Impacts of Land-Use Mix on Passenger Vehicle Use and Greenhouse Gas Emissions

Policy Brief

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September 30, 2014

Policy Brief: http://www.arb.ca.gov/cc/sb375/policies/mix/lu-mix_brief.pdf

Technical Background Document: http://www.arb.ca.gov/cc/sb375/policies/mix/lu-mix_bkgd.pdf

California Environmental Protection Agency
Air Resources Board

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Policy Description

Land-use mix or mixed-use development can be defined as the practice of accommodating more than one type of function within a building, a set of buildings, or a specific area. These functions include residential, office, retail, and personal services, as well as parks and open space. Localities can encourage a better balance of land uses through zoning that allows housing, retail establishments, and employment centers to exist in close proximity. Balance can also be increased through policies that encourage infill development and that allow vertical mixing of uses within the same building. Because mixed-use neighborhoods offer a variety of employment, shopping, and recreational opportunities within short distances of residences, they facilitate the use of non-automobile travel modes and can shorten car trips, which in turn may reduce passenger vehicle greenhouse gas emissions.

Impacts of Land-Use Mix

Effect Size

Several studies conducted over the past fifteen years have examined the impact of mixed-use development on vehicle use, as measured by vehicle miles traveled (VMT). These studies have used a variety of measures to capture the amount of land-use mixing present in urban neighborhoods. Some examples of land-use mix measures include:

- Variety and balance of land-use types within a neighborhood (entropy or dissimilarity);
- Ratio of jobs to residents at the neighborhood level (i.e. census tracts, census block groups, or ¼ mile radius areas);
- Vertical mixing of uses and floorspace dedicated to different use types;
- Number of retail and commercial uses within a given distance (typically ¼ mile) of residences; and,
- Number of walking destinations in a neighborhood.

Several studies use entropy and/or dissimilarity as measures of land-use mix. Entropy indices measure the balance of land uses in a neighborhood based on the variety of different use types in the area and indicate the level of mixing at the neighborhood scale by comparing the existing mix with an ideally balanced mix. Entropy values range from 0 (one land use only), to 1 (all land-use categories equally represented). Dissimilarity indices are used to measure mixing at a finer scale, often at the level of individual land parcels or grid blocks (Cervero and Kockelman, 1997). Each parcel or grid block is assigned a score from 0 to 1 based on the number of adjacent parcels whose use is different from its own. For detailed descriptions of these two measures, see Cervero and Kockelman (1997) and Vance and Hedel (2007) and the background document that accompanies this brief.

A summary of the findings from the studies on land-use mix is presented in Table 1. These results suggest that effect sizes range from a 0.01 to 0.17 percent decrease in VMT for each 1 percent increase in land-use mix (or an elasticity of -0.01 to -0.17). Ewing and Cervero (2010) use meta-analysis to conclude that a 1 percent increase in land-use mix results in an average VMT decrease of 0.09 percent. This figure represents the expected VMT benefit from policies designed to increase mixing of land uses.

Table 1: Summary Land-Use Mix Impacts on Vehicle Miles Traveled

Study	**Study Location**	**Study Year(s)**	**Results**		
			Land-use mix measure	*VMT measure*	*VMT change for 1% increase in land-use mix*
Kockelman, 1997	San Francisco Bay Area	1990	Land-use dissimilarity and land-use mix (entropy)	VMT per household	-0.10%
Chapman & Frank, 2004	Atlanta	2001-2	Land-use mix (entropy)	VMT per person	-0.04%
Frank et al., 2005	Seattle	1999	Land-use mix (entropy)	VMT per household	-0.02%
Bento et al., 2005	National	1990	Jobs-housing balance	VMT per household	-0.06%
Frank et al. 2011	King County, Seattle	2006	Mixed-use index	Household VMT	-0.07%
Zhang et al. 2012	Seattle		Land-use mix (entropy)	VMT per person	-0.16%
	Norfolk and Richmond, VA		Land-use mix (entropy)	VMT per person	-0.01%
	Baltimore		Land-use mix (entropy)	VMT per person	-0.08%
	Washington D.C		Land-use mix (entropy)	VMT per person	-0.17%
Nasri and Zhang, 2012	Metropolitan Areas of Atlanta, Baltimore, Norfolk and Richmond, Seattle, Washington D.C.	2006-9	Land-use mix (entropy)	VMT per person	-0.12%
Ewing & Cervero, 2010	Various (meta-analysis)	1997-2009	Land-use mix (entropy)	VMT per household	-0.09%
	Various (meta-analysis)	1997-2009	Jobs-housing balance	VMT per household	-0.02%

Evidence Quality

All of the studies cited above used models that control for the effects of other variables that could impact VMT. These include individual or household demographics such as income, household size, and automobile ownership. The studies also controlled for other aspects of the built environment, such as density, transportation network characteristics, and transit availability. In addition, these studies use individual and household-level data rather than aggregated data for geographical areas. These qualities strengthen the reliability of the evidence.

None of the studies account for residential self-selection. Self-selection occurs when people choose a residential location based on their transportation preferences. For example, people who wish to drive less may move into dense, mixed-use neighborhoods that allow them to use their car less or use non-car modes of transportation more easily. Studies that do not account for self-selection are likely to overstate the effect of land-use mix on VMT.

Caveats

All of the studies listed here considered land-use mix in an urban context. Therefore, they may not accurately capture the effect of increasing land-use mix in more suburban or rural settings as suggested by Zhang et al. (2012).

Greenhouse Gas Emissions

Most of the research on land-use mix has focused on driving, but policies which reduce VMT also reduce greenhouse gas emissions. Generally, GHG emissions reductions will be similar to VMT reductions if vehicle fleet composition and driving patterns are not affected by land-use mix. Some studies (e.g. Fang, 2007; Brownstone and Golob, 2009) have shown that household vehicle choice depends in part on land use. Even so, it is reasonable to expect any VMT reductions that result from increases in land-use mix will also produce reductions in GHG emissions. Frank et al. (2011) found that land-use mix had nearly the same magnitude of impact on GHG emissions as on VMT.

Co-benefits

Perhaps the main co-benefit of mixed-use development is the encouragement of walking and bicycling as modes of transportation. Studies have shown that the impact of mixed-uses on walking trips is greater than for VMT reduction. Ewing and Cervero (2010) estimate that on average, walking trips increase 0.15 percent for each 1 percent increase in land-use entropy, and 0.25 percent for every 1 percent decrease in walking distance to a store. In addition to reducing vehicle emissions, greater use of walking and cycling as modes of transport are important from a public health perspective. Increased physical activity has been shown to produce a number of positive outcomes, and is important for reducing overweight and obesity (Kuzmyak et al., 2006; Boarnet, Greenwald, and McMillan, 2008).

As is the case with other built environment features that reduce VMT, greater land-use mix may help to reduce both congestion and vehicle air pollution in urban areas. These impacts may be increased by including mixed-use development as a part of a coordinated plan that includes density and design features and improvements in regional transportation access. Comprehensive use of these strategies can help reduce VMT and increase mode choice for residents.

Examples

The Anaheim Platinum Triangle project provides an example of a comprehensive attempt to increase land-use mix. The city of Anaheim is converting the area around two major sports facilities into a mixed-use development that includes residential, retail, and office space. The area is zoned for approximately 19,000 new residential units, 14.1 million square feet of office space, and 4.8 million square feet of commercial space (City of Anaheim, 2014). The area will include urban park space and emphasizes walkability and transit access. Ground-floor commercial space and smaller block sizes will be used to encourage walking trips and provide a lively street atmosphere. In addition to new development, the Platinum Triangle plan calls for integrating some existing industrial uses, preserving employment opportunities that currently exist in the area. As of August, 2013, 1920 residential units and 39,369 square feet of commercial space had been completed (City of Anaheim, 2014).

In a case study of two recently constructed neighborhoods in North Carolina, Khattak and Rodriguez (2005) found significant differences in household VMT between mixed and non-mixed use developments. The study compared a typical suburban, single-use neighborhood with a neo-traditional one that was centered on a mixed-use commercial center. The findings indicated that residents of the mixed-use development made approximately the same number of trips, but traveled 14.7 fewer miles per household per day.

The researchers did not attempt to isolate the effects of mixed-use alone, and other design features such as density and network connectivity likely contribute to the difference in household VMT. However, the study illustrates the role that land-use mix can play in encouraging shorter trips and the substitution of car trips with other modes of transportation.

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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.