Policy Brief on the Impacts of Land Use Mix Based on a Review of the Empirical Literature

Steven Spears and Marlon G. Boarnet, University of California, Irvine
Susan Handy, University of California, Davis

Policy Description

Land use mix or mixed-use development can be defined as the practice of accommodating more than one type of land use 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:

- Ratio of jobs to residents at the neighborhood level (i.e. census tracts, census block groups, or ¼ mile radius areas);
- Variety and balance of land use types within a neighborhood (entropy);
- 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.

The two most common measures of land use mix are entropy and dissimilarity. 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.

The three measures used in the studies cited in this brief represent land use mixing at three different scales: jobs-housing balance at the metropolitan to district level, entropy at the neighborhood level, and dissimilarity at the neighborhood to parcel level. Vertical mixing (within buildings) and the number of retail uses have been studied less, and for purposes of this brief both vertical mixing and retail uses are ways to influence jobs-housing balance and measures of entropy and dissimilarity.

A summary of the findings from several studies on land use mix is presented in Table 1. The results shown in this table were obtained from data on individuals and households, and the results were statistically significant at a level of at least 90 percent. Based on either entropy or dissimilarity indices, it can be concluded that generally each 1 percent increase in land use mix results in an average VMT decrease in a range from 0.02 to 0.11 percent (or an elasticity of -0.02 to -0.11). 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.

With the exception of Bento et al. 2005, which examined metropolitan area jobs-housing balance, 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.

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

Study	Study Location	Study Year(s)	Results	
			Measure Type	*Impact (elasticity)*
Ewing & Cervero, 2010	Various (meta-analysis)	1997-2009	Land use mix (entropy)	0.09% decrease in household VMT per 1% increase in entropy.
Ewing & Cervero, 2010	Various (meta-analysis)	1997-2009	Jobs-housing imbalance	0.02% decrease in household VMT per 1% decrease in jobs-housing imbalance.
Frank et al., 2005	Seattle	1999	Land use mix (entropy)	0.02% decrease in household VMT for each 1% increase in entropy
Chapman & Frank, 2004	Atlanta	2001-2	Land use mix (entropy)	0.04% decrease in VMT per person for each 1% increase in entropy
Kockelman, 1997	San Francisco Bay Area	1990	Land use dissimilarity and land use mix (entropy)	0.10% decrease in household VMT per 1% increase in either index
Bento et al., 2005	National	1990	Jobs-housing imbalance	0.06% decrease in household VMT per 1% decrease in imbalance

Evidence Quality

All of the studies cited above used models that control for the effects of multiple other variables that could impact VMT. These include individual or household demographics such as income, household size, and automobile ownership. The studies in Table 1 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 factors strengthen the reliability of the evidence.

Caveats

One potential weakness of these studies is that, with the exception of Bento et al. (2005), none of them account for residential self-selection. As it pertains to travel behavior, 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. When residential location choice is not taken into account, self-selection impacts on travel behavior cannot be easily separated from built environment impacts.

The effects of residential self-selection have recently received attention from transportation researchers. 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). This result indicates that even though the studies cited here did not control for self-selection, there is likely a direct impact of land use mix on VMT.

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. In a report prepared for King County, Washington, Lawrence Frank and Company (2005) developed a model to predict the impact of land use mix on carbon dioxide (CO2) emissions. The model used data from travel diaries, along with vehicle emission profiles, to estimate trip-based carbon dioxide emissions. The results of that study were later incorporated in a report titled *Reducing Global Warming and Air Pollution: The Role of Green Development in California* (Lawrence Frank and Company, 2008). Based on the model, per capita CO2 emissions were estimated to be approximately 13 percent lower in neighborhoods in the highest quintile (highest 20 percent) of land use mixing index values, compared to those in the lowest quintile (lowest 20 percent).

Lawrence Frank and Company (2008) did not report the land use mix index values that correspond to quintiles, so we cannot compare the GHG reduction to the VMT reduction effect sizes in Table 1. Generally, one would expect GHG reduction to be similar to VMT reduction, if vehicle fleet composition and driving patterns are unchanged. Other research (e.g. Fang, 2007, Brownstone and Golob, 2009) has shown that household vehicle choice depends in part on land use. Even so, it is reasonable to expect GHG emissions reductions associated with any VMT reductions that flow from improved land use mix.

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 1.5 percent for each 10 percent increase in land use entropy,

and 2.5 percent for every 10 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, land use mixing 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 diversity. The city of Anaheim plans to convert the area around two major sports facilities into a mixed-use development that includes residential, retail, and office space. The plan currently calls for approximately 10,000 new residential units, 2.3 million square feet of commercial space, and 5.0 million square feet of office space. The area will include urban park space and emphasizes walkability and transit access (City of Anaheim, 2010).

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.

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 mixed-use can play in encouraging shorter trips and the substitution of car trips with other modes of transportation.

Suggested Further Reading

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