Transit and Land Use Form

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Introduction

Several research studies have been conducted over the last several decades regarding transit patronage and urban form. Some of these studies have focused on specific aspects of land use form, such as residential densities and employment center densities, and their influence on transit use. The body of research was summarized in a 1996 Transit Cooperative Research Program (TCRP) Report 16 conducted by the Transportation Research Board (TRB). This effort concluded that there is strong "empirical evidence that transit and urban form relationships are important." (*TCRP Report 16*, p. 2)

The summary of research covered the affects of four aspects of land use form. These include:

1. **Land Use Structure -** which is the way land use is organized in spatial terms, focusing on large geographic areas of analysis. It includes such attributes as *location of uses* and *distinctness of transportation corridors*.
2. **Land Use Density -** which encompasses both residential and employment densities,
3. **Land Use Mix -** which encompasses the range of land uses found within an urban structure; and**,**
4. **Urban Design -** which includes both the character and arrangement of land uses , including *site design* and *pedestrian amenities*.

The primary findings of the studies found that these aspects of land use form operate dynamically with transit investment. Transit, especially rail transit, can influence compact, mixed-use development, which in return can induce greater transit ridership. In other words, the relationship between land use form and transit is symbiotic and ongoing. Additionally, the TCRP report concluded that the bundle of land use form attributes is difficult to break apart, statistically, to determine specific thresholds at which these attributes need to exist in order to significantly influence transit ridership, but "the presence of these attributes clearly makes transit a more attractive choice." (p. 2) The research also concludes:

> "that the coordination of transit-urban form relationships must take place within a larger systems context. Initiatives to coordinate transit investments and urban development should be framed more globally in terms of such complementary initiatives as travel demand management (TDM) planning, road pricing, regional growth management, and community redevelopment." (p. 3)

Land Use Structure

Land use structure affects transit patronage in two ways:

1. The location of employment centers, which affects the probability people will choose transit, and
2. The distinctness of a transit corridor, which is influenced by the distance people are willing to walk, bike or drive within an area to access transit.

Location of Land Uses

Several studies have concluded that when employment is concentrated in a large employment center, that is a Central Business District (CBD), people are more likely to use transit. Research in Houston (Rice Center, 1987) found "that CBD workers are five times more likely to use transit than workers on other activity centers". (p. 5)

A number of metropolitan areas including Boston, Baltimore, Washington, D.C., Dallas, Denver, San Francisco, Portland, and Seattle have conducted simulations using regional travel demand forecasting models to identify the types of urban form that best support transit use. These studies concluded that at least one, if not more of the following land use attributes supports higher transit patronage:

- Compact land use form,
- A reduction in the number of significant employment centers in the region,
- Employment and residential uses in corridors served by high capacity transit,
- A greater mix of land uses in transit corridors, and

- Pedestrian and bicycle enhancements.

The probability of using transit increases significantly if both trip origins and destinations are located in close proximity to transit stations or services. However, the propensity (likeliness) to use transit, is not solely the result of the location of land uses. In *Ridership Impacts of Transit Focused Development in California*, Robert Cervero notes that the transit system characteristics and the cost of parking at the work site strongly influence mode choice. His study found that in major urban centers served by rail transit with high daily parking fares, employees commuting by rail were typically in the 90-98 percent range. In suburban office parks not served well by transit and with free parking, employee transit use was virtually zero percent.

Transit Corridor Distinction

Transit corridors within urban environments can be defined by the lengths of walk and bus access trips. In suburban areas, the corridor is more appropriately defined by the length of automobile-access trips. "The unique combination of station spacings, access modes, and competing transit locations combine to influence the actual configuration of the corridor and the ridership it generates." (p. 9)

In *Accommodating the Pedestrian*, Richard Untermann (1984) concluded that most people are willing to walk 500 feet, with 40 percent willing to walk 1,000 feet and only 10 percent willing to walk a half-mile.
In *Transit Villages in the 21st Century,* Bernick and Cervero (1997) concluded, "...ridership potential is highest within about one-third of a mile to a station, though from the Canadian studies we see that the impact zone can be extended a half mile out or more." (Bernick and Cervero, p. 126) Additional studies have shown that these distances can be increased by creating pleasant urban spaces and corridors. Other factors that have be shown to influence walk distances include the following:

- The quantity, location and price of parking near transit,
- The characteristics of the transit service, including the distance between stations on rail lines, and the frequency and quality of feeder bus service to rail stations and transit centers,
- The characteristics and location of land uses near transit corridors and stations, and,
- Culture.

Land Use Density

A study in Portland, Oregon concluded that the two most significant variables for determining transit demand are overall housing density and overall employment per acre. (Nelson/Nygaard, 1995) Pushkarev and Zupan (1977 and 1982) stated that residential densities in transit corridors, along with the size of the downtown and the distance of the stations from downtown explained demand for a variety of transit modes. The effects of density, however, are interrelated with employment center size, the land use structure within the transit corridor, transit service characteristics and public policies, such as the price of parking.

A number of empirical studies have identified threshold densities to provide a sense of whether there is a propensity for transit use. Newman and Kentworthy in 1989 recommended densities above 12 to 16 persons per acre for pubic transit-oriented urban lifestyles. Frank and Pivo (1994) concluded, based upon a study in the Seattle metropolitan area, that beyond the threshold of 50 to 75 employees per acre, and 9 to 13 persons per gross acre, transit work trips showed a significant increase in modal share. Additionally the threshold for transit shopping trips existed at 75 employees per acre and over 18 persons per gross acre. However, Bernick and Cervero state:

> "The biggest benefits come from going from very low to moderate densities, say from an average of 4 units per acre to 10 to 15 units per acre...Increasing densities to mid and high-rise apartments add relatively smaller benefits in terms of trip reduction. One doesn't need Hong Kong-like densities to sustain mass transit." (1997, p. 83)

Table 1 identifies Pushkarev and Zupan's findings regarding the relationship of residential densities and different types of transit services. Table 2 shows recommended minimum transit service levels for identified residential densities and employment center sizes compiled by the Institute of Transportation Engineers (ITE).

Table 1: Recommended residential densities for transit service (Pushkarev and Zupan, 1982)

Service Levels	**Residential Density Thresholds**
Bus: Minimum service (20 buses/day)	4 dwelling units/acre
Bus: Intermediate service (40 buses/day)	7 dwelling units/acre
Bus: Frequent service (120 buses/day)	15 dwelling units/acre
Light Rail: 5 minute peak headways	9 dwelling units/acre (25-100 sq. mile corridor)
Rapid Rail: 5 minute peak headways	12 dwelling units/acre (100-150 sq. mile corridor)
Commuter Rail: 20 trains/day	1-2 dwelling units/acre (existing track)

Source: *TCRP Report 16*, 1996.

Table 2: Recommended residential densities and employment center sizes for transit service. (Institute of Transportation Engineers, 1989).

Minimum Service Level	**Residential Density Thresholds**	**Employment Center Thresholds**
1 bus/hour	4-6 dwelling units/acre	5-8 million sq. ft. commercial/office space
1 bus/30 minutes	7-8 dwelling units/acre	8-20 million sq. ft. commercial/office space
Light rail and feeder buses	9 dwelling units/acre	35-50 million sq. ft. commercial/office space

Source: *TCRP Report 16*, 1996.

The problems with many of these empirical studies is that the threshold conclusions, in many cases, have not been formally controlled for such factors as household income, household size, or the complimentary influences of land use mix and pedestrian amenities.

The TCRP report recommends that instead of determining minimum density requirements for which transit service types are feasible, the relationship between density (as well as other aspects of land use form) and the cost at which transit service can be provided should instead be determined. This is because decisions about providing services are made in corridors and locations where land use characteristics, including density, types and mix of uses, are quite varied. (*TCRP Report 16*, p. 16)

Further, trip purpose also influences transit service type. In determining how land use form such as residential density and employment center size influences light rail and commuter rail transit demand and service cost, TCRP found that residential densities have more influence on light rail ridership and cost than on commuter rail. In turn, CBD employment density was found to be more important for supporting commuter rail ridership than light rail ridership. However, this should not negate or reduce the importance of providing high levels of access to commuter rail at the trip origin.

Land Use Mix

Mixed land uses can yield a number of transportation benefits:

- The more that complementary land uses are mixed, (ie., offices, shops, restaurants, banks, etc.) the more likely people are to walk and less likely to drive.
- Trips are potentially more spread out throughout the day and week, instead of clumped during the morning and evening peak periods.

- Mixed-use development generates opportunities for resource sharing, such as parking.

Urban and Suburban Employment Centres

Nowlan and Stewart (1991) studied land use patterns in downtown Toronto and concluded that although substantial new office construction occurred between 1975 and 1988, much of its impact on peak-hour work trips into the central area was offset by the addition of a large number of new housing units. Over half of the downtown Toronto housing additions were occupied by people working downtown.

In an analysis of suburban activity centres around the United States, Cervero (1989) found that suburban activity centres with some on-site housing averaged between three (3) to five (5) percent more commute trips by walking, cycling and transit than centres without on-site housing. Additionally, introducing a retail component to the activity centre increased transit use and carpooling by about three (3) percent for every ten (10) percent increase in retail and commercial floor space.

The range of studies that have been conducted have all generally concluded that introducing a larger proportion of commercial and residential uses in employment centres improved transit patronage. Also, multi-use and multi-nodal corridors improve transit ridership and efficiency by generating back-haul usage (trips during peak periods, but in non-peak directions) and off-peak usage (trips during the midday or evening after peak-periods).

Residential Neighbourhoods

Several studies have concluded that land use mix is not as significant in influencing transit mode choice decisions in neighbourhoods as density, although it is difficult to sort out the effects of land use mix because it is so strongly correlated to density. Land use mix, however, is particularly significant for walking and biking modes, which are primary methods of accessing transit service. Because walk and bike trips are typically shorter than transit or auto tips, the presence of a land use mix within the work-to-home trip is essential in ensuring accessibility.

Urban Design

A number of studies have been attempted to identify the affects of urban design on transit mode choice. Urban design is a particularly challenging measure to identify as it is often interrelated with land use mix and density. Most of the research conducted, though, suggests that there is some importance of urban and neighbourhood design in influencing mode choice decisions. (*TCRP Report 16*, p. 22) Some specific research has even attempted to identify some of the intangibles of this land use form characteristic. For example, 1000 Friends of Oregon identified a Pedestrian Environment Factor (PEF) which included the following attributes:

- street connectivity,
- sidewalk connectivity,
- use of street crossing on principal streets, and
- absence of topographic constraints to pedestrian mobility.

The PEF was used to rank each transportation analysis zone in the Portland, Oregon region regarding the presence of each of those above mentioned attributes. As with retail employment density, the PEF proved to be a significant influence on automobile ownership and mode choice decisions.

In another study 1000 Friends of Oregon examined the affects of various land use variables in influencing household vehicle miles travelled (VMT) and vehicle trip generation using multiple regression, whereby the effects of each variable were evaluated while controlling others. Table 3 shows some of the results of this analysis.

A study of several hundred employment work sites in Southern California, conducted by Cambridge Systematics (1994) examined the influence of land use mix and urban design on mode choice decisions for work trips. The study found that the presence of mixed land uses and urban design features at the work sites were responsible for increasing transit mode work trips by three (3) to four (4) percent. Further the study showed that the presence of trees and sidewalks and the absence of graffiti do contribute to mode choice decisions. (*TCRP Report 16*, p. 23)

Table 3: Measures that reduce VMT per household by 10 percent (Portland, OR)

- Increase the quality of the pedestrian environment from average to high (four unit increase in PEF), or
- Decrease the average number of cars per household by 1.5 cars, or
- Increase household density from 2 to 10 or 3 to 15 households per acre, or
- Increase the number of jobs accessible by automobile in 30 minutes by 105,000, or
- Increase the number of jobs accessible by transit in 30 minutes by 100,000.

Source: 1000 Friends of Oregon, 1993

Conclusions

The body of research conducted over the last several decades has generally proven that land use structure, density, mix and design all influence transit use. Although land use mix and design have been shown to be less powerful indicators of transit use, these characteristics are still statistically significant in explaining transit use. However, more than any other characteristic, density or compactness seems to matter the most in influencing transit use. Without it, design and mix are not sufficient to ensure a built environment where transit will have significant patronage support. Table 4 provides a summary of the major findings of TCRP Report 16.

The TCRP report recommends that "public policy should support land use mix design along with compact urban form as prerequisites for transit-oriented regions."(p. 25) Further, the understanding of how land use form influences transit patronage will continue to become more refined as more research and case studies are conducted. One method of refinement was made in *Understanding the Link Between Urban Form and Travel Behavior* (Handy, 1995) by using the concept of "accessibility". Handy proposed that land use structure can be thought of as a means of defining transit accessibility at the regional level. Density, land use mix and design can be thought of as attributes of local accessibility for transit.

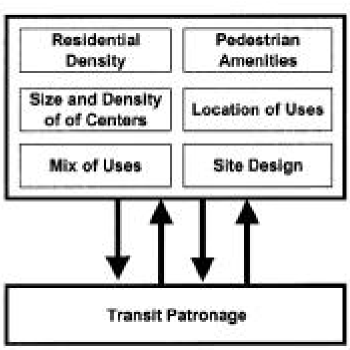

Fig. 1: Relationship between Transit Use and Land Use Form

Density increases accessibility by shortening average trip lengths for all travel modes. Land use mix increases accessibility by increasing the number of nearby destinations available for a given trip purpose or activity. Design increases accessibility by enhancing the directness, safety or attractiveness of travel. Land use structure increases attractiveness and the feasibility of transit services if there are a relatively small number of large compact, mixed-use employment centres. Fig. 1 diagrams the symbiotic and ongoing relationship between transit usage and land use form.

In summary, all the aspects of land use form and land use outlined describe methods which can make transit more useable.

> "The goal of integrating transit and land use should be to create a transit system that offers a comparable level of accessibility to that offered by automobiles..." (*TCRP Report 16*, p. 25)

Therefore, integrated facilities and land uses, along with well-timed, reliable transit service are essential to creating a viable option to the choice of the automobile.

***Table 4: Summary of Research Findings from TCRP Report 16*.**

<u>How Land Use Form Influences Transit Use</u>
How do characteristics of land use form (e.g., residential density, CBD employment size and density) influence the demand for light rail and commuter rail transit and the cost of providing such service?
Main Findings:

- Residential densities have significant influence on rail transit station boardings.
- Residential densities have more influence on light rail ridership and costs than on commuter rail.
- Both the size and the density of the CBD influence light rail ridership.
- CBD density is more important for supporting commuter rail ridership than light rail ridership.
- Other factors within the control of transit agencies, such as the availability of feeder bus service and park-and-ride lots, also influence ridership.

How does the built environment around new rail transit stations affect the mode of access and the size of the catchment area?
Main Findings:

- Residents in higher-density residential areas are more likely to walk to transit.
- Nearly all commuters walk to their destinations in CBDs, but 25 to 50 percent ride buses at other destinations.
- Use of feeder bus service depends mainly on the level of service and parking available, not on the built environment
- Catchment areas are larger in more suburban areas and where transit station parking is ample

Does neighbourhood land use mix and urban design influence the demand for transit?
Main Findings:

- The types and mix of land uses influence the demand for transit as well as the use of non-motorized modes.
- Residents of “traditional” neighbourhoods are more likely to use non-automotive modes for non-work trips than residents of “suburban” neighbourhoods.
- It is difficult to sort out the effects of land use mix and urban design because they are strongly correlated with density.

<u>How Transit Influences Land Use</u>
What public policies and institutions are needed for transit-supportive development to occur near transit stations?
Main Findings:

- Regions with successful transit focused development have the following characteristics:
  - Commitment to a regional vision of high-capacity transit connections between regional centres or in development corridors;
  - Strong, respected institutions that people trust to deliver services;
  - Political cultures that value transit;
  - High-quality transit service that attracts riders;
  - Regional growth that provides the development to channel to station areas;
  - Transit stations in areas where the market supports development;
  - Regional policies that focus growth in transit corridors and limit it elsewhere;
  - Station area policies and programs to support private-sector investments and transit-friendly development; and
  - Long-term commitment.

Source: *TCRP Report 16*, 1996.

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