

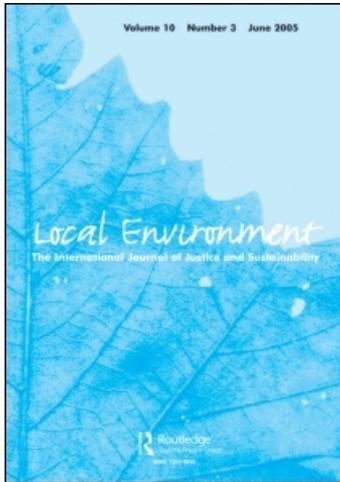
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From transit-adjacent to transit-oriented development

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Downtown Berkeley, Hayward, and Fremont are three Bay Area Rapid Transit (BART) stations with different surrounding built environments. Berkeley is located in a downtown setting, whereas Hayward and Fremont are located in the suburbs. Fremont is the most auto-dominated, whereas Hayward is a hybrid between being a transit-oriented and transit-adjacent development. Downtown Berkeley exemplifies the aims of many planners across the USA who are working to promote transit-oriented development (TOD). This study helps to confirm the importance of a quality built environment upon travel behaviour and vehicle ownership through an analysis of the three BART stations listed above. This article presents a transit-adjacent development – TOD spectrum that may help planners and policy makers better understand what is and what is not a TOD.

Keywords: transit-oriented development; transportation; planning; urban design

Introduction

A new distinction within smart growth literature has been proposed that describes the difference between a transit-adjacent development (TAD) and transit-oriented development (TOD) (Belzer and Autler 2002, Cervero *et al.* 2002, Dittmar and Ohland 2004). Both concepts refer to the area within a 10-min walk, or half-mile radius, around a major transit station. While a TOD describes a station-area precinct that is compact, mixed-use, and facilitates transit connectivity through urban design, a TAD is “physically near transit [but] fails to capitalize upon this proximity. . . [It] lacks any functional connectivity to transit – whether in terms of land-use composition, means of station access, or site design” (Cervero *et al.* 2002, p. 6).

As more and more cities and suburbs are using rail stations as an anchor for redevelopment, the distinction between a TAD and TOD can vary in both space and time. Station precincts can transition from a TAD into a TOD, as illustrated in Figures 1 and 2 from Subiaco, Western Australia. This station area was the subject of a major redevelopment that created a new walkable, mixed-use development around the station.

Most stations fall within a spectrum from TAD to TOD (Figure 3). A national study here in the USA found that about 100 of the nation’s 3300 fixed rail stations are TODs (Cervero *et al.* 2004). Even many of these may be TAD-like because “TOD designations, of course, are quite subjective: one person’s TOD may be viewed by others as little more than an office building with suburban parking ratios that happens to be near a train stop” (Cervero *et al.* 2004). Based on these numbers, even if all of these stations were TODs, nearly 97% of rail stations in the USA would be under-developed or in other words – a TAD.

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Figure 1. Subiaco Rail Station Precinct – Mid-1990s.
Source: Subiaco Redevelopment Authority.



Figure 2. Subiaco Station Precinct – today.
Source: Subiaco Redevelopment Authority.

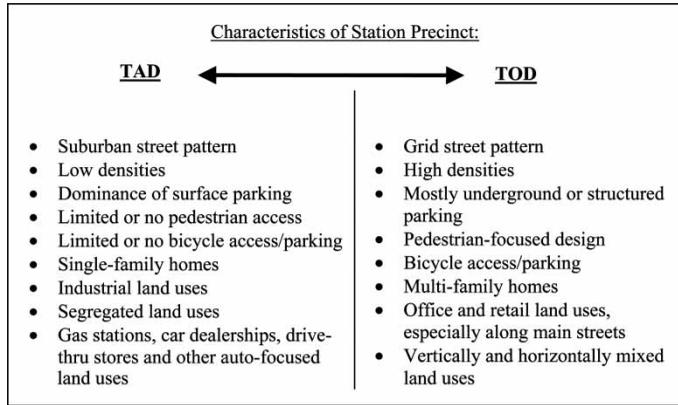


Figure 3. The TAD–TOD spectrum.

A recent study rated TOD as a top real estate investment (Urban Land Institute and Price-WaterhouseCoopers 2005), while the government and transit agencies are placing more and more attention on TOD. This article presents a case study of three major rail stations in the East San Francisco Bay Area to illustrate examples along the TAD–TOD spectrum: Downtown Berkeley, Hayward, and Fremont. Hayward and Fremont are suburban settings that are in the process of redeveloping around their train stations. While this sample is not large enough to be considered statistically valid, it shows how variation of urban design in three station precincts corresponds with travel behaviour and vehicle ownership outcomes. This research is drawn from both the US Census and the California Department of Transportation's Transit-Oriented Development Database (<http://transitorienteddevelopment.dot.ca.gov>). Downtown Berkeley is a TOD with a relatively high-density, mixed-use, and a high-quality urban environment that facilitates walking and bicycling in addition to transit riding. The precinct around the Fremont Bay Area Rapid Transit (BART) station is the most TAD-like of the three. The street layout is the most suburban-like, the density is the lowest, and the quality of the pedestrian environment is poor. Hayward falls between Berkeley and Fremont in the TAD–TOD spectrum.

Bay area case study

Bay area overview

With over 7 million residents in 2000, the San Francisco Bay Area is one of the most populated regions in the USA. The coordination of planning for TOD is complex because the Bay Area is home to over 40 transit agencies, 9 county governments, 100 municipal governments, and several regional authorities (Cervero *et al.* 2004). The Metropolitan Transportation Commission (MTC) and the BART District have become public sector leaders in promoting TOD.

BART, which began service in 1972 with 28 miles of rail, today consists of 43 stations and 104 miles of track (see Figure 4 for a map of the BART system). BART is a heavy rail system that operates independently of the highway system. BART consists of five corridors, all with direct access to four main stations in downtown San Francisco.

According to the American Public Transportation Association (APTA), in 2003, BART had 668 trains, provided over 60 million vehicle miles of service, and accounted for over 93 million passenger trips (American Public Transportation Association 2005a). Compared with other heavy rail systems in the USA, BART had the fifth highest average weekday ridership, behind New York, Washington, DC, Chicago, and Boston, respectively. During the first quarter of

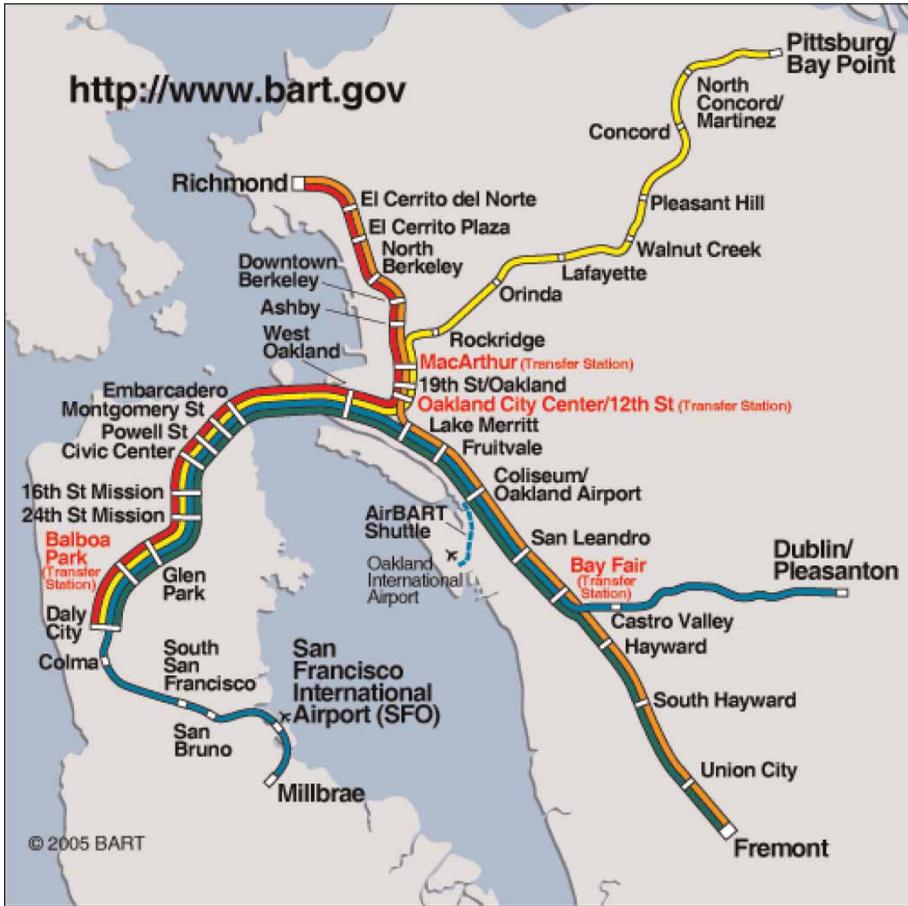


Figure 4. Map of BART. Source: Bay Area Rapid Transit (BART) (2005).

2005, BART served over 320,000 average weekday trips (American Public Transportation Association 2005b).

Sprawl has created a traffic nightmare in the Bay Area. San Francisco’s traffic is consistently rated among the worst in the USA. In 2003, the region was rated second to Los Angeles as having the worse congestion in the country, where the average annual delay per traveller was 72 h – four days each year! (Schrank and Lomax 2005).

Cities and regions all over the USA, including the Bay Area, are rethinking the expansion of highways, as they often lead to induced travel demand for driving due to expanded low-density sprawl. To a certain extent, rail systems also induce new land development, although with the proper policies in place, these developments could be designed as TODs, which may lead to fewer vehicle trips, reduced emissions, and more sustainable outcomes compared with the conventional low-density sprawl model.

The speed and reliability of commuting on BART to jobs in downtown San Francisco and Oakland is a major factor driving TOD in the Bay Area. A one-way commute from Fremont to Montgomery Street in downtown San Francisco on BART is 46 min. This compares to traffic-free driving time of 40 min.¹ When considering the actual time with traffic it is probably

closer to an hour and a half or more not including the time it takes to find parking. Cost is another factor. The cost of a round trip fare for this journey is \$10.00 on BART. Frequent commuters can save 6.25% by purchasing tickets in bulk.² For the same trip in a car, drivers can expect to pay nearly \$10.00 in fuel plus \$3.00 for the Bay Bridge.³ Based on average monthly rates, parking will easily double the cost of this trip. Clearly, BART is more economical for a journey to downtown from a cost and timesaving perspective compared with driving. Also, because BART operates independently from the highway system, the commute time will most likely remain consistent for years to come, assuming BART is able to add trains as patronage grows, whereas traffic congestion will mostly likely worsen as the region grows.

Housing and transportation costs are factors that make TODs desirable in the Bay Area. TOD residents can devote a higher percentage of their budget towards housing, spending less on transportation costs. The benefit of this strategy for individuals is that more of their money ends up in an asset (their home) rather than spent on depreciating items (such as a car). Low transportation costs, due to the extensive public transportation network in the Bay Area, more than balances out high housing costs when comparing this region with others. A recent study showed that Bay Area residents, despite high housing costs, spend about 55% of income on the combination of transportation and housing, which is lower than a number of cities, including: San Diego, Tampa, Miami, Denver, Atlanta, and Phoenix (Cervero 2005).

Downtown Berkeley, Hayward, and Fremont

Downtown Berkeley, Hayward, and Fremont are three BART stations that each have different functions and each perform differently along the TAD–TOD spectrum (see Figure 4 for station locations). All of the stations opened for service in 1973 but each station has developed in a different manner over time because of its different locations within the region and due to differences in local real estate markets and different accessibility *vis-a-vis* BART. Before describing travel behaviour and vehicle ownership outcomes in each station area, it is important to understand each station precincts' location and built environment (Figures 5–7).

Downtown Berkeley is located close to the region's core, just north of Oakland. It takes 23 min to travel to the Montgomery Street BART station in downtown San Francisco. Downtown Berkeley, which is closest to a true TOD along the spectrum, is located in a busy, compact, mixed-use downtown setting with a concentration of jobs, housing, and services. The station is one block from the University of California, which has over 30,000 students and about 9000 full-time staff and faculty. The station does not have a highway nearby or park-n-ride facility and pedestrian and bicycle access to the station is on par with vehicles (California Department of Transportation (CalTrans) 2005).⁴

Hayward, located south of Oakland, is moving towards becoming a downtown-like setting, but as recently as the early 1990s the station area consisted of large parking lots with only a few businesses (CalTrans 2005). Hayward is further from downtown San Francisco compared with Berkeley, with a 38-min travel time to the Montgomery Street BART station. In recent years, nearly 1000 residential units have been built, including a large pedestrian plaza that integrates the BART station with a new town hall and shopping. Pedestrian access was rated in the California TOD Database as being on par with vehicles but bicycling access was considered non-existent (CalTrans 2005). The station area still has surface parking and more than half of BART riders drive alone to the station. Compared with Berkeley, a much smaller percentage of passengers walk to Hayward (Table 1). For these reasons, Hayward is closer to a TAD along the TAD–TOD spectrum in comparison to Berkeley. The design of the built environment focuses more on cars than people.

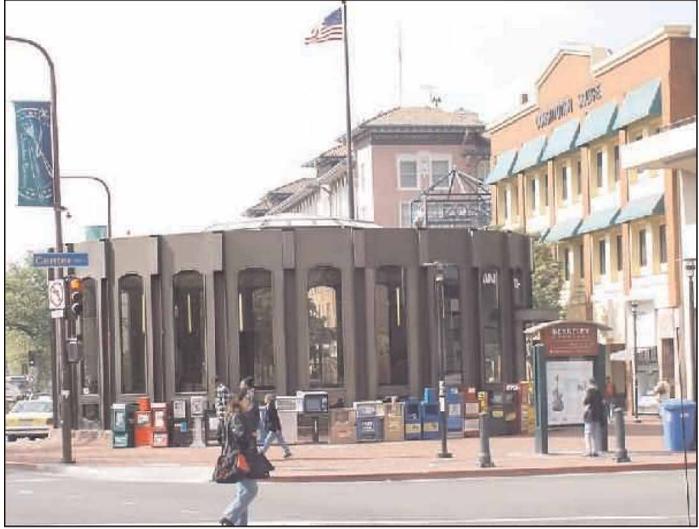


Figure 5. Downtown Berkeley BART station.
Source: CalTrans (2005).

Fremont is the furthest station from downtown San Francisco compared with Berkeley and Hayward. A trip from Fremont to the Montgomery Street BART station in Downtown San Francisco is 8 min longer when compared with Hayward. Similar to Hayward, Fremont is undergoing the redevelopment of the station area, which will include a new mixed-use village centre with compact housing. Although plans are in place to create a vibrant TOD at Fremont, today it is the most TAD-like of the three stations. Fremont's primary role, being at the end of the line, has been a park-n-ride capture station for residents living in the hinterland.



Figure 6. Hayward BART station.
Source: CalTrans (2005).



Figure 7. Fremont BART station.
Source: CalTrans (2005).

Table 1. Transit access characteristics of selected BART stations.

Station ridership	Downtown Berkeley	Hayward	Fremont
Average weekday boardings	10,303	4,201	5,579
Average weekday alightings	9,880	4,363	5,740
<i>Access mode</i>			
Walk (%)	59.3	10.6	7.8
Bicycle (%)	4.6	2.8	1.0
Transit (%)	18.6	15.7	10.2
Drive alone (%)	7.4	55.2	62.0
Carpool (%)	0.9	3.7	6.3
Other (%)	9.2	12.0	12.7

Source: CalTrans (2005).

Note: The boarding and alightings data were from 2001 and the station access data were from 1998.

The station area consists of large parking lots with suburban office buildings that are not well integrated with the train station. While Fremont's station receives more boardings than Hayward, it has a higher percentage of passengers that drive alone. The station has the highest percentage of carpoolers due to its location at the end of the line. Both pedestrian and bicycling accessibility were rated as non-existent (CalTrans 2005).

The relationship between the built environment, travel behaviour, and vehicle ownership

TOD seeks to encourage compact and mixed-use communities around train stations. Analysing the built environment is important for better understanding the land use and design characteristics that lead to higher levels of transit use, walking, and bicycling, and less dependence on cars in station precincts. Table 2 reports the housing density, from 1970 to 2000, for all three stations. In 2000, Berkeley had the highest housing density, followed by Hayward and Fremont,

Table 2. Housing density for selected TODs in San Francisco (total number of housing units per square mile).

Station area	1970	1980	1990	2000
Downtown Berkeley	10,430	10,480	10,255	10,665
Hayward	2,578	2,573	3,004	3,220
Fremont	295	669	1,408	2,485

Source: Author’s calculations from US Census (1970, 1980, 1990, 2000) using the Geolytics Neighborhood Change Database.

respectively. Downtown Berkeley also has the smallest block dimensions, the most street linkages and the most intersections within the half-mile transit precinct (see Table 3 and Figure 8). Hayward has a grid street pattern but the dimensions of the block sizes are larger than Berkeley (see Table 3 and Figure 9). Fremont, without a fully developed grid street pattern, is the most suburban-like of three stations with the lowest density, fewest street linkages, and number of intersections (see Table 3 and Figure 10). Smaller block sizes with more linkages and intersections create greater pedestrian accessibility at the neighbourhood level.

As shown in Table 3, the rating of station design, pedestrian and bicycle accessibility is highest in Berkeley followed in order by Hayward and Fremont. The high-quality design, pedestrian and bicycle accessibility, high-density and small street network in the Berkeley station precinct are all characteristics of an ideal TOD (Calthorpe 1993). The lower density, suburban-like Fremont precinct is the most TAD-like because the built environment is designed to accommodate cars over people. Again, Hayward falls in the middle of the TAD–TOD spectrum (Figures 9 and 10).

These observations help us understand travel and vehicle ownership outcomes across these three stations. Downtown Berkeley reported the highest share of residents commuting on transit (Table 4), the highest shares of walking and cycling (Table 5), and the highest percentage of households with one or no cars (Table 6). Hayward trailed Berkeley for each of these indicators followed by Fremont, the precinct with the most dependence on the automobile. Fremont’s percentage of households owning one or no cars was not much different than the metropolitan average (45.7% versus 42.8%, respectively, as shown in Table 6).

As shown in Table 1, average daily weekday boardings at the Berkeley station in 2001 was 10,303. Due to the intensity of the TOD area, Berkeley had nearly twice as many boardings compared with Hayward and Fremont.

Table 3. Built environment indicators.

Station area	Number of street links	Number of nodes (three-way or more intersections)	Typical block dimensions (in ft)	Station design rating	Pedestrian accessibility rating	Bicycle accessibility rating
Downtown Berkeley	184	102	350 × 700 or less	6 of 8	3 of 4	3 of 4
Hayward	144	80	350 × 700 or more	5 of 8	3 of 4	2 of 4
Fremont	120	58	No clear pattern – suburban street design	5 of 8	1 of 4	2 of 4

Note: Calculations are based on the half-mile station area taken from the street maps available from the California TOD Database.

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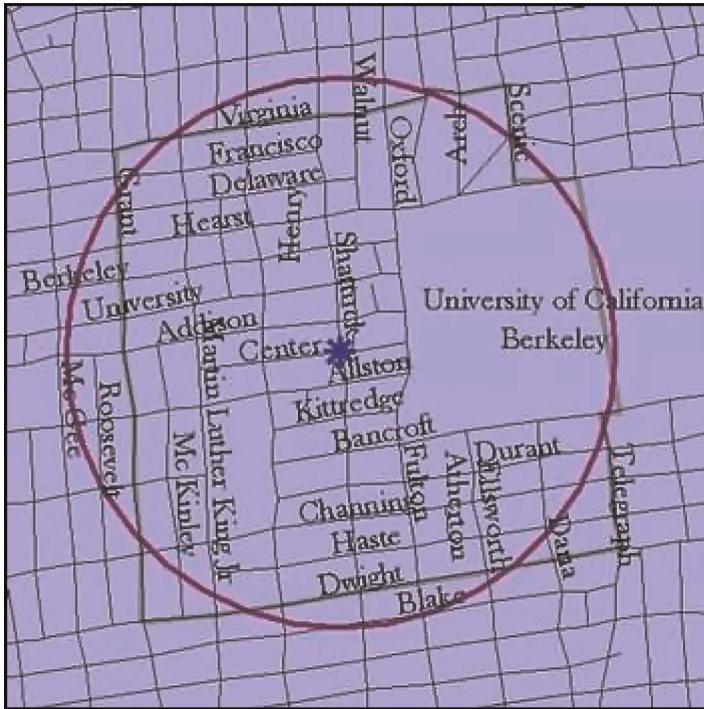


Figure 8. Map of Downtown Berkeley station area precinct.

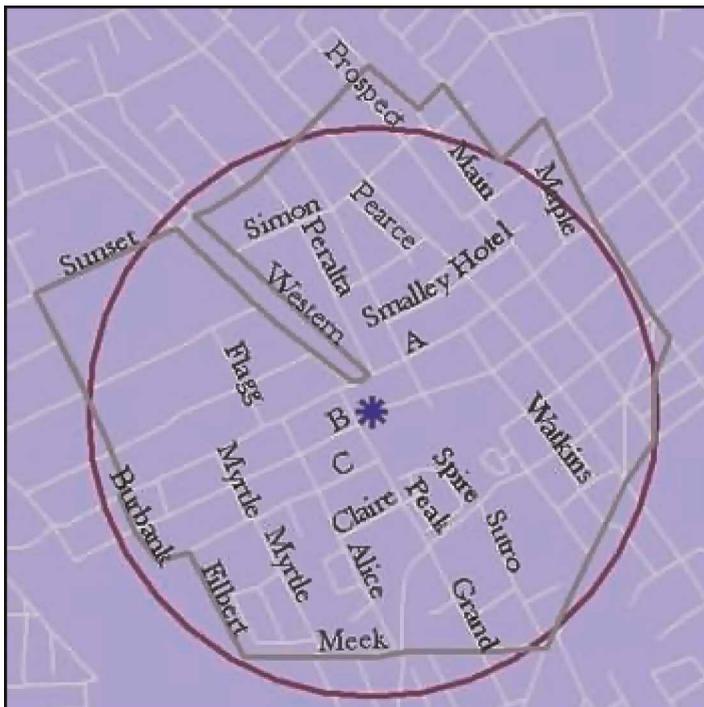


Figure 9. Map of Hayward station area precinct.

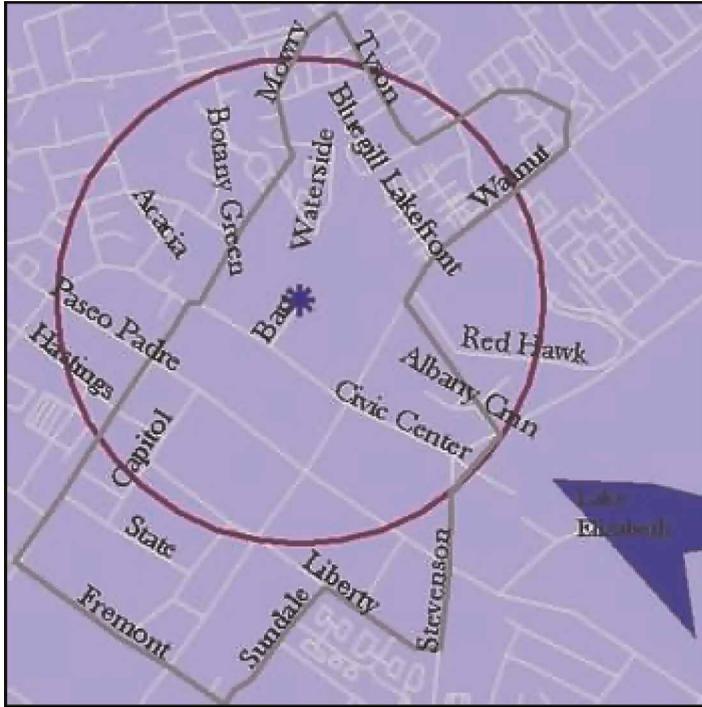


Figure 10. Map of Fremont station area precinct.

The nature of the built environment around the Berkeley station has resulted in more sustainable transport patterns for station access. As reported in Table 1, 82.5% of BART riders arrived at the station using a sustainable mode of transport⁵ (CalTrans 2005). In comparison, Hayward’s mode share for accessing the station by walking, bicycling, transit was 29.1% and Fremont was 19.0%.

When looking at how density and travel behaviour have changed over time, Fremont grew the most with respect to density and transit ridership. Table 7 shows that Fremont became nearly seven and a half times denser from 1970 to 2000. During the same period, the share of transit commuting in Fremont grew by nearly 10 times (Table 4).⁶ In Hayward, housing density increased by 25% and shares of transit commuting grew by 16% percent, whereas Berkeley grew by a modest 2.3% in housing density but added 74% in the share of transit commuting.⁷

Table 4. Share of transit commute trips.

Station area	1970 (%)	1980 (%)	1990 (%)	2000 (%)	Percent change 1970–2000	Percent change 1990–2000
Downtown Berkeley	13.8	20.1	17.7	24.0	74	36
Hayward	18.4	26.3	18.5	21.3	16	15
Fremont	1.1	11.6	7.6	12.0	991*	58
San Francisco regional average	11.6	11.4	9.6	9.5	–18%	–1%

Source: Author’s calculations from US Census (1970, 1980, 1990, 2000) using the Geolytics Neighborhood Change Database.

*This large percent growth is based on the fact that the base year (1970) was such a low number.

Table 5. Shares of walking and bicycling commute trips.

TOD	1970 (%)	1980 (%)	1990 (%)	2000 (%)	Percent change 1970–2000	Percent change 1990–2000
Downtown Berkeley	41.8	40.6	31.2	37.7	–10	21
Hayward	35.6	11.6	6.6	12.0	–66	83
Fremont	15.1	5.0	2.4	4.1	–73	69
San Francisco regional average	8.6	9.1	6.4	4.4	–49	–31

Source: Author's calculations from US Census (1970, 1980, 1990, 2000) using the Geolytics Neighborhood Change Database.

Table 6. Vehicle ownership trends (percentage of households with one or no vehicles).

Station area	1980 (%)	1990 (%)	2000 (%)	Percent change 1980–2000	Percent change 1990–2000
Downtown Berkeley	82.0	80.3	74.0	–10%	–8%
Hayward	59.7	57.2	57.9	–3	1
Fremont	41.2	35.4	45.7	11	29
San Francisco regional average	47.8	42.8	42.8	–10	0

Source: Author's calculations from US Census (1980, 1990, 2000) using the Geolytics Neighborhood Change Database.

Table 7. Housing density trends for selected TODs in San Francisco (total number of housing units per square mile).

Station area	Percent change 1970–1980	Percent change 1980–1990	Percent change 1970–2000	Percent change 1990–2000
Downtown Berkeley	0.5	–2.1	2.3	4.0
Hayward	–0.2	16.8	24.9	7.2
Fremont	126.6	110.6	742.2	76.5

Source: Author's calculations from US Census (1970, 1980, 1990, 2000) using the Geolytics Neighborhood Change Database.

In 1970, Fremont had a residential density of 295 units per square mile with 1.1% of residents commuting to work on transit, but by 2000 the residential density increased to 2485 units per square mile with 12% of residents riding transit to work. Despite this high rate of growth, Fremont still had the lowest housing density by 2000, whereas Berkeley had the highest. Fremont also had more low-density housing, whereas Downtown Berkeley had more high-density housing (CalTrans 2005).

Tables 8 and 9 summarise the relationship between the urban design of the built environment (Table 8) and the travel behaviour and automobile ownership patterns (Table 9) for each station precinct. Along the TAD–TOD spectrum Downtown Berkeley is a TOD because it has a high residential density, high level of mixed uses, and a high quality of pedestrian and bicycle access. Hayward, a hybrid TOD/TAD, has about a third of Berkeley's density and not as many commercial opportunities. The mix of uses is more horizontal than vertical. Horizontal mixing creates a more suburban-like setting compared with vertical mixing, which is usually found in higher density settings. While the pedestrian access is high quality, the bicycle access is only

Table 8. Built environment and urban design summary for station precincts.

Station area	Description of built environment	Pedestrian access	Bicycle access	Housing density (units per square mile)	Mix of uses
Downtown Berkeley	TOD	High quality	High quality	10,665	Highly mixed – both vertical and horizontal
Hayward	Hybrid TOD/TAD	High quality	Fair	3,220	Moderately mixed – mostly horizontal
Fremont	TAD	Poor	Fair	2,485	Moderately mixed – mostly horizontal

Table 9. Travel behaviour and vehicle ownership summary.

Station area	Station access mode	Share of residents commuting on transit, walking, or bicycling (%)	Share of households owning two or more cars (%)
Downtown Berkeley (the TOD)	63.9% – walk/bike 18.6% – transit 17.6% – car/other	61.7	26.0
Hayward (the hybrid TOD/TAD)	13.4% – walk/bike 15.7% – transit 70.9% – car/other	33.3	42.1
Fremont (the TAD)	9.8% – walk/bike 10.2% – transit 81.0% – car/other	16.1	54.3

fair. At the other end of the spectrum from Berkeley, Fremont has the lowest housing density, a poor quality pedestrian environment and fair bicycle access. Again, the mix of uses is more horizontal than vertical.

As shown in Table 9, the Berkeley TOD has the highest share of transit riders accessing the station by walking, bicycling, and transit. It also has the highest share of residents (within the half-mile station area) commuting on a sustainable mode of transport and the lowest household vehicle ownership. At the other end of the spectrum, the Fremont TAD has the highest shares of transit riders arriving by car and the highest shares of residents commuting by car. Not surprisingly, it also has the highest household vehicle ownership. Just as Hayward (the hybrid TOD/TAD) falls in the middle of the spectrum with respect to urban design characteristics, it also falls in the middle with respect to station access, residential commuting, and household vehicle ownership.

Discussion

These findings lend credibility to the importance of the three “D’s” in TODs – density, design, and diversity (land use mix) (Cervero and Kockelman 1997). Several studies have found that increased densities reduce automobile ownership and use, and increased reliance on alternative modes (TRL 2004 cited in Newman and Kenworthy 1999, Ewing *et al.* 2002, Kuzmyak and Pratt 2003, Litman 2005, Newman and Kenworthy 2006).

Chatman (2006) found that variables associated with the inconvenience of driving were the most strongly correlated with travel behaviour within TODs. His *network load density* is a measure of potential roadway congestion. He found that as the network load density increases

there is a lower probability that people make non-work trips by car, have fewer non-work vehicle miles travelled, and a lower share of auto-commuting. His study, which included Berkeley and Hayward (but not Fremont), found stations with higher levels of retail employment were correlated with higher commuting on transit, walking, and bicycling.

This may be because sufficiently high amounts of shops and services increase both walking and transit use by making the walk to and from work, and the walk to and from the transit stop, both more visually interesting and a way to carry out occasional commercial trips during the middle of the day, after work or before work. (Chatman 2006)

Hayward and Berkeley both have a mix of land uses including retail, but Downtown Berkeley had 45.39 workers per acre compared with Hayward's 13.93 (of these Berkeley had 9.98 retail workers per acre and Hayward had 3.40) (Chatman 2006). This further supports the finding from this study that the more compact, mixed-use nature of Berkeley facilitates more walking and transit use compared with Hayward, which is more suburban in its design.

Several studies of stations in the Bay Area found that residents were three to five times more likely to commute via transit compared with non-station areas (Cervero 1994, Lund *et al.* 2004, Renne 2005). Higher shares of transit commuting in TODs result, in large part, from self-selection. Cervero and Duncan (2002) found that self-selection accounted for about 40% of the rail-commute decision. Because the demand to live in TODs far exceeds the supply of TODs, Cervero and Duncan argue that zoning changes ought to occur to allow the process of self-selection to occur naturally in the marketplace.

Levine (2006) argues that the demand for smart growth, which includes TOD, is artificially constrained by zoning laws in most municipalities across the USA. Across the USA, the demand for TODs has been found to be within the range of 10–25% of all households (Center for Transit-Oriented Development 2004; Levine and Inam 2004). A survey conducted for Smart Growth America and the National Association of Realtors found that 61% of people looking to buy a house within the next three years would look to neighbourhoods that demonstrate characteristics of smart growth. Women, African Americans, and Hispanics were most likely to prefer compact and mixed-use communities (Belden Russonello & Stewart 2004). In February 2006, the Board of AARP passed a resolution that favours TOD as a viable alternative to the growing segment of elderly Americans. This decision, in part, was because not only do TODs allow for mobility options, but they also encourage a healthy lifestyle because residents get more exercise in their daily routine (Greenberg *et al.* 2005).

The hot market for TOD stems from the reality that the current supply is so low. Currently, the average TOD accommodates about 10,000 residents, thus the current supply of 100 TODs only serves about 0.5% of the American population. If the studies cited earlier are correct, 800 new TODs would be required to accommodate demand at the 10% level and over 2000 TODs would be required to accommodate demand at the 25% level. This pressure is being noticed in all markets with rail stations across the USA. Transit accessible housing in cities across the country is selling at a premium and new plans for TODs are being released at an unprecedented rate. If the studies are correct, this is a trend that is likely to continue for decades to come.

One of the most important aspects of TOD is that they are usually acceptable locations for higher density development in suburban areas. Newman and Kenworthy (2006) recommend a minimum of 35 people and jobs per hectare are needed to create an urban environment that will reduce automobile dependence. Anything less than this threshold will result in an urban environment that has a density too low to maximise the benefits of an urban design that is focused on walking, bicycling, and public transport. Therefore, within a 10-min walk radius of a station the precinct would need to support a minimum of 10,000 people and jobs (Newman

and Kenworthy 2006). In this study, Downtown Berkeley is the only location that exceeded this minimum threshold. As Hayward and Fremont continue to grow in jobs and population, they will become more TOD-like.

Downtown Berkeley has the characteristics that TOD advocates are trying to create. This includes a high-quality, high-density, downtown environment with good accessibility for pedestrians and bicyclists. The TOD is both an origin and a destination. Not all stations will become a Downtown Berkeley, but more station areas could move in that direction. This will create more “downtowns” in suburban areas like Hayward and Fremont that will be transit-linked with the central city.

Notes

1. This driving distance was calculated using the trip distance calculator on Expedia.com
2. Better discounts are available for senior citizens, school children, and persons with disabilities.
3. Fuel costs are calculated based on \$2.50 per gallon and a fuel efficiency of 20 mpg.
4. The rating of pedestrian access is from the California Department of Transportation’s TOD Database, which can be accessed at: <http://transitorienteddevelopment.dot.ca.gov>.
5. Sustainable transport is defined here as walking, bicycling, or public transit.
6. It is important to note that because BART did not exist in 1970, much of the increase in shares of transit commuting was likely due to new train service. Unfortunately, using 1980 as a base year is also problematic because data is skewed during that year because of the oil crisis. The period from 1990 to 2000 shows that shares in transit commuting increased by 36% in Berkeley, 15% in Hayward, and 58% in Fremont along with an increase in housing density of 4%, 7.2%, and 76.5%, respectively.
7. 1970 serves as a base year because it was before the BART stations were opened. It is unclear why shares of transit commuting increased at a rate much faster than density in Downtown Berkeley. Newman and Kenworthy (2006) suggest that walking, bicycling, and public transit become most valued where there are above 10,000 people and jobs within a 10-min walking radius. They also found that the relationship between urban density and car use is exponential, which may explain why the share of transit commute trips increased faster than density.

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