6/25/2010

DRAFT Technical Background Document on the Impacts of Residential Density Based on a Review of the Empirical Literature

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Study Selection

There have been scores of studies of land use and travel behavior over the past two decades. Extensive reviews are in Badoe and Miller (2000), Boarnet and Crane (2001, chapter 3), Brownstone (2008), Crane (2000), Ewing and Cervero (2001), and Handy (2005), and NRC (2009, chapter 3). There is active debate about appropriate methodology, and only a handful of studies use methodologies that can withstand various criticisms that have been posed in the literature. Beyond that, there is also active debate about how to choose studies. The results, in terms of the elasticity of vehicle miles traveled (VMT) with respect to density, are quite stable over a range of study types and methods. That does not imply that any methodology is appropriate, as key issues such as causality and residential selection (described below) are better handled with individual data. Some studies, mostly from the 1990s, 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. A more recent generation of studies has focused on individual travel diary data, allowing more clear links to behavior and, depending on the study, better inferences about causality.

Effect Size, Methodology and Applicability Issues

Inclusion Criteria for Effect Size

The literature has reached some consensus on the key methodological issues, as summarized by National Research Council (2009). The most methodologically sound studies analyze data for individuals or households from geographic settings larger than a metropolitan area, with a broad set of individual or household sociodemographic control variables, and with sound econometric specifications that control for the possibility that persons might choose where to live based in part on how they wish to travel. Individual data allows stronger behavioral inferences and better causal statements. Using data that are larger than a single metropolitan area gives some reassurance that the results generalize beyond what might be idiosyncratic characteristics of a place. A broad set of individual or household sociodemographic controls is necessary, because much travel behavior is influenced by sociodemographic characteristics, and without such controls, built environment variables might pick up the effect of the characteristics of persons who live in a place, rather than the independent effect of the built environment. Studies that econometrically control for where persons choose to live, allowing measurement of a direct effect of the built environment on travel, are preferred.

The goal was to find robust studies that met the inclusion criteria, rather than to comprehensively review the literature. The two studies that met the inclusion criteria are: Bento et al. (2005), which used data from the 1990 Nationwide Personal Transportation Survey for 114 Metropolitan Statistical Areas, and Brownstone and Golob (2009), who used data from the 2001 National Household Travel Survey (NHTS) for California. Another study was added, Fang (2008), which used the same California sub-sample as Brownstone and Golob (2009), but Fang (2008) did not control for residential selection.

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) allow correlation between the error terms in both equations and econometrically correct for that correlation in error terms. Brownstone and Golob (2009) estimate a joint regression model of residential density, vehicle miles driven, and fuel consumption using a structural equations approach that assumes 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. Fang (2008) estimates a joint discrete-continuous regression model of vehicle ownership and miles driven.

Alternative Approach, Meta-Analysis

An alternative approach which has received prominent attention in this literature is meta-analysis. Meta-analysis combines the quantified results from several studies into one overall effect. Ewing and Cervero have published two meta-analyses of land use and travel, in 2001 and 2010. 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 draws from the same population, using the same analysis methods, and 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 two meta-analyses in this literature (Ewing and Cervero, 2001 and 2010) give elasticities of VMT with respect to residential density that are strikingly similar to the elasticity ranges from the three individual studies used here (Bento, Brownstone and Golob, and Fang). The 2001 Ewing and Cervero study found an elasticity of VMT with respect to density of -0.05, and the 2010 Ewing and Cervero study found an elasticity of VMT with respect to density of -0.04, at the low end of the range of -0.05 to -0.12 suggested by National Research Council (2009). All of those estimates are for residential density alone, although the Brownstone and Golob (2009) study did not include other land use variables, and so density in that study might partly be a proxy for other land use variables.

Aggregate Data

Aggregating data to geographic units (e.g., census tracts or transportation analysis zones) has shortcomings. Making inferences about causality is difficult with aggregate data. For example, Ewing et al. (2008) used aggregate data for 85 U.S. urban areas and obtained estimates of an elasticity of VMT with respect to density of -0.152 and -0.213. That estimate is from a regression with only density in the equation, and so the effect of density likely picks up impacts of other built environment characteristics. One difficulty of aggregate data is that it is difficult to control for characteristics of the driving population, and such controls are inherently for the region rather than for an individual driver. Beyond that, theoretical models of causality, while possible, are more difficult to implement with aggregate data. In general, studies that have looked at the effect of density alone, while controlling for other sociodemographic and land use factors, find elasticities in the range of -0.05 to -0.12.

Remaining 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 effect is one of selection rather than a direct effect of the built environment. This is called the "residential 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 selection. For a discussion of these same concepts, in the context of non-motorized travel, see Cao et al. (2009).

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Acknowledgments

This document was produced through an interagency agreement with the California Air Resources Board with additional funding provided by the University of California Institute of Transportation Studies MultiCampus Research Program on Sustainable Transportation and the William and Flora Hewlett Foundation.