DRAFT Policy Brief on the Impacts of Residential Density Based on a Review of the Empirical Literature

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Policy 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 greenhouse gas (GHG) emissions. Such policies include direct changes to land use, such as relaxing minimum lot size requirements, increasing the density of allowed development, and encouraging urban infill. More broadly, officials can encourage higher density through combinations of infrastructure, zoning, or public finance policies that, for example, focus development around transportation nodes (including transit stations) or raise land prices and hence encourage smaller lot sizes as a result of impact fees.

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.) Some persons distinguish between gross and net density. Gross density is the density on all land, and net density is the density on land zoned for residential use. Employment density is also an important concept for travel behavior, but here we focus only on residential density.

Density is correlated with a large number of land use traits that are associated with travel, including mixed land uses, transit access, the quality of the pedestrian environment, and proximity to regional employment or shopping centers. While density is easily measured, 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). Yet for purposes of summarizing the evidence on density and VMT, unless otherwise noted the evidence here shows the effect of residential density alone on VMT.

Impacts of Residential Density

Effect Size

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

- the studies used data for individuals or households,
- the studies were from geographic settings larger than a metropolitan area,
- the studies controlled for a broad range of individual or household sociodemographic characteristics, and
- the studies, with the exception of Fang (2008), used statistical methods to control for the possibility that persons might choose where to live based in part on how they wish to travel.

A recent National Research Council (2009) report used these same studies (with the exception of Fang, 2008) to conclude that, on average, doubling residential density is associated with VMT reductions that range from 5 percent to 12 percent. Stated equivalently, the National Research Council (2009) report estimated that the elasticity of VMT with respect to residential density was in a range from -0.05 to -0.12. (Elasticity relates the change in density to the associated change in VMT; the elasticity is the percentage change in VMT that is associated with, in this case, a 100 percent change in density.) Table 1 summarizes the evidence that supports the National Research Council (2009) conclusion that, on average, doubling residential density will reduce VMT by from 5 to 12 percent.

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

Study	**Study Location**	**Study Year**	**Results**	
			Built Environment Variable	*VMT Reduction for 1% Change in Built Environment Variable*
Bento et al. (2005)	114 U.S. MSA's	1990	City shape, jobs-housing balance, road density, rail supply – each variable alone	Less than or equal to 0.07%
Brownstone and Golob (2009)	California	2001	Population density	0.12%
Fang (2008)	California	2001	Population density	0.08% to 0.09%

Source: Adapted from National Research Council (2009), with addition of Fang (2008). Impacts verified from studies cited in the table.

A recent meta-analysis (Ewing and Cervero, 2010) concludes that the elasticity of VMT with respect to residential density is -0.04, a magnitude that hardly differs from the National Research Council's conclusion. 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 form in those two cities. Bento et al. (2005) find that predicted VMT in Boston is 25 percent lower than in Atlanta, suggesting that the combined effect of changing multiple land use variables will be larger than the effect of changing density alone.

There is not good evidence on how to choose the impact of residential density on VMT within the -0.05 to -0.12 elasticity range. Similarly, little is known about how the residential density – VMT relationship might vary across urban or rural areas, as the evidence in this literature is largely from urban places. The evidence on land use and travel suggests that factors other than residential density, including regional access to jobs, are more important for VMT. Hence, increases in residential density in places with strong regional access to jobs (e.g., closer to employment centers or sub-centers) may have more of an impact on reducing VMT than similar increases in residential density in places farther from job centers or other travel destinations.

Evidence Quality

The studies in Table 1 use the best available statistical methods to analyze high quality data for individual households. There is some debate about whether the associations in Table 1 show a causal effect of density on VMT, and that is discussed in the sub-section below. 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. Because two of the three studies in Table 1 (Bento et al., 2005 and Brownstone and Golob, 2009) use careful statistical methods to infer causal relationships, policy-makers may infer that the magnitudes shown in Table 1 reflect a likely range of VMT reduction that would result from changes in density over geographies that approximate a metropolitan area.

Many other studies of density and VMT, not cited in Table 1, use aggregate data, meaning the data are not for individuals or households but are aggregated to geographic units. Aggregation has methodological shortcomings. Making inferences about causality is difficult with aggregate data. For that reason, studies that have travel data for households or individuals, such as the studies in Table 1, are preferred.

Caveats

Two methodological issues are most important in the land use - travel literature, and both have ramifications for the relationship between residential density and VMT. First, 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 but only reduces VMT by providing living places for persons who seek to drive less. It would then matter crucially whether higher density neighborhoods are in sufficient supply to meet the demand of persons who seek to live in those neighborhoods. If so, building more such high density neighborhoods would not reduce VMT, If there is a shortage of higher density neighborhoods (relative to demand for such places), building higher density neighborhoods would reduce VMT, even if the only effect were from persons choosing where to live (called “residential selection.”) An extensive review of 38 studies that attempted to control for residential selection found that, in all cases, there was some independent role for the built environment (Cao, Mokhtarian, and Handy, 2009).

Second, there is reason to believe that the impact of land use on travel is characterized by thresholds. For example, Boarnet et al. (2011) give evidence that within small neighborhoods (a mile or less from end to end) residents can have as much as a fivefold difference in walking trip generation rates and differences as large as thirty percent in car trip generation rates. Those travel differences are associated with differences in land use characteristics within the small neighborhoods and persist even after controlling for differences in individual and household characteristics. For policy-making, variations in the impact of land use on travel over such small geographies are important, but are obscured by regional averages such as those reported in Table 1. Often little is known about such localized (neighborhood) effects, and neighborhood impacts can be quite a bit larger than regional averages. The best estimates of the regional impact of residential density on VMT are those in Table 1, above.

Greenhouse Gas Emissions

There are few studies that give direct evidence of the effect of residential density on GHG emissions. The National Research Council (2009) compared GHG reduction from hypothesized residential density increases to a baseline case. The National Research Council (2009) report focused on two scenarios: (1) 25 percent of all future new residential development in the U.S. was assumed to be at twice the average density of new development built in the U.S. in the 1990s, and (2) 75 percent of future new development was assumed to be at twice the 1990s density level. Residential development in the 1990s averaged approximately one or two dwelling units per acre, so doubling that density implies a range from two to four dwelling units per acre. The National Research Council (2009) scenarios show a reduction in GHG emissions ranging from 1 percent to 11 percent below baseline trends in the year 2050. The larger GHG reduction, approximately 11 percent from baseline in 2050, assumed that 75 percent of new development would be built at twice 1990s density levels and that the impact of land use change would include VMT reduction beyond what could be attributed to residential density alone. These results demonstrate that GHG reductions from increasing residential density will be modest in the near-term (the next one to two decades), but can cumulate over time. If multiple policy instruments are used together (e.g. mixing residential and commercial land use, improving metropolitan job accessibility), their combined impact could be considerably larger than what would be obtained by only changing residential density. Many scholars, including the National Research Council (2009) report, therefore argue that planners should consider and implement a large number of land use characteristics and policy variables.

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, concentrations of employment, shopping, and service destinations, and infrastructure and urban design that make non-motorized travel modes (e.g., walking and bicycling) more attractive options. 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). Yet some caution is in order, as increases in walking might partially compensate for reductions in other kinds of physical activity, and 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 hence might be associated with resident satisfaction. Yet density by itself may not be the most important variable for community livablity. 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 neigbhborhood characteristics being more valued by home buyers, but density, after controlling for those other factors, had a small but negative association with house prices.

Examples

Infill development is increasingly common, and can range from developments on one parcel to larger, coordinated plans. The City of Irvine has developed a plan to foster residential development in a 2,800 acre area that was previously a business center. Long-term plans envision as much as 15,000 to 17,038 residential units, all of which could be considered infill development. See http://www.cityofirvine.org/depts/cd/planningactivities/ibc_graphics/default.asp. Outside of California increases in density have been associated with rail transit, including projects such as Atlantic Station in Atlanta and transit-oriented developments in Portland. From 1993 to 2003, population density within Portland's Urban Growth Boundary (as defined in the early

1990s) increased from 3,136 to 3,721 persons per square mile. In Portland, daily VMT per person equaled the national average in 1996, but in 2007 Portland residents drove 17 percent fewer miles per day than the U.S. average (from U.S. and Oregon Department of Transportation Data, cited in National Research Council, 2009, Annex 3-1.) The VMT result for Portland is likely related to that metropolitan area's comprehensive system of land use and infrastructure planning, of which increases in residential density are only one part. More generally, note that high land prices encourage higher density, and prior to the most recent housing downturn, urban areas throughout California were experiencing pressures for increased density, either through smaller lot sizes or urban infill.

Suggested Further Reading

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