Sustainability and Displacement: Assessing the Spatial Pattern of Residential Moves Near Rail Transit

November 2017

A Research Report from the National Center for Sustainable Transportation

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[2] This graph shows households who are in the data (anywhere) for at least two consecutive years.

Sustainability and Displacement: Assessing the Spatial Pattern of Residential Moves Near Rail Transit

EXECUTIVE SUMMARY

Rail transit's association with gentrification has been a presence in the public discourse for some time and Los Angeles is no different. There is a prevailing public perception that Los Angeles' recent boom in rail transit development causes an influx of high income residents and an outflow of low income residents near rail stations. Our research asks whether the presence of rail transit increases the outflow lower-income neighborhood residents.

We use a unique dataset of tax filers in Los Angeles County to address this question. This database tracks the income and location of households across 21 years at a fine spatial scale. This analysis aggregates household data to provide station-area population out-mobility rates for 35 rail station neighborhoods and 35 paired control neighborhoods along two Los Angeles Metro transit lines. Our sample consists of 15 stations along the Red/Purple subway line and 20 station along the Gold light rail line that opened between 1993 and 2013. We measure effects on four income brackets: below 30% of Area Median Income (AMI) (<$15,000 in 2013), 30-50% of AMI, 50-80% of AMI and above 80% of AMI (>$40,000 in 2013).

Residents living in the neighborhoods surrounding these stations tend to be lower-income or and/or minority households, and in the Red/Purple case, foreign born, compared to Los Angeles County averages. Members of each of these demographic groups are less likely to own a vehicle and more likely to use public transit. This makes our study particularly salient. The neighborhoods in question have very high renter concentrations compared to county and national averages. Monthly rents tend to be lower in these neighborhoods than county averages with a few exceptions. Some of the neighborhoods in question have seen sizeable residential real estate development activity in the 2000s, especially in Hollywood and Koreatown on the Red/Purple line and Pasadena on the Gold line, while other neighborhoods have seen little to no development activity. Most of the new units produced have been rentals and monthly rents for new units in the neighborhoods with the most activity have risen above their historical median rental rates and, in some cases, above county averages.

Mobility rates have been declining in the United States since at least the mid-20th century. We confirm this for L.A. County for all incomes. In recent years, the decline in mobility has slowed or reached a plateau. In L.A. County, we see this plateau at about 20% annually. Renters consistently move at least twice as often as home owners. Los Angeles has a particularly large renting population, which expectedly pushes up the mobility rate in L.A. County. This is particularly true around the rail stations along the Red-Purple line where we observe high percentages of lower-income individuals and renter proportions above 90%.

The population of households near the Red-Purple Line has grown by about 50% between 1993 and 2012; however, this growth has not been uniformly distributed. Most growth occurred around rail-stations with historically lower population densities where the proportion of higher-income households increased. In contrast, the Gold line neighborhoods have seen much lower household population growth.

We estimate a 29% annual out-mobility rate for neighborhoods near the Red/Purple line and 23% for the Gold line, both higher than county level rates. These high rates likely reflect the high proportions of renters in these neighborhoods and the fact that lower-income households tend to have out-mobility rates 18-23% greater than higher income households in both transit corridors and in the county.

We find mixed results on the effect of rail station openings on out-mobility rates. Rail station openings are estimated to increase out-mobility by 0-3 percentage points for an effect magnitude of 0-17%. These are only statistically significant for Gold line stations across income groups and for Red/Purple line stations for lowest-income households (below 30% of AMI). For the Gold line, in statistically significant difference in difference estimates it appears that the magnitude of the rail station opening effect on out-mobility rates is greatest for higher-income households (17%), compared to 30-50% of AMI households (12-13%) and lowest-income households (8%). In fact, the effect of Gold line rail station openings appears to narrow the out-mobility rate gap between the highest and lowest income households. In contrast, Red/Purple line station openings seem to increase the out-mobility rate gap between the lowest and highest income households in our fixed effects estimates. Thus, effects of rail station openings on mobility rates are mixed and context dependent. As such, our findings do not provide clear evidence that rail stations openings displaced lower-income households between 1993-2013 in Gold or Red/Purple line neighborhoods, en masse.

These results raise a set of interesting follow-up questions. How unique is Los Angeles County in its mobility characteristics and in its response to rail station openings? We will work toward incorporating other California regions to provide a relevant comparison group. What are the housing-market impacts of high out-mobility? Specifically, do these patterns change the demand for particular housing types or the level of valuations? While the FTB dataset does not link to housing units or provide housing information, we will attempt to overlay other housing data in exploring these questions. What are the implications of high out-mobility on transit-oriented development? What are mitigating strategies for displacement around rail stations? In future work, we may compare case studies of particular transit-oriented developments and how they fared vis-a-vis out-mobility. We will isolate programmatic or development policies for those cases more able to stem displacement.

Introduction: Residential Mobility and Rail Transit

Rail transit and its impact on neighborhoods have become linked in the public mind. Anecdotal examples of rail transit being associated with neighborhood gentrification abound. In Washington, D.C., the Green and Yellow lines, north and east of downtown, are associated with changes in residents' racial composition, from black to white, and retail and commercial changes from long-time neighborhood staples to those catering to a new, wealthier, professional consumer (*1, 2, 3*) In Los Angeles, gentrification concerns along the Gold, Expo, and Red/Purple lines have been associated with ethnoracial changes *(4)*, an influx of artists *(5, 6)*, and increases in housing prices *(7, 8)*. Research in the San Francisco Bay Area concludes that gentrifying neighborhoods are disproportionately near rail transit *(9)*. The same concerns about gentrification are present in almost any large metropolitan area that is building or expanding rail transit.

More recently, the concern about gentrification has been refocused on two questions regarding mobility and displacement:

1. Do rail transit stations affect residential mobility rates in surrounding neighborhoods?
2. Are lower-income or long-term residents disproportionally displaced from the neighborhood?

This report uses mobility data and station openings of the Red and Purple Subway Lines in Los Angeles, CA, to attempt to answer these questions.

The Los Angeles metropolitan area presents an ideal study area for analyzing transit-oriented development (TOD) and potential displacement. From the TOD perspective, prior to 1990, Los Angeles had not had any intra-urban rail transit service for decades. Since then, 93 new rail-transit stations (see Figure 1 for map) have been opened by the Los Angeles Metropolitan Transit Authority (L.A. Metro) and an additional 17 are currently under construction *(10)*. This buildout amounts to about half of the U.S. spending on new rail transit *(11)*. Within L.A. Metro, 21% of its budget between 2005-2040 will go toward rail transit capital and operations expenditures *(11)*. Concurrently, regional and local plans anticipate over half of new) housing and employment to occur within a half-mile of a well-serviced transit corridor, including rail *(11, 12)*.

Los Angeles' new transit stops and TOD plans have emerged at the same time as the city and county are experiencing a housing affordability crisis. Home prices and incomes diverge widely: a median income household in 2012 Los Angeles can afford a $190,000 home yet home prices average $400,000 *(13)*. Renters have not been spared: real rents have increased by more than 20% in real terms between 1990-2010 despite slightly decreasing real incomes *(14)*. Housing supply has not kept up with demand, as Los Angeles has annually permitted an average of only 7,500 housing units in 2000-2014 *(15)* or one third of estimated demand *(16)*. Politicians have reacted and these facts have spurred a mayoral pledge to add 12,500 housing units annually from 2014-2021 *(17)*. Recent evidence suggests that such permitting increases are possible, with over 10,000 units permitted annually since 2013, and over 16,000 units in 2015 alone *(18)*. Most of these units are in large, often high-rise and mid-rise developments of at least 50 units.

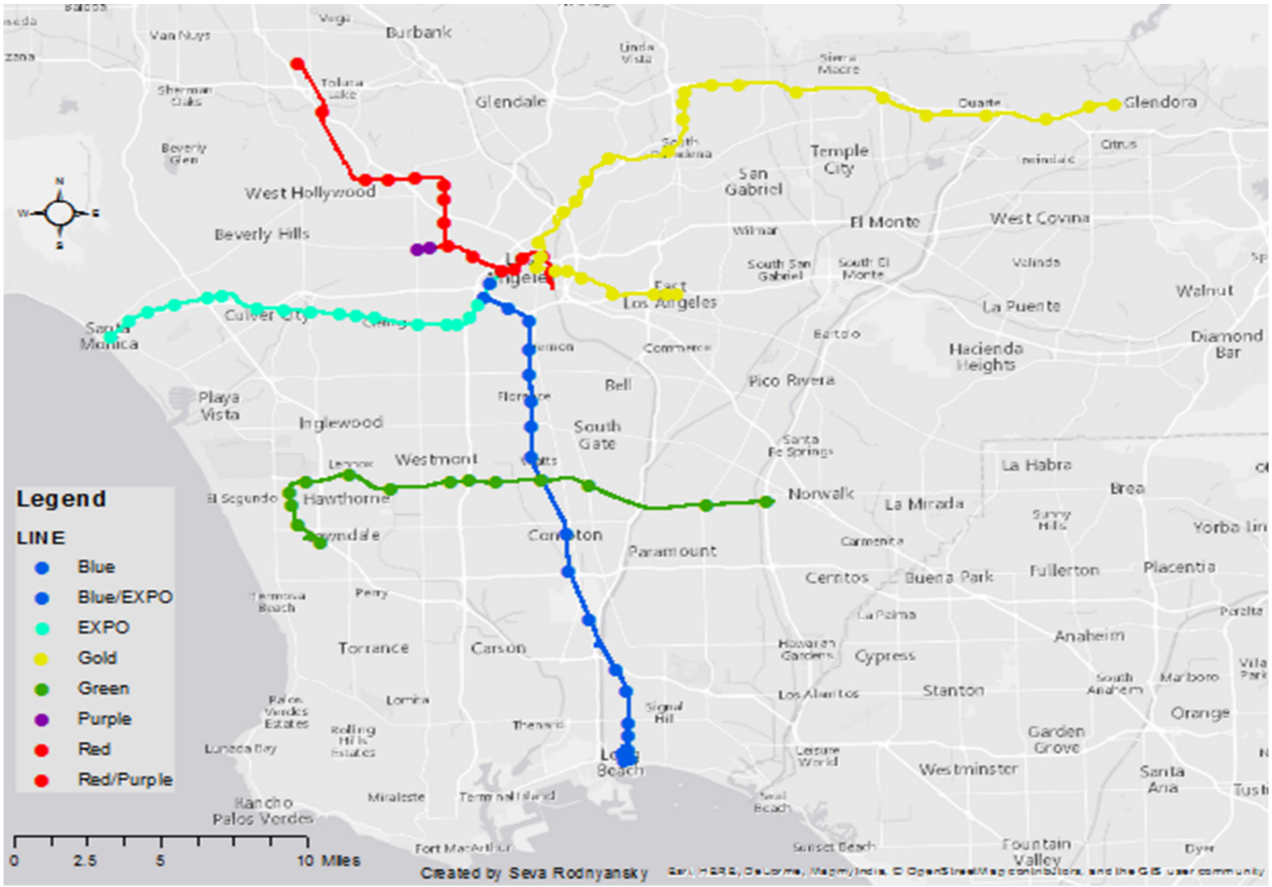

Figure 1. Los Angeles Metro Rail Transit System, 2017

Despite the more recent upturn in permitting, much of the newly permitted and newly built housing supply has catered to higher-income households and the permitted total is still below estimated needs (*16*). An attendant increase in affordable housing permits has not been noted. Together, these facts continue to exacerbate Los Angeles County's housing affordability crisis.

Resulting housing price increases have lead middle- and higher-income households to seek housing in neighborhoods they would not have looked in prior housing market conditions. These locations include neighborhoods near Los Angeles Metro rail stations, home to higher proportions of rental housing as well as minority and lower-income households. This has led to speculations about gentrification and displacement surrounding potential or actual neighborhood change. Examples include: rent increases and conversions from rental to owner housing in Echo Park *(7)*, high-end artist galleries in Boyle Heights *(5, 6)*, and changing ethno-racial composition in Downtown to name a few *(4)*. On a more systematic basis, the Urban Displacement Project has found that 44% of census tracts in Los Angeles County had the potential to gentrify over the 1990-2013 timeline, and 15% did end up gentrifying between either 1990-2000 or 2000-2013 *(8)*.[3]

Los Angeles County's rail development, housing affordability crisis, and gentrification patterns raise the question of whether neighborhood displacement is caused by or associated with TOD development. Despite anecdotal evidence and speculation on gentrification, a correlational or causal link between TOD development and the displacement of residents has yet to be established. To understand the scope of the displacement phenomenon and close this gap in the literature, this report measures the incidence of rail-related displacement by analyzing the effect of TOD development on intra-urban household mobility. Out-mobility rates are computed for rail-station area neighborhoods and compared to similar control neighborhoods' out-mobility rates, as well as to county-level out-mobility rates. Then, these neighborhood-level out-mobility rates are analyzed against rail-station opening timelines. This approach measures whether the opening of a rail station increases or decreases mobility in a statistically and economically rigorous way. Results for L.A. Metro Gold light rail line[4] and Red/Purple subway line neighborhoods are presented in this report.

Literature Review

Defining Gentrification and Displacement

Research on gentrification defined as the "pattern of neighborhood change in which a previously low-income neighborhood experiences reinvestment and revitalization, accompanied by increasing home values and/or rents" *(19)* began in the 1960s. However, earnest conversations about displacement in the U.S. only started in the late 1970s after forced displacement of whole communities for interstate highway construction, the federal Urban Renewal program, and other government actions placed the issue in the public mind *(20, 21)*. In his discussion of neighborhood upgrading, Clay (1979) notes the public attention shifting to concerns about residential displacement *(22)*. At the same time, a U.S. Housing and Urban Development report in 1978 identified risk conditions for displacement, which included, among many others, natural and human-induced disasters, new regulations, code enforcement, public capital investments, and rising prices *(23)*. Accordingly, Grier and Grier (1978) provide an early definition of displacement: a household is forced to move from its residence because of conditions outside of its control, which occur despite meeting pre-imposed conditions of occupancy, and which make occupancy "impossible, hazardous, or unaffordable" *(23)*.

As the topic of displacement gained more attention, Marcuse (1986) provided a more holistic four-part definition of the phenomenon from the perspective of a housing unit: 1) direct displacement of prior residents, 2) chain displacement, 3) exclusionary displacement, 4) displacement pressure *(24)*. Direct displacement focuses on the last occupying household in a

[3] Author calculations of data from Zuk & Chapple, 2015a *(4)*
[4] Excluding Foothills Extension

housing unit, chain displacement focuses on previous households who may have been displaced before the current household at risk of displacement moved in, exclusionary displacement is the inability of a household to move in due to conditions outside of its control and is similar to Grier and Grier's definition, and displacement pressure indicates a broader feeling of other neighborhood residents that the neighborhood is changing and spurring some of them to consider moving *(24)*. Most research on quantifying and assessing displacement focuses on Marcuse's first category of direct displacement of prior residents *(20)*. This category is easiest for both conceptualization and data collection. Though our current paper focuses on direct displacement too, we intend to use our dataset to explore chain displacement and displacement pressure in future studies.

Prior Findings on Gentrification and Displacement

Here, we summarize some of the key recent studies of displacement. To date, many of the recent works on displacement utilize either cross-sectional, simulation, longitudinal housing unit, or case study approaches.

Cross-Sectional Approaches

Using the cross-sectional approach, there is an on-going effort to establish a clear relationship between transit-oriented development (TOD), gentrification and displacement. Chapple (2009) provides a cross-sectional and case study approach to linking gentrification and transit in the San Francisco Bay Area from 1990-2000 *(9)*. She shows that over 80% of 102 gentrifying census tracts during the 1990s were within half-mile of a rail or ferry transit station, compared to only ~40% of neighborhoods experiencing other forms neighborhood change *(9)*. Factors associated with the likelihood of gentrification include high availability of multi-family and rental housing, higher density of parks and youth facilities, higher income diversity and high rent burdens, among others *(9)*. In previous research, Chapple (2006) notes that low-income residents are likely to be particularly sensitive to the services and social resources in their neighborhoods, saying that low-income residents "depend on intricate social systems, local interaction, and intermediaries in order to connect to the mainstream" *(25)*. The sum of Chapple's work indicates associations between rail transit and gentrification in the San Francisco Bay Area.

Lin (2002) measures whether rail station proximity leads to gentrification as measured by property values in Chicago in three time periods from 1975-1991 *(26)*. He finds mixed results and concludes that while the existence of rail transit helps predict gentrification, it is highly context- and time-specific. Specifically, the presence of rail transit increased property values in two of three five-year time periods, but not in the other one. Additionally, the relationship between the rate of property value increase and distance to a rail station varied across the three time periods *(26)*.

Kahn (2007) measures gentrification by changes in the income, educational attainment, and home prices of the inhabitants of 14 of 16 U.S. cities that have built new transit stations since 1970 *(27)*. Using a pre/post methodology to identify treated census tracts, he controls for endogeneity by establishing adequate control tracts and deals with selection and heterogeneous effects by using an instrumental variable. He finds that receiving a new station did not necessarily gentrify a tract. Kahn's (2007) results indicate that stations exhibiting 'walk and ride' characteristics, with adequate planning for non-motorized accessibility to the station did show evidence of gentrification, while 'park and ride' type stations, which favored driving to the station, parking did not show gentrifying evidence *(27)*.

Heilmann (2016) looks at income segregation in Dallas neighborhoods and compares areas treated with a light-rail station to those with an unbuilt and/or canceled light-rail station. Findings indicate that new light-rail stations increase income segregation, with low-income households leaving high-income neighborhoods at faster speeds *(28)*. These results may indicate displacement, but the paper does not specifically address the issue of displacement or household mobility directly.

These cross-sectional efforts uncover interesting patterns tying rail stations and gentrification. However, they do not address the question the effect of rail station openings on displacement. Nor do they consider how household mobility patterns affect changes in neighborhoods (except for Heilmann (2016). In contrast, McKinnish, Walsh, and White (2010) looked for evidence of displacement in gentrifying tracts, using a cross-sectional approach to sample households from the 1990 and 2000 Census Long Form survey *(29)*. They found "no evidence of displacement [of] non-white households" showing instead that lower-educated African-American households disproportionally stayed in gentrifying neighborhoods *(29)*. While an important finding, their analysis did not consider the effect of transit on the gentrification – displacement relationship.

Longitudinal Approaches

Several studies adopt a longitudinal approach to measure the incidence of displacement. Though these studies do not specifically look at rail-station neighborhoods, their methods and findings are instructive and provide background for the study of displacement as a topic.

Freeman and Braconi (2002, 2004) used the New York City Housing and Vacancy Survey (NYCHVS) and U.S. Census data to test the propensity of gentrification to induce household displacement at various income strata *(30, 31)*. Comparing gentrifying to non-gentrifying neighborhoods, they found that gentrification reduced the propensity for displacement among low-income residents in gentrified neighborhoods and induced higher income residents to move in (*30, 31*). Freeman and Braconi (2002) see displacement as responsible for 5.1-7.1% of all moves[5] between 1987 and 1999 or affecting 0.114%-0.157%[6] of all New York City residents *31)*. In a response study, Newman and Wyly (2006) use the same dataset expanded to all of New York City's neighborhoods, excluding movers from outside of New York City and movers

[5] Defined as including moves for the following reasons: "housing expense, landlord harassment, and displacement by private action" *(31)*

[6] Computed using 1-year average displacement from Freeman and Braconi, 2002, table 1 *(31)* and the 1990 and 2000 U.S. Census population measures for New York City

within the same building *(32)*. They find displacement rates of 6.2-9.9% of movers or 0.142-0.179% of the total city population *(32)*. Both sets of authors draw different conclusions from essentially similar numbers. Freeman and Braconi (2002, 2004) contend that in-movement of middle-class households does not directly displace low-income households, whereas Newman and Wyly (2006) see the displacement rates as a significant public policy worry *(30, 31, 32)*. In a qualitative analysis, Newman and Wyly (2006) find that 93% of low-income households who are able to stay in gentrifying neighborhoods do so using public housing, rent control, or other regulatory program *(32)*.

Vigdor et al. (2002) studied neighborhood renewal in Boston between 1970 and 1998. This study used longitudinal data on housing units in Boston from the American Housing Survey (AHS) over three periods between 1974-1993, and defined neighborhoods as AHS zones (about 100,000-200,000 population each) *(33)*. Their research results show that redevelopment could result in displacement when relocation costs are low and in decreased standards of living when relocation costs are high. Ellen & O'Regan (2010) use the AHS' longitudinal survey of housing units to examine occupancy changes throughout the 1990s at the national level. As with prior studies, they find "no evidence of heightened displacement (proxied by exit rates) even among the most vulnerable, original [neighborhood] residents" *(34).*

Also at the national level, Freeman (2005) also used a geocoded panel of individual households from the Panel Study of Income Dynamics (PSID) linked to census tracts to assess the relationship between gentrification and displacement by comparing gentrifying neighborhoods to potentially gentrifying *(35)*. He found a modest relationship between displacement and gentrification from revitalization: 1.3% versus 0.9% displacement in non-gentrifying neighborhoods *(35)*. The study concludes that while these numbers do not suggest an economically significant gentrification-induced displacement rate, "the fact that lower socioeconomic status households are no longer moving into these neighborhoods implies a diminishing of housing opportunities for some" *(35)*. This may also imply that gentrification leads to exclusionary displacement *(24)*, rather than direct displacement.

In a recent follow-up study, Freeman et al. (2015) use a similar approach to Freeman (2005) to measure the relationship between displacement and gentrification in England and Wales *(35, 36)*. They use households-level data from the British Household Panel Survey geocoded to Lower Level Super Output Areas from the UK Census in 2001-2009 *(36)*. Freeman et al. (2015) generate mixed results. On one hand, across England and Wales, they find little variation in mobility rates between gentrifying and non-gentrifying neighborhoods for either low-income or working class households *(36)*. On the other hand, in London, low-income households in gentrifying neighborhoods were ~2.5 times likelier to move than those living in non-gentrifying neighborhoods; however, working-class households had the reverse result: they were ~2.5 likelier to move to non-gentrifying neighborhoods compared to gentrifying ones *(36)*. Freeman et al. (2015) view their results as potentially indicative of the different baseline mobility levels in low-income versus working-class neighborhoods *(36)*.

The findings from Ellen and O'Regan (2010), Freeman (2005), Freeman and Braconi (2004), Freeman et al. (2015), and Vigdor et al. (2002) speak largely to the general question of displacement in gentrifying neighborhoods, rather than the specific case of new rail transit service. Hence the transportation link is not as clear from those studies as policy-makers would prefer.

Simulation Approaches

Other scholars have turned to simulations to assess the effects of rail stations on neighborhood change. While not inherently a causal exercise, simulations can help forecast or predict the effects of a policy on a population. Chapple et al. (2017) undertake a multi-pronged simulation effort focused on understanding potential displacement due to development in transit neighborhoods *(37)*. This study aims to support Metropolitan Planning Organizations (MPOs) and local governments to incorporate social equity into their Regional Transportation Plans and Sustainable Community Strategies and was funded by the California Air Resources Board *(37)*. They find that in a location choice model, household out-movement choices are driven by changes in rent burdens (proportion of income spent on rent) and not by ethnic, racial, or other demographic characteristics, in the San Francisco Bay Area *(37)*. For household in-movement, they find that households in the bottom two income quartiles are most sensitive to rents and that significant clustering exists across household characteristics and race, but, that higher income Blacks and Hispanics tend to move to more integrate neighborhoods (*37*). A report related to this research finds a tendency toward gentrification and neighborhood upscaling in Los Angeles County's rail station areas *(4)*. Zuk & Chapple (2015a) note that transit areas are relatively likelier to see decreases in disadvantaged, lower-income, and lower-educated populations *(4)*. Additionally, the findings convey that the largest displacement potential seems to occur where TOD is coupled with other improvements to city form *(4)*. In the San Francisco Bay Area, this research shows that over half of low-income households are experiencing displacement pressure, and those in neighborhoods which contain rail stations are at an even higher risk *(38)*.

In a different simulation effort, Dawkins and Moeckel (2016) assessed how TOD-based affordable housing policies influence the intra-urban mobility destination choice of low-income households in Washington D.C. *(39).* Using the Simple Integrated Land-Use Orchestrator model as a simulation basis, they showed that some gentrification resulted from the development of transit *(39)*. They also find that adding supply-side affordability requirements to TOD developments helps mitigate displacement for qualifying households *(39)*. However, they also find that households earning above the income restrictions face the full brunt of transit-induced gentrification *(39)*. In sum, the simulation literature adds to our knowledge of TOD and displacement and recommends policies for more equitable TOD, but does not causally test the link between transit development and displacement.

Other Approaches

A final set of studies provide policy-level recommendation on forestalling potential displacement in TODs. Pollack et. al. (2010) provide detailed policy recommendations set amid numerous case studies to develop transit-rich neighborhoods more sustainably, geared towards the diversity of housing and population in TOD neighborhoods in the face of gentrification. The authors see these strategies as being able to cope with potential negative consequences of gentrification, including displacement. Cervero (2008) provides recommendations for how to enact better policies to encourage affordable units near transit. He concedes, however, that existing TOD projects are less affordable (and also less environmentally sustainable, another common goal of TODs), mainly because of incorrect assumptions about the traffic they generate *(40)*. Chapple and Zuk (2016) describe the establishment of early warning systems for displacement, which aid policy makers, activists, and community organizers in reducing displacement among low income households *(41)*.

Recent literature reviews by two sets of scholars summarize the state of the literature on displacement and TOD. Both of them, Rayle (2015) and Zuk et al. (2015, 2017), find that major methodological, definitional, and data shortcomings exist in studying displacement, leading to likely undercounts / overcounts depending on context *(20, 21, 42)*.

Rayle (2015) performs a qualitative analysis combined with a literature review to show that "even if physical displacement rates are small, social and psychological displacement may have greater effects on residents" which most studies do not consider *(42)*. Additionally, Rayle (2015) theorizes why some studies may find little connection between gentrification and displacement. She finds that cost-reductions from improved transportation access created by TODs may counterbalance increased rents from the capitalization of transit amenities *(42)*. Additionally, she posits that advocacy groups may use the TOD planning process to score benefits for low-income constituencies, partially limiting their exposure to displacement pressure; however, more evidence of this is needed *(42)*.

Zuk et al. (2015) point to four methodological shortcomings in studies of displacement and TOD: "1) inconsistent definitions and operationalization of the terms gentrification and displacement, 2) differences in the definitions of a comparison group and controls to calculate and compare displacement rates, 3) the time-scale of analysis that may not capture the full processes of neighborhood change, 4) ambiguous criteria against which to determine the significance and meaning of research results" *(20).*

Concurring with Zuk et al. (2015), our research seeks to methodologically improve on prior studies, with a focus on the relationship between rail stations and displacement. Our research provides a definition for displacement, focusing on neighborhood household mobility rates. We draw a control group to compare displacement rates. We conduct our analyses at a fine spatial scale over a two-decade time period. Finally, we calculate baseline measures to serve as an adequate comparison for displacement measures and to estimate the economic significance of our findings.

Data and Geocoding

Dataset description

We constructed a station-area longitudinal panel of household mobility patterns as a measure of neighborhood-level displacement. We obtained tax filing data from the California Franchise Tax Board (FTB) from 1993-2013. The data universe contains all individuals who have ever filed California taxes from 1993 to 2013 in Los Angeles County, a dataset of over 140 million records. For households who moved in or out of the county, records from any years in which they lived outside of Los Angeles County and filed California tax returns, even if from outside of California, are also present in the dataset. Household specific identifiers enable year-to-year tracking[7]. The longitudinal dataset includes information available on the California tax return including the households' income, state taxes paid, approximate location, and other characteristics for every year the household is in the data.

Previous longitudinal research using income tax data has shown that such data are reliable and precise cross-section or aggregate data in topics that range from historical income inequality *(43, 44, 45)* to intergenerational mobility *(46, 47, 48)* and intergenerational income mobility *(49)*.

Geocoding

To assess whether a household moved filing location from year to year while preserving taxpayer confidentiality, FTB geocoded the data. The geocoded dataset does not contain filers' filing addresses, but does include a code for the taxpayer's zip code. Following FTB's confidentiality guidelines, the level of zip code reported is chosen based on the number of taxpayers in the zip code. About half of all records were in zip codes with enough taxpayers to be coded at the 9 digit level. For most of the remaining records, zip code was coded at the 5 digit level. 9-digit zip codes, frequently known as zip+4, are unique U.S. Postal Service designations for a set of addresses within one city block, block-face, set of buildings, or individual building. The zip+4 identifies a household's location within one city block.

We matched the 9-digit zip codes with latitude and longitude coordinates using conversion files from Geolytics, a private provider of location data *(50)*. 9-digit zip code locations may change over time, based on U.S.P.S. needs. However, we measured the change in centroid distance between years for 9-digit zip codes in 2000, 2004, 2007, 2009, 2012, 2013, and 2014, and found that it is greater than 1 kilometer in less than 0.2%-1% of cases[8]. We are thus comfortable using

[7] Certain households file in earlier or later years; these were detrended to their nominal filing year to obtain a more balanced panel. Duplicate entries were likewise removed.
[8] Depending on comparison year

geocodes from each of the years listed above. We match FTB data to geocoded Geolytics data based on the closest year available[9]. For 9-digit zip codes not present in any Geolytics year or for households without a 9-digit zip code, we used the latitude and longitude of the centroid for the 5-digit zip code[10], which was provided for most of the observations. Observations with neither 5- nor 9-digit zip codes were dropped from the analysis (ranging from 0.12-2.83% of total observations). The incidence of observations lacking any zip code data appears to be random and diminishes over time. The incidence of 5-digit versus 9-digit zip code identification also appears random, excepting confidentiality cases. As such, we are comfortable that our sample restriction and geocoding approaches do not knowingly bias our measurements.

Sample Restriction

To establish baseline county-wide mobility, we count households that change tax-filing locations from one year to the next and measure how far they have moved, using income tax data from the Franchise Tax Board. Figure 2 shows three measurements of baseline mobility for Los Angeles County computed in three different ways.[11] Model 1 has no restrictions, presenting the tax data as is, and yields an average annual household mobility level of 49% for all of Los Angeles County. By contrast, Model 2 makes a few adjustments and offers a 21% average annual mobility rate while Model 3 places significant restrictions on the data and yields a 17% rate.

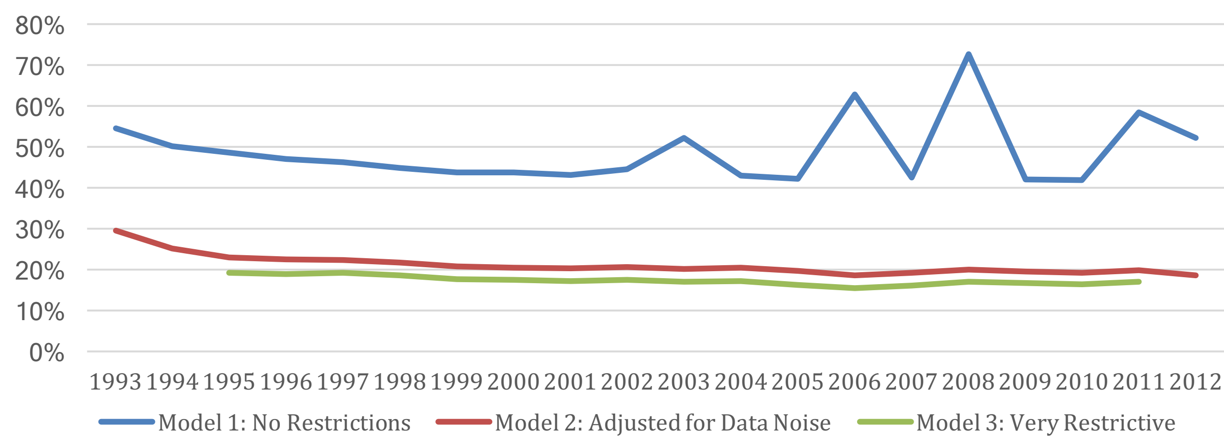

Figure 2. Annual Mobility Rate by Model, Los Angeles County

Model 1 uses every observation with an available geographic coordinate in any given year (4.8 million per year, on average) and counts every move, no matter how small (even several meters) in its measure of mobility. However, Model 1's 49% annual mobility rate is more than

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[9] For example, 2005 FTB data is geocoded using 2004 Geolytics data and so on.

[10] 5-digit zip code centroid coordinates for the U.S. and for California were obtained from Boutell.com's "Free Zip Code Latitude and Longitude Database" *(51)* and from Zip-code.com's "California ZIP Code database" *(52)*

[11] Mobility rate (i.e., out-mover rate) = (Number of mover from year 0 to year 1) / (Total number of filers in year 0)

four times the national residential mobility rate of 11.7% in 2013 and more than three times higher than the 16.3% rate in 1996 *(53)*.

Figure 3 breaks down the components of Model 1's mobility rate. Households who drop out of a data in a given year account for 10-15% of the mobility rate in Model 1 (Figure 3). Filing in one year and dropping out in the next makes measurement of location change impossible, as dropped out households do not show a location for the dropped out year. In addition to moving out of California12, reasons to drop out of the data set include marriage, death, income dropping below the filing threshold, becoming a dependent of another filer, or other circumstances. Federal estimates of tax non-compliance (non-filing) range from 10 – 16% in the mid-2000s *(54, 55, 56)*; in California, this is estimated at 11% during the same time period *(57, 58)*. Households are only required to file taxes federally if their annual incomes are above a certain level. In 2013, this threshold was $20,000 for families and $10,000 for individuals federally (*59),* and $25,125 for families and $12,562 for individuals in California *(60)*. Income-based filing thresholds are indexed to inflation and thus vary slightly from year to year.[13] A study of federal tax non-filers using 2005 data estimated that 77% households who did not file had annual incomes below $20,000, the federal income mandate *(62)*. This shows that lack of mandate to file, not blatant tax evasion, is the primary reason not to file taxes. We are not concerned, however, that our data is missing a significant portion of the lowest-income households, because 75% of eligible California households claim the Earned Income Tax Credit (EITC), a tax credit for low and lower-middle income working households often with children, which requires them to file a tax return *(63)*. Thus, many of the lowest-income households still file taxes, even if they fall below the mandatory filing threshold.

Figure 3 also shows that 13% of all households moved fewer than 100 meters per year and an additional 3% annually moved 100 to 800 meters. These move distances also show notable peaks in households moving between the years of 2003 to 2004, 2006 to 2007, 2008 to 2009, and 2011 to 2012. We believe that these peaks and the high percentage of very short distance moves reflect constraints of the geographic unit – the 9-digit zip code – available for this data.[14] As a result, moves under 800 meters (0.5 miles), likely constitute noise from geocoding and likely do not reflect actual household behavior.

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[12] Households who move out of California, but still generate income in California are required to file taxes in California and are thus included in the dataset

[13] The California Franchise Tax Board provides the filing thresholds for each year on its website *(61)*

[14] See above. About 0.1-2.5% of 9-digit zip codes change centroid distance by more than 1 kilometer (0.6 miles). An additional 1-20% change centroid distance by 100-1000 meters.

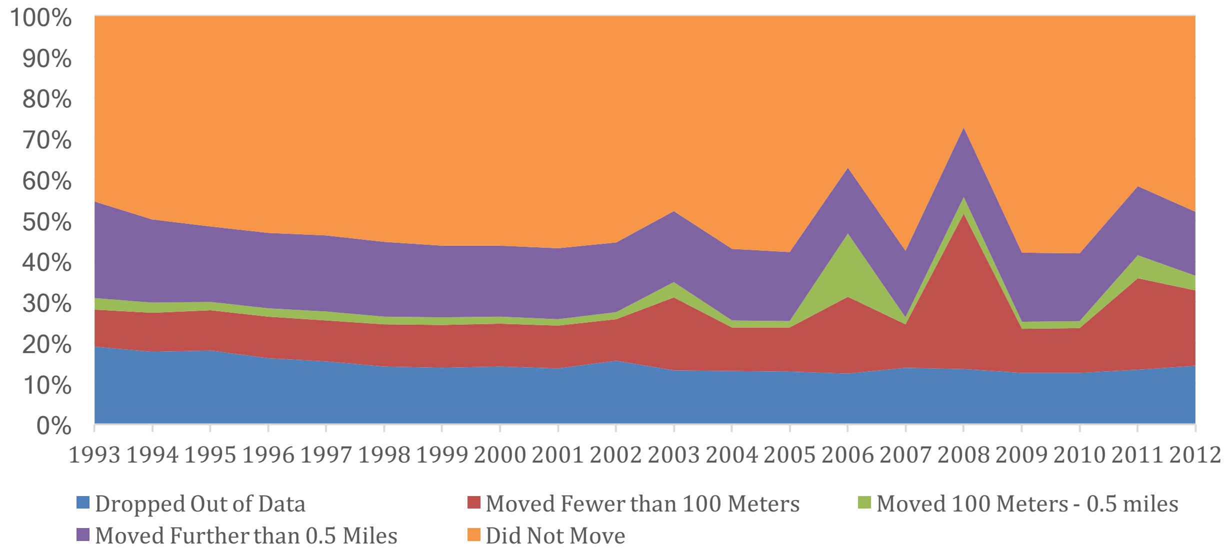

Figure 3. Breakdown of Model 1 by Move Type by Year

Understanding the issues with Model 1, we considered 6 alternatives to overcome the data drop-out issue. Each option progressively required a more restrictive definition of mobility and increasing sample restriction, based on the number many consecutive years a household appears in the data and whether these years are before or after the move in question (Table 1). Each of these alternatives only considered moves of at least 0.5 miles as real household moves. Table 1 uses the example of the Vermont / Sunset Metro rail station neighborhood[15] to illustrate the differences in outcome and sample size between the alternatives. Model 2 provides an improved measurement while sacrificing the fewest observations. In contrast, Model 3 provides the narrowest definition of mobility but removes more than half of the observations, while not differing significantly in outcomes. The remainder of the options fall somewhere between models 2 and 3 in efficiency and effectiveness. Ultimately, we chose Model 2 as the closest representation of actual household moves. Model 2 underlies the analyses in the remainder of the paper.

[15] Every household living within 0.5 miles of the rail station

Table 1. Seven Models to Combat Data Inconsistency using the Example of Vermont / Sunset Station Area

	Consecutive Data Years					Vermont / Sunset station over 5 years		
Model #	Year T-2	Year T-1	Year T	Year T+1	Year T+2	Average stay rate	Average out-mobility rate	Station Area Sample Size
1	No	No	Yes	No	No	56%	44%	2085
2	No	No	Yes	Yes	No	71%	29%	1672
3	Yes	Yes	Yes	Yes	Yes	74%	26%	1009
4	No	Yes	Yes	No	No	60%	40%	1614
5	No	Yes	Yes	Yes	No	72%	28%	1351
6	No	No	Yes	Yes	Yes	73%	27%	1421
7	No	Yes	Yes	Yes	Yes	73%	27%	1169

The next section shows descriptive statistics for Los Angeles County mobility rates and compares them to national-level mobility rates.

Mobility Rates in the United States and in Los Angeles County, CA

A. National and Local Mobility Rates

In this section, we present the calculated mobility rates for Los Angeles County, CA and compare them to national level mobility estimates. We measure the mobility rate, i.e., the out-mover rate, by dividing the total number of movers from year 0 to year 1 (moving at least 0.5 miles from their origin) by the total number of filers in year 0, conditional on filers being in the data for both years 1 and 0.

Los Angeles County is the largest county by population in California and in the U.S., and it contains the city of Los Angeles and 87 other municipalities. From 1993-2013, Los Angeles County has exhibited a 21% average annual out-mover rate (Figure 4). This rate has been gradually decreasing from the beginning of the study period to the end of the study time period. At a national level, the U.S. Census Bureau, through the decennial census, the Current Population Survey (CPS), and other methods, measures how often households move throughout the country, both across county lines and within county lines. The Census Bureau finds that within-county mobility has been decreasing steadily at the national level since the mid-20th century (Figure 5) *(53)*. In 1948, 13.6% of households reported moving within a county annually, while in 2016, the rate was 6.9% *(53)*. However, the decrease has levelled off since 2008 *(53)*. The Los Angeles County rate has declined by 2.4% annually from 1993-2012, faster than the 1.5% national annual rate decline for a similar time period.

Figure 4. Residential Out-Mobility Rates for Los Angeles County, 1993-2012
Source: Author Calculations of California Franchise Tax Board Data

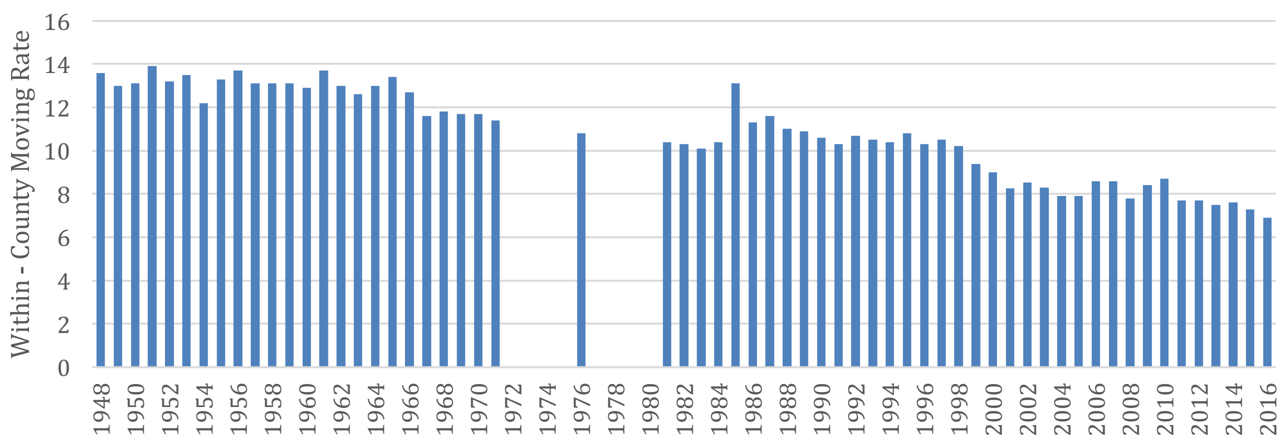

Figure 5. Within-County Move Rate Percentages Nationally, from 1948-2016.
Source: U.S. Census Bureau, Current Population Survey, 1948-2016

The 21% mobility rate in L.A. County is higher than the 11% national rate. There are several possible reasons for the difference between national and Los Angeles County rates. First, Los Angeles County (and city) is one of the largest renter markets in the United States with most households renting rather than owning their residence *(65)*. Moreover, many neighborhoods near Los Angeles Metro stations have a very high proportion of renters *(66)*. Second, according to the U.S. Census Bureau, renters have historically moved at much higher rates than homeowners (Figure 6) *(*. Figure 6 shows that renters' and owners' mobility rates routinely differ by 15-20 percentage points, nationally. Both renters' and owners' mobility rates have experienced steady declines over the past three decades. The Los Angeles County mobility rates thus follow the profile of its residents: more renters indicate a higher mobility rate.

Additionally, our 21% average annual mobility rate for Los Angeles County squares well with other survey studies. For example, Clark and Ledwith (2006) found an 18% mobility rate for the Los Angeles using a sample of 2,644 households in sixty-five neighborhoods in Los Angeles County over 2002-2006 *(68)*.[16] Our findings are also close to Coulton et al. (2012), who find a 19% annual mobility rate (57% over three years), in their survey of 10 low-income and changing neighborhoods *(69)*. Taken together, we are encouraged that our county-level mobility rates logically relate to prior findings and national level statistics. This shows also the potential of this new administrative dataset to yield reasonable results in line with other sources.

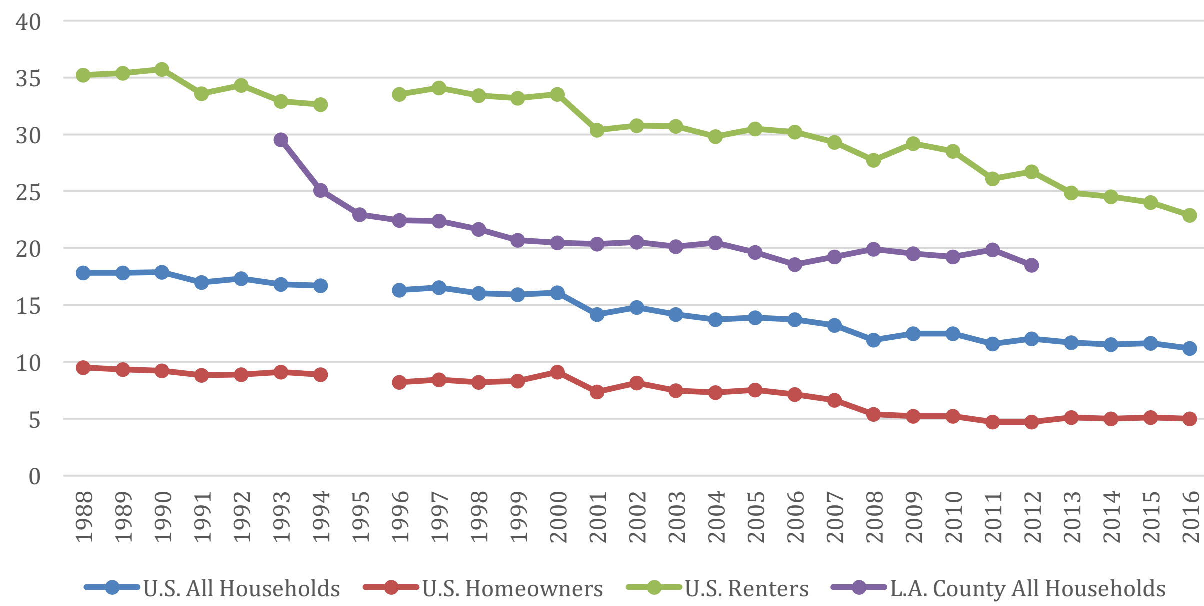

Figure 6. Mobility by Housing Tenure, 1988-2016
Source: U.S. Census Bureau, Current Population Survey, 1988-2016

B. Who moves, how far, and why?

Having established a baseline move-out rate, we now provide descriptive statistics on how far households move, which households, and for what reason.

Figure 7 decomposes out-mover rate by distance moved for Los Angeles County. On average, 2.1% of households annually moved more than 100 miles, which in Los Angeles County likely constitutes a move away from the Los Angeles metropolitan area. Another 7.3% of households moved annually between 5 – 100 miles, which in the context of Los Angeles is likely within the metropolitan area. 8% of households moved from 1 – 5 miles, and 3.8% from 0.5 – 1 miles, both of which can be considered within area or within neighborhood moves.

[16] Clark and Ledwith's (2006) household data comes from the Los Angeles Family and Neighborhood Study (LAFANS) *(68)*

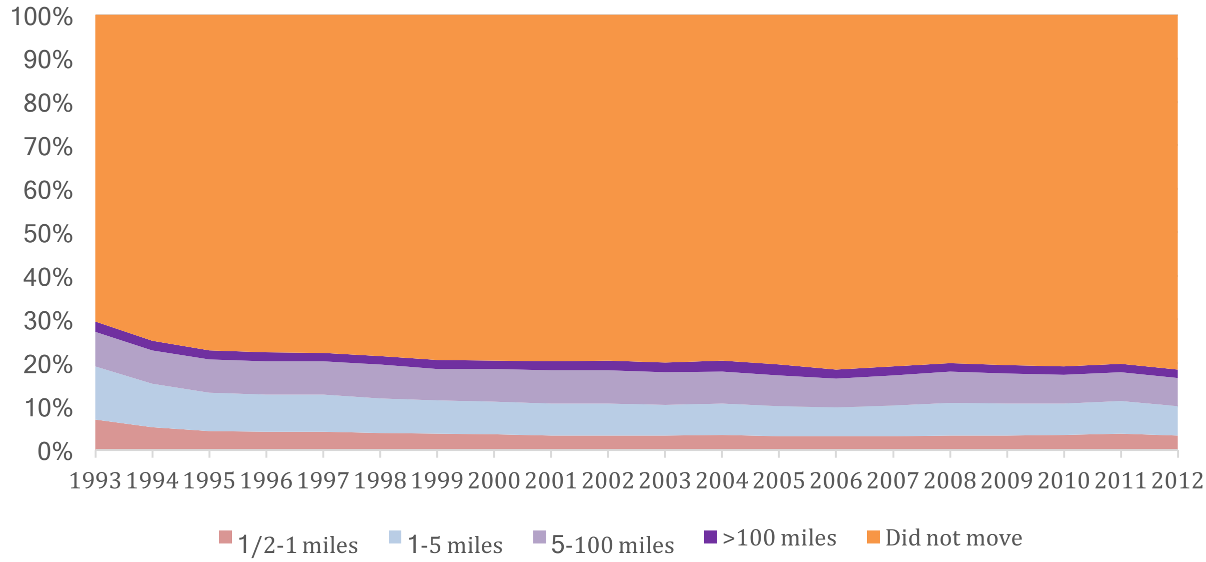

Figure 7. Model 2 Mobility Rate by Move Distance, Los Angeles County

In addition to renting versus owning and distance, moving rates also vary by household income. In Los Angeles County, higher income households, who earn more than 80% of Area Median Income (AMI), or about $40,000 in 2013, are least likely to move (Figure 8). When they do move, those above 80% of AMI, they are most likely to move longer distances (above 100 miles) and consequently out of the County (see Table 2a and 2b). Households making less than 80% of AMI, or below $40,000 in 2013, tend to move shorter distances and more frequently: the lower the income, the shorter distance are the moves. These findings square with national statistics: households making less than the Poverty Line tend to move more often and move within a county, compared to households making more than 1.5 times the poverty line, who move less often (Table 2b). The national data has a regional dimension: in the West of the US, for individuals below the poverty line 70% of moves are within county and the moving rate is almost double for those 100-149% of the poverty line *(70).*

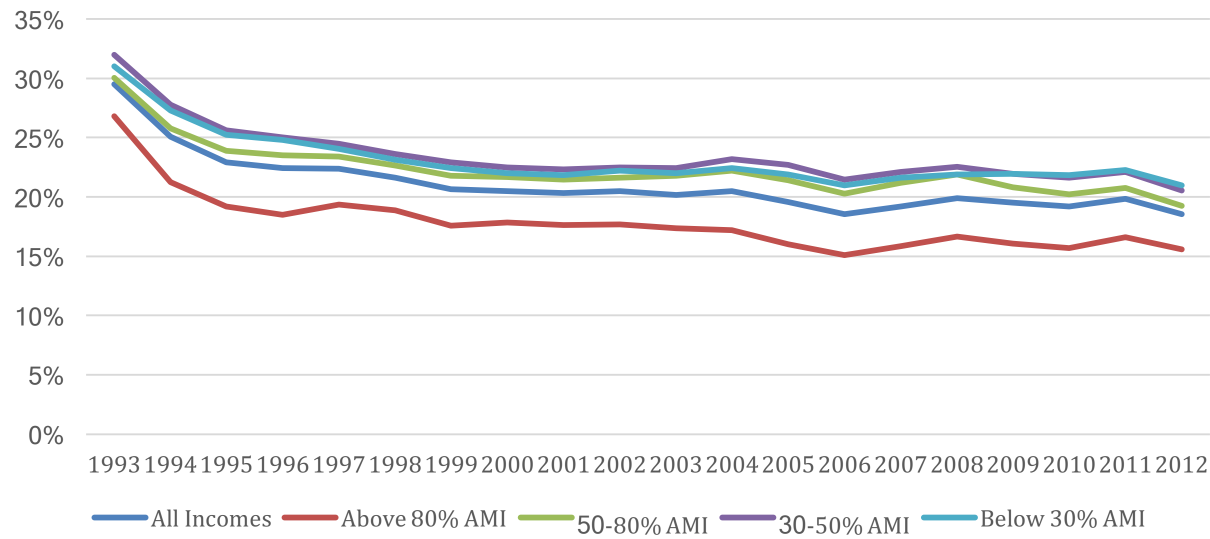

Figure 8. Los Angeles County Mobility Rates by Income Group, 1993-2012

Table 2a. Average Mobility Rates by Income Group and Distance Moved, Los Angeles County

Distance	**All incomes**	**Above 80% AMI**	**50-80% AMI**	**30-50% AMI**	**Below 30% AMI**
0.5-1 miles	4%	3%	4%	4%	4%
1-5 miles	8%	7%	8%	9%	9%
5-100 miles	7%	2%	8%	8%	8%
>100 miles	2%	6%	2%	2%	2%
Did Not Move	79%	82%	78%	77%	77%

Source: author calculations from California Franchise Tax Board data

Table 2b. Average Mobility Rates by Poverty Status by Move Distance in the U.S. (2012-2013)

Move Distance	**All Incomes**	**Above 150% of Poverty Line**	**100-150% times Poverty Line**	**Below 100% of Poverty Line**
Within County	9%	8%	12%	15%
Within State	2%	2%	2%	3%
Within U.S. Region	1%	1%	1%	1%
To Different U.S. Region	1%	1%	1%	1%
Abroad	0%	0%	0%	1%
Did Not Move	87%	88%	84%	79%

Source: U.S. Census Bureau, Current Population Survey Table 01-14

The above tables show move patterns by income and distance but do not show reasons why households move. The U.S. Census' Current Population Survey asks why households move at a national level. U.S. households are most likely to move across county lines for housing-related reasons[17], followed by work and family / life course related moves (Figure 7a) *(71)*. This trend has been consistent over time, making housing a key component of mobility. Changes in the supply or affordability of housing from gentrification or from transit investments may thus be rightfully assumed to influence a household's decision to move. For moves within a county, housing features even more prominently as the reason to move: a recent Census Bureau report suggests that the majority (57.6%) of intra-county moves between 2012 and 2013 were for housing *(64)*. Additionally, people with lower levels of education are more likely to move for housing reasons which suggests that lower-income households are more likely to move locally, just as our data. Moreover, those who hold at least a Bachelor's degree are more likely to make long-distance moves for jobs, college, or other non-housing reasons *(70)*. Nationally, housing is the top cited reason to move within a county for households with annual incomes below $10,000 and above $60,000. Family and life course reasons are also important for lower and middle-income households.

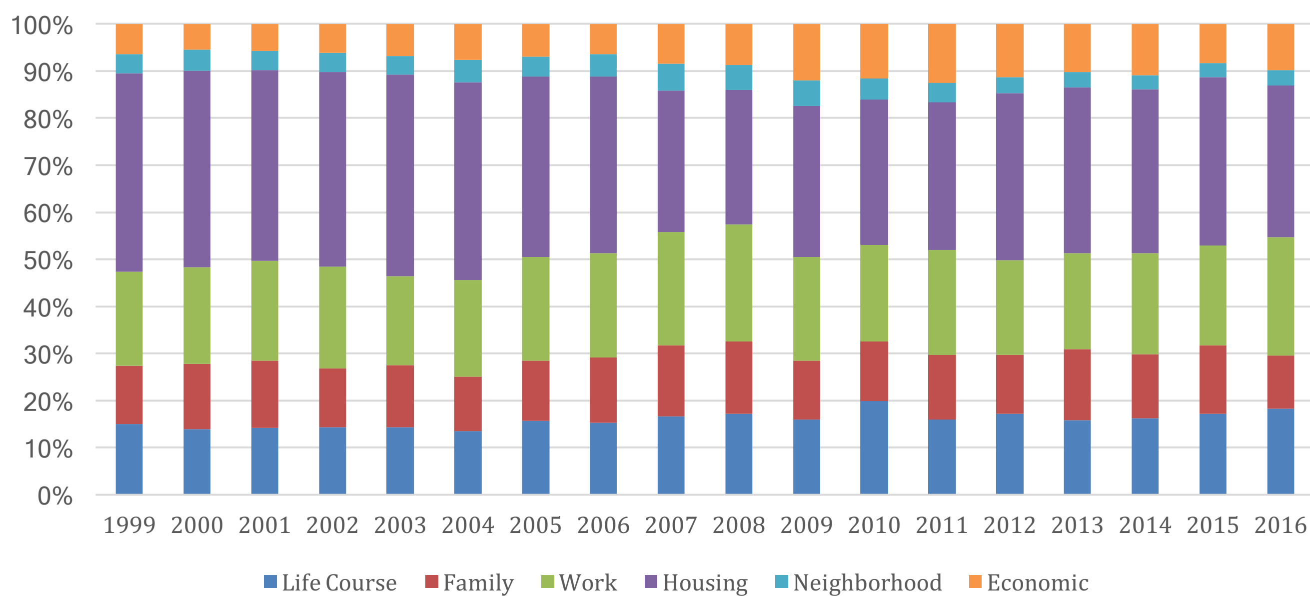

Figure 9a. Reasons Why Households Move, U.S. National, (1999-2016)
Source: US Census Bureau, Current Population Survey Table A-5

[17] Housing-related reasons include "foreclosure/eviction", "wanted better neighborhood / less crime", "wanted own home / not rent", "wanted cheaper housing", "wanted a new or better home / apartment", "other housing reason" *(70)*

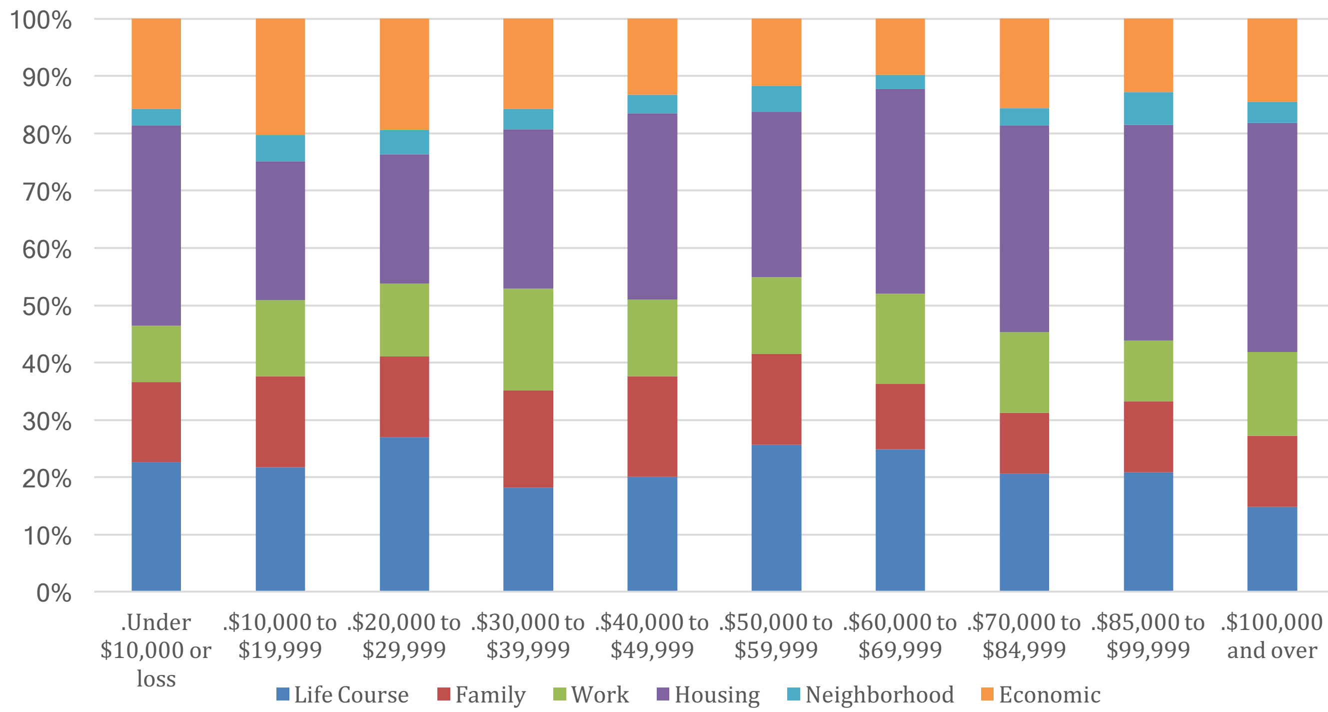

Figure 9b. Reasons Why Households Move within County, by Income, U.S. National, 2012-2013

Source: US Census Bureau, Current Population Survey Table A-5

Los Angeles Metro Station Neighborhoods Descriptive Statistics

Neighborhood Demographics of Red / Purple Line Subway and Gold Line Light Rail

The Red and Purple Subway Line corridors pass through the Downtown Los Angeles, Westlake, Koreatown, East Hollywood, Hollywood, Studio City, and North Hollywood neighborhoods of Los Angeles (see figure 19 in appendix for map). Subway service first opened from Downtown to Westlake in 1993, then extended to Koreatown by 1996, to East Hollywood by 1999, and to Hollywood and the San Fernando Valley by 2001. The Gold light rail line connects Pasadena and the neighborhoods that comprise Northeast Los Angeles to Downtown Los Angeles (Pasadena branch) and also connects East Los Angeles and Boyle Heights to Downtown Los Angeles (East LA branch). The Pasadena branch opened in 2003 and the East LA branch in 2009. The next several charts characterize the demographics of the neighborhoods within 15-20 minute walking distance of each station area along the Red/Purple and Gold lines.[18]

Most of the stations on the Red/Purple and Gold line serve the surrounding neighborhoods where more than 60% of households are low and lower-middle income (below $50,000

[18] Demographics charts (figures 8-12) drawn from Boarnet et al. (2015) *(72)*.

annually) (Figures 10a, 10b). Exceptions to this are much of Pasadena, South Pasadena, and Sierra Madre Villa on the Gold line as well as Universal City / Studio City on the Red line. household incomes in the neighborhoods surrounding Red/Purple Line stations are below L.A. County median incomes, except for Universal City / Studio City.

The Red/Purple Subway Line corridor is a racially and ethnically diverse area. Latino households comprise more than half of the population in the Westlake, Vermont/Beverly, and Vermont/Santa Monica station areas, and more than 40% in Wilshire/Vermont and Wilshire/Normandie (Figure 11a). The stations in Koreatown and in Downtown also have high populations of Asian households, well above L.A. County medians. The Gold line has three patterns across races and ethnicities (Figure 11b). First, station neighborhoods in East LA and Boyle Heights are predominantly Latino, as is much of Northeast LA though to a slightly lower proportion. Next, downtown areas are more diverse with significant Latino, Asian, and Black populations. Third, the Pasadena-area stations have a plurality of white residents, but with significant Asian and Latino concentrations as well.

Nearly every Red/Purple line station area has a higher foreign-born population than the L.A. County average (Figure 12a). The Koreatown and Westlake neighborhoods in particular have high proportions of immigrants. In contrast, the Gold line neighborhoods generally have foreign-born populations in line with county averages, except for spikes around Mariachi Plaza and Pico/Aliso, Chinatown, and downtown Pasadena stations.

Lower-income households, minority households, and foreign-born households are all more likely to use transit and more likely to not own a vehicle *(72)*. Our study of mobility and displacement near their areas of residence is particularly salient.

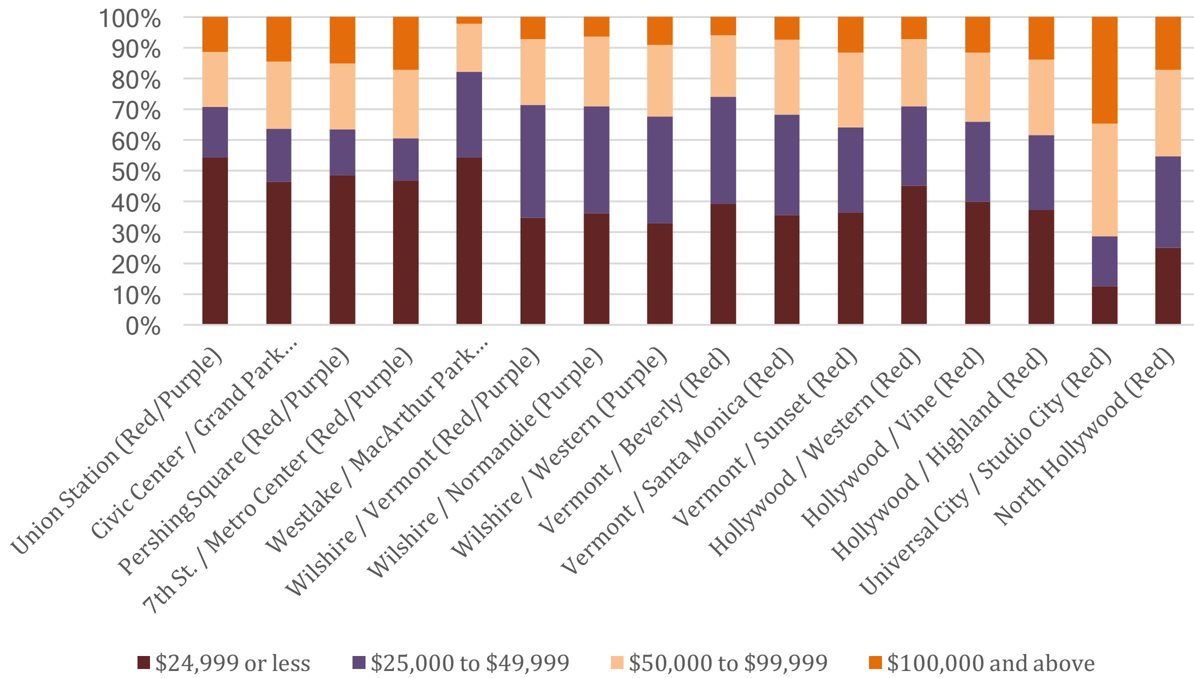

Figure 10a. Red/Purple Line, Household Income Distribution, Half-Mile Station Areas
Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

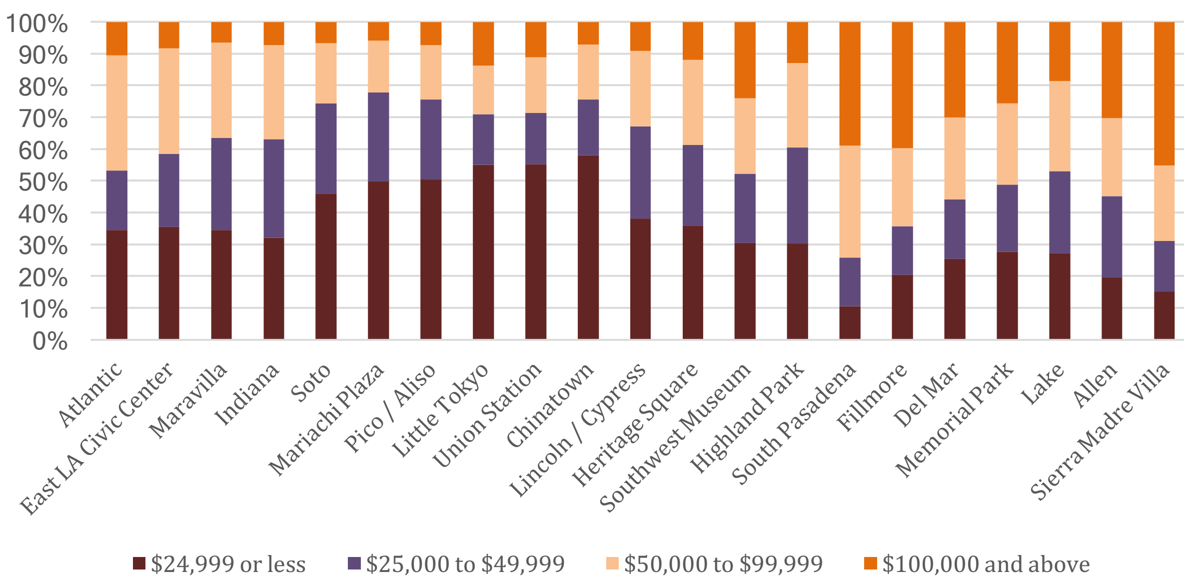

Figure 10b. Gold Line, Household Income Distribution, Half-Mile Station Areas
Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

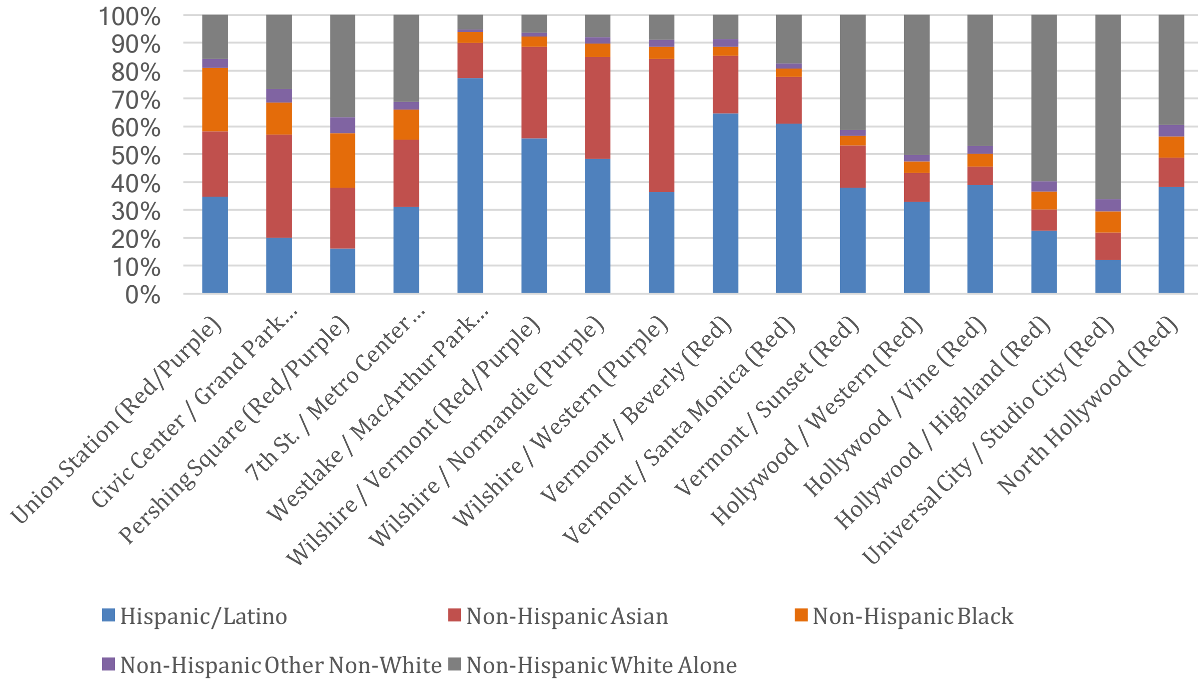

Figure 11a. Red/Purple Line, Race/Ethnicity of Residents within Half-Mile of Stations
Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

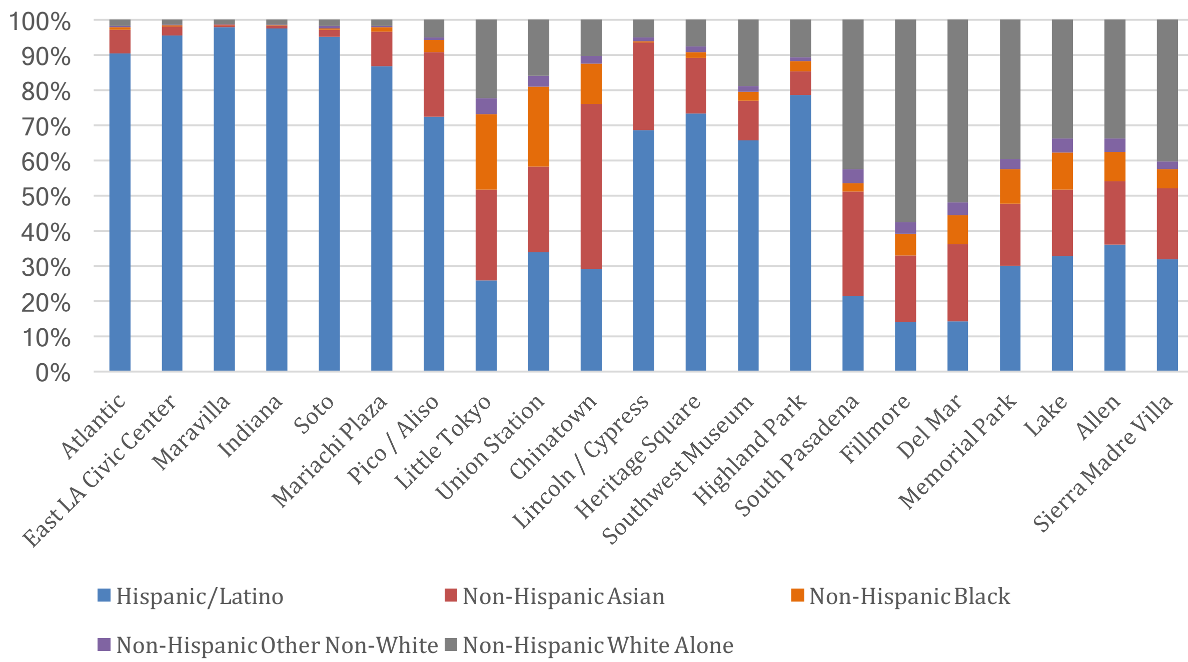

Figure 11b. Gold Line, Race/Ethnicity of Residents within Half-Mile of Stations
Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

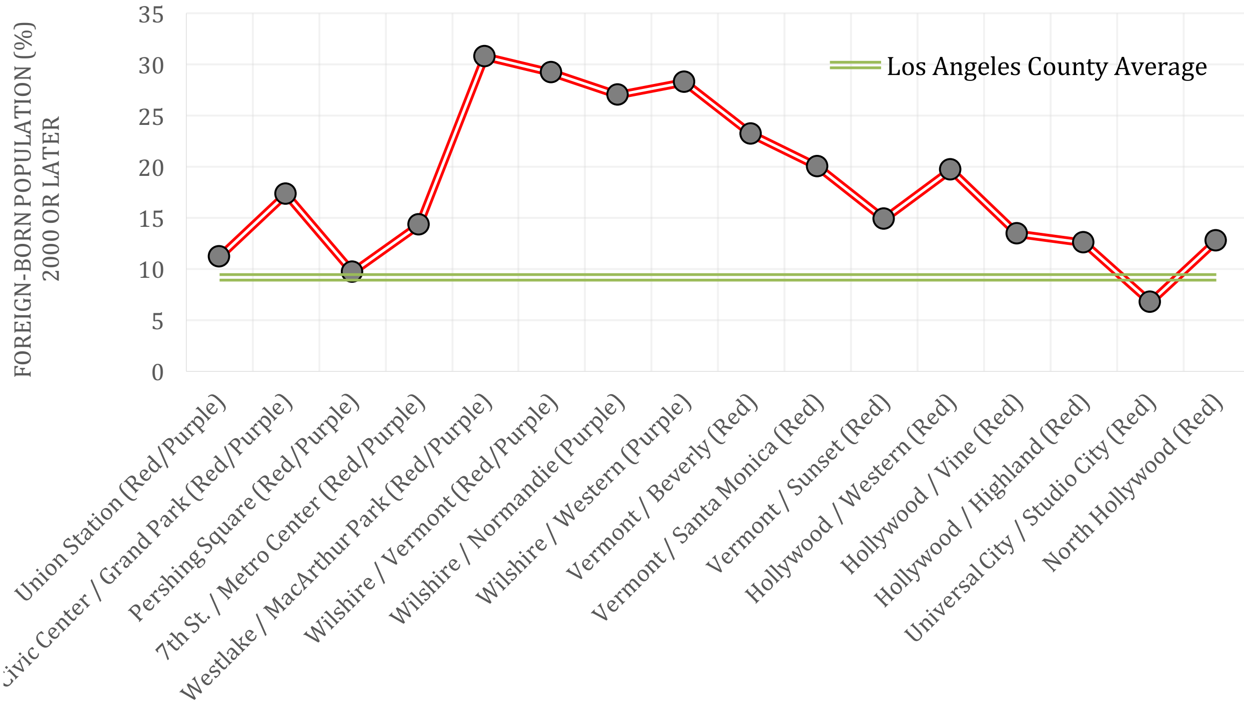

Figure 12a. Red/Purple Line, Foreign-born Population (arriving in the U.S. after 2000) within Half-Mile of Stations

Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

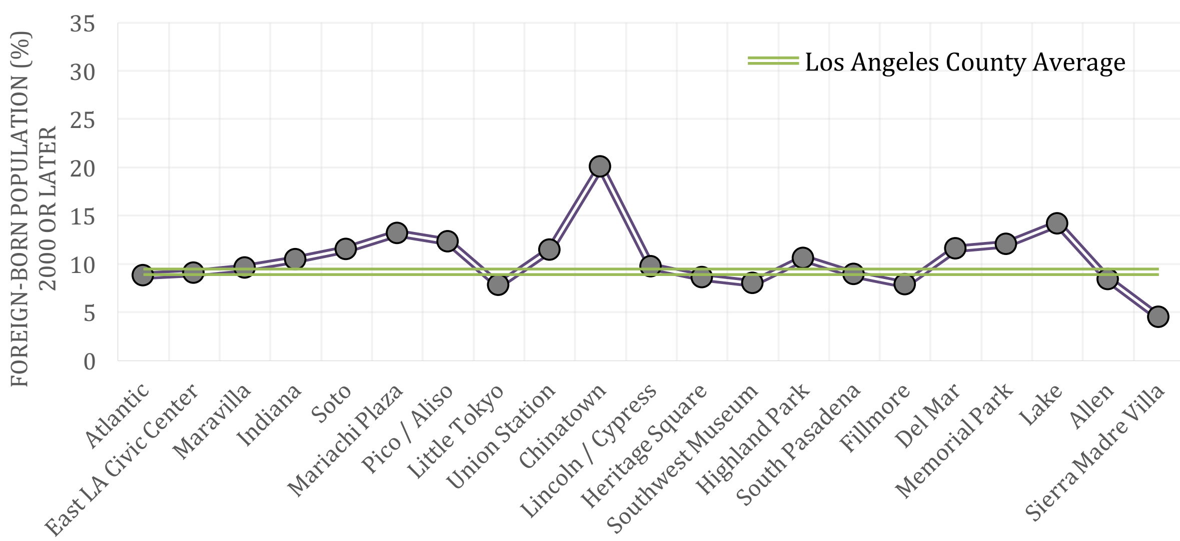

Figure 12b. Gold Line, Foreign-born Population (arriving in the U.S. after 2000) within Half-Mile of Stations

Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

The Red/Purple and Gold lines also display different patterns of housing tenure, rent, and development patterns. Stations along both lines display a very high proportion of renters compared to U.S., L.A. County and even Los Angeles City averages (Figures 13a, 13b). However, renter percentages along Red/Purple line are astronomical, at above 90% for all but 1 station. Most Gold line station neighborhoods have 60-80% renters, though Sierra Madre Villa is an exception with predominantly owner-occupiers. The high proportion of renters as well as the relatively low income of inhabitants likely increases the baseline mobility rates in these neighborhoods (see Figure 6).

Median rents ranged between $800-$1200 per month for Red/Purple line neighborhoods according to the 2009-2013 American Community Survey (ACS) (Figure 14a). This is lower than the Fair Market Rents for Los Angeles County as calculated by the U.S. Department of Housing and Urban Development (HUD) for all stations, except for University City / Studio City station. Along the Gold line for the same time period, rents trended between $900-$1100 per month in East LA, Boyle Heights, Downtown LA, and Northeast LA and between $1200-1600 in South Pasadena, Pasadena, and Sierra Madre Villa.

The Red and Purple Line stations opened between 1993-2001. Since 2000, about half of stations have seen a significant increase in residential construction, both for renter-occupied and owner-occupied units (Figure 15a). Rents for newly built units near stations Downtown and in Koreatown are higher than median rents by $400-$800 per month, and in Hollywood, Studio City, and North Hollywood by $600-800 per month (Figure 15a vs. Figure 14a). On the other hand, rents for new units in East Hollywood are very similar to neighborhood medians, though these neighborhoods have seen much less residential development than the other stations.

The Gold line stations opened in 2003 and 2009. Since 2000, development activity has been slower than along the Red/Purple line (Figure 15b). Development activity has been uneven: no activity in East LA or parts of Northeast LA and South Pasadena and more activity in Pasadena and around Downtown LA. Rents for new housing units in Pasadena-area station neighborhoods have been well above county averages and prior averages (Figure 15b vs. Figure 14b). On the other hand, new unit rents near Indiana, Soto, Mariachi Plaza, and Pico / Aliso stations are lower than county averages and in line with previous rents, possibly due to major affordable housing project developments in the area *(73)*. The development patterns for both of these transit corridors provide context for studying station-level and corridor-level mobility.

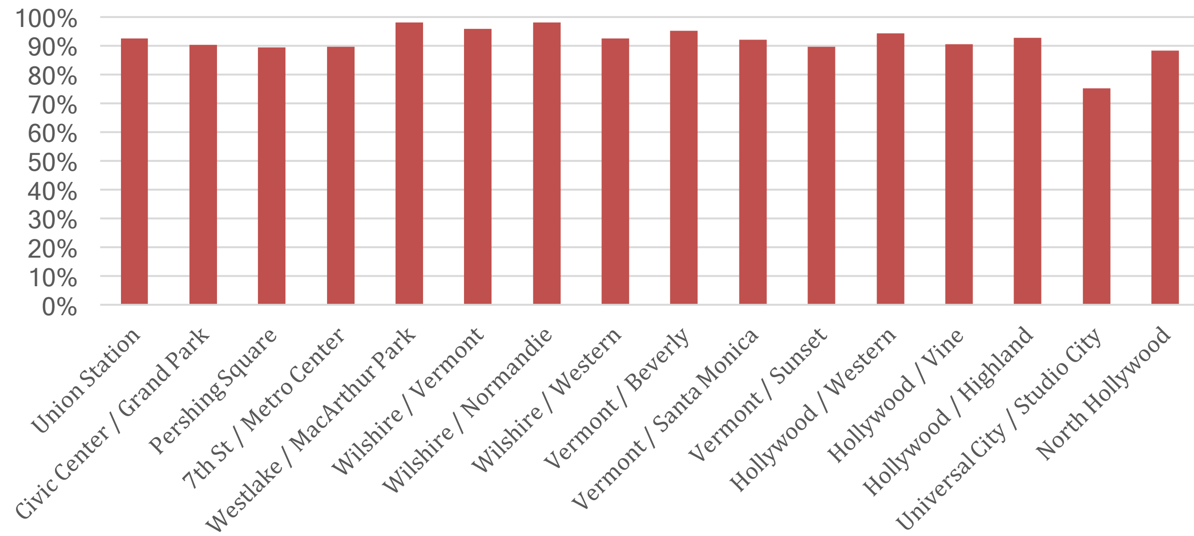

Figure 13a. Red/Purple Line, Renter Occupied Units Percentage
Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

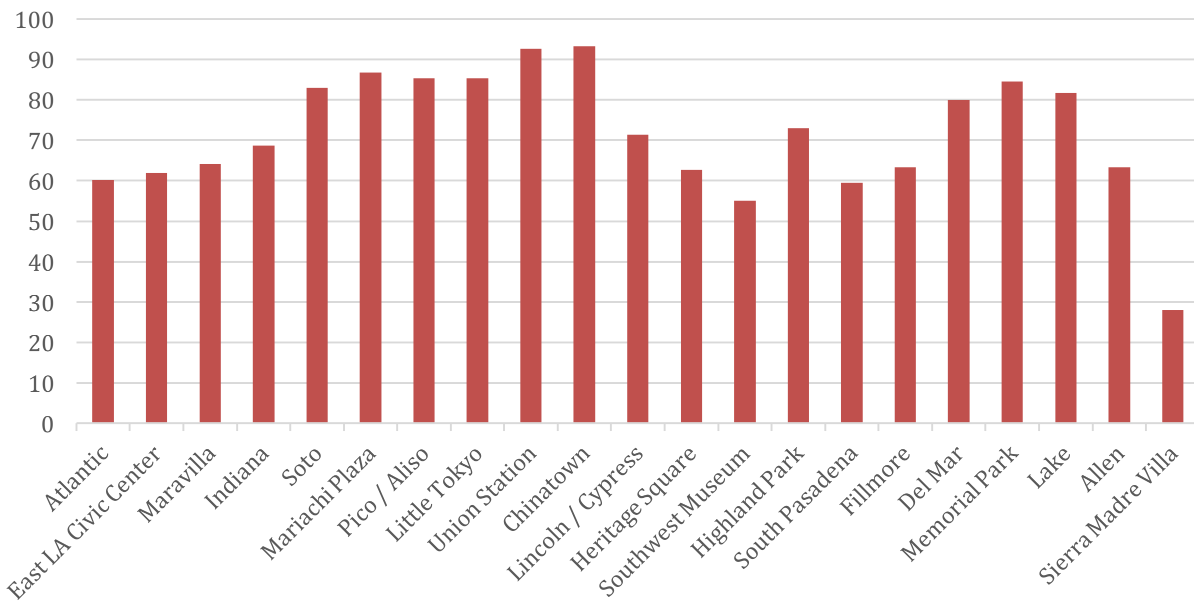

Figure 13b. Gold Line, Renter Occupied Units Percentage
Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

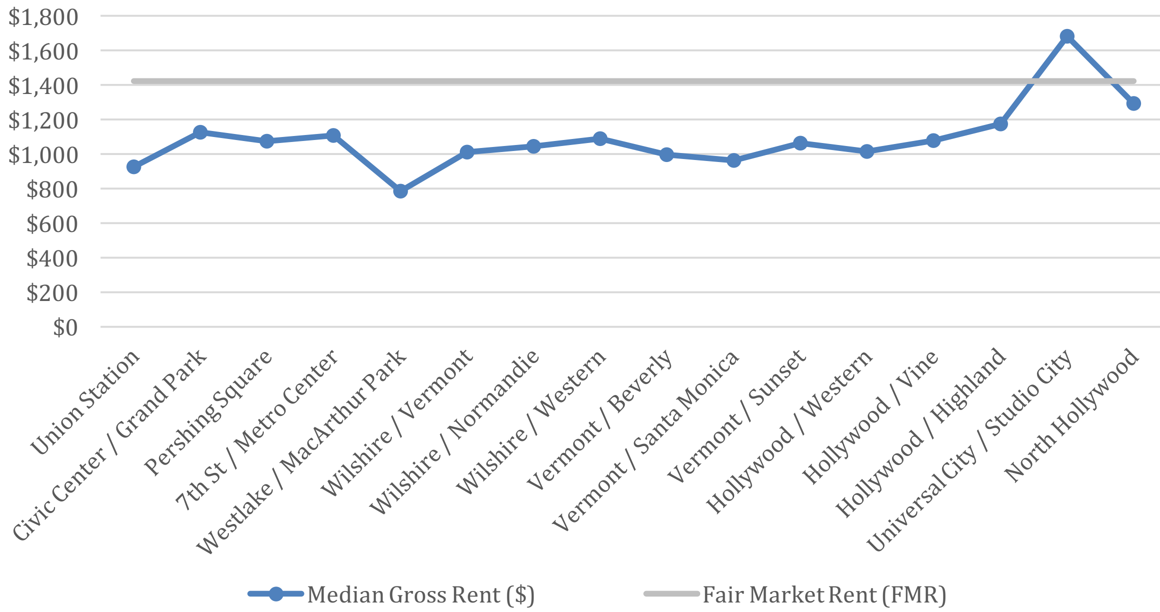

Figure 14a. Red/Purple Line, Estimated Median Gross Rent (2013 $) within Half-Mile of Stations
Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

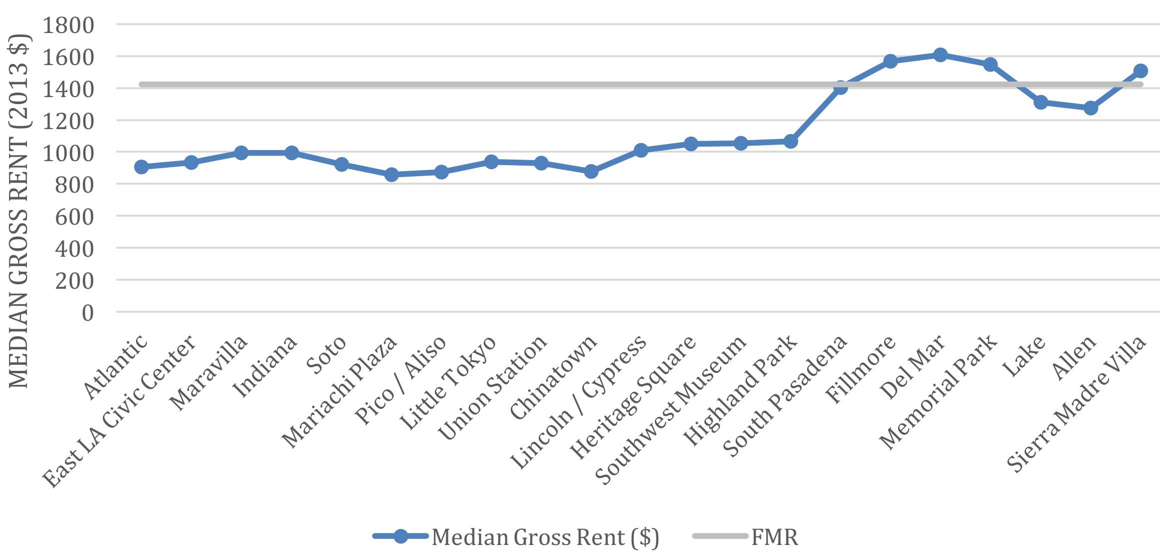

Figure 14b. Gold Line, Estimated Median Gross Rent (2013 $) within Half-Mile of Stations
Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

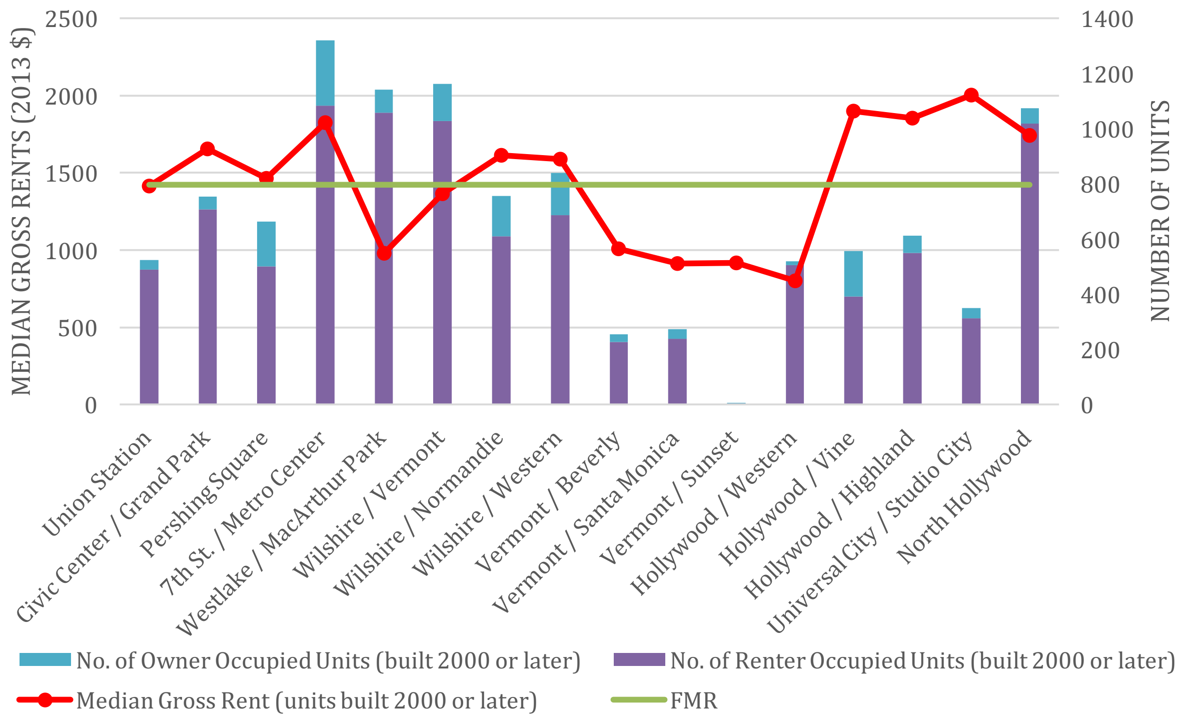

Figure 15a. Red/Purple Line, Estimated Median Gross Rent of New Units (built 2000 or later) within Half-Mile of Stations

Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

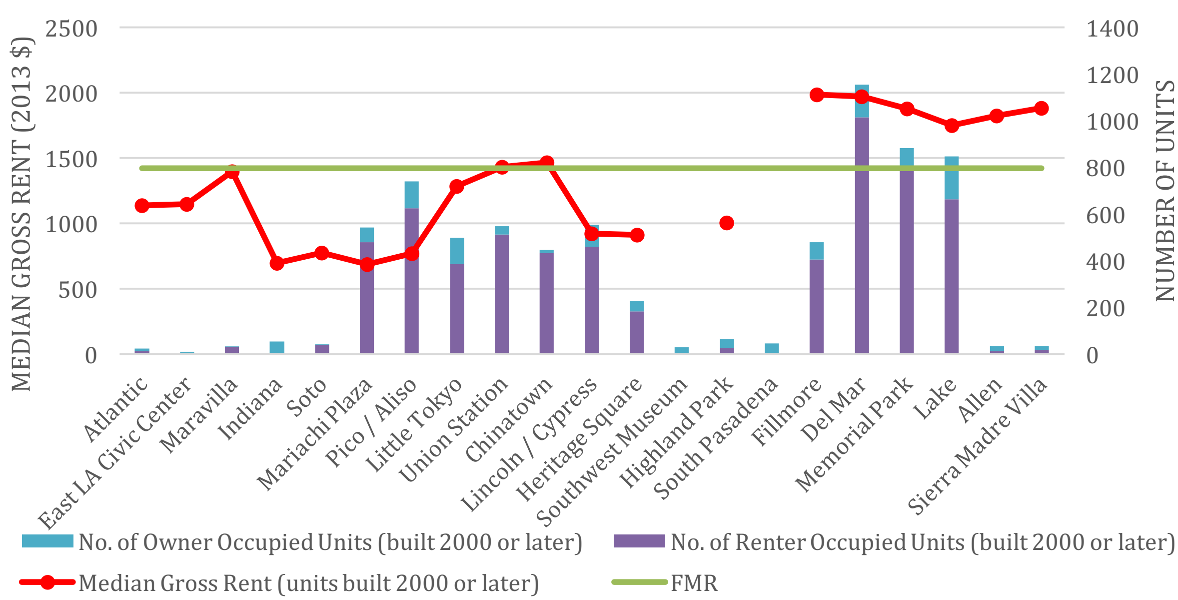

Figure 15b. Gold Line, Estimated Median Gross Rent of New Units (built 2000 or later) within Half-Mile of Stations

Source: American Community Survey (ACS) 2009-2013, Boarnet et al. (2015)

Measuring Mobility on the Red and Purple Subway and Gold Light Rail Lines

As a precursor to measuring neighborhood out-mobility rates, we look at the total population of households present in our data in each year, by income, for both transit corridors. As shown in Figure 16a, since 1993, the number of households living within the Red-Purple Line corridor (within 15 stations and their surrounding neighborhoods) has increased from around 65,000 to 95,000, growing at an average annual rate of 2.1%. The growth has not been even across income groups. Wealthier households with incomes above 80% of AMI have grown the fastest at 3.5% annually, followed by middle income households with 50-80% of AMI who grew at 2.6% annually, then lower-middle income households with 30-50% of AMI who grew at 2.1% annually, and finally low income households below 30% of AMI who grew at 1.1% annually. This trend was particularly pronounced in many station areas surrounding East Hollywood: Hollywood/Western and Vermont/Sunset; the eastern side of Koreatown: Vermont / Beverly and Wilshire / Vermont; and in Hollywood/Highland (Table 3a). This overall Red/Purple line trend reflects a compositional shift toward higher income in the population of households. This does not suggest displacement, though it may suggest gentrification.

Growth across Red-Purple Line station areas has not been even either. Dowtown-area stations, Wilshire/Vermont, and Hollywood/Western have seen the largest overall growth in households (Table 3a, right-most column). In general, growth rates are higher for stations which had fewer than 5,000 households in 2012, likely reflecting more capacity for growth from more empty or low-zoned lots and more development potential than some of the more populated station areas.

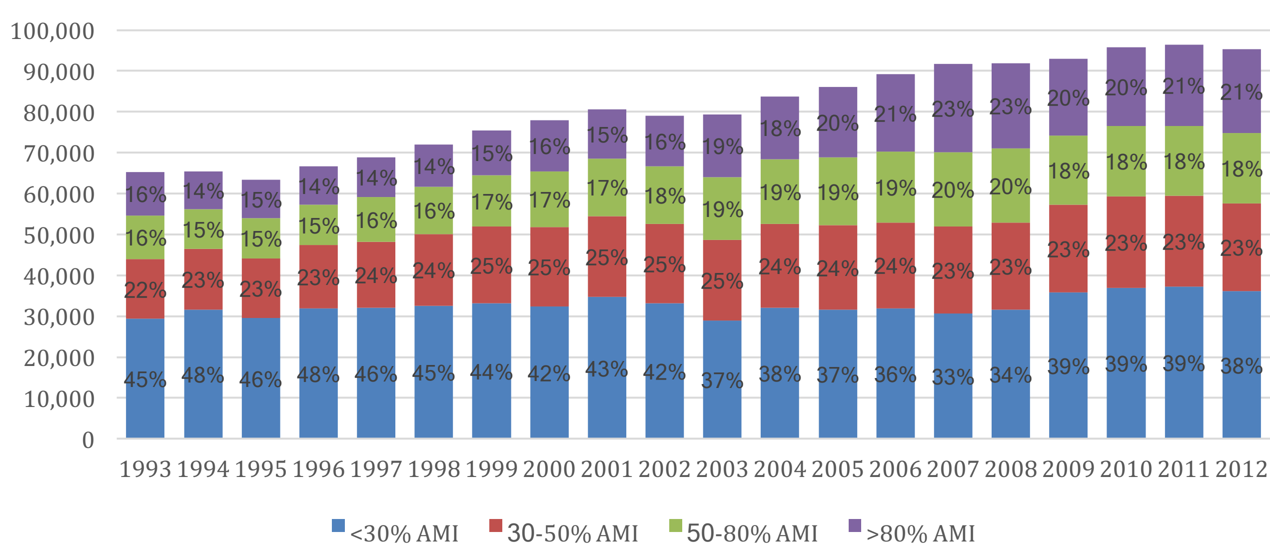

Figure 16a. Number of Households by Income Group, Red-Purple Line Station Neighborhoods, 1993-2012.

Source: Author calculations from FTB data.

Table 3a. Station-Area Household[19] Growth Rate by Income Group, by Income Group, Red-Purple Line Station Neighborhoods, 1994-2012[20].

Stations West-to-East	Number of Households (2012)	<30% AMI growth rate	30-50% AMI growth rate	50-80% AMI growth rate	>80% AMI growth rate	All Incomes Growth Rate
North Hollywood	5,000-10,000	1%	1%	1%	2%	1%
Universal City / Studio City	<5,000	4%	4%	3%	5%	4%
Hollywood / Highland	<5,000	2%	3%	5%	7%	4%
Hollywood / Vine	5,000-10,000	0%	1%	3%	5%	2%
Hollywood / Western	<5,000	4%	5%	8%	8%	6%
Vermont / Sunset	<5,000	2%	3%	4%	7%	4%
Vermont / Santa Monica	5,000-10,000	0%	1%	2%	3%	1%
Vermont / Beverly	<5,000	2%	3%	6%	8%	4%
Wilshire / Western	>10,000	0%	1%	2%	3%	1%
Wilshire / Normandie	>10,000	1%	3%	4%	5%	2%
Wilshire / Vermont	<5,000	3%	4%	7%	9%	5%
Westlake / MacArthur Park	5,000-10,000	1%	2%	3%	2%	2%
Pershing Square	<5,000	0%	6%	8%	7%	5%
Civic Center / Grand Park	<5,000	2%	10%	11%	10%	7%
Union Station	<5,000	0%	0%	1%	2%	1%

Source: Author calculations from FTB data.

In contrast to the robust 2.1% annual household growth in the Red/Purple line corridor, growth in the Gold line corridor over the same time period has been a tepid 0.9% annually, growing from about 63,000 in 1993 to 71,000 in 2012 (Figure 16b). There has been almost no growth in

[19] This graph shows households who are in the data (anywhere) for at least two consecutive years.
[20] For station-level growth rates, we use 1994-2012 growth rates rather than for 1993-2013 for data consistency purposes

the lowest-income below 30% of AMI household category; 30-50% of AMI and 50-80% of AMI categories have similarly grown quite slowly, at 0.7% and 1.0% annual growth respectively. The above 80% of AMI category has grown more rapidly at 2.4% annually. As with the Red/Purple line pattern above, this does not suggest displacement, but may be the beginning of gentrification along the Gold line.

As with the Red/Purple line, growth has been uneven by station. Station area neighobrhoods with higher initial populations appear to not have gained, or in some cases lost, households over the study period (Table 3b). This is likely due to having more developable land and empty lots near the less-populated stations. Geographically, growth has been robust in Pasadena-area stations, except Memorial Park, and this growth has been evident across the income spectrum, though the highest income strata has grown the most. South Pasadena, Highland Park, and Lincoln/Cypress neighborhoods lost population over the time period, whereas Southwest Museum and Heritage Square gained significantly, especially households in the 50-80% of AMI and above 80% of AMI categories. Little Tokyo / Arts District, an area which has seen new housing development (Figure 15b), has grown rapidly, and the population of households over 80% of AMI has grown by double digit percentages annually, albeit from a low base. The Boyle Heights station area neighborhoods of Mariachi Plaza and Soto have not gained households in this time period. In contrast, the East Los Angeles stations have gained households in every income category, with slightly higher increases in the highest income group.

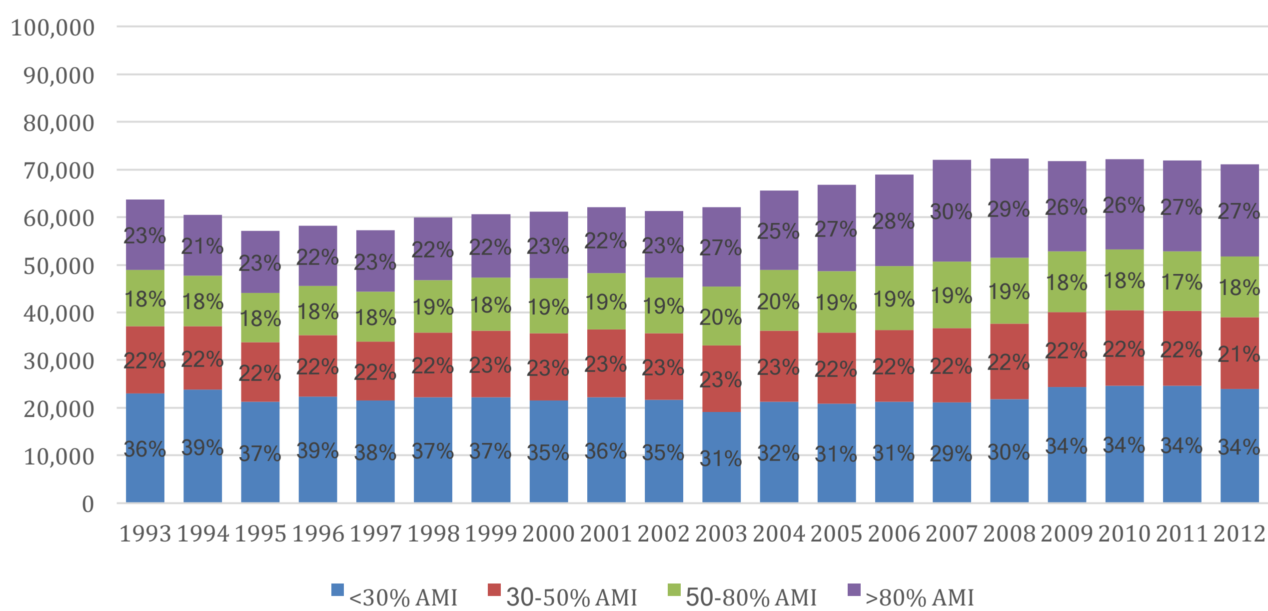

Figure 16b. Number of Households by Income Group, Gold Line Station Neighborhoods, 1993-2012.

Source: Author calculations from FTB data.

Table 3b. Station-Area Household[21] Growth Rate by Income Group, by Income Group, Gold Line Station Neighborhoods, 1994-2012[22].

Stations Northeast to Southeast	Number of Households (2012)	<30% AMI growth rate	30-50% AMI growth rate	50-80% AMI growth rate	>80% AMI growth rate	All Incomes Growth Rate
Sierra Madre Villa	<5,000	4%	3%	5%	7%	5%
Allen	<5,000	3%	2%	3%	6%	4%
Lake	<5,000	3%	4%	5%	8%	5%
Memorial Park	5,000-10,000	0%	-1%	0%	2%	1%
Del Mar	<5,000	4%	4%	4%	8%	6%
Fillmore	<5,000	3%	4%	3%	7%	5%
South Pasadena	5,000-10,000	-2%	-3%	-2%	0%	-1%
Highland Park	5,000-10,000	-1%	-1%	-2%	-1%	-1%
Southwest Museum	<5,000	4%	4%	7%	8%	6%
Heritage Square	<5,000	4%	5%	6%	11%	5%
Lincoln Heights / Cypress Park	5,000-10,000	-1%	-1%	-1%	0%	-1%
Chinatown	<5,000	1%	1%	2%	2%	1%
Little Tokyo / Arts District	<5,000	4%	5%	7%	13%	7%
Pico / Aliso	<5,000	2%	5%	6%	8%	4%
Mariachi Plaza / Boyle Heights	5,000-10,000	-1%	-1%	0%	2%	-1%
Soto	5,000-10,000	-1%	0%	1%	2%	0%
Indiana	<5,000	1%	4%	4%	7%	3%
Maravilla	<5,000	2%	4%	5%	6%	3%
East LA Civic Center	<5,000	2%	4%	5%	6%	3%
Atlantic	<5,000	3%	5%	5%	7%	5%

[21] This graph shows households who are in the data (anywhere) for at least two consecutive years.
[22] For station-level growth rates, we use 1994-2012 growth rates rather than for 1993-2013 for data consistency purposes

The Effect of Rail Station Openings on Residential Mobility

Methods

To ascertain the effects of rail station openings on residential mobility, we compare neighborhood-level out-mobility rates before and after a station opens. To isolate the effect of the rail station opening on mobility rates from other possible influences, we select a comparison or control neighborhood for each Gold and Red/Purple line stop. These control neighborhoods have similar demographic characteristics and are near the Red/Purple Line neighborhoods but do not have rail stations in them. This section explains our methodology, discusses controls selection, and presents the results.

Regression Model Equations

Two regression models were utilized to attempt to isolate the effect of rail station openings on neighborhood-level out-mobility rates: 1) Difference-in-Difference (DID) model and 2) Fixed Effects (FE) model.

The Difference-in-Difference (DID) model measures the effects of an event on a treatment group before and after the event, and compares it to the control group, which could have, but did not experience the event, also before and after the event occurred. In this case, the event is the opening of a rail-station, denoted by the binary variable rail_open, which takes the value of 1 if the rail station in question is open in that year and 0 otherwise. The treatment group consists of neighborhoods within one half-mile of rail stations and the control group of neighborhoods that are at least 1 mile from the rail station and have similar population density, minority proportion, and income. An underlying assumption of this model is that the trend in out-mobility rate is similar in slope before the event in both control and treatment groups. Our dependent variable is the out-mobility rate by neighborhood represented by Y. A baseline average level of out-mobility is represented by α, in Equation 1 below. Next, the DID model tests whether there is an initial difference in out-mobility between control neighborhoods and treatment neighborhoods, this is represented by β. The model also tests for all stations the difference before and after the event occurs, represented by γ. Finally, δ is our coefficient of interest, representing the effect on rail station neighborhoods once the station is open. ε represents unexplained error in the model.

<u>Equation 1</u>:

$$Out\ Mobility\ Rate\ (Y) = \alpha + \beta * treatment + \gamma * rail_{open} + \delta * (treatment * rail_{open}) + \varepsilon$$

The rail station-opening effect, δ, can also be obtained by subtracting sample averages from each sub-group, as in Equation 2.

Equation 2:

$$\delta = \left(Y_{treatment,post-event} - Y_{treatment,pre-event}\right) - \left(Y_{control,post-event} - Y_{control,pre-event}\right)$$

The Fixed Effects (FE) regression measures the effects of an event on a population controlling for characteristics that do not change over time, space, or other variable. The dependent variable is the out-mobility rate Y and the baseline level of out-mobility is represented by α in Equation 3 below. Our coefficient of interest is again δ, representing the effect on rail station neighborhoods once the station is open. Additionally, we add two fixed effects: time and geography. The fixed effect $Year_t$ is a variable that takes the value of 1 in a particular year, 1993-2012. This controls for events in particular years that may have affected the out mobility in all groups. It is hence 'fixed' across all station areas. The second fixed effect, $Neighborhood_i$, takes the value of 1 for each neighborhood across each year. This controls for neighborhood-specific idiosyncrasies that may affect the out-mobility rate but are not related to whether a station has opened there or not. These effects are things that generally do not vary year to year. ε represents unexplained error in the model.

Equation 3:

$$Out\ Mobility\ Rate\ (Y) = \alpha + \delta * \left(treatment * rail_{open}\right) + Year_t + Neighborhood_i + \varepsilon$$

Control Neighborhood Selection

Control neighborhoods were selected to test whether mobility rates were affected by rail station openings or by other factors. Each rail station was paired with a control neighborhood, surrounding a major road intersection at least one mile away from the station itself *(74)*. The control neighborhoods were picked to have similar population density, proportion of minority households, and income to the neighborhoods surrounding the rail station. Ostensibly, the control intersections could have received a rail station, but did not, due to political or planning processes. Using control neighborhoods as a comparison group is also helpful to thwart potential bias in rail-station neighborhood selection, since siting of rail stations is often of a political and planning nature, rather than a technical optimization based on ridership or other characteristics. See Schuetz et al. (2016) for a discussion. Neighborhoods were drawn as half-mile circles around the control intersections. Figures 17a and 17b map the treatment and control neighborhoods for Red/Purple and Gold lines and Table 4 lists treatment neighborhoods by station name and control neighborhoods by the center street intersection.

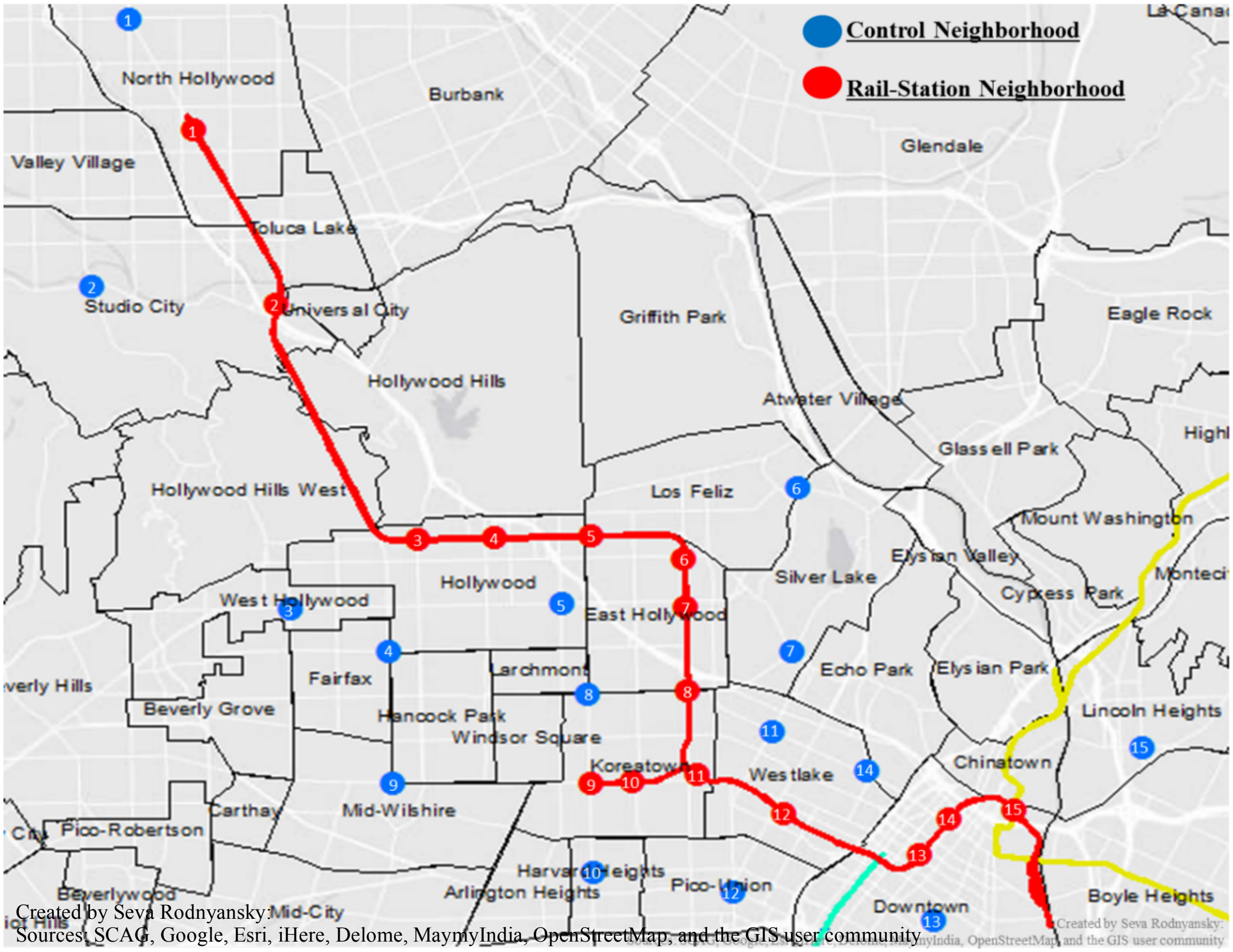

Figure 17a. Map of Los Angeles City Neighborhoods and Red/Purple Subway Line Stations and Controls.

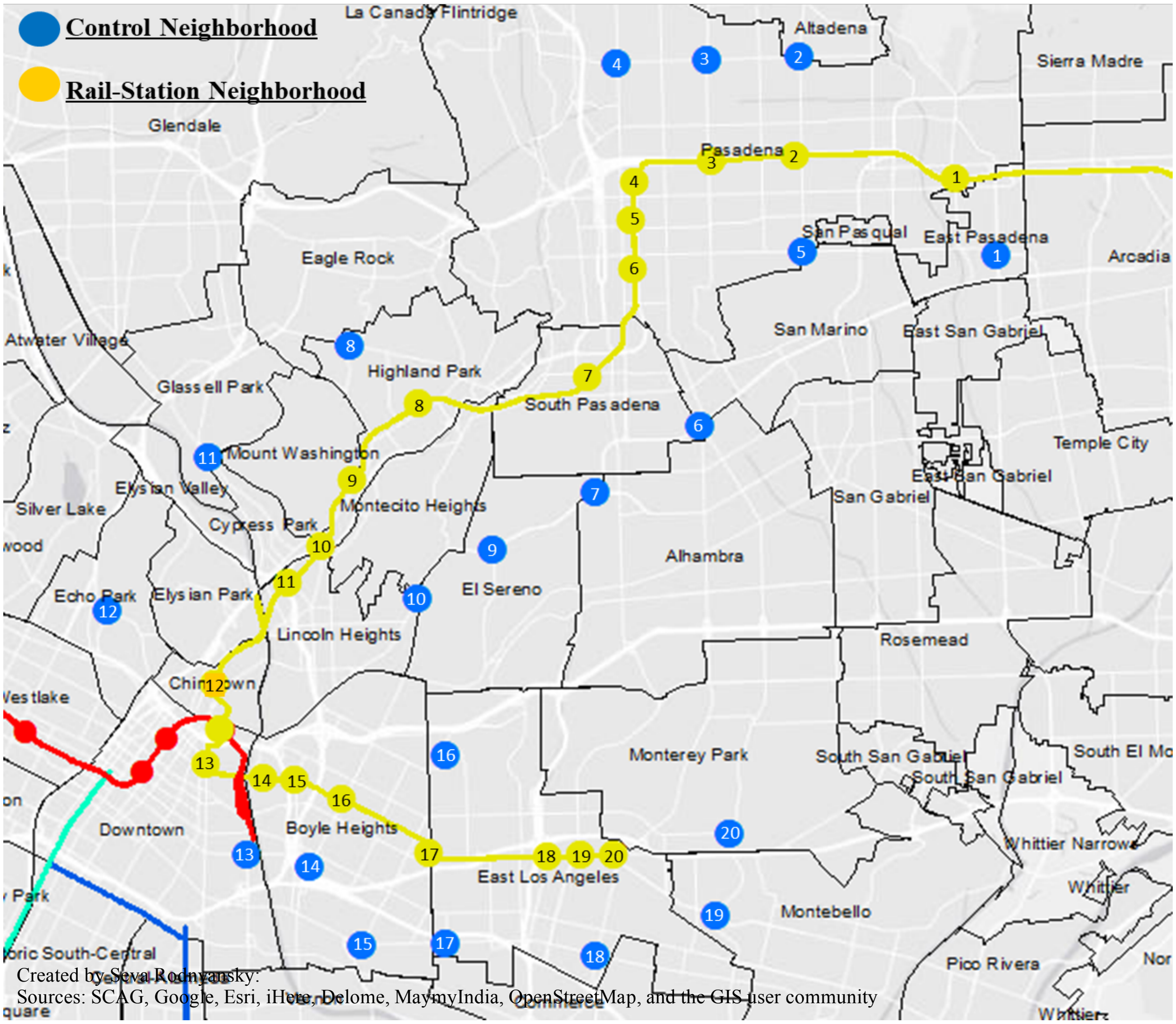

Figure 17b. Map of Los Angeles City Neighborhoods and Gold Line Stations and Controls

Table 4. List of Rail Station Neighborhoods and Paired Controls (Ordered West to East)

Line	Treatment Neighborhood	Paired Control Neighborhood
Red/Purple	North Hollywood	Victory / Lankershim / Colfax
Red/Purple	Universal City / Studio City	Ventura / Laurel Canyon
Red/Purple	Hollywood / Highland	Fairfax / Santa Monica
Red/Purple	Hollywood / Vine	Melrose / La Brea
Red/Purple	Hollywood / Western	Wilton / Santa Monica
Red/Purple	Vermont / Sunset	Rowena / Hyperion
Red/Purple	Vermont / Santa Monica	Sunset / Silver Lake
Red/Purple	Vermont / Beverly	Western / Beverly
Red/Purple	Wilshire / Western	Wilshire / La Brea
Red/Purple	Wilshire / Normandie	Pico / Western
Red/Purple	Wilshire / Vermont	Beverly / Rampart
Red/Purple	Westlake / MacArthur Park	Venice / Hoover
Red/Purple	Pershing Square	San Pedro / 8th St
Red/Purple	Civic Center / Grand Park	1st / 2nd / Lucas / Beverly / Glendale
Red/Purple	Union Station	Main / Griffin
Gold	Sierra Madre Villa	California / Rosemead
Gold	Allen	Washington / Allen
Gold	Lake	Lake / Washington
Gold	Memorial Park	Fair Oaks / Washington
Gold	Del Mar	California / Allen
Gold	Fillmore	Huntington / Garfield
Gold	South Pasadena	Huntington / Main
Gold	Highland Park	York / Avenue 50
Gold	Southwest Museum	Eastern / Huntington
Gold	Heritage Square	Heritage / Soto
Gold	Lincoln Heights / Cypress Park	Cypress / Division
Gold	Chinatown	Sunset / Echo Park
Gold	Little Tokyo / Arts District	7^{th} / Santa Fe
Gold	Pico / Aliso	Soto / 8^{th}
Gold	Mariachi Plaza / Boyle Heights	Olympic / Lorena
Gold	Soto	City Terrace / Pomeroy
Gold	Indiana	Olympic / Ditman
Gold	Maravilla	Olympic / Atlantic
Gold	East LA Civic Center	Beverly / Garfield
Gold	Atlantic	Garfield / Riggin

Results

This section presents the baseline mobility rates and rail-station opening effects for the Red/Purple and Gold line corridors across both regression methods. The baseline annual average neighborhood mobility rate in Red/Purple line station areas is 28% and in Gold line station areas is 22-23% (Figure 18a & 18b). These are both higher than the 21% county-wide rate. Red/Purple is much higher, likely reflecting the very high renter rates found in those neighborhoods. In general, these high mobility rates suggest there is a lot of moving out and churn in these neighborhoods. The highest income groups in both corridors have lower baseline mobility rates – 23% Red/Purple line and 18-19% Gold line – compared to other income groups (Figures 18a,b). This follows patterns observed in national and county-level mobility statistics (Figure 8 and Tables 2a and 2b).

The rail station opening effect diverges by transit corridor and by specification (Figures 18a & 18b). Estimates of mobility attributed to rail station opening range from near 0% on Red/Purple line to 3% on Gold line using Difference in Difference (DID). Fixed effects estimates fit within this range. The magnitude of the rail station opening effect on mobility thus ranges from 0% to 17%. However, not all of the rail station opening effects are statistically significantly different from zero. Only in the case of Gold line DID is the rail station opening effect consistently statistically significant across all income groups. This is also the highest magnitude effect, contributing 17% to mobility for households with incomes greater than 80% of AMI and 8% for those with incomes below 30% of AMI. Conversely, no rail station effects are statistically significant using the DID method for the Red/Purple line corridor. Fixed effects estimates show a significant finding for all incomes and for the lowest income group in Red/Purple line neighborhoods with a magnitude of 3% and 4% respectively. For Gold line fixed effects, only the 30-50% of AMI category's rail station effect is statistically significant. Generally speaking, the high baseline mobility rates dwarf the small rail station effect magnitudes, except for in the Gold line DID results.

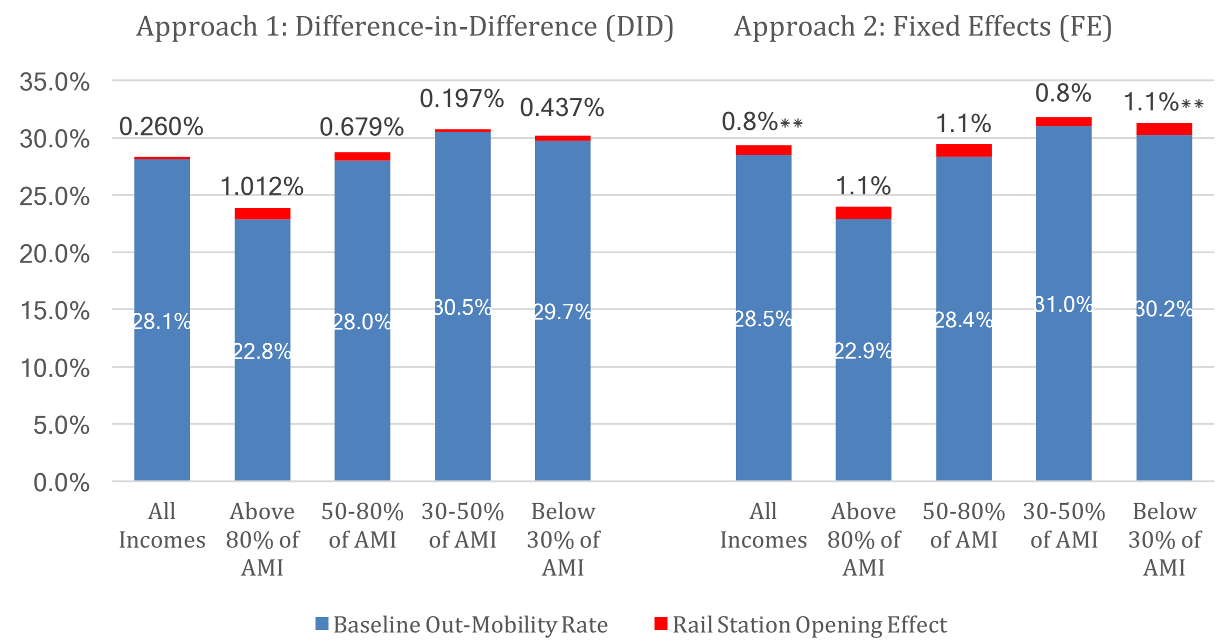

Figure 18a. Out-Mobility Rate and Rail Station Opening Effect Estimates by Income Group for Red-Purple Subway Line Neighborhoods and Controls
*Statistical significance: *** p<0.01, ** p<0.05, * p<0.10*

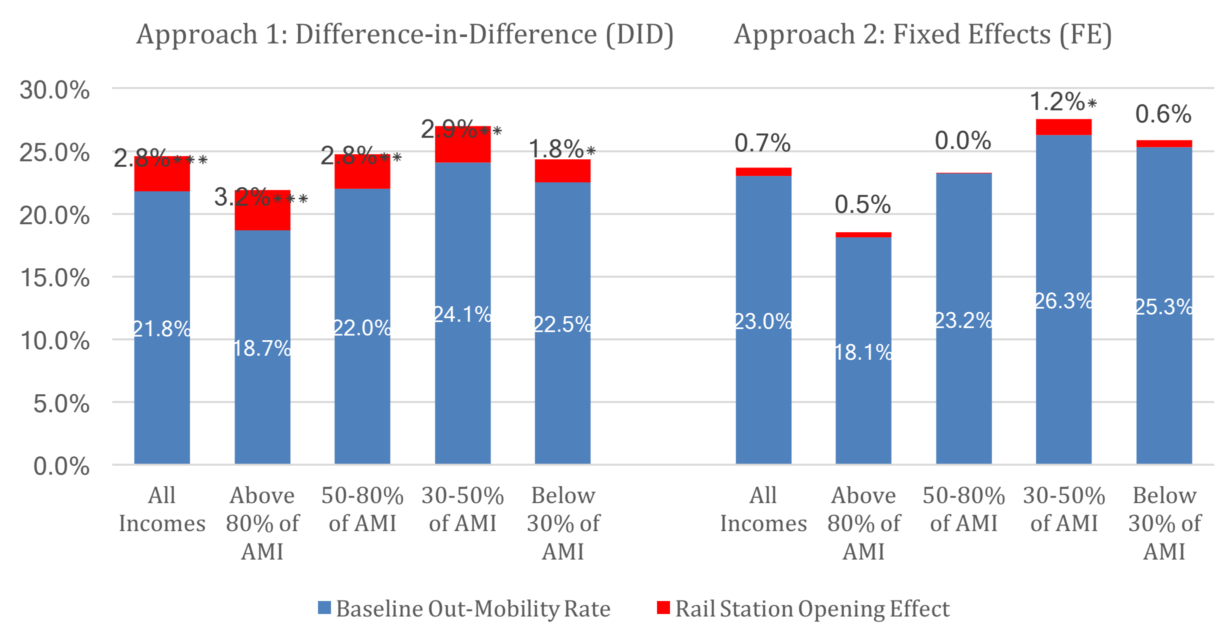

Figure 18b. Out-Mobility Rate and Rail Station Opening Effect Estimates by Income Group for Gold Light-Rail Line Neighborhoods and Controls
*Statistical significance: *** p<0.01, ** p<0.05, * p<0.10*

Estimating the out-mobility trends annually gives a more nuanced picture. Figures 19a and 19b show predicted values for annual out-mobility rates from the fixed effects specification for both rail lines. While, the two-decade Red/Purple Line out-mobility average is 28%, it does follow a pattern similar to L.A. County and the U.S. over time: decreasing mobility from about 33% through the 1990s and plateauing in the 2000s at around 26%. Gold line mobility rates similarly decrease over the study time period. Interestingly, out-mobility from these neighborhoods increased slightly during and after the Great Recession. The various income groups follow a similar pattern over time. However, the mobility rates for lowest, lower, and middle-income households converge closer to the higher-income households in the 2000s for the Red/Purple line but not for the Gold line.

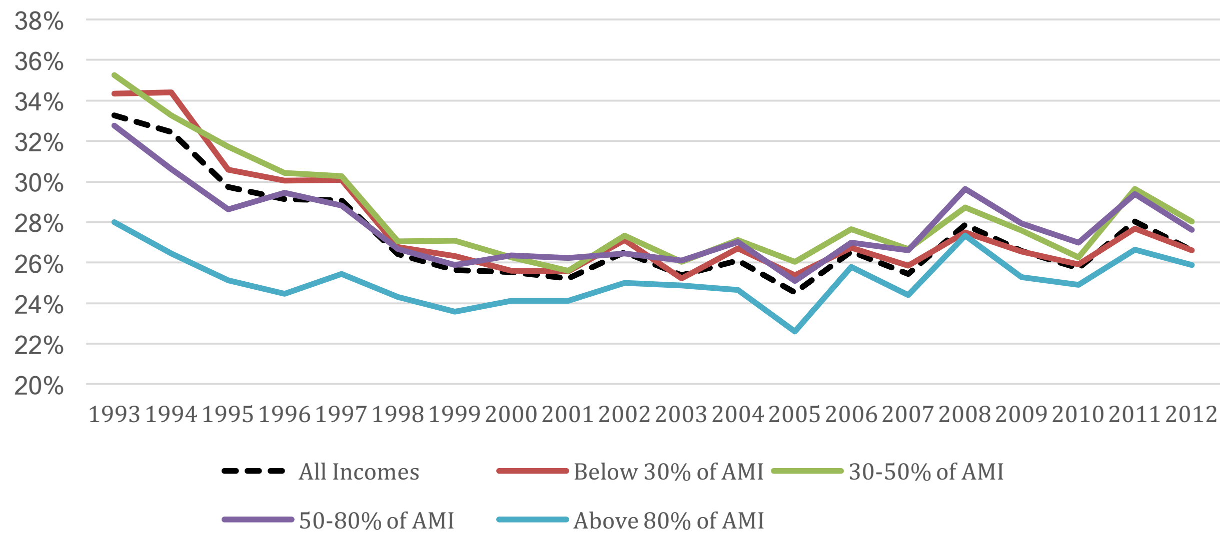

Figure 19a. Predicted Estimates of Red/Purple Subway Line Mobility Rate by Year by Income Group using Fixed Effects specification

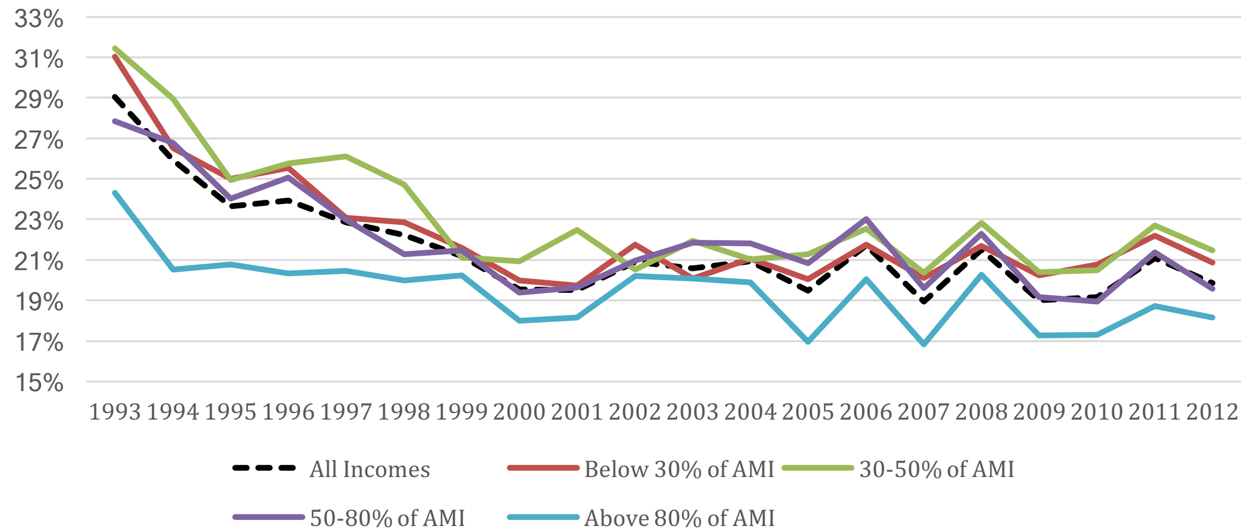

Figure 19b. Predicted Estimates of Gold Light Rail Line Mobility Rate by Year by Income Group using Fixed Effects specification

We also compare line-wide mobility estimates to predicted mobility rates for each station. In Red/Purple line neighborhoods, mobility rates vary across stations by as much as 18 percentage points (Figure 20a). This variation does not seem to be correlated with demographic or development patterns described in figures 10-15: income, renter proportion, minority and foreign born percentage, rents, or the number of new units built. The Gold line also has mobility rates that vary by up to 22 percentage points (Figure 20b). However, mobility rates have a more pronounced spatial pattern: East LA and Northeast LA station neighborhoods have lower out-mobility rates, while downtown Pasadena neighborhood and Little Tokyo have higher out-mobility rates.

Digging deeper into each station area, tables 5a and 5b provides a breakdown of out-mobility rates per station by income group. Several patterns emerge. In ten out of fifteen Red/Purple and nine of twenty Gold line stations, the lowest-income group has a higher-mobility rate than the highest-income group; some by as much as 10% higher (Vermont/Santa Monica, Universal City/Studio City, Pershing Square, Sierra Madre Villa, Allen, Heritage Square, and Pico/Aliso). In the remainder of Red/Purple line neighborhoods, the highest-income group in fact has the highest mobility rate, while on the Gold line, the 30-50% of AMI income group has high out-mobility rates. Chinatown station, in contrast, has a unique and opposite pattern: out-mobility is higher by 8 percentage points for higher-income households than lower-income households. This variety of patterns continues to underscore the diversity of experience for households of different income groups across these neighborhoods.

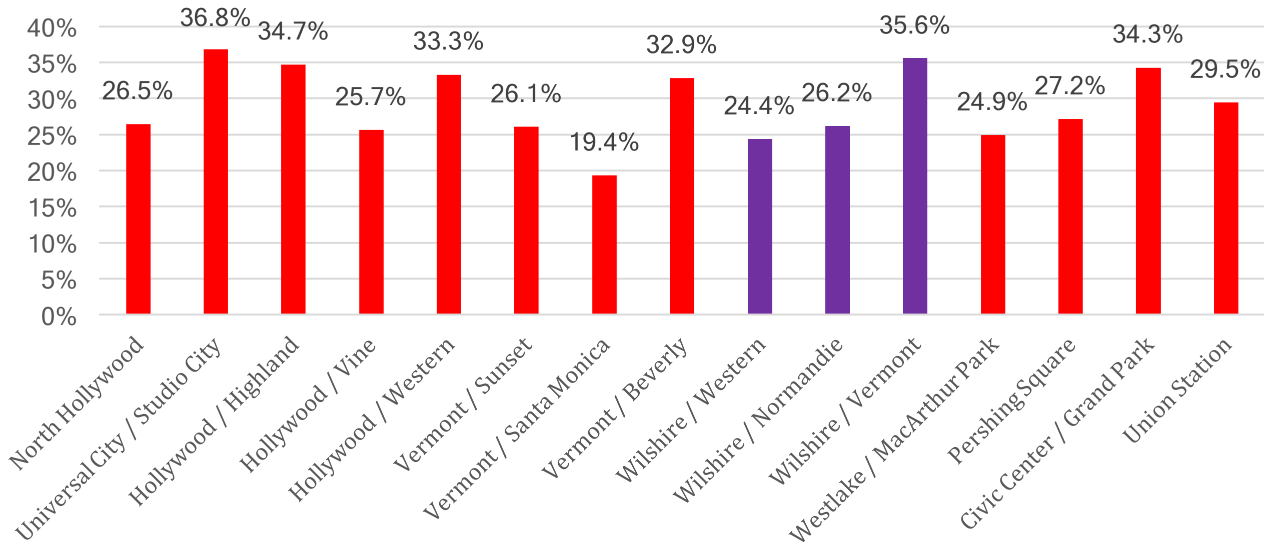

Figure 20a. Predicted Out-Mobility Rate by Red/Purple Line Station Neighborhood (Ordered West to East, Purple Line Stations in Purple, Red Line in Red)

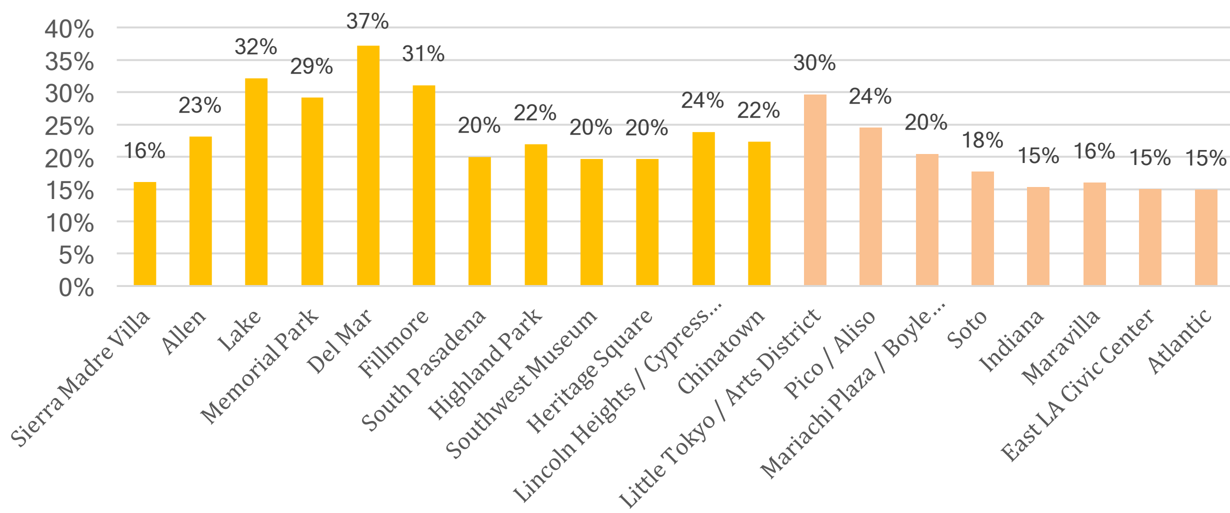

Figure 20b. Predicted Out-Mobility Rate by Gold Line Station Neighborhood (Ordered Northeast to Southeast; Pasadena branch in Gold, East LA branch in Salmon)

Table 5a: Predicted Out-Mobility Rate Estimates by Red/Purple Line Station Neighborhood by Income Group (Ordered West to East, Purple Line Stations in Purple, Red Line in Red)

Station Neighborhood	<30% AMI	30-50% AMI	50-80% AMI	>80% AMI
North Hollywood	26.6%	26.8%	26.3%	26.1%
Universal City / Studio City	38.2%	40.8%	40.4%	33.7%
Hollywood / Highland	35.5%	35.6%	34.8%	32.8%
Hollywood / Vine	25.7%	25.6%	25.2%	26.2%
Hollywood / Western	33.2%	34.4%	34.3%	30.2%
Vermont / Sunset	26.5%	26.5%	25.7%	24.3%
Vermont / Santa Monica	19.7%	19.5%	19.2%	17.4%
Vermont / Beverly	33.2%	34.1%	30.9%	30.8%
Wilshire / Western	24.9%	24.2%	23.9%	23.9%
Wilshire / Normandie	26.2%	25.8%	26.2%	26.4%
Wilshire / Vermont	35.4%	36.3%	35.5%	34.2%
Westlake / MacArthur Park	24.4%	24.8%	26.1%	26.2%
Pershing Square	28.3%	28.6%	28.8%	25.3%
Civic Center / Grand Park	32.8%	33.1%	33.7%	34.2%
Union Station	27.9%	29.1%	31.9%	30.3%

Table 5b. Predicted Out-Mobility Rate Estimates by Gold Light Rail Line Station Neighborhood by Income Group (Ordered from Northeast to Southeast, Pasadena Branch in Gold, East Los Angeles Branch in Pink)

Station Neighborhood	<30% AMI	30-50% AMI	50-80% AMI	>80% AMI
Sierra Madre Villa	17.0%	15.4%	16.8%	14.9%
Allen	24.9%	24.0%	24.6%	20.7%
Lake	31.6%	32.6%	33.5%	31.3%
Memorial Park	29.4%	29.0%	29.8%	28.7%
Del Mar	37.4%	40.9%	37.0%	36.4%
Fillmore	30.8%	34.5%	31.5%	30.0%
South Pasadena	21.2%	21.8%	21.5%	18.7%
Highland Park	22.4%	22.3%	21.9%	21.0%
Southwest Museum	21.4%	21.4%	21.5%	15.7%
Heritage Square	20.3%	19.9%	19.6%	17.2%
Lincoln Heights / Cypress Park	24.1%	24.3%	23.6%	22.6%
Chinatown	19.1%	20.6%	25.6%	27.9%
Little Tokyo / Arts District	30.7%	30.3%	30.2%	27.3%
Pico / Aliso	25.5%	24.6%	23.5%	21.9%
Mariachi Plaza / Boyle Heights	20.8%	20.7%	20.4%	19.0%
Soto	17.9%	17.6%	17.3%	17.4%
Indiana	15.9%	15.8%	14.1%	13.5%
Maravilla	16.4%	17.0%	14.9%	13.7%
East LA Civic Center	15.6%	15.9%	13.7%	13.1%
Atlantic	16.0%	16.2%	13.9%	12.6%

Discussion and Conclusion

This research tries to better understand the processes of displacement and gentrification by looking at out-mobility rates in transit-oriented developments. We hypothesized that the presence of rail transit would increase household out-mobility rates relative to a counterfactual. Using a tax filer database from the California Franchise Tax Board, we calculated population outflow rates for 35 station area neighborhoods and 35 control neighborhoods along L.A. Metro's Red/Purple and Gold rail lines. Then, we utilized a panel fixed effects and difference-in-difference models to test the effect of the presence of an open rail station on household out-mover rates at the neighborhood level.

We highlight four main findings. First, mobility measures are sensitive to noisy input data, but our measures are precise for household moves greater than one-half (0.5) mile and for households who file taxes in consecutive years. Second, Los Angeles County exhibits stable mobility patterns across move distances and income bands: a) 21% of households move at least 0.5 miles every year, b) lowest-income households have a 5 percentage-point higher out-move rate than the highest-income households, and c) higher-income households are more likely to move outside of Los Angeles County (greater than 100 miles) than poorer households. These county-level mobility rates are higher than the 12% suggested by national averages *(75)*, but are consistent with a high level of neighborhood-level mobility found in other research *(68, 69)*, and likely reflect the high renter rate in Los Angeles County. Third, when looking at transit-oriented neighborhoods, we find the baseline mobility rate is higher than at the county level: 22% for Gold line and 29% for the Red/Purple line station neighborhoods. This reflects a very high degree of mobility in these dense, urban, high renter concentration neighborhoods. In these transit-oriented neighborhoods, lower-income households have higher baseline out-mobility rates than higher-income households: by 4 percentage points along the Gold line and 7 percentage points along the Red/Purple line. This translates to 18% and 23% higher mobility rates for households with incomes below $15,000 (in 2012) compared to households with incomes above $40,000 (in 2012). Fourth, the opening of a rail station in a neighborhood is estimated to increase out-mobility rates by 0-3 percentage points for an effect size of 0-17%, depending on the transit line and statistical methodology used. However, the rail station opening effects are only statistically significant for all income groups along the Gold line and for the lowest-income group along the Red/Purple line.

Our findings do not provide clear evidence that rail stations openings displaced lower-income households between 1993-2013 in Gold or Red/Purple line neighborhoods, en masse. For the Gold line, in statistically significant difference in difference estimates it appears that the magnitude of the rail station opening effect on out-mobility rates is greatest for higher-income households (17%), compared to working class households (12-13%) and lowest-income households (8%). In fact, the effect of Gold line rail station openings appear to narrow the out-mobility rate gap between the highest and lowest income households. By contrast, our fixed-effect estimates suggest Red/Purple line station openings increase the out-mobility rate gap between the lowest and highest income households. Thus, effects of rail station openings on mobility rates are mixed and context dependent.

While our current findings raise more interesting questions, we aim to advance our research further to take advantage of this data source and approach. Our current sample includes the Red/Purple and Gold line station: we plan to expand the analysis to the three other L.A. Metro lines. We will also continue to analyze key displacement trends in further detail to understand neighborhood level variation.

Our main finding, that transit-proximate neighborhoods, have mobility rates upwards of 30% annually, indicates much flux. Possibly, the composition of a whole neighborhood could change in four years, with all new residents, though this scenario is not very likely. At the same time, we see variation in overall household growth, leading to potentially different conclusions. The Red/Purple line corridor has seen an increase in the number of households from 65,000 in 1993 to 95,000 in 2013, while the Gold line corridor increase has only been 5,000 households off of the same base. This implies that the in-mobility rate is even higher for Red/Purple line neighborhoods and indicates much turnover over the past two decades. Whereas Gold line neighborhoods appear to be seeing less turnover, consistent with a lower level of residential development. Together, these findings beckon at least three follow-up questions: 1) why is there so much mobility, 2) what are the outcomes for households, 3) and what are the outcomes for neighborhoods?

Households across the U.S. move for many reasons, with housing chief among them. In this report, we examined whether the opening of a new rail station helps explain the high mobility in the Red/Purple and Gold line corridors. We find that our estimated effect of a new rail station opening on the out-mobility rate is small (0-3 percentage points) and varies by line and approach. This 0-3% is dwarfed by the overall 22-29% mobility rate.

We believe there are several possible reasons for why the rail-station effect is low. First, our data includes households who file taxes in consecutive years. This may exclude some of the lowest-income households who are below the state filing mandates. However, we believe that this is moderated by the high percentage of low-income filers who claim the EITC. Second, the development effects and behavior change from new transit investments can be felt over a long period of time, often as much as a few decades. Some stations in this report have been open over twenty years, while others fewer than ten years. Perhaps the station opening effects need to be measured over a longer time frame. Third, we exclude households who do not appear in the data in consecutive years. This may disproportionately affect lower-income households who may not be required to file every year. Finally, our present sample size may be insufficiently large to detect minute changes in mobility rates. Together, these reasons possibly affect the low rail-station opening effect.

We believe our results provide at least a conservative estimate of rail station opening effects on mobility. Also, we cannot overstate the importance of better understanding the causes and outcomes of the very high baseline mobility rates found along Los Angeles County's transit corridors. Our future research is focused on better understanding the characteristics of movers, their destination neighborhoods, and in-mobility rates.

These results raise a set of interesting follow-up questions. How unique is Los Angeles County in its mobility characteristics and in its response to rail station openings? We will work toward incorporating other California regions to provide a relevant comparison group. What are the housing-market impacts of high out-mobility? Specifically, do these patterns change the demand for particular housing types or the level of valuations? While the FTB dataset does not link to housing units or provide housing information, we will attempt to overlay other housing data in exploring these questions. What are the implications of high out-mobility on transit-oriented development? What are mitigating strategies for displacement around rail stations? In future work, we may compare case studies of particular transit-oriented developments and how they fared vis-a-vis out-mobility. We will isolate programmatic or development policies for those cases more able to stem displacement.

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