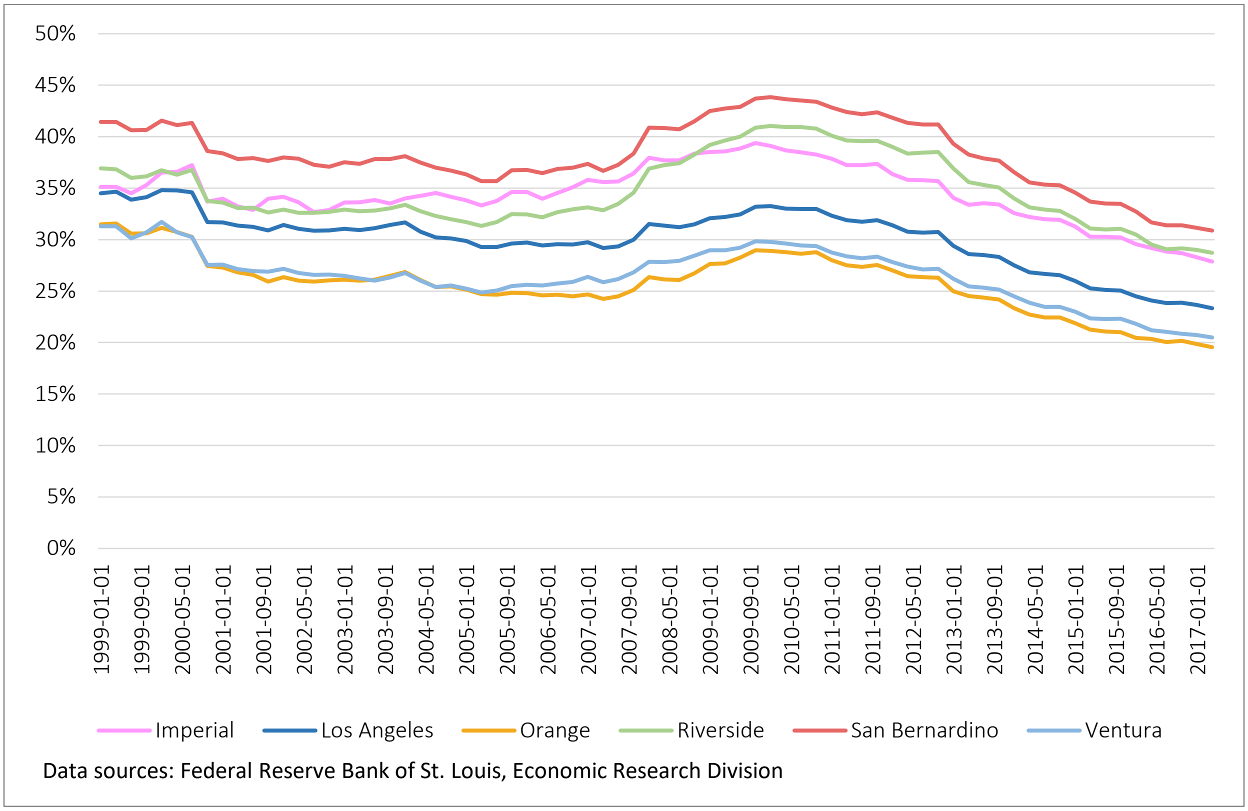

Figure 35. Percent of sample with credit scores below 660, by county in SCAG region.

CONCLUSION

Per capita transit ridership, long sluggish in Southern California, began to fall in 2007. In 2012 that per capita decline accelerated, and manifested as a more noticeable and more alarming absolute decline. The precise reasons for this decline are almost certainly manifold, and hard to disentangle. Gas prices fell sharply after rising steeply. The explosive growth of Uber and Lyft provided new mobility options to some people who had been mobility-constrained. In Orange County, fares rose substantially. On LA Metro, by at least some accounts, feelings of danger increased. Some of the people most likely to use transit moved to areas where transit was less prevalent. Especially in recent years, all these factors most likely contributed to transit's downturn.

[19] Data come from the New York Federal Reserve Bank's Consumer Credit Panel.

But in weighing the evidence, the overwhelming factor appears to be a dramatic increase in the stock of private automobiles. Between 2000 and 2015 Southern Californians acquired vehicles at nearly four times the rate they had between 1990 and 2000. This growth of the private vehicle stock lines up—in timing, in magnitude, and in theory—with the region's falling transit use. Vehicle access grew across all income levels and groups, but disproportionately among those groups, like the low-income and foreign-born, who are most likely to ride transit. Transit ridership in the SCAG region has long depended on a sizable minority of people who did not, largely for economic reasons, have access to cars. After 2000, many of these people acquired cars, and it should not surprise us that they started riding transit less.

To be sure, the case we build in reaching this conclusion is circumstantial. For reasons we have already enumerated, the data available to examine transit riders are scarce and fragmented, which leaves alternative explanations possible if not plausible. Certainly future research should emphasize more data collection. Given the data available today, however, in our judgement rising vehicle ownership is the best explanation for falling transit ridership.

If this explanation is sound, it poses a daunting problem for transit operators. When lower-income people graduate from transit to driving, transit agencies bear a cost, but the other side of that cost is a large benefit for both the people who start driving *and* for society overall. In the aggregate, Southern Californians drive too much, once the various costs of pollution, congestion and crashes are accounted for. But some Southern Californians – the poorest of them – drive *too little*, and both their lives and the region as a whole would be improved if they drove a bit more. The low-income person who acquires a vehicle often makes fewer trips than an affluent person (driving is expensive) and the trips they make are often essential, and have social benefits that exceed their social costs. A car trip by a low-income household is more likely than one by an affluent household to involve finding and keeping work, getting to school, or accessing better health and daycare options. These trips might modestly increase congestion and pollution, but they have large paybacks in employment, earnings, and overall well-being that exceed those costs. Affluent households, in contrast, make many more trips, and more trips whose social value is lower (they might increase congestion and pollution not just by driving to work, but also by driving to lunch, or to visit friends).

Given the powerful difference a car can make in the lives of low-income people, efforts by transit agencies to recapture low-income riders can have a perverse impact: they would target some of the highest-value vehicle trips in the region. Ideally, of course, transit agencies would pull people away from lower-value vehicle trips. It makes little sense to deprive a low-income person of their trip to work at a location poorly served by transit, when affluent people routinely drive for errands and visits that they could easily complete by foot or transit. A quick trip to a store a half mile away (or a trip to a store a mile away when a comparable store is a quarter mile away) is more likely to have social costs that exceed its benefits. And these trips are abundant.

Given this situation, and given the ambitious greenhouse gas reduction goals that California has assigned to transit, planners and operators may need to expand transit's target market. Transit should by no means abdicate its social service mission, but as we stated in the introduction, per capita transit use falls when current riders stop riding, and when new residents don't start. Transit today relies on a high rate of use by a narrow base of people. But if that narrow base of people is acquiring vehicles, transit's healthy future lies in reversing those circumstances, and striving for at least a low rate of use by a broad base of people. The SCAG region lost 72 million transit rides annually from 2012 to 2016. This number seems daunting, but the region has 18.8 million people. According to the CHTS, about 77 percent of those people (roughly 14.5 million), ride transit rarely or never. Herein lies vast untapped potential. If one out of every four of those people replaced a single driving trip with a transit trip once every two weeks, annual ridership would grow by 96 million—more than compensating for the losses of recent years.

The obstacle to this outcome, however, is large and beyond the direct control of transit operators: driving is too cheap. The large subsidies given to transit in recent years pale next to the longstanding subsidies for automobiles that are hidden in unpriced road use, unpriced or underpriced street parking, high minimum parking requirements, and taxpayer- and developer-financed road-widenings. If public policy does not adequately confront underpriced driving, then transit ridership will likely continue to falter, and transit will not meet its ambitious environmental goals.

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Appendix A

Fare regression output.

Descriptive Data (data are in panel form; observations are agency-years). Route coverage = route miles/service area. Headways = route miles/ (revenue miles/service miles). The service area is in square miles. Service area and service population are the difference between UZA average level of service and service area/ service population.

Absolute Levels

	mean	sd	n
unlinked passenger trips	15,213,380	130,300,000	9,030
vehicle revenue hours	395,268	1,659,684	9,037
headway	33.07	51.01	6,954
route coverage	3.18	6.32	6,922
service area	713.2	8,963.3	9,793
service population	718,549	1,729,745	9,794
fare (2015$)	$1.71	$2.52	8,647

Change from Prior Year

	mean	sd	n
change in unlinked passenger trips	170,442	6,338,137	8,037
change in vehicle revenue hours	5,015	87,867	8,047
change in headway	0.02	18.81	6,277
change in route coverage	-0.07	5.45	6,255
change in service area	0.0	0.4	8,852
change in service population	0	0	8,853
change in fare (2015$)	$0.01	$0.64	7,702

Regression Output:

The regressions are linear and all variables are naturally log-transformed. Models were run with the dependent variables being levels and changes. Model 4 is the model discussed in the text.

* change from the prior year is calculated using absolute levels

y=passenger trips VARIABLES	(1) OLS	(2) OLS	(3) OLS	(4) FE
vehicle revenue hours	1.264***	1.312***	1.289***	0.754***
	(0.00974)	(0.00950)	(0.00947)	(0.0108)
headway	-0.155***	-0.193***	-0.209***	-0.0152*
	(0.0128)	(0.0129)	(0.0116)	(0.00833)
route coverage	0.0416***	0.0635***	0.0824***	0.0164***
	(0.00809)	(0.00815)	(0.00697)	(0.00555)
service area (miles^2)	-0.126***	0.00594		
	(0.0129)	(0.0104)		
service pop	0.214***		0.139***	0.0380***
	(0.0128)		(0.0102)	(0.00679)
fare (2015$)	-0.0270**	-0.0105	-0.0249**	-0.162***
	(0.0106)	(0.0108)	(0.0107)	(0.00677)
Constant	0.0223	-0.434***	-0.134	5.708***
	(0.0918)	(0.0895)	(0.0910)	(0.123)
Observations	6,767	6,767	6,767	6,767
R-squared	0.868	0.862	0.866	0.498
Number of agencies				620

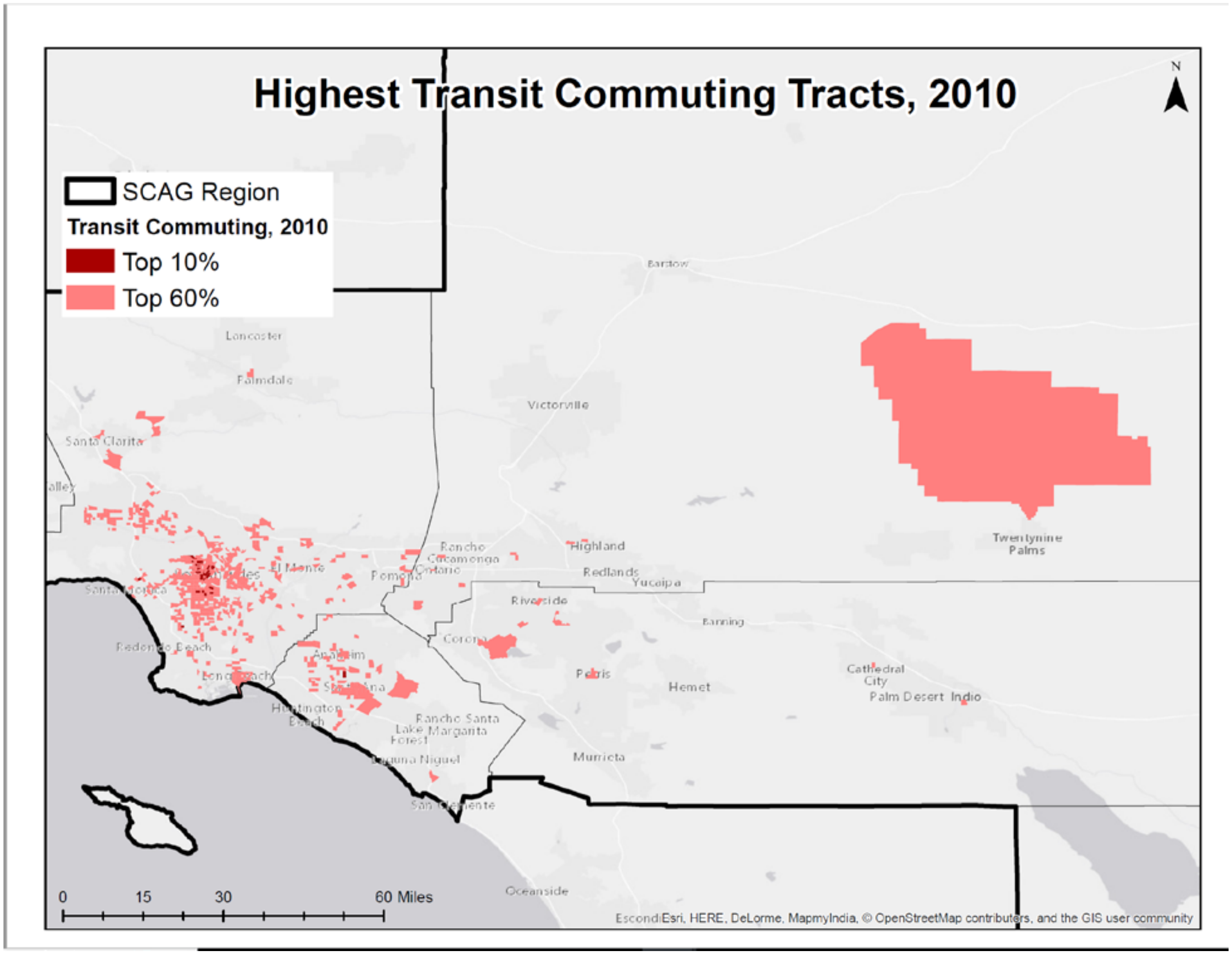
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

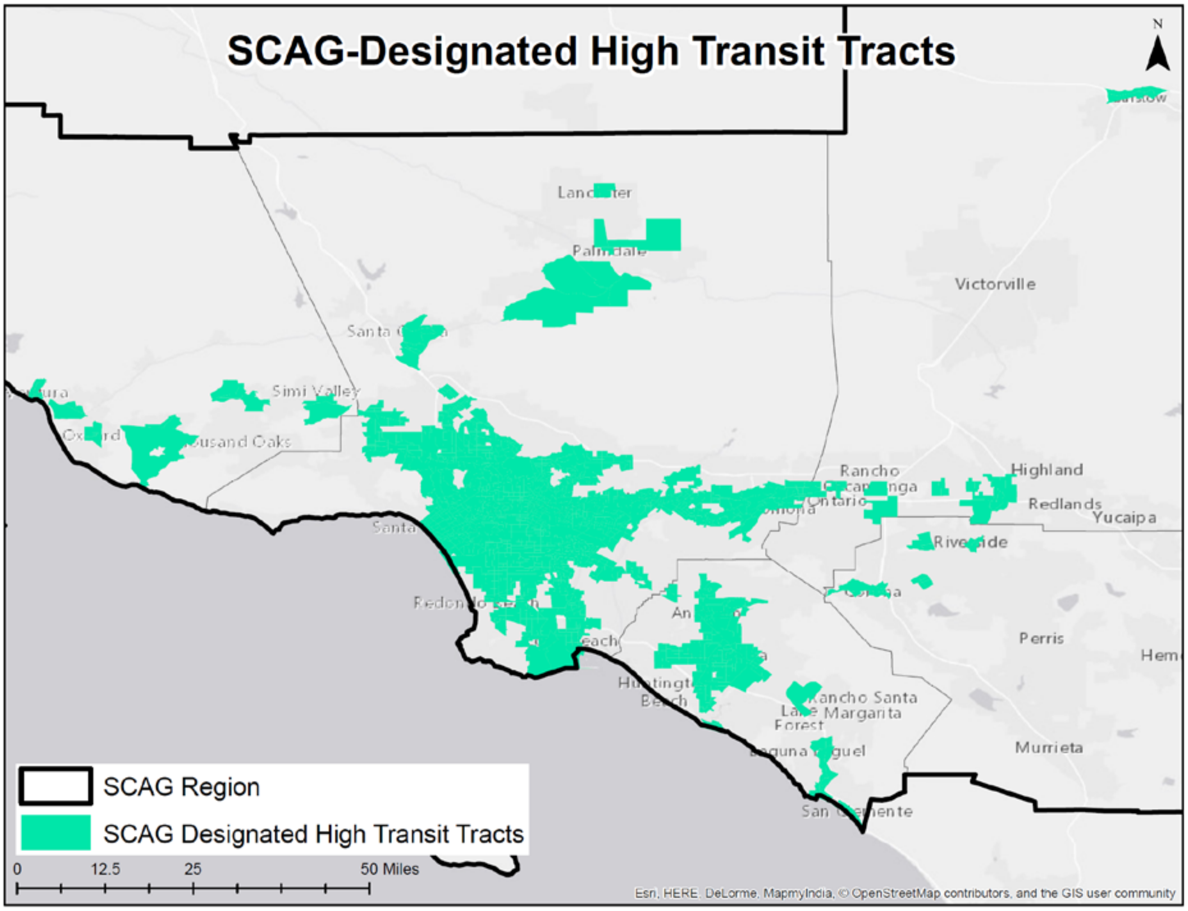
y=change in passenger trips VARIABLES	(1) OLS	(2) OLS	(3) OLS	(4) FE
change in VRH	32.08***	32.08***	32.08***	27.19***
	(1.096)	(1.096)	(1.096)	(1.147)
change in headway	-12,979**	-12,973**	-13,133**	-9,162
	(5,995)	(5,994)	(5,981)	(6,095)
change in route coverage	28,528	28,498	29,237	18,718
	(20,642)	(20,637)	(20,554)	(21,703)
change in service area ($miles^2$)	-98,385	-95,007		
	(263,173)	(259,378)		
change in service pop	19,953		3,401	
	(262,368)		(258,587)	
change in fares (2015$)	-287,046*	-286,709*	-287,167*	-301,584*
	(172,940)	(172,869)	(172,928)	(178,218)
Constant	31,160	31,496	31,138	59,982
	(86,058)	(85,937)	(86,052)	(84,787)
Observations	6,102	6,102	6,102	6,102
R-squared	0.124	0.124	0.124	0.094
Number of agencies				602

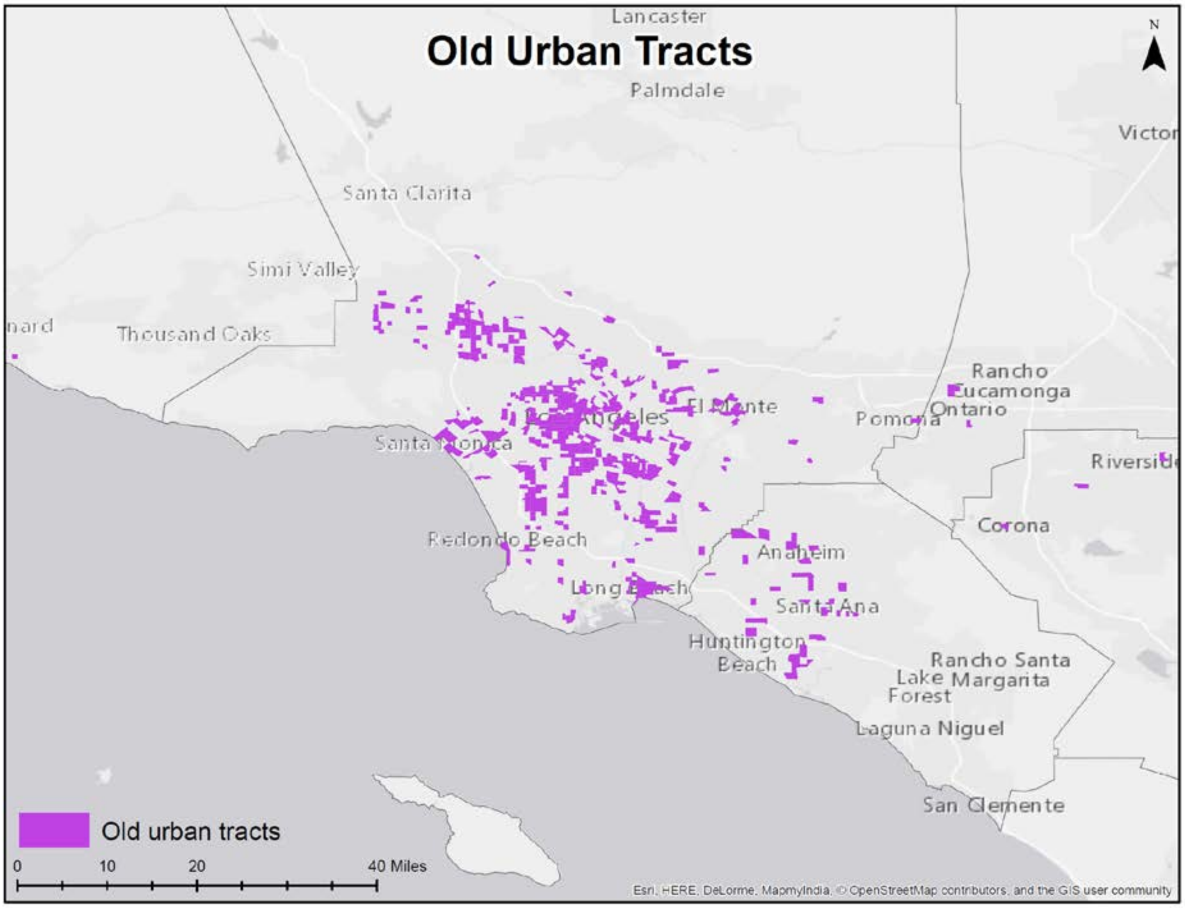
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix B

Neighborhood change attributes and locations.




SCAG-Designated High Transit Tracts
N
Victorville
Simi Valley
Highland
Redlands
Yucaipa
Perris
Murrieta
Rancho Santa
Margarita
SCAG Region
SCAG Designated High Transit Tracts
0
12.5
25
50 Miles
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



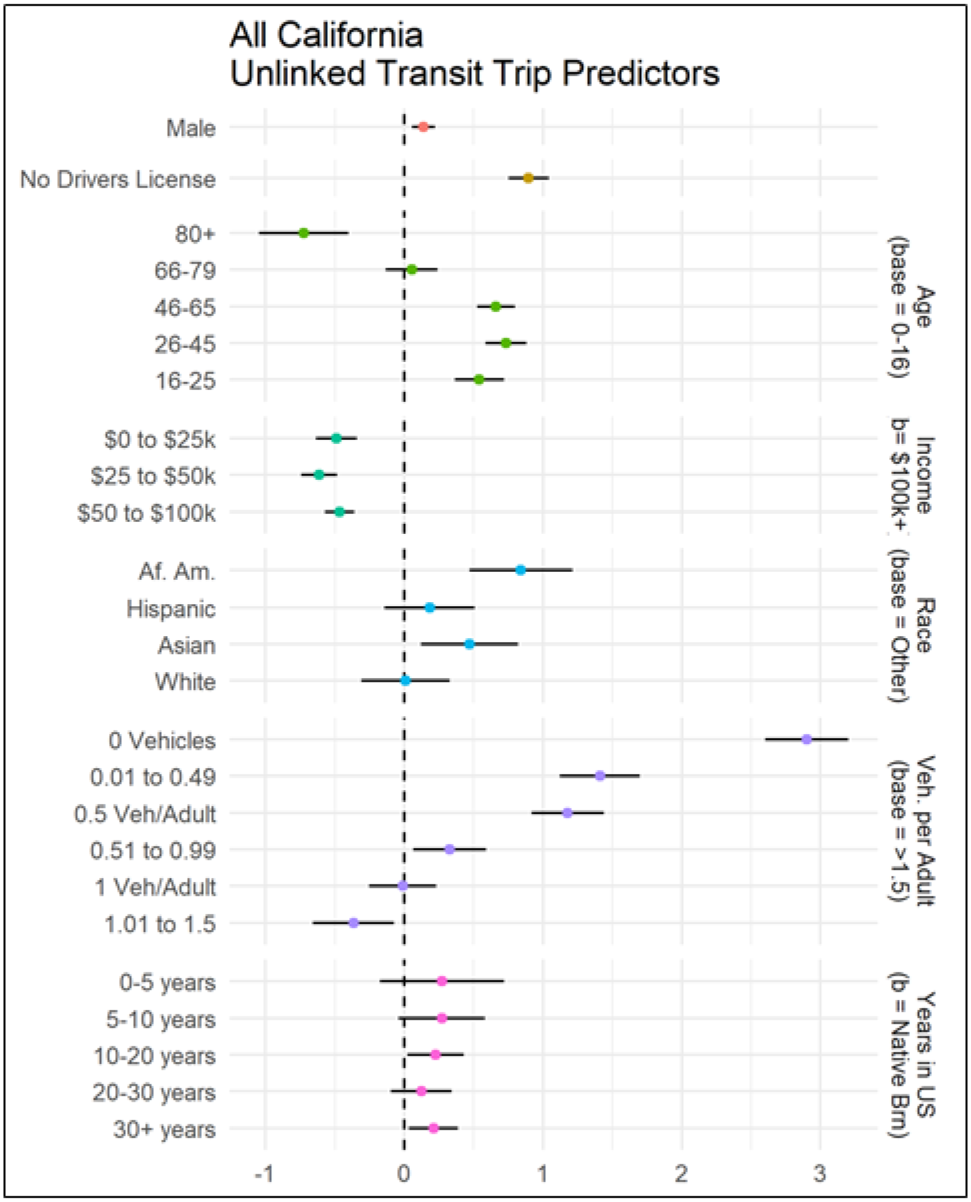
Mean Characteristics of Transit-Rich Neighborhoods:
Change over time in Tracts with High Concentrations of Transit Commuters in 2000

10 Percent	2000	2010	2015
% Transit Use	38%	33%	33%
% Poverty	38%	32%	36%
% Foreign Born	63%	62%	57%
% 0-Vehicle Households	43%	34%	34%
% NH White	9%	10%	8%
N Tracts	48	48	48
% of All Tracts in Region	1.4%	1.2%	1.2%
Total Tracts	3,393	3,954	3,953

60 Percent	2000	2010	2015
% Transit Use	16%	14%	13%
% Poverty	27.79	23.13	26.55
% Foreign Born	47.84	44.31	42.10
% 0-Vehicle Households	22.78%	15.76%	15.68%
% NH White	14.39	17.42	15.86
N Tracts	691	691	691
% of All Tracts in Region	20.4%	17.5%	17.5%
Total Tracts	3,393	3,954	3,953

Sources: US Census 2000, ACS 2006-2010, ACS 2011-2015

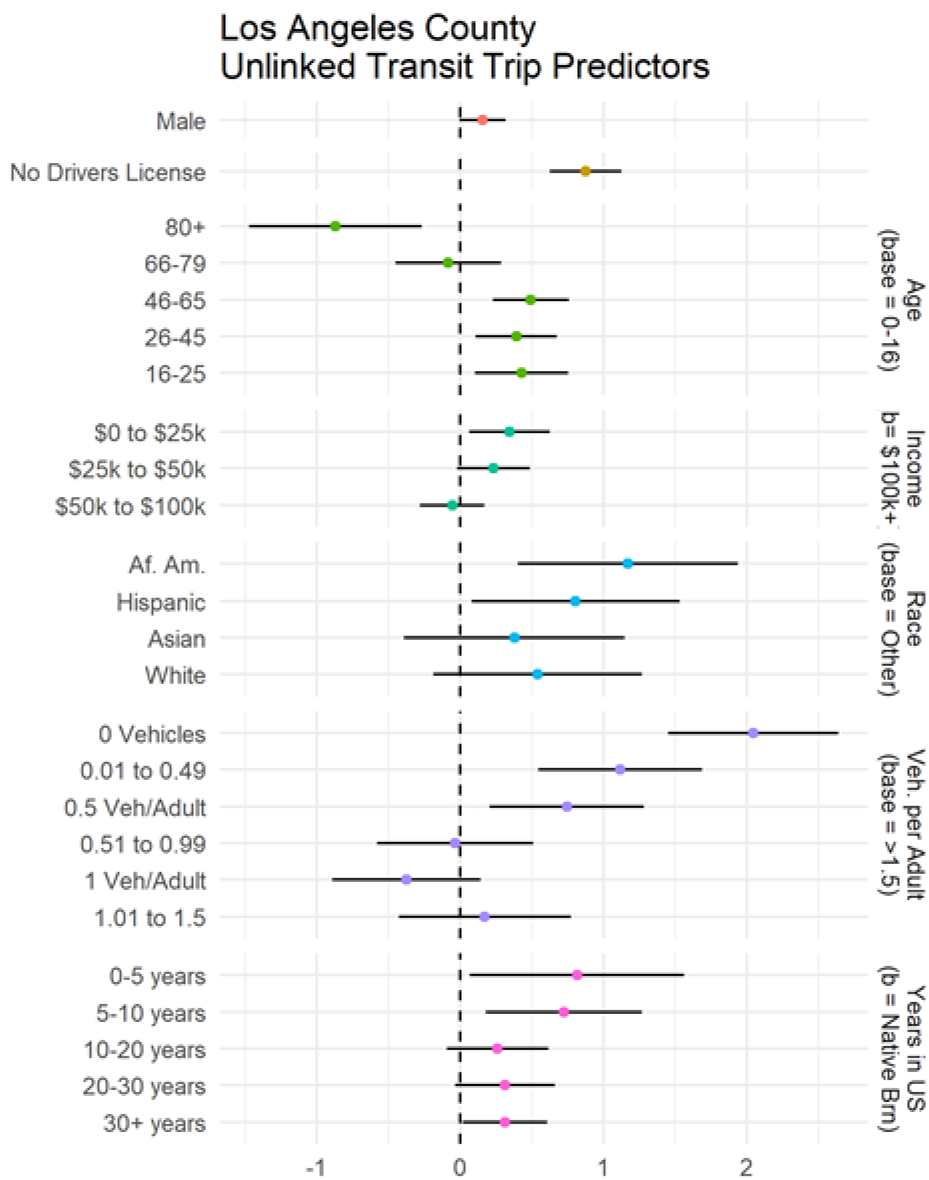
Appendix C

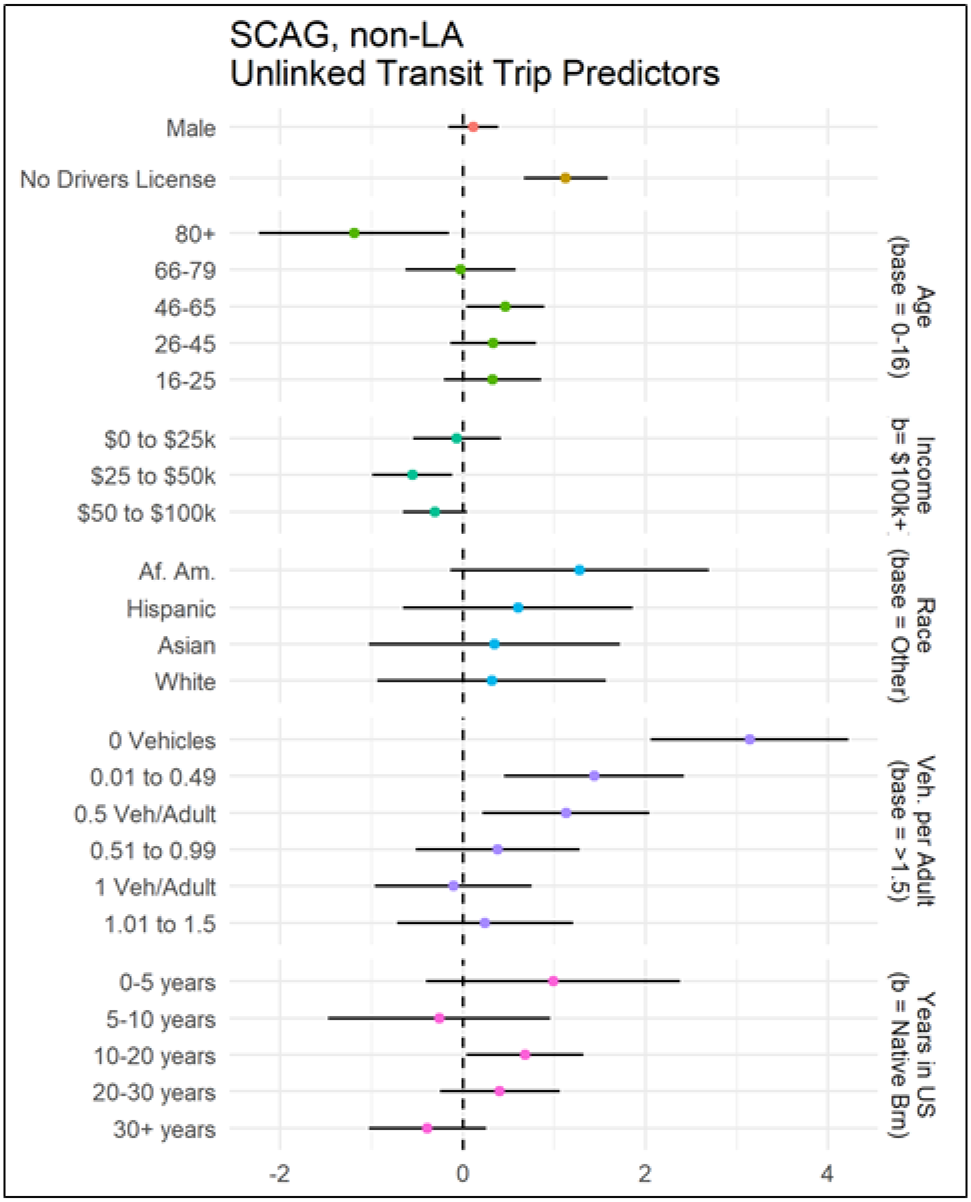


All California
Unlinked Transit Trip Predictors
Male
No Drivers License
80+
66-79
46-65
26-45
16-25
Age (base = 0-16)
$0 to $25k
$25 to $50k
$50 to $100k
Income b= $100k+
Af. Am.
Hispanic
Asian
White
Race (base = Other)
0 Vehicles
0.01 to 0.49
0.5 Veh/Adult
0.51 to 0.99
1 Veh/Adult
1.01 to 1.5
Veh. per Adult (base = >1.5)
0-5 years
5-10 years
10-20 years
20-30 years
30+ years
Years in US (b = Native Brn)
-1
0
1
2
3

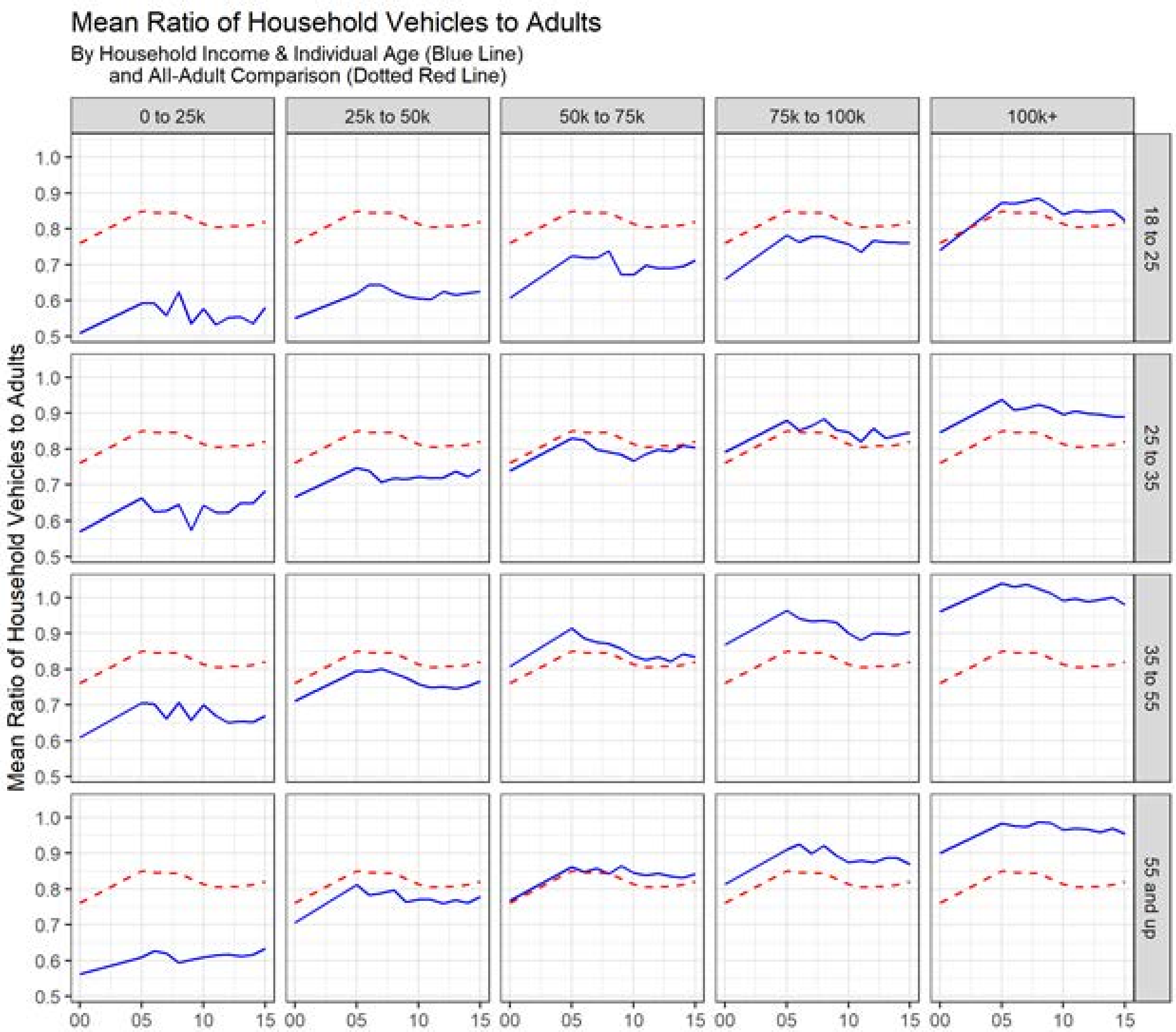
Appendix D

Additional trip predictors and descriptive data.





SCAG, non-LA
Unlinked Transit Trip Predictors
Male
No Drivers License
80+
66-79
46-65
26-45
16-25
Age
(base = 0-16)
$0 to $25k
$25 to $50k
$50 to $100k
Income
b= $100k+
Af. Am.
Hispanic
Asian
White
Race
(base = Other)
0 Vehicles
0.01 to 0.49
0.5 Veh/Adult
0.51 to 0.99
1 Veh/Adult
1.01 to 1.5
Veh. per Adult
(base = >1.5)
0-5 years
5-10 years
10-20 years
20-30 years
30+ years
Years in US
(b = Native Brn)
-2
0
2
4


Mean Ratio of Household Vehicles to Adults
By Household Income & Individual Age (Blue Line)
and All-Adult Comparison (Dotted Red Line)
0 to 25k
25k to 50k
50k to 75k
75k to 100k
100k+
18 to 25
25 to 35
35 to 55
55 and up
Mean Ratio of Household Vehicles to Adults
1.0
0.9
0.8
0.7
0.6
0.5
00
05
10
15