

## **Technical Background Document on the Impacts of Transit Access (Distance to Transit) Based on a Review of the Empirical Literature**

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### **Study Selection**

The effect of transit access, measured as distance to a bus stop or rail station, on vehicle miles traveled (VMT) has not been widely studied. It is more common for studies to report the effect of transit access on transit ridership or share of trips by transit. Conversely, studies of the impact of land-use on VMT do not often use measures of distance to transit. Measuring the impact of transit access on VMT, while controlling for characteristics of the population, density and land-use mix, and characteristics of the destination, is challenging.

The key criterion for including studies in the research brief was reporting of the effects of distance to transit on VMT, while controlling for socio-demographic and spatial characteristics. If the study did not report the effect in terms of change in VMT per change in miles to the station, then it had to report sufficient information to enable an estimation of the effect in this form. Additional considerations included U.S. location for the data (though studies in other developed countries were also considered), published since 1990 to help to ensure current relevance, and data collected from a sample of residents of both areas with transit supply and areas without it.

Studies meeting the criteria were Ewing and Cervero (2010), Pushkar, Hollingworth, and Miller (2000), Bailey, Mokhtarian, and Little (2008), and Bento, Cropper, Mobarak, and Vinha (2003). Several notable studies were not included for various reasons: Frank and Engelke (2005) did not report VMT effects; Frank, et al. (2009) presents forecasting results for scenarios rather than empirical results; Naess (2005) reports a VMT elasticity but no data on average VMT to enable calculation of an effect size; Zegras (2007) used commute data only from 1991 for Santiago, Chile; and Hedel and Vance (2007) report the effect of walking time but not distance on VMT, using data from a German survey.

Some studies of transit access and VMT 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, we selected only studies that use travel data for households or individuals.

### **Effect Size, Methodology and Applicability Issues**

#### *Effect Calculations*

Several of the included studies did not report effect size as change in VMT per change in miles from the station. In these cases, the reported data were used to estimate the

effect size, as follows. Note also that the effects can be reported as negative, if they measure transit access or proximity to transit (better access or better proximity means lower VMT), or as positive, if the measure is distance to transit (greater distance means higher VMT).

1. *Ewing and Cervero (2010)*: This study reports results from a meta-analysis of studies from around the world from the last 25 years. Elasticities from individual studies are weighted by the sample sizes of the studies and averaged to produce a single elasticity for transit access. The study reports an elasticity of -0.05 for transit access, meaning that a 1 percent increase in proximity (decrease in distance) to transit leads to a 0.05 percent decrease in VMT. The study does not differentiate between distance to rail and distance to transit. This elasticity implies that a 100 percent reduction in distance, from the point at which transit access has no effect on VMT to the site of the station or bus stop, leads to a 5 percent reduction in VMT. The maximum distance at which transit has an effect is not reported in this study, but if a distance of 2 miles is assumed (based on Bailey, et al.), then moving from having no transit service (i.e. nearest station is 2 miles away) to 1 mile, a 50 percent reduction in distance to transit, leads to a 2.5 percent reduction in VMT.

2. *Pushkar, Hollingworth, Miller (2000)*: This study presents an ordinary least-squares linear regression model for VKT (vehicle-kilometers travelled) for the Toronto area. As shown in Table 2 of the study, the coefficient for distance from a public transit station is 0.552, meaning that a 1 km reduction in distance to the station leads to a reduction of 0.552 VKT. The study reports that the average distance from the station for the sample is 3.48 kilometers and the average VKT per household is 74.7 kilometers per day. Based on these values, it is possible to calculate a point elasticity of 0.026 (calculated as  $(0.552/74.7) * (1/3.48)$ ). Starting from the average distance to transit of approximately 2 miles (2.12 miles, converted from 3.48 kilometers), a reduction in distance of 1 mile equates to a 50 percent reduction in distance and will result in 1.3 percent decrease in VMT.

3. *Bailey, Mokhtarian, Little (2008)*: This study employs structural equations modeling to examine the relationship between transit access and household VMT. The study uses data from the 2001 National Household Travel Survey and separately examines the impact of distance to bus stations and distance to rail stations. The study first analyzes access to transit, taking into account acceptable walking distances of 0.75 miles to rail stations and 0.25 miles to bus stops. According to this analysis, access to rail effectively ends at 2.25 miles from the station and access to bus at 0.75 miles. According to Table 5 in the study, the impact on VMT of “going from no availability to having a rail stop next door” (pg. 21) is -5.8 miles; the impact on VMT for bus is -2.6 miles. Given average household VMT of 43.75 miles, we calculated the maximum percentage impact of access to transit as about 13 percent ( $5.8/43.75$ ) for rail and about 6 percent ( $2.6/43.75$ ) for bus. To simplify the calculation of a VMT effect size, we assume a simple linear relationship between distance to transit and VMT for rail from 0 to 2.25 miles from the station and for bus from 0 to 0.75 miles from the station. Assuming an impact of zero at 2.25 miles and 0.75 miles respectively, we then

calculated the effect size as 5.8 percent per mile for rail (13percent/2.25 miles) and 2 percent per 0.25 mile for bus (6 percent/0.75 miles/4; note that we calculate the effect size on a quarter-mile basis because the effect ends at 0.75 miles).

4. *Bento, Cropper, Mobarak, Vinha (2005)*: This study reports the VMT impact of public transit access based on scenarios of population location using 114 urbanized areas in the 1990 Nationwide Personal Transportation Survey (NPTS) excluding New York City. The analysis uses a two-step model: a multinomial logit model for the number of cars per household and a set of ordinary least-squares regression model for VMT per vehicle, with separate models for each category of car ownership (e.g. 1, 2, or 3 or more vehicles per household). The variable used to measure distance to transit is “instrumented distance to nearest transit stop,” which reflects level of service as well as distance. According to the analysis, a 10 percent increase in instrumented distance will increase VMT by 0.8 percent, equating to 151 miles per year.

#### *Evidence on Transit Use*

In addition to the studies that show the effect of transit access on VMT, other studies provide evidence on the impact of transit access on transit use, or what might be called a “precursor” of VMT. If transit use goes up in response to an increase in transit access, it is reasonable to assume that VMT will go down, though the size of the effect might differ. The effect of transit access on transit use is often measured in the aggregate, as the share of trips originating in a specified area that are made by transit. We reviewed two studies that examine the effect at the level of the individual or household, as follows and as summarized in Table 1:

1. *Lund, Cervero and Willson (2004)*: This study focused on residents of TOD projects and found that public transit was used for 27 percent of trips originating within 0.5 mile from the rail station and for 7 percent of trips originating between 0.5 mile and 3 miles from the station.

2. *Cervero (2002)*: This study focused on commute trips and explored the impact of the proximity of destinations to transit stations and transit mode share for residents around transit stations but also among commuters who work next to transit stations. Study sites included BART stations in the San Francisco Bay Area and LRT stations in the Sacramento region. The study reports transit shares of 17.8 percent of home-based work trips originating within 0.5 mile of a BART station, 12 percent of trips originating within 0.5 mile of an LRT station for Sacramento, 6.3 percent of work trips ending within 0.5 mile of an LRT station in suburban Sacramento, and 5.4 percent of work trips ending within 0.5 mile of a bus station, also for suburban Sacramento.

Based on these two studies, the estimated effect on transit share ranges from 12 percent to 27 percent of trips originating within 0.5 miles of a rail station; urban locations and those will be at the higher end of this range, suburban locations and those with LRT will be at the lower end of this range. The estimated effect on transit share for work locations ranges from 5.4 percent to 6.3 percent of trips ending within 0.5 miles of a

station for suburban locations.

*Table 1. Effect of Access to Transit on Transit Use*

Author	Date of Data	Geographic Location	Effect Size
Lund, Cervero, Willson	2000	California	27% of trips originating within ½ mile of the station on rail; 7% of trips originating ½-3 miles of the station on rail
Cervero	1990	California	17.8% of home-based work trips originating within ½ mile of a station on BART 12% of trips originating within ½ mile of a station on LRT, for Sacramento 6.3% of work trips ending within ½ mile of a station on LRT, for Sacramento suburban locations. 5.4% of work trips ending within ½ mile of a station on bus, for Sacramento suburban locations.

#### *Methodological Considerations*

In applying the estimated effects, there are several methodological limitations that should be considered.

First, the nature of transit service varies considerably from community to community. As shown in the Bailey, et al. study, the effect of access to transit on VMT is greater for rail than for bus. Other characteristics of transit service, such as service frequency or the quality of transit stations and vehicles, might also moderate the VMT effect. The studies included here do not control for such differences. Three of the four studies make use of data from a wide range of geographic areas and thus yield what could be considered average effect sizes, reflecting a wide range of transit systems. However, it is important to note that two studies (Ewing and Cervero, 2010, and Bailey, et al. 2008) include New York City, which, given its high level of transit use, probably biases the effect size upward.

Second, residential “self-selection” might partly explain the effects observed in these studies. If residents who prefer to use transit are more likely to choose residential locations within close distance of transit stations, their lower VMT would stem from their transit preference as well as their proximity to the station. Of the studies included here, only Bailey, et al. partially control for self-selection by allowing urban form variables to co-vary with socio-demographic characteristics. Not controlling for self-selection may produce an overestimate of the effect of transit access on VMT. None of the studies uses a longitudinal design that directly measures changes in VMT that occur following an increase in access to transit (decrease in distance to transit).

Currently, evidence of the effect of transit access on VMT is limited. Few studies have examined this effect, and those that do have notable methodological limitations. Some evidence points to counter-intuitive results, suggesting a need for further research and

more sophisticated research designs. For example, Chatman (2006) found a positive correlation between proximity to the rail station and household VMT, i.e. households closer to the station had higher VMT than those farther away, which he attributes to the more peripheral regional locations of some of the new TODs in California.

Studies on the impact of distance to transit on travel mode choice use the same methodologies as the studies of VMT impact, with similar biases and quality problems. However, because the connection between transit access and transit use is more direct than the connection between transit access and VMT, the estimated effects for the former are less likely to be moderated by other factors. Note that estimated effects on transit use cannot be directly translated into estimated effects on VMT for a variety of reasons: not all transit trips replace a driving trip, and even when they do, a person's destination may change when his mode changes, leading to differences in trip distance.

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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.