

# **The Importance of Trip Destination in Determining Transit Share**

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## **Abstract**

*For a variety of reasons, policymakers in recent years have taken a greater interest in increasing the use of transit. However, it is difficult to substantially impact transit use at a large scale, because it is strongly dependent on development density and other slow-changing features of urban land use. This article argues that policymakers hoping to increase transit use should focus on increasing the size of downtowns and developing suburban job centers at downtown sizes and densities. There are both empirical and practical arguments.*

*Empirically, large, dense destinations have a very substantial impact on mode choice, regardless of the characteristics of the trip origin. From a practical standpoint, there are two arguments. First, it may be easier to increase densities in commercial areas, both because political opposition is less acute and because developable land is often more available. Second, commercial areas can be developed at much higher densities, with a corresponding impact on transit ridership.*

## **Introduction**

There are few options available for policymakers hoping to manage the problem of urban traffic congestion. One of these involves reducing the number of cars on the road by shifting trips to transit. However, although transit use has generally been holding constant over the last few years, there have been few, if any, major examples where transit share has substantially increased as a result of policy intervention.

One likely reason for this is that transit use is highly dependent on the nature of the urban land use in which transit operates. A multitude of studies have confirmed the link between residential population density and the share of trips made by transit. The link is so well established that the most visible recent literature is concerned with identifying specific characteristics of neighborhood design that are important to the decision to use transit. Boarnet and Crane (2001) provide an extensive recent survey of the literature on the effect of urban design characteristics on transit share and other travel behavior measures.

A critical issue in this debate is the relative lack of acknowledgment of the role that trip destinations play in determining transit use. The work of Calthorpe (1993), for example, has been very influential among policymakers, but is focused on residential neighborhood characteristics. Some studies, such as Cervero and Gorham (1995), include measures such as access to downtown in the analysis; however, actual differences in destination choice, as opposed to hypothetical access measures, are usually not considered. Frank and Pivo (1994) are an exception. They find a “dramatic increase” in transit use at high employment densities. However, they do not place this finding within a broader context of overall urbanized area transit share.

A significant work that addressed the destination as a key contributor to transit use was Pushkarev and Zupan (1977). Their conclusions about the importance of employment density in determining transit use do not seem to have had much influence on recent studies, despite the high quality and comprehensiveness of their work. Indeed, many of the results and arguments in the present article appeared in Pushkarev and Zupan 25 years ago. Given recent hopes for using transit as a congestion management tool, this seems like a good time to bring them up again.

Table 1 illustrates anecdotally the importance of the central business district (CBD) in determining overall urbanized area transit share. A more formal analysis

of the 31 largest U.S. urbanized areas in Barnes (2001) found that a measure of the localized density of employment (essentially a proxy for the size and density of the downtown) explained considerably more of the variation in transit share across cities than did measures of residential density.

**Table 1. Transit Share and Destination Across Cities (1990)**

	<i>Transit Share to CBD</i>	<i>Transit Share to Non-CBD Destinations</i>	<i>Percent of Total Regional Jobs in CBD</i>	<i>Overall Urbanized Area Transit Share</i>
Los Angeles	14.3	3.8	5.2	4.3
Atlanta	15.7	3.7	9.5	4.8
Twin Cities	22.0	3.0	15.0	5.9
Pittsburgh	29.0	3.6	20.1	8.7

The omission of destination choice from transit share analyses is important from a methodological standpoint, because differences in transit share across neighborhoods or even urban areas may be inappropriately attributed to residential characteristics when they are really due to differing destination choices. It is also important from a policy perspective, because the overwhelming academic focus on residential characteristics can give policymakers the impression that nothing else matters.

The purpose of this article is to make the case that destination choice not only is a critical variable in the determination of transit use, but that, from a policy standpoint, it is more important than residential characteristics. Empirically, it matters not only because the overall transit share from a given trip origin is strongly dependent on the destination, but also because the impact of increasing residential density is very different as trip destinations change.

Perhaps even more importantly, transit destination matters to policy because it is, as a practical matter, considerably easier to have a substantial impact on commercial areas than on home locations. It is very difficult to increase density in both existing residential neighborhoods and new developments, due to both political and economic reasons. These constraints are not true to the same extent as com-

mercial areas. Downtown areas are routinely developed at extremely high job densities with much less opposition and fewer constraints.

This article is written from the perspective of increasing transit share of worktrips as a way of managing peak period congestion, not to improve transit agency cost recovery. Indeed, without a corresponding increase in off-peak transit use to keep the additional buses and drivers occupied, such a strategy may impose higher costs on the transit agency. This, in turn, may necessitate higher subsidies (justified by reduced congestion costs) or strategic subcontracting of routes with little off-peak demand. These are important issues to consider when developing land use strategies.

The first part of this article contains a simple empirical analysis of transit use in the Minneapolis-St. Paul metropolitan area. The objective is to clarify the impact of trip destination relative to origin neighborhood characteristics and to establish that this is a variable that matters a great deal. The second part of the article discusses, from a theoretical and political perspective, why commercial land use, rather than residential, represents a more viable policy option for influencing transit use.

## **Empirical Analysis**

The Minneapolis-St. Paul (Twin Cities) metropolitan area is a seven-county region with about 2.5 million residents. There are two separate downtowns about 10 miles apart; the two central cities abut each other and have about 650,000 residents between them. This analysis uses an aggregation of the 1,165 regional traffic analysis zones into 66 larger zones. These are loosely based on political boundaries with the objectives of maintaining roughly similar populations across zones and uniform land uses within zones. In this way, some small cities and towns are combined, and some large cities are broken into multiple zones. Except for three cases (the two downtowns and the airport), all the zones have at least 10,000 residents. Figure 1 shows the zones and their division, for purposes of this analysis, into non-central city, central city nondowntown, and the two downtowns.

The zone corresponding to the Minneapolis downtown has about 125,000 jobs in about 2 square miles. The St. Paul downtown has about 60,000 jobs in a slightly smaller area. In both cases, the jobs are concentrated in the center of the zone. The Minneapolis campus of the University of Minnesota constitutes a third subcenter of about 35,000 jobs; after this, job densities are much lower in the rest of the

**Figure 1. Twin Cities Transit Areas**



region. While some suburban zones have many jobs, they are spread out over large land areas, and are very difficult to serve effectively with transit. As a result, much of the transit service in the region is focused around the two downtowns.

The analysis uses 1990 Census Transportation Planning Package (CTPP) data for the Twin Cities to analyze the relative impacts of destination, residential density, and a number of other variables in determining transit share for worktrips. The densest residential zone has about 13,500 people per square mile; the second densest is about 9,000. About a third of the zones are essentially nonurbanized, with densities below 1,000 per square mile. About a third of the zones have overall worktrip transit shares below 2 percent, another third are between 2 and 5 percent, and the final third are higher than 5 percent. About half of these have shares in excess of 15 percent up to a maximum of 27 percent. The overall density of the

urbanized part of the region is about 2,000 per square mile; the overall worktrip transit share in 1990 was 5.9 percent.

***A Simple Analysis***

An initial illustration of the importance of the destination aggregates the zones into three area types. The first consists of all zones that are not in one of the two central cities. The second is central city zones, excluding the downtowns. The third area consists of the two downtowns. Table 2 shows the worktrip transit share and the total number of transit worktrips from each origin area type to each destination area type.

**Table 2. Origin-to-Destination Total Work Trips and Transit Share**

<i>From Row to Column</i>	<i>Noncentral City</i>		<i>Central City</i>		<i>Downtowns</i>		<i>Total from Origin</i>	
Noncentral City	610,090	0.6%	132,237	3.5%	101,523	15.8%	843,850	2.9%
Central City	97,391	4.8%	122,887	11.1%	72,179	31.2%	292,457	14.0%
Downtowns	2,287	18.8%	2,430	35.5%	5,746	17.6%	10,463	22.0%
Total to Destination	709,768	1.2%	257,554	7.5%	179,448	22.1%	843,850	5.9%

While the importance of the origin is further confirmed by the fact that central city residents are considerably more likely to use transit to access all destinations, the key point for purposes of this article is the very high transit shares into the downtown areas relative to the rest of the central cities. A relatively high share is obtained even from noncentral city origins, which includes a huge area and population, most of which has little, if any, easily accessible transit service. It is also worth noting that this is based on 1990 data. Express service into the downtowns from suburban areas was expanded considerably during the 1990s in the Twin Cities, so the difference between origins may be even smaller now.

Failure to account for differences in destination choice can lead to inappropriate conclusions regarding the importance of various origin characteristics. There is particular reason to be concerned about this issue in studies that compare matched pairs of origins. Table 3 shows an example of two (hypothetical) central city origins, which differ only in the fraction of their workers who commute into downtown versus the suburbs. The fact that origin 2 has more people working

downtown, and fewer in the suburbs, leads to a 5.3 percent increase in transit share compared to origin 1, even when the transit shares broken down by destinations are identical.

**Table 3. Impact of Differing Destinations on Transit Share**

	<i>Transit Share to Destination</i>	<i>Percent Working at Each Destination (Origin 1)</i>	<i>Percent Working at Each Destination (Origin 2)</i>
Non Central City	4.78	40	20
Central City	11.13	40	40
Downtowns	31.22	20	40
Total Transit Share		12.6	17.9

### **Regression Analysis**

A second, more detailed analysis involved a series of regressions using origin zone transit shares to various destinations as the dependent variable. The regressors were population density, an income measure, and distance of the origin zone from the nearest downtown. The income measures were average zonal income and the fraction of households in the zone with income below \$25,000 (1990 dollars). The second of these turned out to be the superior variable in terms of significance and explanatory power.

The distance of the zone from downtown was never significant when included in a regression with population density; thus, it is omitted here. This is to say that, while distance from downtown strongly influences where people work, it does not apparently influence whether they use transit to get there, given where they work and given the residential density of the origin zone.

One final point is that the downtown zones generated transit shares as origins that were quite disproportionate to their density and income characteristics, to the extent that they substantially distorted the regression results. This happened because residents of these areas could take advantage of the superior transit service created by the high downtown destination densities. These two zones were omitted; the regressions were run using the other 64 origin zones.

For every destination, population density (in thousands of people per square mile) and percent of total households with low incomes were always statistically significant, and no other variable was significant when included with these two. Table 4 shows the regression results for the three destination types, and for overall transit share. The entry of "0" indicates a result that was not statistically significant. All other entries are significant at a 5 percent level or better. The R squared figures indicate that about 80 percent of the variation in transit share across zones was explained by differences in these two variables, given a particular destination.

**Table 4. Regression Result**

	<i>Intercept</i>	<i>Population Density Beta</i>	<i>Low Income Beta</i>	<i>R squared</i>
To Downtown	6.3	2.43	0.70	.76
To Central City	0	1.15	0.31	.83
To Suburbs	-1.4	0.63	0.19	.80
All Destinations	-1.9	1.49	0.45	.86

The interpretation of these numbers would mean, for example, that an extra 1,000 people per square mile in a given area would add 1.49 percentage points to the overall transit share for that area, and an extra 1 percent of the households having low incomes would add 0.45 percentage points, if the work destinations are the average for the region. However, in a hypothetical residential zone where everyone worked in the suburbs, such as might happen in an exurban development, the same density increase of 1,000 per square mile would increase the transit share by only 0.63 percentage points.

***Varying Impact of Residential Density***

The key point of this analysis is that higher residential population density has a much bigger impact on transit share for trips that are going to downtown areas, or, in principle, to suburban areas of similar size and density. The impact is roughly twice as big as it is for other central city destinations and four times bigger than for suburban destinations. Residential neighborhood characteristics matter, but the extent to which they matter is very strongly influenced by where people are going.



The very high intercept value for trips to downtown highlights this point; this represents essentially the worst case transit share. Thus, a population density of just 1,000 per square mile would generate a transit share of 8.73 percent into downtown (the intercept of 6.3 plus the density increment of 2.43). It would take a density of 7,500 per square mile to get the same transit share to other central city destinations (no intercept, and a density increment of 1.15). Even more striking, it would take a density of 16,000 per square mile (denser than any zone in the Twin Cities) to get an 8.73 percent transit share from an origin where everyone works in the suburbs (intercept of  $-1.4$ , plus a density increment of 0.63). This could raise questions about the likely efficacy of new high-density residential developments on the urban fringe, in terms of increasing transit use.

There is an important policy point here. There has been much discussion in the literature and among policymakers of the need for higher density residential development as a prelude to higher transit use. But the relationship between residential density and transit use is not as simple as it is often portrayed. The impact of higher residential density is very strongly dependent on the characteristics of the areas where the residents work. Increasing the size and density of work locations, at least beyond some minimum threshold, will increase the likelihood of transit use by the people that work there, even if the residential density around their home does not change at all.

## **Using Commercial Development to Impact Transit Use**

The focus of this study is the explicit identification of the work destination as an important variable in determining transit share. It influences both the overall share and how changes to residential density impact transit use. While most of the literature focuses on residential density, the finding in the previous section is that there are two different land use tools for influencing transit use: increases in residential density and the development of large, dense, commercial centers. The second purpose of this article is to argue that the latter of these is actually the better policy tool, both politically and from the standpoint of the potential impact.

### ***Constraints on Residential Development Density***

While it may be true that in most American cities there is more demand for than supply of high-density residential environments, it is also probably true that the number of people desiring to live in such an environment, who do not already do so, is probably not large enough to impact regional transit use very much. Creat-

ing a significant regional increase in transit use would be much easier if somehow transit use could also be increased among all the people who are already housed in lower density environments. From the standpoint of using residential development as the lever, this would require increasing the density of existing neighborhoods.

In this case, there is the problem of convincing the existing residents, who tend to have two issues with new development. First, the reason they moved to the area was because they liked the environment, so they will oppose anything that changes it much. Second, rightly or wrongly, people see high-density and especially rental housing as attracting undesirable types of residents. Therefore, there is a relatively low limit on how much residential densities can reasonably be increased. Many, perhaps most, of the recent examples of high-density residential redevelopment in the Twin Cities have arisen on reclaimed commercial and industrial properties in and near the downtowns and the University of Minnesota, where there are few, if any, neighbors to object to them.

Cervero and Landis (1999), in a study of the land use impacts of San Francisco's BART rail system, concluded that the system has had little impact on land use outside downtown, in large part for this reason. Existing neighborhoods had no interest in being redeveloped around transit stations. From a transit perspective, it is undoubtedly better to develop residential areas at higher densities rather than lower, but as a political matter there appear to be significant constraints on how much impact this strategy can have.

Even if politics were not an issue, Guiliano (1995) has noted that significant residential land use changes are unlikely, simply because housing structures maintain their usefulness and value and, hence, are very long-lived. It is typically not cost effective to tear down a well-maintained house and replace it with something else, because the house will still have value to someone. Since the housing stock changes so slowly, it will be difficult to have major impacts on overall density patterns by focusing on this exclusively.

But from a transit standpoint, densities should be as high as possible. Given the above findings, an area of 10,000 per square mile would generate about a 15 percent transit share on average, or 1,500 total transit riders per square mile. An area of 20,000 per square mile would generate a 30 percent transit share, or 6,000 total riders. That is, a doubling of density would normally double the transit share *and* the number of people involved, for a quadrupling of total transit ridership.

In this way, the impact of residential density is limited, because political constraints and the slow turnover of the housing stock place practical limits on the densities that can be achieved. However, these constraints are not true to the same extent as commercial areas.

### ***Effectiveness of Using Commercial Development***

Compared to residential redevelopment, political barriers to commercial land use changes seem to be generally less significant. Major commercial developments in the Twin Cities, to the extent that they provoke any public controversy at all, tend to generate concerns about the relatively manageable issues of traffic and parking. Given that these issues can be addressed, surrounding businesses and their workers do not, in general, seem to feel that their quality of life will be negatively impacted by the presence of additional businesses and workers nearby. Empirically, the areas around the two Twin Cities downtowns and the University of Minnesota have accommodated a very sizable amount of new development (both commercial and residential) in the last 10 years. No established residential neighborhood has seen anything remotely comparable.

In addition to the simplified political issues, another possible explanation for why most new infill development seems to take place on reclaimed commercial and industrial properties is that large developable parcels of land seem to be more available in this context. Technologies and markets change over time; as a result, commercial buildings sometimes become inadequate for their intended purpose and cannot easily be adapted for other uses. This relatively frequent availability of significant areas of centrally-located land, which occurs very rarely in residential areas, adds to the potential to aggregate a substantial fraction of the region's jobs (and at least some of its housing) into a few very large, dense centers, which can be effectively served with transit.

In terms of achievable densities, downtown areas are routinely developed at job densities that exceed the highest residential densities of their cities by a factor of five or more (Barnes 2001). And high densities mean high transit shares; combined with a large number of jobs, this means a lot of transit users. The two Twin Cities downtowns are responsible for 60 percent of the transit work trips in the region, although they contain only 15 percent of the jobs.

As a simple example of the potential impact, suppose that the number of jobs located in the downtowns were twice what it is now—that is, 30 percent of the total rather than 15 percent. Then, given the transit shares into the downtowns

(22%) versus the rest of the region (3%), the overall transit share for the region would rise from 5.9 percent to 8.7 percent. To achieve the same increase through higher residential density would, according to the earlier results, require an average density increase of 2,000 per square mile across the entire urbanized area, or roughly a doubling of the average density. Commercial land use changes of this magnitude are, at least in principle, politically and financially feasible; residential land use changes of this magnitude probably are not.

### ***Generating High Transit Share***

Many studies have pointed to the cost of parking as a key factor influencing the level of transit use into downtown areas. Therefore, development of large dense commercial centers is probably not enough, in itself, to guarantee high transit shares; there must also be a commitment to the imposition of relatively high parking costs. High parking costs increase transit use by making transit relatively cheaper compared with driving. This effect, however, cannot occur unless reasonable transit service is available in the first place. Attempting to impose parking costs on a sprawling suburban job center where there is little transit service available would be a very hard sell politically.

Frequent transit service to a place becomes viable when there are a lot of customers. This, in turn, requires both a large number of potential customers and a relatively high transit share. A high transit share comes about because transit service is competitive with auto travel; monetary cost is one aspect of this, and travel time is another. Competitive travel times are much more likely when buses can travel on freeways (for longer distance trips) and when they do not have to make many stops at the end of the trip. Nonstop travel on freeways is viable when there is a reasonable load of passengers going to roughly the same place. Typically, only a big destination is likely to generate this load.

Quick discharge at the end of the trip is possible only when most of the destination buildings are close together, so that everyone can reasonably walk to their building from one of a small number of closely-spaced stops. This is critical because, unlike the home end of the trip, where there are many options for accessing transit, generally, walking is the only available option at the work end. In a downtown, because the buildings are tall and close together, there are tens of thousands of jobs within walking distance of any bus route.

Quick discharge in suburban areas is much more difficult, given that buildings in these areas are generally separated by wide, high-speed streets, long distances, and

large surface parking lots. Increasing suburban service frequency to downtown levels will not have the impact that it does in downtown. The buses themselves will still be slow, due to the large number of stops they would need to make and the long travel time between those stops. Of course, providing such service would be financially burdensome in the absence of the high transit use needed to offset costs.

## **Conclusions**

Planners and policymakers hoping to manage urban traffic congestion through increased transit use are limited in the short term by the strong influence that existing land use exerts on mode choice. While this point has been widely acknowledged, most research and policy discussion on this topic has focused on increasing residential densities. However, the conclusion of this article is that the development and expansion of very large, high-density job centers is the best tool available for most cities to achieve substantial increases in transit use.

While there are many ways to improve transit use, achieving the substantial increases necessary to impact congestion levels will probably ultimately require greatly improved service frequency or higher costs of driving, such as parking charges. Higher parking charges will be politically infeasible in the absence of adequate transit service as an alternative; however, improved transit service is hard to justify in the absence of a sufficiently large market.

Creating a large market appears to reduce to two options: the well-known solution of increasing residential density and the less-considered option of focusing on the work end of the trip. While both of these tactics appear to be effective in principle as well as practice, it is, for a variety of reasons discussed in this article, very difficult to have impacts on residential density that are large enough to have regional significance.

The constraints that limit the use of residential density increases as a tool are not in force to nearly the same extent for commercial development. A gradual transition of a relatively small amount of office space from isolated or low-density settings into a few large dense centers could lead to sizable increases in regional transit use in a relatively short time.

The Twin Cities area illustrates the possibilities of this approach. There are two downtowns, but Minneapolis is much larger and is geographically in the center of the developed area. Downtown St. Paul is relatively small and close to the edge by

comparison, yet still attracts a substantial transit share. This hints at the possibility that even suburban locations, if they are developed to a sufficient size and density, can become major transit attractors.

Increased densities at the work end of the trip, by making improved transit service frequency more viable, could also help to increase nonauto access to retail and other nonwork opportunities. While higher density residential development can also have an impact, the effect is much larger when the increased density occurs in or around high-density commercial areas, both because more trips will be made to these high-transit attractors and because these areas support relatively good transit service going out as well as coming in. Increased commercial densities, especially in the suburbs, may be the only tool available for inducing significant transit use from the vast suburban areas of most cities that are already developed at low densities, and which will probably stay that way forever.

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