POLICY BRIEF

Residential Density

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April 2025

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Project Description

This project reviews and summarizes empirical evidence for a selection of transportation and land use policies, infrastructure investments, demand management programs, and pricing policies for reducing vehicle miles traveled (VMT) and greenhouse gas (GHG) emissions. The project explicitly considers social equity (fairness that accounts for differences in opportunity) and justice (equity of social systems) for the strategies and their outcomes. Each brief identifies the best available evidence in the peer-reviewed academic literature and has detailed discussions of study selection and methodological issues.

VMT and GHG emissions reduction is shown by effect size, defined as the amount of change in VMT (or other measures of travel behavior) per unit of the strategy, e.g., a unit increase in density. Effect sizes can be used to predict the outcome of a proposed policy or strategy. They can be in absolute terms (e.g., VMT reduced), but are more commonly in relative terms (e.g., percent VMT reduced). Relative effect sizes are often reported as the percent change in the outcome divided by the percent change in the strategy, also called an elasticity.

Summary

Strategy Description

Residential density is typically measured either as a ratio of persons divided by land area (e.g., persons per square mile) or housing units divided by land area (e.g., dwelling units per acre). Density increases occur either as a result of infill development or when new development is at higher densities than existing development, either through market forces or through policy incentives such as zoning or land use regulation changes.

Behavioral Effect Size

The literature provides strong confidence in density effect sizes on per capita or per household vehicle miles traveled (VMT) in the range of 7% to 12%. By that, we mean that a 100% increase (doubling) in residential density would be associated with a 7% to 12% decrease in VMT. The effect size might be even larger; there are estimates that give, for a doubling of density, a 19%-22% reduction in VMT.

Strategy Extent

Density is a neighborhood-scale variable. Infill development will increase density, but new development anywhere at a higher density than surrounding development will increase density. Because density changes as the built environment changes, a coordinated planning approach and/or framework that spans years or decades is helpful, and many but not all successful infill approaches use such a framework. While density changes might seem slow, requiring from a few years to one to two

DOI: 10.7922/G2VQ312R

decades, those changes are difficult to reverse once put into place and occur on time scales similar to those of major infrastructure projects.

Strategy Synergy

Density is a proxy variable, picking up the effect of proximity to downtown or employment centers, access to transit, mixed land uses, and supportive walking environments. Density by itself might be less important than those other factors. There is evidence of synergies across land use variables, such that changing multiple land use variables at once likely results in VMT reductions that are more than the sum of individual land use effect sizes.

Equity Effects

The equity effect of densification runs primarily through the increasing housing cost associated with increasing density which directly and indirectly impacts lower-income households' mobility and welfare. Increasing housing costs tightens households' transportation budgets and can lead to relocation to lower housing-cost neighborhoods that require more driving. Policies to increase density can sometimes mitigate the risk of displacement or relocation but with some limitations.

Strategy Description

Policies that will result in higher densities have often been mentioned in the suite of land use tools that might reduce vehicle travel, as measured by vehicle miles traveled (VMT) or, more recently, greenhouse gas (GHG) emissions produced by the transportation system. Density is usually measured as residential density – most often as a ratio of persons divided by land area (e.g., persons per square mile) or housing units divided by land area (e.g., dwelling units per acre). More recently, density has been measured by a sum of persons plus total jobs divided by land area (e.g., the sum of persons plus jobs per square mile). Less commonly in the research literature on driving and travel behavior, density is employment density – total jobs divided by land area.

Approaches to increasing density include modest upzoning (e.g., allowing duplex or fourplex units in locations zoned for single-family), auxiliary dwelling units, or larger scale permitting to foster infill development.

Density is correlated with a large number of land use traits that are associated with variations in travel behavior, including mixed land uses, transit access, the quality of the pedestrian environment, and proximity to regional employment or shopping centers. Density is both a variable that directly affects travel and also a variable that proxies for the effect of those other land use characteristics such as proximity to employment centers, transit access, mixed land use, and the quality of pedestrian and non-automobile infrastructure. Many planning researchers believe that policy attention should focus not only on density but on a more holistic set of land use characteristics (see, e.g., Chatman, 2008).

While there are many ways to increase density, how density happens can pose equity issues. First, large infill development and large-scale investments within a neighborhood can accelerate displacement (Zuk et al., 2018). Second, the lack of affordable housing can increase overcrowding (possibly due to displacement) and lead to unhealthy housing outcomes (Sims and Sarmiento, 2023). For those reasons, density increases should be evaluated in light of impacts on communities that are at risk of displacement and the availability of affordable housing. One mitigating approach is policies that foster opportunities for workforce or similar housing (e.g., rental housing near schools, health care, and the like).

Strategy Effects

Behavioral Effect Size

The table below summarizes the results from studies that met the following criteria:

- the studies used data for individuals or households,
- the studies were within the US,
- the studies were from geographic settings that included multiple metropolitan areas,
- the studies controlled for a broad range of individual or household sociodemographic characteristics, and
- the studies used statistical methods to control for the possibility that persons might choose where to live based in part on how they wish to travel.

The studies that meet those criteria are listed in Table 1. A 2009 National Research Council (2009) report used some of the studies in Table 1 to conclude that, on average, doubling residential density is associated with VMT reductions that range from 5% to 12%. Since then, more sophisticated methods and additional studies have found effect sizes in a similar range.

Table 1 lists two meta-analyses, by Ewing and Cervero (2010) and Stevens (2017). Meta-analyses either average the effects from multiple studies or, as in the case of Stevens (2017), use regression analysis to develop an estimate of the average impact from the literature. The other studies in Table 1 used data that were national (Bento et al., 2005; Duranton and Turner, 2018) or from California (Brownstone and Golob, 2009; Heres-Del-Valle and Niemeier, 2011). The estimates of effect sizes are largely within the range of the 2009 National Research Council study, with the exception of Heres-Del-Valle and Niemeier (2011) and Stevens (2017). The 22% effect size from Stevens is adjusted for the possibility that persons might choose their residential location in part based on their preferences or constraints on travel (e.g., transit-dependent individuals), and hence is more reliable than Stevens' 10% effect size. We have strong confidence in density effect sizes (on VMT) in the range of 7% to 12%, with the possibility that the effect is as large as the 19% to 22% measured by Heres-Del-Valle and Niemeier (2011) and Stevens (2017).

Table 1. Density and VMT: Results from Studies of Individual or Household Travel

Study	Study Location	Study Year(s)	Built Environment Variable	VMT Reduction for 100% Change in Built Environment Variable
Bento et al. (2005)	114 US MSA's	1990	City shape, jobs-housing balance, road density, rail supply – each variable alone	Less than or equal to 7%
Brownstone and Golob (2009)	California	2001	Population density	12%
Duranton and Turner (2018)	US	2009	Population + employment density	7% to 10%
Ewing and Cervero (2010)	Meta Analysis (> 50 studies, largely in the US)	Various	Population density	4%
Heres-Del-Valle and Niemeier (2011)	California	2001	Population Density	19%
Stevens (2017)	Meta Analysis (37 studies, largely in the US)	Various	Population density	10% to 22%

Co-Benefits

Increases in density should be considered as part of coordinated land use plans, rather than in isolation. There are many possible co-benefits from land use policies that encourage higher residential densities. Increases in non-motorized travel might bring health benefits, and there is evidence that land use characteristics, including higher residential density, are associated with increased walking (e.g., Boarnet, Greenwald, and McMillan, 2008; Boarnet et al., 2011). However, increases in walking may only partially compensate for reductions in other kinds of physical activity, so health benefits may not scale one-for-one with increases in walking (see, e.g., Rodriguez, Khattak, and Evenson, 2006). The shifting of trips from motorized to non-motorized modes will also have positive impacts on local and regional air quality. More generally, the land use elements associated with non-motorized travel are often associated with vibrant neighborhoods and may be associated with strong sense of place or community resident satisfaction. However, density by itself may not be the most important variable for community livability. In Song and Knaap (2003), factors such as street connectivity, transit access, and pedestrian access to shopping were associated with higher house prices, which is consistent with those neighborhood characteristics being more valued by home buyers.

Extent

Scale of Application: The studies cited in Table 1 typically measure density at the scale of a census tract, census block group, or circles within 1 kilometer around a residence. (Duranton and Turner used both 1 km and 10 km circles and found virtually no variation in effect sizes across those two distance bands.) Overall, this literature is focused on the scale of a neighborhood, often a short drive (e.g., within 5 to 10 minutes) or a distance could walk (e.g., within 15 minutes).

Efficiency or Cost: Density increases in urban areas typically require infill development. Such increases are possible and are often financed in large part by private developers. There can be complexities in approvals and the availability of supportive infrastructure. Even when the direct public cost might be low, infill developments are complex to build and benefit from a supportive policy and planning context.

Time / Speed of Change: Neighborhood density usually changes slowly. Depending on the health of the real estate market, the timeframe for new developments can range from a small number of years to decades. This long timeline means that changes in VMT might also be gradual.

Some infill, particularly large downtown redevelopments, at times leads to displacement of lower-income residents (who drive less) and replacement by higher-income residents (Saito, 2022). Depending on where displaced people go (e.g., less transit-rich areas), the decrease in VMT by new residents may be countervailed by an increase among displaced residents who now must rely on car travel. Because of that, and for equity reasons, large redevelopment projects with displacement potential should have programs and policies to support current residents.

Location within the Region: Density increases are often associated with infill development. The studies in Table 1 are drawn from national or statewide samples, and that suggests that increased density outside of core urban areas will also deliver VMT reduction.

Differences between Regions: Zahabi et al. (2015) find that a 100% increase in density is associated with a 22 percent reduction in VMT in Montreal – an effect size at the high end of the estimates in Table 1. Zahabi et al. (2015) suggested that Montreal's well- developed alternatives to car travel (transit, walking) might lead to the higher estimated impact of density on driving. This suggests the possibility that regions and locations with better alternatives to car travel might see a higher effect size for density on driving.

Equity

Lower-income households drive less than moderate and higher-income households, and still less when they live in dense, central urban neighborhoods (Howell et al., 2018). In large part, the difference in VMT at different income levels reflects the high cost of transportation and competing costs, notably housing. The increasing housing cost associated with densification can, directly and indirectly, impact lower-income households' mobility and welfare.

Densification is often part of a widespread, regional wage growth which, when unequally distributed, increases housing costs more than wages at the lower end of the distribution. The higher housing cost displaces households' transportation budget and can curtail the ability to reach essential services like health care and grocery shopping and exacerbate vulnerability to price shocks such as gas prices (Li et al, 2018).

Households who face the tradeoff between housing and transportation may adjust by moving to lower housing cost areas farther away from the city center. The decision to move farther from the city center increases VMT without necessarily improving financial security if transportation costs more than offset housing savings (Blumenberg and Wander, 2022). In many cases, densification can force the decision to move due to the residential displacement redevelopments cause. Many cost-constrained households with few options end up in crowded and subpar housing (Hwang and Shrimali, 2021, Cavicchia, 2023).

Governments have attempted to address the financial stress due to high housing costs with policies to increase affordable housing. Inclusionary housing policies offer developers density-based incentives in exchange for the inclusion of a minimum share of residential units affordable to lower-income people. While these policies are often insufficient to prevent displacement, they can result in greater accessibility and transportation costs for lower-income residents.

Subsidized housing programs like the Low-Income Housing Tax Credit (LIHTC) have targeted lower-poverty neighborhoods to develop affordable housing opportunities. In many cities, these neighborhoods also have higher transportation costs. The correlation between higher shares of Black and Latino residents and lower transportation and housing costs creates a tension between the goals of deconcentrating poverty and reducing racialized segregation while increasing accessibility (Riena et al, 2019).

Private sector-driven development is the primary mechanism of densification in the United States, but more incremental mechanisms are relevant in California. Accessory dwelling units (ADU) can slowly increase the density of a neighborhood when homeowners subdivide their properties. Informality in the face of high cost and regulatory burden significantly blurs the outcomes of ADU development and can contribute to housing insecurity or improve affordability in high-opportunity neighborhoods (Cipkar,2023).

Synergy

Changing multiple land use variables at the same time can produce larger effects from synergies across the different land use characteristics. Bento et al. (2005) compared predicted VMT for identical persons living in Atlanta, Georgia, and Boston, Massachusetts, to get insight into the effect of changing multiple land use variables in ways that reflect the different urban forms in those two cities. Bento et al. (2005) found that the predicted VMT of a typical household living in Boston was 25 percent lower than the predicted VMT of that same household living in Atlanta, suggesting that the combined effect of changing multiple land use variables will be larger than the effect of changing density alone.

Confidence

Evidence Quality

The studies in Table 1 use the best available statistical methods, controlling for household characteristics and household residential location choices, to analyze high-quality data for individual households, and Table 1 includes the two best meta-analyses on this topic. Several recent studies have examined the question of whether the impact of land use variables, residential density included, on travel is causal or merely an association. The literature has focused carefully on that question, and the studies in Table 1 all use statistical controls to isolate the causal impact of density on VMT. Duranton and Turner (2018) pursue an especially careful approach to identifying the causal relationship between density and VMT, and they estimate that at most $1/6^{th}$ of their estimated effect size is due to persons moving into higher-density neighborhoods to support an underlying preference to drive less. In other words, Duranton and Turner estimate that from 5/6th to all of their effect size is a causal impact of density on VMT. Additionally, the long literature on density and VMT, now spanning two decades, has found effect sizes consistently within the ranges shown in Table 1, adding to confidence in the results. We conclude that there is high confidence in the evidence and effect sizes in Table 1.

Caveats

Persons might choose to live in high-density settings because they seek to drive less and, if so, the density does not directly reduce VMT, rather persons would be choosing to live in places that support their existing driving patterns. As noted above, that concern about whether the association between density and VMT shows causality has been carefully addressed in recent studies, and the evidence is that the bulk (and possibly all) of the effect size of density on VMT is a causal impact that shows VMT reduction if persons were to move to higher density neighborhoods – or, equivalently if persons were to stay in their residence and the neighborhood densified. For a review of 38 studies, which reach similar conclusions, see Cao, Mokhtarian, and Handy, (2009).

Technical & Background Information

Study Selection

There have been scores of studies of land use and travel behavior over the past three decades. Extensive reviews are in Badoe and Miller (2000), Boarnet and Crane (2001, chapter 3), Boarnet (2011), Brownstone (2008), Crane (2000), Ewing and Cervero (2001), and Handy (2005), and National Review Council (2009, chapter 3), among others. We selected studies that met the following criteria:

We prioritized meta-analyses, which are systematic quantitative averages of effect sizes from multiple studies. We used estimates from two systematic meta-analyses of travel and the built environment: Ewing and Cervero (2010) and Stevens (2017).

For individual studies, we selected studies that:

- were from the US,
- used data for individuals or households,
- were from multiple metropolitan areas or geographic settings larger than a single metropolitan area,
- controlled for a broad range of individual or household sociodemographic characteristics, and
- used statistical methods to control for the possibility that persons might choose where to live based in part on how they wish to travel.

We used these selection criteria for the following reasons. Individual data allow stronger inferences about the impact, and the causal impact, of density on travel (including on vehicle miles of travel). Some studies, mostly from the 1990s and earlier, use data aggregated to geographic observations, such as census tracts or transportation analysis zones. In those studies, the unit of observation is the geographic area, not an individual traveler. This makes it difficult to link those results to behavioral theories of travel or to make causal inferences, and hence studies with aggregate data were excluded from the policy brief.

Studies from larger geographies are more likely to generalize beyond one metropolitan area. Studies that control for individual characteristics can better isolate the effect of the built environment and might provide stronger causal inferences (as discussed in Brownstone, 2008). Studies that use statistical methods to control for the possibility that persons choose where to live in part based on how they wish to travel provide stronger causal inference.

In addition to these criteria, we only selected studies that expressed effect sizes in terms of elasticities, showing how a percentage change in density would translate into a percentage change in vehicle miles traveled (VMT). Many studies in this literature use non-linear regression routines with coefficients that cannot be translated into elasticities. Those studies (e.g., Ewing et al., 2015) were excluded. Several recent studies are from international settings, and were excluded due to uncertainty about how will studies in different development and transportation settings will apply to the US context. Some studies used outcome variables that were not VMT and hence were excluded. (An example of one such study is Rezaei and Millard-Ball, (2023), who studied the link from the effect of density on PM2.5 exposure and to access to park space in 462 cities worldwide, but who did not provide evidence on VMT.)

In addition to individual studies, we included and prioritized meta-analyses, which is an approach that has received prominent attention in this literature. Meta-analysis combines the quantified results from several studies into one overall effect. Ewing and Cervero published a meta-analysis of land use and travel in 2010. Stevens (2017) updated the Ewing and Cervero analysis with additional studies and with regression techniques to control for the characteristics of the studies. The advantage of meta-analysis is that several studies are summarized into an "overall" effect, often by taking an average or a weighted average of the elasticities or effect sizes from individual studies. Disadvantages of meta-analysis include the possibility that methodologically flawed studies are included (possibly even given equal weight) with methodologically sound studies. More technically, meta-analysis applies best in domains where the various studies can be viewed as drawing from the same population, using the same analysis methods, and where there is much variation both in geographic area and in methods used in land use-travel studies. Despite these concerns about meta-analysis, the results from the meta-analyses in this literature (Ewing and Cervero 2010 and Stevens 2017) give elasticities of VMT with respect to residential density that are similar to the elasticity ranges from most of the individual studies used here.

Methodological Considerations

The most prominently debated methodological consideration in this literature has been the possibility that persons might move to more dense environments to support their desire to drive less, and hence the resulting effect is one of selection rather than a direct effect of the built environment. This is called the "residential self-selection" question in the literature. Cao, Mokhtarian, and Handy (2009) reviewed 38 land use-travel studies that attempted to correct for residential self-selection. They found that, in virtually all cases, the role of built environment factors remained after controlling for residential self-selection, although there remains some question about how much of the net effect is directly from land use and how much is residential self-selection. For a discussion of these same concepts in the context of non-motorized travel, see Cao et al. (2009). Note that a different concept would be displacement – the question of whether density increases force residents who otherwise might wish to stay to leave a neighborhood. The statistical controls for residential self-selection were not designed with displacement in mind, and so it is not clear to what extent studies are able to control for displacement effects when estimating the effect of density on VMT.

The studies that met the inclusion criteria are: Bento et al. (2005), who used data from the 1990 Nationwide Personal Transportation Survey for 114 Metropolitan Statistical Areas; Brownstone and Golob (2009), who used data from the 2001 National Household Travel Survey (NHTS) for California; Heres-Del-Valle and Niemeier (2011) who used data from the California Statewide Household Travel Survey (2000 and 2001); and Duranton and Turner (2018) who used data from the 2009 National Household Travel Survey. The effect size of density on VMT is remarkably similar across studies with data that span from 1990 to 2009.

Bento et al. (2005) used a multinomial logit to estimate household vehicle ownership, in categories of zero, one, two, and three or more vehicles, and then ran a regression for miles driven per vehicle conditional on vehicle ownership. Because unobservable factors might affect the error term in both a vehicle ownership and miles-driven regression equation, Bento et al. (2005) allowed correlation between the error terms in both equations and econometrically corrected for that correlation in error terms. Brownstone and Golob (2009) estimated a joint regression model of residential density, vehicle miles driven, and fuel consumption using a structural equations approach that assumed that households first choose their residential location (and hence their neighborhood residential density) and then choose vehicle ownership and driving patterns conditional on their residential location choice. Heres-Del-Valle and Niemeier (2011) used a two-part regression model (to account for the fact that their one-day VMT data included a large fraction of households with zero VMT on the survey day) and instrumental variables to control for the possibility that residential location and driving patterns are chosen simultaneously by households.

Duranton and Turner (2018) used regressions of household VMT on density with two advanced methods to control for residential selection. First, the authors used instrumental variables methods to control for the possibility that high density places have unobserved factors that correlate with driving. The instruments were characteristics that are associated with development but likely are not associated with driving: earthquake intensity, underground aquifers, and landslide risk. Second, they added a large number of individual and household characteristics to the regression and compared the regression coefficients to coefficients without such controls, a method formalized by Oster (2019). Their analysis suggested that residential self-selection – the possibility that households who wish to drive less choose to live in more dense places – accounts for at most $1/6^{th}$ of the effect size of density on VMT, and possibly none of the effect size (i.e., that the entire effect of density on VMT might be causal.)

The meta-analysis by Stevens (2017) used regression analysis to estimate weighted averages of the effect size from several studies. Stevens in part focused only on studies that controlled for residential self-selection, and when doing that found an average effect size of -0.22, implying that increasing density by 100% would reduce VMT by 22%. That effect size was larger than the -0.10 that Stevens found when using studies that did not correct for residential self-selection.

References

Badoe, Daniel A, and Eric J Miller. 2000. “Transportation–Land-Use Interaction: Empirical Findings in North America, and Their Implications for Modeling.” *Transportation Research Part D: Transport and Environment* 5 (4): 235–63. https://doi.org/10.1016/S1361-9209(99)00036-X.

Bento, Antonio M., Maureen L. Cropper, Ahmed Mushfiq Mobarak, and Katja Vinha. 2005. The Effects of Urban Spatial Structure on Travel Demand in the United States. *The Review of Economics and Statistics* 87,3: 466-478.

Boarnet, Marlon G., and Randall Crane. 2001. *Travel by Design: The Influence of Urban Form on Travel*. Spatial Information Systems. Oxford ; New York: Oxford University Press.

Boarnet, Marlon G., Michael Greenwald, and Tracy McMillan. 2008. Walking, Urban Design, and Health: Toward a Cost-Benefit Analysis Framework, *Journal of Planning Education and Research* 27: 341-358.

Boarnet, Marlon G., Kenneth Joh, Wally Siembab, William Fulton, and Mai Thi Nguyen. 2011. Retrofitting the Suburbs to Increase Walking: Evidence from a Land Use – Travel Study**.** *Urban Studies* 48,3: 129-159. DOI number 10.1177/0042098010364859.

Blumenberg, Evelyn, and Madeline Wander. 2023. “Housing Affordability and Commute Distance.” *Urban Geography* 44 (7): 1454–73. https://doi.org/10.1080/02723638.2022.2087319.

Brownstone, David. "Key relationships between the built environment and VMT." *Transportation Research Board* 7 (2008).

Brownstone, David and Thomas Golob. 2009. The Impact of Residential Density on Vehicle Usage and Energy Consumption. *Journal of Urban Economics* 65: 91-98.

Cavicchia, Rebecca. 2023. “Urban Densification and Exclusionary Pressure: Emerging Patterns of Gentrification in Oslo.” *Urban Geography* 44 (7): 1474–96. https://doi.org/10.1080/02723638.2022.2100174.

Cao, Xinyu, Patricia Mokhtarian, and Susan L. Handy. 2009. Examining the impacts of residential self-selection on travel behavior: A focus on empirical findings. *Transport Reviews* 29 (3), 359–395.

Chatman, Daniel G. 2008. Deconstructing development density: Quality, quantity and price effects on household non-work travel. *Transportation Research Part A* 42: 1008–1030.

Cipkar, Sarah. 2023. “ADUs and the Just City: How Additional Dwelling Units Can Shape Urban Environments toward Equitable Outcomes in Canadian Cities.” *Frontiers in Sustainable Cities* 4 (January): 1053439. https://doi.org/10.3389/frsc.2022.1053439.

Crane, Randall. 2000. “The Influence of Urban Form on Travel: An Interpretive Review.” *Journal of Planning Literature* 15 (1): 3–23. https://doi.org/10.1177/08854120022092890.

Duranton, Gilles and Matthew A. Turner. 2018. Urban form and driving: Evidence from US cities. *Journal of Urban Economics* 108:170-191.

Ewing, Reid, and Robert Cervero. 2001. “Travel and the Built Environment: A Synthesis.” *Transportation Research Record: Journal of the Transportation Research Board* 1780 (1): 87–114. https://doi.org/10.3141/1780-10.

Ewing, Reid and Robert Cervero. 2010. Travel and the Built Environment: A Meta-Analysis. *Journal of the American Planning Association,* 76:3, 265-294, DOI: 10.1080/01944361003766766.

Ewing, Reid, Guang Tian, Jp Goates, Ming Zhang, Michael J Greenwald, Alex Joyce, John Kircher, and William Greene. 2015. “Varying Influences of the Built Environment on Household Travel in 15 Diverse Regions of the United States.” *Urban Studies* 52 (13): 2330–48. https://doi.org/10.1177/0042098014560991.

Handy, Susan. "Critical assessment of the literature on the relationships among transportation, land use, and physical activity." *Transportation Research Board and the Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use. Resource paper for TRB Special Report* 282, no. 1 (2005): 1-81.

Heres-Del-Valle, David and Deb Niemeier. 2011. CO2 emissions: Are land-use changes enough for California to reduce VMT? Specification of a two-part model with instrumental variables. *Transportation Research B* 45: 150-161.

Howell, Amanda, Kristina Currans, Steven Gehrke, Gregory Norton, and Kelly Clifton. 2018. “Transportation Impacts of Affordable Housing: Informing Development Review with Travel Behavior Analysis.” *Journal of Transport and Land Use* 11 (1). https://doi.org/10.5198/jtlu.2018.1129.

Hwang, Jackelyn, and Bina P. Shrimali. 2021. “Constrained Choices: Gentrification, Housing Affordability, and Residential Instability in the San Francisco Bay Area.” Federal Reserve Bank of San Francisco, Community Development Research Brief Series. https://www.frbsf.org/community-development/publications/community-development-research-briefs/2021/april/gentrification-housing-san-francisco-bay-area/.

Li, Tiebei, Jago Dodson, and Neil Sipe. 2018. “Examining Household Relocation Pressures from Rising Transport and Housing Costs – An Australian Case Study.” *Transport Policy* 65 (July): 106–13. https://doi.org/10.1016/j.tranpol.2017.03.016.

National Research Council (NRC), Committee on Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption. 2009. *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions*. Washington, D.C.: National Academies Press.

Oster, Emily. "Unobservable selection and coefficient stability: Theory and evidence." *Journal of Business & Economic Statistics* 37, no. 2 (2019): 187-204.

Reina, Vincent J, Jake Wegmann, and Erick Guerra. 2023. “Are Location Affordability and Fair Housing on a Collision Course? Race, Transportation Costs, and the Siting of Subsidized Housing.”

Rezaei, Nazanin, and Adam Millard-Ball. 2023. "Urban Form and Its Impacts on Air Pollution and Access to Green Space: A Global Analysis of 462 Cities." Edited by Ahmed Mancy Mosa. *PLOS ONE* 18 (1): e0278265. https://doi.org/10.1371/journal.pone.0278265.

Rodriguez, Daniel A., Asad Khattak, and Kelly Evenson. 2006. Can new urbanism encourage physical activity? Physical activity in a new urbanist and conventional suburban neighborhoods. *Journal of the American Planning Association* 72 (1): 43-54.

Saito, Leland T. 2022. *Building Downtown Los Angeles: The Politics of Race and Place in Urban America*. Stanford, California: Stanford University Press.

Sims, J. Revel, and Carolina S. Sarmiento. 2023. "Squeezed in and Pushed out: Dual and Contradictory Displacements in Santa Ana, CA." *City* 27 (3–4): 294–320. https://doi.org/10.1080/13604813.2023.2207248.

Song, Yan and Gerrit Knaap. 2003. New urbanism and housing values: a disaggregate assessment. *Journal of Urban Economics* 54: 218-238.

Stevens, Mark R. 2017. Does Compact Development Make People Drive Less? *Journal of the American Planning Association*, 83:1, 7-18, DOI: 10.1080/01944363.2016.1240044

Zahabi, Seyed Amir H., Luis Miranda-Moreno, Zachary Patterson and Philippe Barla. 2015. Spatio-temporal analysis of car distance, greenhouse gases and the effect of built environment: A latent class regression analysis. *Transportation Research Part A* 77: 1-13.

Zuk, Miriam, Ariel H. Bierbaum, Karen Chapple, Karolina Gorska, and Anastasia Loukaitou-Sideris. 2018. "Gentrification, Displacement, and the Role of Public Investment." *Journal of Planning Literature* 33 (1): 31–44. https://doi.org/10.1177/0885412217716439.