Using the Real Estate Market to Establish Streetcar Catchment Areas
Case Study of Multifamily Residential Rental Property in Tucson, Arizona

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Abstract

Though it seems widely known that people will only walk or bike so far to access public transit, few studies have estimated their catchment areas. Perhaps the largest share of those that do evaluate outcomes over narrow distances from fixed guideway transit stations, such as one-quarter and one-half mile. Recent literature uses the real estate market to help estimate catchment areas, but all those studies focus on light rail transit (LRT) systems. This study is the first to use the real estate market to estimate the multifamily rental catchment area for streetcars, based on a case study of Tucson, Arizona. Using CoStar rental data, census data, and spatially related measures, we find that the streetcar catchment area for multifamily rental properties is about five eighths of one mile, or just slightly farther than the conventional half-mile circle. This is in contrast with prior research showing the catchment area for multifamily rental properties near LRT systems may be up to 1.25 miles. We offer land use planning implications.

Overview

In this article, we review the role of fixed guideway transit systems in reshaping metropolitan development patterns, introduce streetcars as America's newest transit mode, review research into establishing catchment areas for transit, and present research into estimating the catchment area for Tucson streetcar system. We conclude with implications for land use planning.

Streetcars: America's Newest Public Transit Mode

The modern streetcar in the US has its genesis in Portland, Oregon, which started operations in 2001. They are no longer the charming relic of a bygone era found only in a handful of cities, such as New Orleans, Philadelphia and San Francisco, which had not paved over their tracks decades ago (Hinners and Larice 2016). Since 2001, there have been 25 new streetcar systems in operation, under construction, or planned.

Streetcars are sometimes criticized as an inefficient way of moving people around. They can get stuck in traffic, and indeed cause traffic congestion, do not move much faster than a person on foot or bicycle, and require tens to hundreds of millions of dollars to construct. Some argue it is better to expand existing systems or improve existing roads (The Economist 2014). This view is seconded by Brown, Nixon and Ramos (2015), who note that streetcars are far less efficient as a public transit mode than conventional bus, in terms of cost of operation, as well as efficiency and speed of carrying passengers. It is worthy to review Portland's pioneering streetcar investment.

Portland North-South Line cost $56.9 million, an investment financed entirely locally. Its original length was 2.4 miles serving downtown, extended to 4 miles also serving downtown, and then across the Willamette River to create a loop. The Portland streetcar's planning goals are to:[1]

- Provide neighborhoods with convenient and attractive transportation alternatives.
- Fit the scale and traffic patterns of existing neighborhoods.
- Provide quality service to attract new transit ridership.
- Reduce short inner-city auto trips, parking demand, traffic congestion and air pollution.
- Encourage development of more housing & businesses in the Central City.

Within a decade, Portland's streetcar investment was associated with nearly $4 billion in private investment. Though certainly some of this may have occurred anyway, the combination of redevelopment planning facilitated by the streetcar certainly led especially to many thousands of new residential units, a large share of which are clustered around streetcar stops.

Tucson launched its streetcar system in summer of 2014; it is called SunLink. It operates within existing streets connecting the University of Arizona medical center to the main campus, the university-related commercial area (Main Gate), a commercial strip connecting the university

[1] See www.portlandstreetcar.org.

area along Fourth Avenue to downtown, downtown commercial and government centers as well as the convention center, and across the Rillito River into a large area slated for redevelopment just west of downtown (see Figure 1). Its overall cost was $196 million funded through a combination of local, regional and federal sources. By some estimates, the streetcar is associated with about $1 billion in new private and public investments including hundreds of new rental residential units, mostly for students.[2]

For the most part, land use planning around streetcar stops has been focused on the redevelopment of blighted or underinvested areas, with little guidance on how far away from streetcar stops the market will respond to their presence. Like other transit modes, streetcar system planning seems focused on the one-half mile circle—the standard for transit oriented development (TOD) planning. Is this appropriate? One way in which to understand how far TOD boundaries should extend from streetcar stops is based on how the market responds to station proximity. The next several sections summarize literature, pose a theory and a methodology to test the theory, apply the theory and methodology to Tucson's streetcar system, present results, and offer implications for planning of station areas. We will show that at least in the case of streetcars that the conventional one-half mile circle may have an analytic foundation, at least in Tuscon.

[2] See http://tucson.com/news/business/has-streetcar-really-brought-million-in-investment/article_59796f85-e4b8-5ebd-84fd-01a8f30a6912.html

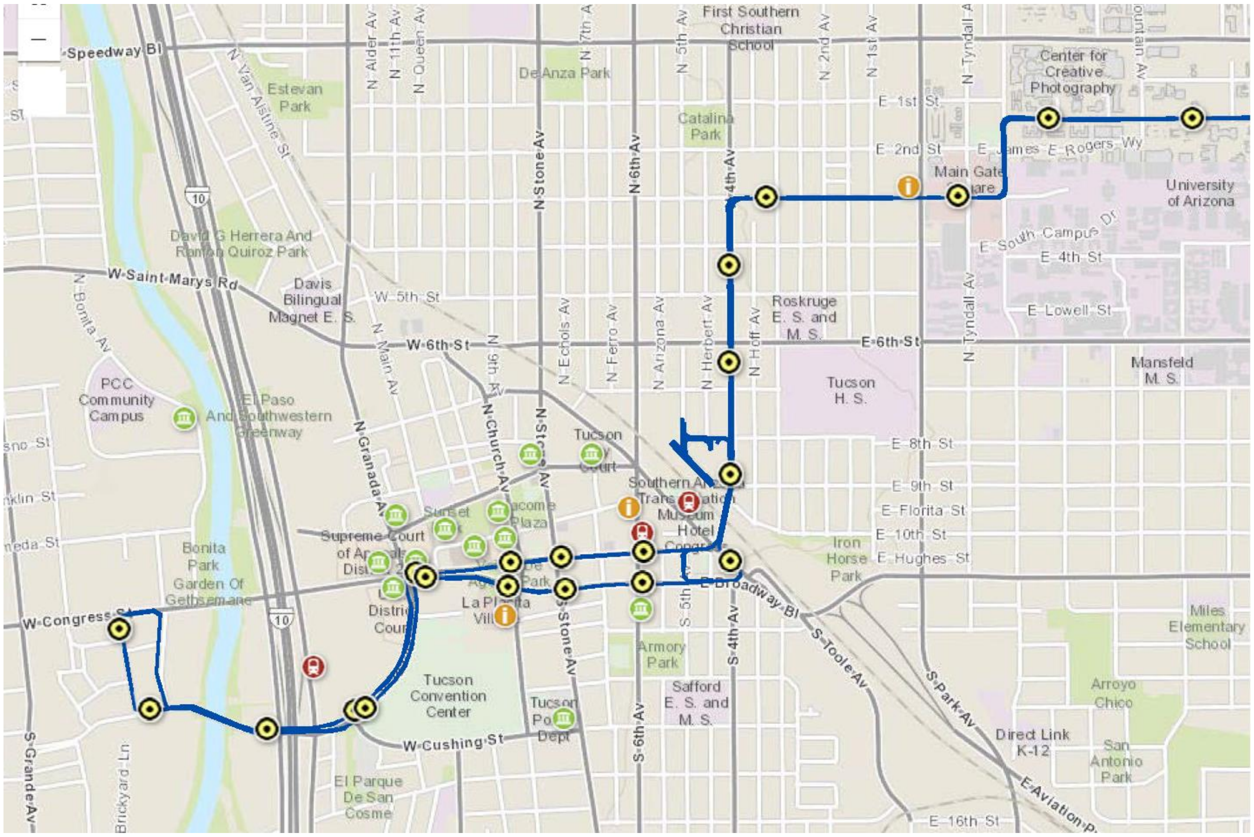

Figure 1

SunLink Tucson streetcar route map

Source: http://www.sunlinkstreetcar.com/how-to-ride/maps

Literature Summary

As our starting point, we summarize the literature reviewed by Petheram et al. (2013) in their study (see below) of the same issue as it applied to estimating light rail transit (LRT) catchment areas in Salt Lake County. We start with Guerra et al. (2011) who studied 1,449 high-capacity transit stations in 21 U.S. cities. For the purpose of assessing whether the half-mile circle best represents transit station catchment areas. Based on riders' walking distances to transit stations, they surmised the half-mile circle was reasonable.

With planning and design, the catchment area can be pushed out perhaps a mile or more, according to Canepa (2007). This can be achieved by removing physical barriers between land uses and transit stations, perhaps by constructing direct pathways to transit stations that allow unimpeded connection between stations and destinations near them. For instance, at uninterrupted walking speed of about three miles per hour, one-half mile can be covered in 10 minutes, and at nearly 4 miles per hour—the typical walking speed in many major cities—nearly three quarters of a mile can be traversed.

The distance over which people are willing to walk to access transit is but one measure; another is understanding how the market responds to transit station proximity. Literature reviews by Guerra, Bartholomew and Ewing (2011), and Higgins and Kanaroglou (2016) show one thing in common: most studies assessing market responses to transit station proximity measure differences in values or rents in distance bands, and most of those studies use the one-half mile band though some use one-quarter and one-half mile bands, and others use one-half and one-mile bands. (We recommend readers especially to Higgins and Kanaroglou). Results are mixed: while the largest number of such studies show positive real estate value effects with respect to transition station proximity, many studies show negative or inconclusive effects, and none assess affects with respect to streetcar stations.

What did Petheram et al. find? Using a regression analysis of assessor data on 1,301 multifamily rental properties in Salt Lake County, Utah, they found market capitalization of light rail station proximity to 1.25 miles away, based on distance bands of one-quarter mile. Notably, they found the square foot mean value of apartment buildings in Salt Lake County was higher for each one-quarter mile distance band from LRT stations in the manner shown in Table 1. Notably, the highest value increment occurs in the closest band while all the other bands had roughly comparable value increments. Figure 2 illustrates their findings.

We now present our theory and model, and apply it to our Tucson, Arizona streetcar case study.

Table 1

Light Rail Transit Proximity Premium by Quarter-Mile Distance Bands, Salt Lake County

Distance Band	Premium per Square Foot
Within 1,320 feet	$7.276*
Between 1,321 and 2,640 feet	$3.628*
Between 2,641 and 3,960 feet	$4.739*
Between 3,961 and 5,280 feet	$3.621*
Between 5,280 and 6,600 feet	$3.647*

$^{*}p < 0.05$

Source: Petherham et al. (2013)

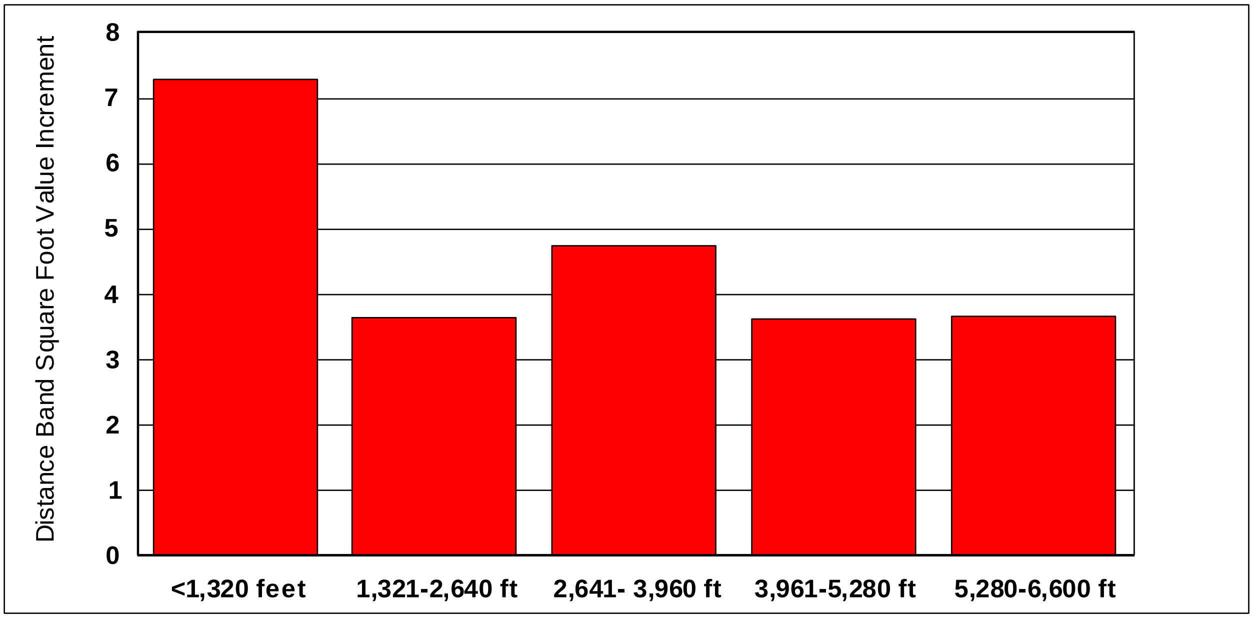

Figure 2

Multifamily property value increment by distance band from nearest light rail transit station in Salt Lake County, Utah

Source: Petherham et al. (2013)

Theory and General Model

Conventional urban location theory developed by Alonso (1964), Muth (1969) and Mills (1972) shows that in a monocentric city, where all jobs are in the central business district (CBD), the cost of transportation increases as distance increases from the CBD at a declining rate, as a function of increasing land area of the commuting shed. Transportation costs thus affect land value so that the "bid rent" curve for land also declines as distance increases. Where transportation costs are lowest, in the CBD, land prices are highest. To afford higher land prices ("rent") in the CBD, more economic exchange is needed, resulting in higher development intensities among office, retail, and high-value multifamily housing land uses among others. Economic activities that cannot compete for CBD locations are pushed outward to locations where they can outbid other land uses, a process called urban land use invasion and succession (Park and Burgess 1925).

In relaxing the strict monocentric city model, one can imagine the same principles at work only at smaller scales that are distributed across a metropolitan area (see Hajrasouliha and Hamidi 2017). For instance, in focusing transportation activity at nodes, rail transit stations can become small version of CBDs. Economic activities will bid up land prices close to rail transit stations; lower value activity moves away from transitions to location there they can outbid competing land uses. Numerous studies show negative bid rent gradients with respect to distance from rail transit stations (Higgins and Kanaroglou 2016).

The choice of functional form is important. Standard urban economic theory posits that land value will decline with distance from the CBD or other nodes, but this presumes the point of measure itself does not generate negative externalities. If it does, Nelson et al. (1992) show that a quadratic transformation of the distance variable may be needed, so that both positive and negative effects with respect to distance can be estimated. But when negative externalities are not present, other functional forms can be used. But which is appropriate? Since our key aim is to estimate that distance beyond which the market does not capitalize distance from streetcar stops, we follow the lead of Petherham et al. (2013) in using distance bands. The general model including distance bands is thus:

$$\mathbf{R}_i = f(\mathbf{B}_i, \mathbf{S}_i, \mathbf{L}_i)$$

where:

R is the price of rent per square foot for property *i*;

B is the set of building attributes of property *i*;

S is the set of socioeconomic characteristics of the vicinity of property *i*; and

L is a set of location attributes of property *i* comprise of distance to the CBD as well as distance to streetcar stations based on distance bands.

In the next section, we apply the general model to the Tucson streetcar with respect to multifamily rental property.

Application to Tucson Streetcar

Table 2 summarizes the multifamily rental data collected for this study, variable specifications, and predicted signs of association. Notably, by permission, we are able to use CoStar's asking rent database for rental multifamily for the first two quarters of 2017. Our dependent variable, asking rent per square foot, is logged so that the unlogged coefficients of the independent variables can be interpreted as percentage change in rental price associated with a unit change in the independent variable. Among the building attributes, we expect lower rent for the incremental increase in the size of the unit above the mean; higher rent per square foot for larger complexes because scale economies allow for more on-site amenities; newer buildings will command higher rents than older ones; and, because the streetcar route is influenced by a large student population, a variable for properties restricted to students is included, and is expected to have a negative sign because of rental restrictions. Among socioeconomic attributes, we expect higher rents associated with higher percentages of White non-Hispanic persons in census block groups, and higher median household income. Distance from the central business district (CBD) is expected to have a negative sign, consistent with standard theory. Our experimental variable, distance from the nearest CRT station, includes 10 distance bands of one-eighth mile each extending to 1.25 miles, or the distance over which Petherham et al. found positive influences of LRT stations on the market value of multifamily rental property in Salt Lake County, Utah. In all, roughly a quarter of all multifamily rental structures in our study area are within 1.25 miles of a streetcar station. Table 3 presents the mean statistics for each metropolitan area.

Results are reported next.

Table 2
Rental Multifamily Variables, Specifications, Predicted Signs, and Data Sources

Variable	Specification, Predicted Sign	Data Source
Dependent Variable		
Asking rent per square foot	Continuous, logged	CoStar
Building Attributes		
Average Unit Size in Square Feet	Continuous -	CoStar
Gross Leasable Square Feet	Continuous +	CoStar
Year Built	Continuous +	CoStar
Student-Restricted	Binary (rent restriction is the referent) +	CoStar
Socioeconomic Characteristics		
Percent Not White Non-Hispanic	Percent x 100 +	American Community Survey 2015
Median Household Tract Income	Continuous x 1,000 +	American Community Survey 2015
Location		
Distance to CBD, miles	Continuous -	GIS measure from parcel centroid to CBD centroid
Experimental Variables		
Distance to Nearest CRT Station in One-Eighth Mile Increments to 1.50 miles	Binary +	GIS measure from parcel centroid to station centroid

Table 3

Mean Rental Multifamily Property Variable Statistics

Variable	Mean
Rent Square Foot	$0.91
Average Unit Size	741
Gross Leasable Area	19,001
Year Built	1967
Student Restricted	2%
White Percent	49%
Median HH Income	$28,705
Distance to CBD, miles	3.18
Streetcar < 0.125 mile	2%
Streetcar 0.125-0.250 mile	3%
Streetcar 0.250-0.375 mile	3%
Streetcar 0.375-0.500 mile	4%
Streetcar 0.500-0.625 mile	2%
Streetcar 0.625-0.750 mile	2%
Streetcar 0.750-0.875 mile	2%
Streetcar 0.875-1.000 mile	1%
Streetcar 1.000-1.125 mile	1%
Streetcar 1.125-1.250 mile	2%

Results

Ordinary least squares regression results are reported in Table 4. Among the building attributes, all coefficients were significant and had the expected signs of direction. Among the socioeconomic characteristics, only the coefficient for the percent of White non-Hispanic residents at the block group was significant and it had the correct sign, though median household income also had the correct sign. The CBD distance variable was also significant and had the correct sign

Of interest to us is the extent to which multifamily rents are affected by proximity to streetcar stops by distance band. Notably, all but one distance band outward to 0.50-0.625 mile were significant and all coefficients to that distance had the expected sign, as did the next distance band (0.625-0.75 mile). It would seem that the multifamily rental market capitalizes proximity to streetcar stations to about five-eighths mile, or roughly the standard half-mile distance assumption. The first two distance bands, being the first quarter mile from streetcar stations, show the greatest rent increment. The next band, to three-eighths mile, has a small but insignificant, though positive coefficient. The fourth band shows about a quarter less rent increment than the first quarter mile while the last band, out to 0.625 mile, has a coefficient roughly three quarters less. Figure 3 illustrates these relationships.

Implications are discussed next.

Table 4

Regression results for Multifamily Rent with Respect to Tucson Streetcar Station Distance

Variable	**Coefficient**	***p***
Constant	-2.030	*
Building Attributes		
Average Unit Size	0.000	*
Gross Leasable Area	3.486E-007	*
Year Built	0.001	*
Student Restricted	-0.113	*
Socioeconomic Characteristics		
White Percent, Block Group	0.001	*
Median HH Income, Block Group	3.874E-007	
Location		
Distance CBD, miles	-0.010	*
Experimental Variables		
Streetcar < 0.125 mile	0.119	*
Streetcar 0.125-0.250 mile	0.125	*
Streetcar 0.250-0.375 mile	0.024	
Streetcar 0.375-0.500 mile	0.093	*
Streetcar 0.500-0.625 mile	0.038	*
Streetcar 0.625-0.750 mile	0.026	
Streetcar 0.750-0.875 mile	-0.032	
Streetcar 0.875-1.000 mile	-0.028	
Streetcar 1.000-1.125 mile	0.006	
Streetcar 1.125-1.250 mile	-0.002	
Performance		
Cases	574	
Adjusted R2	0.352	
F-ratio	19.27	*

* p < 0.10

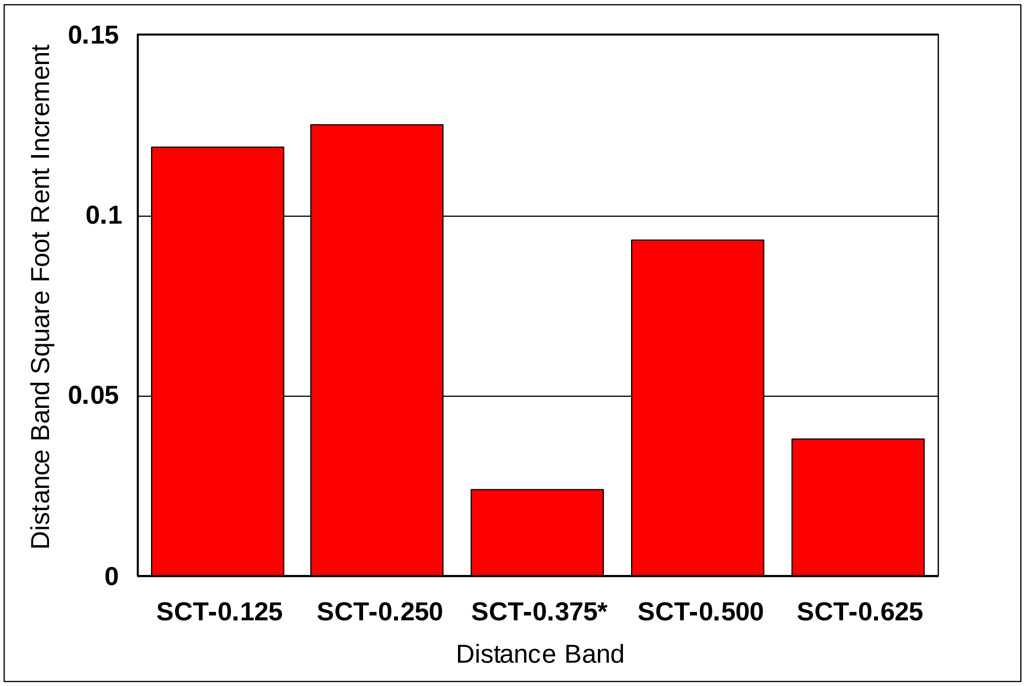

Figure 3

Multifamily property value increment by distance band from nearest streetcar station in Tucson, Arizona

Source: Nelson and Hibberd

Implications

Our analysis indicates there is a fairly tight catchment area around Tucson's streetcar stops, perhaps slightly more than one-half mile. Compared to similar analysis of light rail transit catchment area in Salt Lake County, Tucson's streetcar catchment area is about half. Why?

First, there may be fundamentally different market responses between LRT and streetcar systems; future research is needed to assess this possibility. One reason for the difference could be the much larger regional reach of LRT systems; if one uses LRT one may be willing to live further away to access it, perhaps through feeder buses, park and ride, and other "first/last mile" modes.

Second, unlike the Salt Lake City LRT system, which started in the late 1990s, the Tucson streetcar system is very new, having been launched only in late 2014. The full extent of market responsiveness to the streetcar may be a few years away.

Third, we know first-hand of many barriers between multifamily rental housing and streetcar stations, which will be the subject of future planning and design assessment. Important barriers include, especially, Speedway Boulevard, a major 6-8 lane, high capacity arterial that quite literally deprives efficient access from residential areas north of Speedway to the streetcar stops south of it. We refer to Canepa's (2007) concern alluded to earlier.

Fourth, while there have been several multifamily projects built near the streetcar in recent years, we suspect full market responsiveness may be inhibited by existing detached residential neighborhoods nearby combined with planning restrictions preventing the market from building more multifamily structures farther away.

Additional research is needed along several fronts. For one thing, both our and Petherham et al.'s study designs should be applied to other metropolitan areas with LRT and streetcar, and other forms of fixed guideway transit. Only through large-scale, cross-section analysis will we be able to determine whether markets respond to different transit modes differently, and perhaps how improved station accessibility can extend catchment areas.

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[NOTE: The references will be reformatted to follow the Transportation Research Record style should this paper be published. References are in the order of appearance.]

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