Trip and Parking Generation at Transit-Oriented Developments

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Abstract

Standard guidelines for trip and parking generation come 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.

In the travel literature, developments are often characterized in terms of D variables. The five TODs studied in this project are more or less exemplary of the Ds. 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, TODs (even the most auto-oriented) create significantly less demand for parking and driving than do conventional suburban developments. With one exception, peak parking demand in 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*.

Reducing the number of required parking spaces, and vehicle trips for which mitigation is required, creates the potential for significant savings when developing TODs. Guidelines are provided for using study results in TOD planning.

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 or TODs (1). The question of how much vehicle trip and parking demand reduction occurs with TODs is largely unexplored in the literature. This study gives hard numbers, albeit for only five TODs in five different regions.

The only way to increase the generalizability of this study, and increase the likelihood of a good match to a proposed TOD, 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.

LITERATURE REVIEW

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" (2, pp. 1). 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." This kind of modification is seldom done in practice.

Surveying 17 housing projects near transit in five U.S. metropolitan areas, Cervero and Arrington (3) 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 percent 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 (4). At the same time, Bay Area residents living in developments near transit are reported to have higher rates of transit trips than residents living at greater distances (4-6), especially for commuting trips (3-4, 7-8). These results are specific to multifamily development near transit. To our knowledge, there is only one study of vehicle trip generation at TODs (defined as mixed-use developments – reference 9).

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" (10). Studies show that the vehicle ownership is lower in transit-served areas than those that are not transit-served (5-6). By comparing parking-generation rates for housing projects near rail stops with parking supplies and with ITE's parking-generation rates, Arrington and Cervero (11) and Cervero et al. (12) found there is an oversupply of parking near transit, sometimes by as much as 25-30 percent. Oversupply of parking spaces may result in an increase in vehicle ownership (3). This is supported by the strong positive correlation between parking supply and vehicle ownership (13-14) and auto use (13, 15-16). Again, these studies mostly relate to residential developments. To our knowledge, there is no study of parking demand at TODs (again, defined as mixed-use developments).

METHODOLOGY

TOD Definition

TODs are widely defined as compact, mixed-use developments with high-quality walking environments near transit facilities. For this study, we limited our sample of TODs to sites developed by a single developer under 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 multistory multifamily housing),
(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 comprise the TOD. The criterion precludes TODs in a typical downtown that share public parking with non-TOD uses. Thus, our findings will be most applicable to the many proposed and self-contained TODs in less urban or more suburban locations.

TOD Selection

Given our seven criteria, we selected good (arguably the best) self-contained TODs in each of five regions: Denver, Los Angeles, San Francisco, Seattle, and Washington, D.C. These five regions were selected based on the presence of high-quality transit and on sampling convenience. Our consulting partners (Fehr & Peers and Nelson\Nygaard) have branch offices in these regions. This expedited the data collection for the sampled sites.

For each region, we identified TOD candidates from multiple sources in a multi-step process. The first step was to consider mixed-use developments (MXDs) near transit from an MXD database collected for another purpose (17). The MXD database includes developments in two of the five study regions: Denver and Seattle. We identified all MXDs in close proximity to transit stations in the two regions.

The second step was to ask our consulting partners with branch offices in our case study regions to identify candidate sites within their regions that meet our seven criteria. Concurrently, we contacted regional transit operators and/or metropolitan planning organizations with the same question. A surprising number of transit agencies and MPOs have staff specifically dedicated to promoting TODs. These were contacted, told our criteria, and asked for the best local examples of TOD.

The third step was to review candidate sites with Google Earth imagery to check for clustering of buildings around transit stations, typically with well-defined boundaries. This was followed by the use of Google Street View to establish that TOD criteria (dense, mixed use, pedestrian-friendly with self-contained parking) were actually met. Several top candidate TODs were ranked in this manner for each metropolitan area.

The final step was to visit each of the metropolitan areas and, once there, take transit from one candidate station area to the next. In each location, we walked around and through the development to determine whether our criteria were in fact met and went to the property management office to get contact information. We also made a photographic record of each development. In virtually all cases, the relative ranking of sites changed with on-the-ground inspections.

Ultimately, we identified one TOD in each region that met our criteria and was feasible to study. Table 1 provides statistics on the density/intensity of development for the five TODs studied in this paper. Floor area ratios (FARs) for commercial development (which are calculated as commercial floor area divided by acreage of commercial and mixed uses) are relatively low, while gross residential densities exceed the guidelines in most transit-oriented design manuals (18). The typical TOD has ground floor retail and apartments above, meaning that the commercial FAR is generally limited to 1.0, while the residential density depends on the number of stories. Fruitvale Village TOD, with its heavy concentration of clinics, a high school, a library, etc., is one exception to the low FAR rule. But the very substantial vehicle-trip and parking reductions documented in this study suggest that very high density/intensity of development is not a requirement for success.

TABLE 1 Net and Gross Residential Densities, and Floor Area Ratios for Commercial Uses, for the Five TODs Studied

TOD	*Metropolitan Area*	*Gross Area (acres)*	*Gross Residential Density (units per gross acre)*	*Net Residential Area (acres)*	*Net Residential Density (units per net acre)*	*Gross Commercial FAR (for retail and office uses)*
Redmond TOD	Seattle	2.5	129	2.5	129	0.11
Rhode Island Row	Washington, D.C.	6	46	6	46	0.27

Fruitvale Village	San Francisco	3.4	14	3.4	14	0.94
Englewood	Denver	30	15	10.7	41	0.25
Wilshire/Vermont	Los Angeles	3.2	140	3.2	140	0.27

Data Collection

The multimodal transportation planning firms of Fehr & Peers and Nelson\Nygaard developed a data collection plan and protocols. The firms also managed data collection in the field and subsequent data entry for three types of travel data: (1) full counts of all persons entering and exiting the buildings that make up the TODs, (2) brief intercept surveys of samples of individuals entering and exiting the buildings that make up the TODs, and (3) parking inventory and occupancy surveys of all off-street parking accessory to the commercial and residential uses of the TODs.

The intent of this approach was to develop an accurate measure of total trip generation associated with the commercial and residential uses at the site, as well as complementary travel survey and parking utilization data that provide a picture of the mode of travel, origin/destination, parking location – if applicable – and purpose for all trips to and from the building throughout the course of the day.

Surveyors counted and attempted to intercept only individuals observed walking to or from an entrance to the TOD buildings (or, in observation of the garage entrance, only drivers and passengers in vehicles entering/exiting the garage driveway to/from the public street). Individuals waiting for the bus or train, or walking between the transit stops park-and-ride garages, were not counted or surveyed.

The data was conducted between 7:30 am and 9:00 pm on Tuesday, May 28, 2015 for Redmond TOD, between 7:00 am and 9:00 pm on Wednesday, September 16, 2015 for Rhode Island Row, between 7:30 am and 8:00 pm on Thursday, November 5, 2015 for Fruitvale Village, between 7:00 am and 9:00 pm on Tuesday, October 13, 2015 for Englewood TOD, and between 7:00 am and 9:00 pm on Thursday, November 17, 2015 for Wilshire/Vermont TOD.

RESULTS

There is a certain logic or predictability to the summary statistics that follow. See individual case study chapters of our final report, for detailed information on how these summary statistics were derived (19).

Mode Shares

From Table 2, walk mode shares fall within a fairly narrow band, from 16.6 percent at Rhode Island Row to 28.3 percent at Fruitvale. They mostly reflect the environment in which the TOD is located, and secondarily the number of commercial trip attractions contained within the TOD. Wilshire/Vermont and Fruitvale are in the most urban settings. They have dense neighborhoods nearby and many commercial trip attractions on site. In contrast, Rhode Island Row and Englewood abut big-box retail development, which supports few if any walk trips. Redmond, which also has a relatively low walk mode share, has neighborhoods nearby that should generate walk trips, but also has the smallest number of commercial trip attractions of the TODs surveyed.

Bike mode shares are small for all TODs studied, although all but Rhode Island Row do exceed the national average for bike mode share. The mean bike mode share for this five-TOD study is only 2.5 percent. For planning purposes, it is safe to assume a small bike mode share for any planned TOD. It will not have much effect on overall vehicle trip and parking generation whether you assume a 1 percent bike mode share, the national average, or a 4 percent bike mode share, the highest for our five TODs. The bike mode share model of Tian et al. (17) might be used to check whether the bike mode share assumed is, in fact, realistic.

Bus mode shares vary from a low of 3.3 percent at Englewood to a high of 21.1 percent at Wilshire/Vermont. All TODs studied, including Englewood, are served by multiple bus lines and have bus transfer operations adjacent to the TODs. All but bus-only Redmond TOD provide relatively seamless transfers from rail to bus and bus to rail. It is a matter of exiting one vehicle, walking a very short distance, and entering another vehicle. The bus transfer area at Englewood is not nearly as amenity-rich as at other TODs; there are no benches or shelters. At the other extreme, Wilshire/Vermont lies at the intersection of two major bus corridors. Density and related vehicle ownership may also have something to do with the contrasting mode shares. To the visitor, three-story Englewood reads very differently than seven-story Wilshire/Vermont; with ground floor retail both places, it is the difference between two stories of residential and six stories of residential.

Finally, rail transit proves its dominance over bus transit at three of the four locations where both are present. The exception is Wilshire/Vermont, where they have nearly identical mode shares. And, of course, there is no comparison for Redmond because it has only bus service. The smallest rail mode share is 13.6 percent at Englewood. The largest shares are 27.2 percent at Rhode Island Row and 26.1 percent at Fruitvale. Not surprisingly, these two TODs are located in Washington, D.C., and San Francisco, the regions with the best rail systems. In terms of ridership, Washington, D.C.'s Metro system ranks second in the U.S. behind New York City, while San Francisco's BART system ranks fifth. In terms of system route miles, they rank second and third in the United States, respectively.

TABLE 2 Average Mode Shares for TODs Studied

TOD	***Count***	***Mode shares***					
		Walk	***Bike***	***Bus***	***Rail***	***Auto***	***Other***
Redmond	1,981	18.9%	1.7%	13.0%	NA	64.9%	1.5%
Rhode Island Row	8,451	16.6%	0.3%	9.3%	27.2%	42.5%	4.0%
Fruitvale	16,558	28.3%	4.3%	15.2%	26.1%	23.0%	3.1%
Englewood	14,073	19.2%	3.8%	3.3%	13.6%	59.7%	0.2%
Wilshire/Vermont	11,043	27.4%	2.2%	21.1%	20.1%	25.9%	3.4%
Simple Averages	NA	22.1%	2.5%	12.4%	21.8%	43.2%	2.4%

Vehicle Trip Generation

Vehicle trip generation at the TODs in this study occurs at much lower rates than predicted by ITE guidelines. Table 3 shows that the number of vehicle trips at TODs range from one-third below to two-thirds below ITE rates. The biggest reductions are at Rhode Island Row and Redmond, where the numbers of vehicle trips are, respectively, 34.7 and 37.4 percent of the number of trips predicted by the ITE *Trip Generation Manual*. These numbers represent a 65.3 percent reduction and a 62.6 percent reduction in vehicle trip-making relative to ITE's suburban, auto-oriented developments.

Similarly, vehicle trips at Wilshire/Vermont and Fruitvale are about half what is predicted by ITE. These are the most urban of the TODs in the sample. Off-site retail and housing options abound near both developments, and mode shares for walking are correspondingly high. Mode shares for transit use are also high, and auto mode shares are by far the lowest of the five TODs studied, a fact we will return to momentarily.

The smallest reduction is at Englewood. But even here, vehicle trips fall to 69.8 percent of the number predicted by ITE, a 30.2 percent reduction. That is, even in a relatively auto-oriented TOD like Englewood, with an abundance of free parking, vehicle trip reductions are substantial relative to the suburban standard.

TABLE 3 Average Vehicle Trip Reductions Relative to ITE Rates

TOD	*ITE vehicle trips*	*Actual vehicle trips*	*% of ITE trips*	*% reduction*
Redmond	1,767	661	37.4%	62.6%
Rhode Island Row	5,808	2,017	34.7%	65.3%
Fruitvale	5,899	3,056	51.8%	48.2%
Englewood	13,544	9,460	69.8%	30.2%
Wilshire/Vermont	5,180	2,228	43.0%	57.0%

Parking Generation

Parking generation is much more complicated than vehicle trip generation. There is both supply of and demand for parking. There is residential, commercial, and mixed-use parking. And, of course, there are ITE guidelines and actual parking numbers for our TOD sites. There are also issues such as shared parking between different land uses, bundled parking (guaranteed parking spaces as part of a rent payment) for residential uses, and paid parking for commercial uses. There are so many comparisons that could be made that we risk simply creating confusion, so we will try to keep it as simple as possible.

The bottom line of this section is clear. In almost all cases, the TODs in the sample supply much less parking than is called for in ITE guidelines. Despite these supply restrictions, demand for parking at TODs is well below the supply. But there are exceptions, as discussed below. Readers are referred to the individual case study chapters of our final report (20) for more detailed discussions of parking supply and demand at the five TODs.

All of the featured TODs have apartments in multi-story buildings, so that is the land-use category to which we compare TOD residential supplies to the ITE supply guideline. As noted in the individual chapters, supply is relatively easy to measure except where there is shared parking. In Redmond, Englewood, and Wilshire/Vermont, and in the south garage at Rhode Island Row, residential users have their own parking garages or lots, or have sections of garages reserved for them. Only in Fruitvale, and in the north garage at Rhode Island Row, is parking shared with commercial uses. Also, for computing supply per dwelling unit, we use the total number of residential parking spaces and the total number of apartments, not just the occupied apartments. The total number of apartments is easier to determine.

In Table 4, we present supply numbers on a per dwelling unit basis (the common way of representing residential parking). The supply of parking stalls for residential use at TODs ranges from 0.81 stalls per dwelling unit at Rhode Island Row (57.9 percent of the ITE guideline) to 1.60 stalls per dwelling unit at Englewood (114.3 percent of the ITE guideline). Englewood actually provides more residential parking than ITE would suggest because of the agreement between the City of Englewood and the big-box retailer Wal-Mart, which was concerned that residential parking would spill over into the retailer's parking lot.

Now for a comparison of actual demand for residential parking at TODs to the supply at TODs. Peak demand for residential parking is trickier to estimate than parking supply. Unlike supply, we use only occupied apartments to compute the number of parking spaces per dwelling unit. We also make the assumption, where parking is shared, that residential parking demand peaks in the late night/early morning hours when apartment dwellers are presumably all at home, and commercial and transit users presumably have left. The peak demand for parking ranges from 0.44 spaces per occupied dwelling unit at Rhode Island Row (south garage) to 1.29 spaces per occupied dwelling unit at Englewood. From Table 5, the occupancy of residential parking spaces (peak demand divided by actual supply) ranges from 54.3 percent at Rhode Island Row (south garage) to 80.6 percent at Englewood.

TABLE 4 Residential Parking Supplies as a Percentage of ITE, and Residential Peak Parking Demand as a Percentage of Actual Supplies

TOD	*ITE supply (spaces per unit)*	*TOD supply (spaces per unit)*	*TOD peak demand (occupied spaces per unit)*	*TOD supply as % of ITE supply*	*TOD peak demand as % of TOD supply*
Redmond	2.0	1.19	0.86	59.5%	72.3%
Rhode Island Row	1.4	0.81	0.44	57.9%	54.3%
Fruitvale	1.4	NA*	1.02	NA	NA
Englewood	1.4	1.6	1.29	114.3%	80.6%
Wilshire/Vermont	2.0	1.10	0.81	55.0%	73.6%
Average	1.55	1.18	0.87	71.7%	70.2%

* Fruitvale's east and west garages both have shared residential and commercial parking.

Now on to commercial parking supplies and demands. As with residential parking, commercial parking supplies are well below ITE guidelines, but peak parking demand uses up most of the reduced parking supplies. For commercial parking, we can only report on aggregates, since parking is shared by the individual commercial uses in these multiuse projects. For Redmond, Englewood, and Wilshire/Vermont, commercial parking is separate from residential, and we can therefore compute statistics specific to commercial parking supply and demand. For parking supplies, we apply ITE supply rates to the specific square footage of leased commercial uses present within the development. For parking demand, we do the same with ITE peak demand rates (see individual case study chapters of our final report for examples). Unlike residential parking demand, which peaks at night, commercial parking demand peaks during the day.

For Rhode Island Row (north garage) and Fruitvale, commercial uses share parking with residential uses, and we can only compute statistics for the resulting mix of parking users. For mixed-use parking garages, we apply ITE supply rates to both residential and occupied commercial uses within the development. For mixed uses, we use the actual daily peak parking volume (the one hour across the day when the number of parked cars is greatest) to represent the peak parking demand.

From Table 5, actual parking supplies for commercial and mixed-use garages and lots in our TODs range from 22.6 percent of ITE supplies at Fruitvale to 61.2 percent of ITE supplies at Englewood. These are huge reductions relative to ITE supplies. As noted in the Englewood case study, even relatively auto-oriented Englewood TOD conserves on parking.

With these reduced supplies, the TODs in our sample use most of their parking supplies during the peak hour. Peak demand for commercial/mixed-use parking garages and lots ranges from a low of 74.3 percent of parking supply at Englewood to 140.7 percent of supply at Wilshire/Vermont. Wilshire/Vermont is able to exceed the actual supply of parking spaces by using tandem, valet parking.

TABLE 5 Commercial/Mixed Use Parking Supplies as a Percentage of ITE, and Commercial/Mixed Use Peak Parking Demand as a Percentage of Actual Supplies

TOD	*Commercial/mixed use parking supply as % of ITE guideline*	*Commercial/mixed use peak parking demand as % of actual supply*
Redmond	27.5%	85.7%
Rhode Island Row	50.8%	78.9%
Fruitvale	22.6%	84.0%
Englewood	61.2%	74.3%
Wilshire/Vermont	25.4%	140.7%

A final set of comparisons captures the potential of these exemplary developments to conserve on parking relative to ITE supply guidelines. This is the most extreme comparison, comparing peak demand for these mixed-use developments to supplies.

For this final comparison, we sum parking utilization across residential, commercial, and mixed-use parking areas for the hour when occupancy is at its highest for residential and commercial uses. We do not include transit park-and-ride parking in this comparison. At all TODs studied, transit users have their own garages or lots. The one exception is Englewood, where transit users share parking with commercial users in the civic center garage.

The first comparison (aggregate peak demand to aggregate ITE parking supplies) indicates just how wildly over-parked these developments would be if parking were built to ITE guidelines rather than scaled back for alternative mode use (walking and transit use). From Table 6, at the overall peak hour, parked cars would fill only 19.0 to 45.8 percent of parking spaces if built to ITE standards.

The second comparison (aggregate peak demand to aggregate actual supply) indicates the degree to which these developments are over-parked relative to their theoretical potential. From Table 6, at the overall peak hour, only 58.3 to 84.0 percent of parking spaces are filled. The latter is for Fruitvale, which has shared parking for residential and commercial uses. Due to limited shared parking, even these exemplary developments (except Fruitvale) do not achieve their full potential. This fact is discussed in the next section.

TABLE 6 Residential/Commercial/Mixed Use Parking Supplies as a Percentage of ITE Supplies, and Residential/Commercial/Mixed use Peak Parking Demand as a Percentage of Actual Supplies

TOD	**Residential/commercial/mixed use *peak parking demand as % of ITE supply guideline***	**Residential/commercial/mixed use *peak parking demand as % of actual supply***
Redmond	41.6%	73.5%
Rhode Island Row	32.7%	63.6%
Fruitvale	19.0%	84.0%
Englewood	45.8%	58.3%
Wilshire/Vermont	33.0%	66.8%

DISCUSSION AND CONCLUSION

D Variables and Parking Policies

Developments are often characterized in terms of D variables. The Ds all bear a relationship to travel demand. The first three Ds—development density, land-use diversity, and urban design—were coined by Cervero & Kockelman (20). Two additional Ds—destination accessibility and distance to transit—were included in later research (21-22). Other Ds include demand management and demographics.

The five TODs studied in this project are more or less exemplary of the Ds. All contain a diverse land-use mix, though Fruitvale could use more residential development and Redmond, in particular, could use more commercial development. All have public spaces, ample sidewalks, street trees, curbside parking, small building setbacks, and other features that make them well designed from a pedestrian standpoint. All minimize distance to transit, literally abutting transit stations. Fruitvale and Rhode Island Row are served by two of the best rail systems in the nation, and thus have exemplary destination accessibility via transit. Wilshire/Vermont has exemplary bus accessibility as well. Several provide affordable housing, and thus attract the demographics most likely to use transit and walk.

In terms of density, these developments (except Wilshire/Vermont) would be classified as low rise (five or fewer stories). The commercial floor area ratio is moderately high only at Fruitvale (see Table 1). Even density of residential development would be considered high only at Wilshire/Vermont and Redmond (see Table 1). The three-story developments at Englewood, Fruitvale, and Rhode Island Row represent a lost opportunity from a transit-supportive standpoint.

A sixth D, demand management (parking management), is mixed in TODs studied. Only Fruitvale and the north garage at Rhode Island Row share residential and commercial parking in the sense that the same spaces can be used at different hours by different users. In other cases, residential and commercial users may occupy the same garage, but with spaces reserved for one use or another (commercial at Redmond, residential at Wilshire/Vermont). And only Englewood shares parking between TOD and transit park-and-ride users. Again, they may share a garage as at Rhode Island Row, but spaces are reserved for transit park-and-ride users. At all surveyed developments, transit has its own, exclusive park-and-ride garage and/or lot. We are not implying that some reserved parking isn't warranted for market reasons, but the extent of reserved parking in these otherwise smart developments comes as a surprise.

A parking space/permit comes with each apartment in Englewood and Wilshire/Vermont, whether the renters want it and use it or not. Parking is effectively free. Fruitvale has a hybrid parking policy, where the first space/permit comes with the apartment. The second space (if renters want one) costs them $90 per month. Very few renters opt for the second space, evidence that unbundled parking suppresses parking demand. Only in Redmond and Rhode Island Row is parking totally unbundled. In Redmond, reserved parking spaces are leased for $95 per month ($90 at the time of our study); and in Rhode Island Row, reserved parking spaces are leased for $150 per month.

Redmond and Englewood have free commercial parking. Of the other three, Rhode Island Row charges commercial parkers $2 per hour or a maximum of $24 per day (or $4.50 for early birds). Comparable charges for Fruitvale Village are $3 per hour and a maximum of $12.50 per day; and for Wilshire/Vermont, the charge is $6 per hour and a maximum of $30 per day. All in all, except at Wilshire/Vermont, parking charges are modest.

In terms of parking policies, Englewood is the least progressive and has the highest vehicle trip generation rate relative to ITE. Imagine how much further parking supplies could be reduced if residential, commercial, and transit parking were shared, residential parking were unbundled, and commercial parking were on a pay basis (23).

Study Limitations

The limitations of this study are summarized here. The first and most important is the small sample size. These are truly case studies, as opposed to a cross-sectional sample. Due to labor-intensiveness of data collection (two people at each entry point to a TOD, one to count and the other to survey), our sample is limited to five TODs. Only one of our TODs is exclusively bus-based, Redmond TOD. Only one is served by LRT, Englewood TOD. Only one is predominately commercial, Fruitvale Village (although Englewood has ample strip commercial along its southern boundary).

A second limitation is an inability to account for internal capture of trips within these TODs. Internal trips are trips that begin and end within a mixed-use development. Such trips obviously have much less impact on the environment and are generally subtracted from total trip-generation rates in traffic-impact studies. Our TODs are small and, we argue elsewhere, likely have low internal capture rates. It is hard to imagine, except perhaps at Englewood, anyone doing anything but walking within our sample of TODs. But as we expand our sample to larger TODs, we will want to ask a third question in our intercept surveys beyond the current two (those two being mode of travel and purpose of trip). We will want to ask whether the origin and destination are within the development.

A third limitation is related to the phenomenon of residential self-selection. Residential self-selection occurs when people who would use transit anyway elect to live in a TOD. The literature strongly suggests that not everyone living in a TOD does so for the transit connection. But many probably do. If there is ever a case where self-selection is likely to be prevalent, it is at developments that offer immediate, high-quality transit options like our case studies. While the transportation statistics from these case studies can be used to plan individual TODs, which will likewise benefit from self-selection, these statistics probably (due to self-selection) overstate the benefit to the region as a whole in having TODs. Again, these self-selectors would be inclined to use transit anyway, so there is not as much impact on regional mode shares or vehicle trips or perhaps even parking demand as our statistics imply.

There are other limitations, such as the fact that our vehicle counts are typically from 7:00 a.m. until 9:00 p.m., rather than the full 24 hours as with ITE. Another is that the seventh D variable, demographics, may be different for these TODs than others because most of the developments in our sample offer some affordable (as opposed to market rate) housing. But we still contend that this study has important practical planning implications, as discussed in the next section.

Applications to TOD Planning

How might the statistics in Tables 3 through 6 be used to plan for other TODs? Our statistics represent default values, to be used when better estimates are not available. For planned TODs around other stations, in the same or other regions, our statistics may be used in tandem with regional travel model forecasts for a particular TOD or its respective traffic analysis zone. Regional travel models can capture the effects of transit service at a particular site, but typically do not capture the full effects of the D variables on travel demand. On the other hand, our mode shares, trip generation rates, and parking generation rates are actual (not modeled) values that reflect all the D variables of particular TODs, but are particular to these developments and their contexts. Whether they apply to TODs with different D variables and different contexts will always be debatable. That is why we say that both modeled regional travel model forecasts and actual trip and parking generation rates for TODs should be considered in the planning of other TODs.

One other source of travel data for mixed-use developments (MXDs) might be used to obtain independent estimates for TODs. For a sample of 412 MXDs in 13 diverse regions of the U.S., Tian et al. (17) estimated models relating internal capture rates and external walk, bike, and transit mode shares to D variables for the developments and their surroundings. It would not be difficult to estimate these outcome variables for any given TOD. This would provide a third independent estimate of TOD travel characteristics around which to triangulate.

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. As an example, a TOD proposed for a Salt Lake City station area might be matched to Englewood TOD in Denver, since the metropolitan regions are most similar and both regions have LRT (light rail transit) rather than HRT (heavy rail transit). This would be particularly appropriate if the planned TOD were large and relatively auto-oriented, like Englewood TOD. Conversely, if the TOD were compact and pedestrian-oriented, largely commercial, and inclusive of affordable housing, one might match to Fruitvale Village, despite differences in rail systems (LRT vs. HRT) and metropolitan regions (Salt Lake City vs. San Francisco). Obviously, any application of these statistics would ideally involve triangulation in light of regional travel demand model forecasts and MXD model estimates.

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