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Research Paper

Trip and parking generation at transit-oriented developments: Five US case studies

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HIGHLIGHTS

- Parking demand at the five TODs is generally less than half the US guideline.
- Trip generation at the five TODs is generally less than half the US guideline.
- Automobile mode shares at the five US TODs are as low as one quarter of all trips.
- Results suggest the potential for significant savings in TOD developments.
- Guidelines are provided for using study results in TOD planning.

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ABSTRACT

Guidelines for trip and parking generation in the United States come mainly from the Institute of Transportation Engineers (ITE). However, their trip and parking manuals focus on suburban locations with limited transit and pedestrian access. This study aims to determine how many fewer vehicle trips are generated at transit-oriented developments (TODs), and how much less parking is required at TODs, than ITE guidelines would suggest.

Our sample of TODs is small, which limits our ability to generalize. However, the five cases selected for this study are more or less exemplary of the D variables, at least in comparison with US norms. They are characterized by land-use diversity and pedestrian-friendly designs. They minimize distance to transit, literally abutting transit stations. They have varying measures of destination accessibility to the rest of the region via transit. Three have progressive parking policies, which fall under the heading of demand management. Two have high residential densities, and one has a high intensity of commercial development.

Simply put, our case study TODs create significantly less demand for parking and driving than do conventional suburban developments. With one exception, peak parking demand in these TODs is less than one half the parking supply guideline in the ITE *Parking Generation* manual. Also, with one exception, vehicle trip generation rates are about half or less of what is predicted in the ITE *Trip Generation Manual*. Automobile mode shares are as low as one quarter of all trips, with the remainder being mostly transit and walk trips.

1. Introduction

How best to allocate land around transit stations is a debated topic, with transit officials often opting for park-and-ride lots over active uses such as multifamily housing, office, and retail organized into transit-oriented developments (TODs). The question of how much vehicle trip and parking demand reduction occurs with TOD is largely unexplored in the literature. This study gives hard numbers, albeit for only five TODs in five different regions.

For planned TODs in the same or other regions in the US, our findings may be used in tandem with regional travel model forecasts. Perhaps conservatively, one could set a floor on alternative mode shares and percentages trip and parking reductions equal to the minimum values for our five TODs, or could set a cap on these equal to the maximums from this study. Also, one could look for the best match to a particular TOD being proposed from among our sample of TODs.

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The only way to increase the generalizability of this effort, and increase the likelihood of a good match, is to expand the sample of TODs studied, particularly including larger TODs and TODs on light-rail lines. In this vein, we call for additional research on trip and parking generation at TODs.

2. Literature review

Previous researchers have examined the relationship between urban density and transportation. Low density and separate land uses create high auto dependency (Catalán, Saurí, & Serra, 2008; Clifton, Currans, Cutter, & Schneider, 2012; Reilly, O'Mara, & Seto, 2009). TOD is one of the strategies for planners to mitigate the problems associated with high auto dependency. The basic idea behind TOD is to capture more trips internally and encourage more walking and transit trips by creating an urban form that is relatively high density, mixed in terms of different land uses, served by high quality transit, and with pedestrian-friendly designs.

A large amount of urban land is dedicated to parking, especially in auto dominated cities in the U.S. Davis, Pijanowski, Robinson, and Kidwell (2010) estimate that the states of Illinois, Indiana, Michigan and Wisconsin allocate 1260 km^2 of their land to parking lots. This accounts for approximately 4.97% of urban land use and more than one parking space per adult. Wu and Thompson (2013) found the impervious surface increased rapidly in Iowa in recent decades, with parking lots being one of the most prevalent impervious surfaces. As one of the most common impervious surfaces human created during urbanization, parking lots contribute to many environment concerns, such as urban sprawl, water quality, and the urban heat island effect. Urban lands used for parking lots tend to have lower green coverage (Kremer, Hamstead, & McPhearson, 2013). States that have a higher proportion of their urban land devoted to parking lots are states where urban sprawl is more prevalent (Davis et al., 2010).

First we review the literature on vehicle trip generation at TODs. The ITE *Trip Generation Manual* itself states that its "[d]ata were primarily collected at suburban locations having little or no transit service, nearby pedestrian amenities, or travel demand management (TDM) programs" (ITE, 2012). It goes on to say: "At specific sites, the user may wish to modify trip-generation rates presented in this document to reflect the presence of public transportation service, ridesharing, or other TDM measures; enhanced pedestrian and bicycle trip-making opportunities; or other special characteristics of the site or surrounding area" (ITE, 2012). This kind of modification is seldom done in practice.

Surveying 17 housing projects near transit in five U.S. metropolitan areas, Cervero and Arrington (2008) found that vehicle trips per dwelling unit were substantially below the ITE's estimates. Over a typical weekday period, the surveyed housing projects averaged 44% fewer vehicle trips than that estimated by using the ITE manual (3.754 versus 6.715). Another study by the San Francisco Bay Area Metropolitan Transportation Commission found that residents living near transit generated half as many vehicle miles traveled (VMT) as their suburban and rural counterparts (SFBAMTC, 2006). Nasri & Zhang (2014) found people living in TOD areas reduced their VMT by around 38% in Washington, D.C. and 21% in Baltimore, compared to their non-TOD counterparts. At the same time, residents living in developments near transit are reported to have higher rates of transit trips than residents living at greater distances (Faghri & Venigalla, 2013; Olaru & Curtis, 2015; SFBAMTC, 2006; Zamir, Nasri, Baghaei, & Mahapatra, 2014), especially for commuting trips (Arrington & Cervero, 2008; Cervero, 1994; Faghri & Venigalla, 2013; Lund, Cervero, & Wilson, 2004; Lund, Willson, & Cervero, 2006). However, another study found that new residents in seven TODs in North American adopted more active and transit trips only for amenities and leisure after they relocated to a TOD but that they were less likely to do so for work and shopping (Langlois, van Lierop, Wasfi, & El-Geneidy, 2015). These results are specific to multifamily development near transit. To our knowledge, there is only one previous study of vehicle trip generation at TODs (defined as mixed-use developments – Handy, Shafizadeh, & Schneider, 2013).

Next we review the literature on parking generation at transit-served sites. The ITE *Parking Generation* manual notes that study sites upon which the manual is based are "primarily isolated, suburban sites" (ITE, 2012). ITE (2010) studies show that the vehicle ownership is lower in transit-served areas than those that are not transit-served (Faghri & Venigalla, 2013; Zamir et al., 2014). By comparing parking-generation rates for housing projects near rail stops with parking supplies and with ITE's parking-generation rates, Cervero, Adkins, and Sullivan (2010) found there is an oversupply of parking near transit, sometimes by as much as 25–30%. Oversupply of parking spaces may result in an increase in vehicle ownership (Cervero & Arrington, 2008). This is supported by the strong positive correlation between parking supply and vehicle ownership (Chatman, 2013; Guo, 2013) and auto use (Chatman, 2013; Weinberger, 2012; Weinberger, Seaman, & Johnson, 2009). Again, these studies relate to residential developments. Although Loo, Chen, and Chan (2010) studied rail-based TODs and the connection with variables such as parking and car ownership, they did not examine parking demand. To our knowledge, there is no previous study of parking demand at TODs (again, defined as mixed-use developments), only parking demand at residential developments near transit.

3. Methodology

3.1. TOD definition

TODs are widely defined as compact, mixed-use developments with high-quality walking environments near transit facilities (Cervero, Murphy, Ferrell, Goguts, & Tsai, 2004). For this study, we limited our sample of TODs to sites developed by a single developer under a master development plan. TODs may also include a clustering of development projects near transit facilities developed by one or more developers pursuant to a master development plan.

The first three criteria used to select TODs for this study are consistent with the definition above. TODs must be

(1) Dense (with multi-story buildings),
(2) Mixed use (with residential, retail, entertainment, and sometime office uses in the same development), and
(3) Pedestrian-friendly (with streets built for pedestrians as well as autos and transit).

We have added four criteria to maximize the utility of the sample and data. TODs must be:

(4) Adjacent to transit (literally abutting and hence integrally related to transit),
(5) Built after a high-quality transit line was constructed or proposed (and hence with a parking supply that reflects the availability of high quality transit),
(6) Fully developed or nearly so, and
(7) Self-contained in terms of parking.

By self-contained parking, we mean having dedicated parking, in one or more parking garages or lots, for the buildings that comprise the TOD. This criterion is dictated by our need to measure parking demand for the combination of different land uses that