Transportation Research Record

The (Overlooked) Association between Express Bus Station/Stop Proximity and Multifamily Rents with a Surprise about Transit Mode Synergism and Implications for Transit and Land Use Planning

--Manuscript Draft--

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Order of Authors:	Arthur C. Nelson
	Robert Hibberd

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Arthur C. Nelson (corresponding author)
University of Arizona

Robert Hibberd
University of Arizona

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ABSTRACT

Despite hundreds of studies into the association between real estate value and proximity to fixed route transit (FRT) systems, none has assessed the association with respect to express bus transit (XBT) stations/stops. Ours is the first to do so. Using a static, cross-section quasi-experimental research design, we evaluate CoStar multifamily (MF) rent per square foot to estimate the difference in rent with respect to proximity to (XBT) stations/stops. However, we are also interested in knowing whether there are synergistic price effects at the intersection of XBT and other FRT systems such as light rail transit (LRT). In this article, we estimate the MF rent premium with respect to XBT and LRT (XBT+LRT) station/stop proximity separately, rent premiums for combined XBT and LRT stations/stops, and for those MF cases that are more than 1.0 mile beyond the nearest LRT station. In all cases, whether separately or combined with LRT stations or away from LRT stations, with find positive associations between MF rent and proximity to XBT stations/stops. However, we also find evidence of negative externalities at or near XBT, LRT, and XBT+LRT stations/stops. Express bus transit and land use planning implications are offered.

OVERVIEW

Cities emerge largely because agglomeration economies create economic development synergies: the larger and more densely developed, the more jobs are created (1, 2). This can stress transportation systems as congestion may lead to inefficient economic interactions that reduce advantages of agglomeration (3). In the US, one solution is to build new highway networks connecting downtowns to suburbs, suburbs to each other, and even metropolitan areas to one another (4). Opening vast amounts of cheap land for development allowed people to move outward where housing was cheaper (per square foot) which in turn attracted firms to locate near its labor supply (5). But these highway networks also became congested, arguably undermining overall metropolitan economic performance (6, 7).

During the last quarter of the 20th century, dozens of metropolitan areas built and expanded fixed route transit (FRT) systems, in part to overcome the diseconomies of congestion (8). Indeed, studies have shown that overall metropolitan economic performance improves with the presence of FRTs (9, 10). Studies attributing economic development outcomes to specific modes of public transit have focus mostly on rail services such as heavy or third rail transit (HRT), light rail transit (LRT), commuter rail transit (CRT) and streetcar transit (SCT), with some extension to bus rapid transit (BRT) (11, 12, 13). Higgins and Kanaroglou (14) synthesize research to show the contribution of rail transit and BRT to property values, which is a proxy for economic development (15). Yet, no study has explored the relationship between express bus transit (XBT) and economic outcomes. This article helps close this gap in research.

Before proceeding, we need to differentiate between types of bus service. The most common is conventional bus service where standard buses make numerous stops along routes that can change frequently.

Then there are bus rapid transit (BRT) and express bus transit (XBT) systems. The Metropolitan Atlanta Rapid Transportation Authority (16, 17), provides a useful way in which to distinguish between XBT and BRT systems as paraphrased below:

Express Buses (also known as commuter bus service) is intended to run faster than normal bus services between the same two commuter or destination points. Express bus service usually has a limited number of stops to decrease the travel time. It uses flexible stop locations with various design options

BRT is a fixed-route bus mode that is characterized by operations primarily in dedicated right-of-way during peak periods and features that emulate rail fixed guideway services, including: (a) defined stations/stops, (b) traffic signal priority, (c) short headway, (d) bi-directional services, (e) pre-board ticketing, (f) platform level boarding and (g) separate branding. BRT may include portions of service that are fixed-guideway and non-fixed-guideway. It typically uses fixed stations/stops with a pre-boarding payment. Some systems have flexible stop locations.

We acknowledge that there are important differences between types of express busses from conventional busses to modern, sleek busses designed for express bus purposes (see Figure 1). We provide further details on XBT systems below.

Our article is comprised of four sections. In the first, we review theory, pose the research questions and outline a research strategy. The second section describes our research plan in terms of the research design, the general model that will be used to guide data and analysis, our choice of functional form, the study area, the specific model and data, and identification of transit data challenges. The third section presents our results and offers discussion. The final section offers our implications for express bus transit and land use planning.

INSERT FIGURE 1 ABOUT HERE

1. THEORY AND RESEARCH QUESTIONS

Conventional urban location theory developed by Alonso (18), Mills (19), and Muth (20)—also known as the AMM theory—shows that where all jobs are in the central business district (CBD), the cost of transportation increases with respect to distance from the CBD at a declining rate. Transportation costs reduce land value as distance from the CBD increases. Where transportation costs are lowest, in the CBD, land prices are highest. There is thus competition for location near CBDs considering the land use needs among competing office, retail, institutional, residential and other land uses. Only those land uses that generate the highest economic exchanges win the most central locations. Land uses that cannot compete for CBD locations are pushed outward to areas where they can outbid other land uses, a process called land use invasion and succession based on ecological principles (21).

As one relaxes constraints of the AMM monocentric city model, it is possible to imagine the same principles are at work only at smaller scales in a more distributed fashion (22). In particular, rail transit stations/stops can become localized, smaller versions of CBDs. Accordingly, economic activities will bid up land prices close to rail transit stations/stops; lower value activity is pushed away from stations/stops to locations where they may outbid competing land uses. Dozens of studies confirm negative real estate bid-rent gradients with respect to distance from rail transit stations suggesting these local level outcomes. That is, real estate falls with respect to distance from transit stations, *ceteris paribus*. Yet none address the proximity effects of XBT stations/stops on real estate value (14).

Given XBT systems are primarily a commuting service for suburban residents and in the context of theory and prior research, our research question is:

Do multifamily rents increase with respect to proximity to XBT stations/stops?

There is another context that we want to explore: the extent to which the interaction between XBT and other types of FRT stations/stops also affects real estate value. Many XBT stations/stops connect to FRT stations/stops either directly or nearby. Indeed, many XBT lines terminate at FRT stations/stops.

Our particular study area includes 16 light rail transit (LRT) systems operating in the US excluding major metropolitan areas of the Northeast and Great Lakes regions (defined as more than five million residents) as well as the Los Angeles and San Francisco metropolitan areas. Those metropolitan areas are excluded because their complex web of different types of transit systems makes it difficult to tease out difference effects attributable to any given transit mode. Our data thus allows us to estimate synergistic or value added association. In particular, we can estimate whether and the extent to which XBT and LRT systems sharing the same stations areas add real estate value because they improve the accessibility of nearby property to more residents in the metropolitan area. We call these combined XBT+LRT stations/stops. Consistent with theoretical expectations, we should find rent positive rent premiums with respect to XBT+LRT station/stop proximity. Our second research question is thus:

Do multifamily rents increase with respect to proximity to combined XBT+LRT stations/stops?

We proceed with our research plan. This is followed by results with interpretations. We conclude our article with implications for XBT stations/stops and land use planning.

2. RESEARCH PLAN

This section presents our research plan including research design, general model, functional form, study area, and specific model and data.

Research Design

We apply theory through a static, cross-section quasi-experimental research design. That is, using one period of time (2018), we test for the effect of XBT station and combined XBT+LRT station/stop proximity on multifamily rents across multiple metropolitan areas with XBT and LRT systems. Though analysis is not causal, associations can be used as guidance for transit and land use planning purposes. For reasons noted below, we use rent instead of sales as a proxy for real estate value (23).

General Model

Using these theoretical and research design foundations as a guide, we develop the following general model to test the theory. It is adapted from Nelson (8):

$$\mathbf{R}_i = \mathbf{f}\,(\mathbf{S}_i, \mathbf{SES}_i, \mathbf{U}_i, \mathbf{C}_i, \mathbf{DB}_i, \mathbf{M}_i) \qquad (1)$$

Where:

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

S is the set of structural attributes of property *i* including its architecture, mass, height, age and effective age, interior amenities, flow efficiencies and so forth;

SES is the set of socioeconomic characteristics of the vicinity of property *i* such as population features, income, education;

U is a set of measures of urban form of the vicinity of property *i* such as the nature of surrounding land uses, terrain, physical amenities (such as parks), street characteristics and related;

C is a set of centrality attributes of property *i* such as distance to downtown and distance to the nearest freeway/expressway ramps;

DB is the distance band (see below for specification details) of property *i* to an XBT station/stop as well the distance band of the same property to an XBT station within one-half mile of another kind of FRT station, being LRT stations in this case; and

M is a set of metropolitan area controls. As metropolitan area conditions and markets vary between them, identifying the location of property *i* within its respective market helps control for metropolitan-specific influences.

Functional Form

The AMM theory posits that land value will decline with distance from the CBD or other high activity nodes. Linear, semi-log, and double-log functional forms are the dominant forms reported in literature (14,23, 24).

The *linear functional form* assumes a straight line deduction in property value with respect to distance away from a node, such as a transit station.

The *semi-log functional form*—where the dependent variable is logged—estimates the percent change in value associated with a unit change in an independent variable.

The *double-log functional form* generates elasticities—continuously measured variables on both sides of the equation are logged although categorical and binary variables are not.

In our view, none of these functional forms are very useful to transit and land use planners who need to know how to arrange transit investments and land use policies to maximize the economic benefits of transit station proximity. Lacking guidance from studies using these conventional functional forms, planners tend to settle on quarter-mile and half-mile planning areas around stations/stops, with very little empirical justification.

A less-used approach, the *quadratic* functional form, is specified such that the linear distance term is squared and both terms are included in an analysis. This equation has the potential to pinpoint the break point in the transit station distance curve. In the context of FRT stations/stops, the concern is that rail stations/stops themselves can be nuisances such that real estate values and rents may be dampened very near them (25).

As Nelson and McClesky (25) theorize, the market capitalizes both amenity effects of rail station proximity as well as negative externality effects, for instance those associated with noise (such as dispatching broadcasts at station platforms), and congestion (such as when vehicles use park and ride lots during peak hours) (26). So long as amenity effects outweigh negative externalities, the bid-rent gradient will slope downward and away from rail transit stations/stops. However, in theory it is possible for negative externalities to outweigh amenities. But quadratic functional forms may not be very useful either, especially if both signs are in the same direction (increasing or decreasing value at a faster rate with respect to distance). Even where signs are different, the smaller the second term relative to the first the flatter the slope. For example, if the second term above is 1.00, the minima is 10 miles which may not be very useful to planners crafting plans around stations/stops.

Figure 2 shows numerous potential relationships between rail stations/stops—as both sources of amenities and negative externalities—and real estate value, in our case being multifamily rents (see below):

> The line R^a shows the land rent (R) curve with amenity ("a" for amenity) value from a rail transit station, u_0, outward to a point, u_1, where the amenity effects of rail transit proximity disappear, beyond which the overall market rent, unaffected by the presence of the rail transit station, R^m is revealed.

Negative externality effects of rail transit stations/stops are shown in line R^n ("n" for negative externality). As distance from the rail station increases, the negative externality effects are reduced until they become zero at u^1.

Amenity and negative externality effects interact in the market leading to overall positive or negative bid rent curves with respect to distance from rail transit stations/stops to u_1. Line $R^a + R^n{}_1$ is revealed where overall amenity effects outweigh negative ones. Line $R^a + R^n{}_2$ is revealed where overall negative externality effects outweigh positive ones. Overall effects disappear at u_1 beyond which market rent, R^m, in the absence of amenity and negative externality is revealed.

Distance bands offer a practical middle ground between knowing whether and the extent to which real estate markets respond to transit stations/stops within discrete distances of FRT stations/stops. They also provide statistical significance test results for each band separately. Unfortunately, most distance-band studies use only one-quarter or one-half mile distance bands, (14) or occasionally two bands (27). But that assumes all relevant interactions which are useful for planners to know occur only within those distance bands, and that those bands apply to all transit modes in all metropolitan areas. Following Hibberd et al., (23) and Nelson and Hibberd (24) this article uses the **distance band functional form** described in more detail below.

INSERT FIGURE 2 ABUOT HERE

The foregoing discourse has important implications for evaluating the price or rent effects of transit systems on multifamily real estate. Rail transit usually runs on dedicated tracks that can generate negative externalities in terms of noise, vibration and sometimes glare, among others. For their part, express busses usually operate along collectors, arterials and limited access highways that also generate negative externalities for the same reasons plus exhaust. One would expect that, between stations and stops, real estate value would be less along both tracks and XBT-serving highways because of negative externalities. On the other hand, amenity effects of transit stations/stops occur only proximate to them.

There is still another compounding issue. Income-producing real estate usually depends on access to major highways even if they generate negative externalities. Higher density commercial development is especially dependent on major highway access which is why they cluster along them. Nonetheless, highway related negative externalities may dissipate some distance away from highway which may be revealed in rents or prices. On the other hand, the only amenity effect of rail access is with respect to station/stop proximity. These particular nuances of highway and rail proximity are not addressed directly in this research but are part of our longer term agenda.

Finally, we note the following interpretive strategy. The theory on which Figure 2 is based concedes that all we can see are the revealed effects, not the disaggregated ones. However, the rise of values away from a station/stop outward to a peak, followed by declining values forming an inverted U would be a tell-tale sign of externality effects of the station/stop on rents. We will elaborate on this later.

Study Area

For prior research, we created a dataset comprised of 16 metropolitan areas with LRT systems (see Figure 3). These metropolitan areas also have XBT systems which we identified through assembly of General Transit Feed Specification data reported by local transit agencies (see below for more detail). We matched these data against those for BRT systems used in another analysis (13) to check for duplications, finding none. This is not to say that one or more XBT systems could in fact be considered BRT systems but none are identified as such in any inventory of which we are aware, including our own from prior research. (See below for elaboration.)

We apply our model to these metropolitan areas. However, we exclude specialized bus services such as “airporters.” We note that sometimes XBT bus routes runs parallel with conventional buses but we mapped only XBT stations/stops. We took advantage of another opportunity: Because they include both LRT and XBT systems, we can evaluate interaction effects where or near where they interconnect. We discuss this is more detail below.

Finally, we note that some metropolitan areas served by LRT systems are also served by other forms of FRT systems such as BRT, street car transit, and commuter rail transit systems. Only two metropolitan areas in our dataset have all systems (Dallas and Salt Lake City) while others have one or two of those systems but not all of them. Future work will extend the analysis presented in this article to the interaction of XBT systems with all those other modes considering all metropolitan areas in which they operate, as well as between other modes such as LRT and BRT systems. In this respect, our article establishes a proof-of-concept for those extended analyses.

INSERT FIGURE 3 ABOUT HERE

Specific Model and Data

We operationalize the general model dimensions and functional form here. Notably, we report the statistical association between rent per square foot for multifamily properties with respect to XBT station proximity as well as combined XBT and FRT stations/stops using one-eighth mile distance bands to one-half mile, holding other factors constant.

R is the asking rent per square foot for property *i* reported by CoStar during 2018. (CoStar has the largest, national commercial property data base where data are collected using a standardized protocol.) Rents are monthly per square foot. Normally, statistical analysis is applied to samples of a universe. In this case, the study includes the universe of all multifamily properties reported by CoStar in our study area. As CoStar data come from real estate brokerages participating in its network, the data exclude non-participating brokerages or entities and properties not for rent such as owner-occupied properties. By logging the dependent variable, the semi-log model allows for coefficients to be interpreted approximately as the percent change in rent attributable to a one unit change in an independent variable such as an individual distance band.

S is the bundle of structure and lease restriction attributes for property *i* reported by CoStar. This includes occupancy characteristics noted below. For all properties, this includes:

Gross leasable area in building square feet with the expectation that there will be a positive association between building area and rent because larger buildings presumably include more amenities than smaller ones.

Effective year built which is the later of the year of construction or the year of renovation as reported by CoStar with the expectation that newer buildings will command more rent than older ones.

Vacancy rate with the expectation that the higher the vacant rate the lower the rent. However, this may not always be the case as high demand markets could result in high vacancy rates as owners wait for higher paying tenants. Accordingly, signs may not be predictable especially considering that the study area is comprised of stable to rapidly growing central counties.

The number of *Stories* is also included with the expectation that the taller the building the higher the mean rent. However, for retail, *Stories* are excluded because of scant variation among retail structures.

Occupancy restrictions are also included, notably *Senior* or *Student* housing with *Market Rate* housing being the referent. The expectation is that relative to Market Rate multifamily units, rents for *Student* housing will be lower because average annual rents will be based on occupancy during only part of the year. Rents for *Senior* housing will be higher assuming that seniors will be willing to pay more for apartments where other seniors live and thus enjoy similar services tailored to them. These are binary (yes =1, no=0) variables.

The **SES** dimension is comprised of *Median Household Income* from the five-year sample of the 2016 American Community Survey (ACS) for the block group within which a CoStar property is located, for which a positive association is expected with respect to rent (28).

Two variables comprise the **U** dimension: One for a version of jobs-housing balance and the other for employment mix as an indirect measure of land use mix.

Workers-per-labor-force-member is our calculation of jobs-housing balance, being the number of jobs in a census block group (BG) from the Longitudinal Employment-Household Dynamics database divided by the number of residents of labor force age (being 15 to 65 years old). The higher the ratio the more people work in the BG relative to those who live there. As such, more pressure is put on rents so we expect a positive association (29).

Employment mix, is patterned after Ewing and Hamidi (30). The greater the mix, the higher rents should be because of efficiencies gained in the interaction between land uses.

A normalized employment mix measure is applied as follows:

$$\sum_{i=1}^{n} \sum_{j} \left(\left(P_j * LN(P_j) \right) / LN(j) \right) \quad (2)$$

where:

i is the enumeration unit—in this case census block groups, *n* equals the number of units per county, *j* equals the number of employment sectors, and *Pj* = proportion of jobs in sector *j.* This measure denotes the degree of land use similarity or dissimilarity in each enumeration unit. The normalizing weight is the natural log of the number of sectors. The employment mix variable is interpreted as follows: the higher the number, which is between 0 and 1, the more evenly mixed the land uses are by employment sector.

Two variables comprise the **C** dimension: one for downtown distance and the other for freeway ramp distance.

The first location control is *Distance from Downtown* for which a negative association is expected based on the AMM theory. Using Google Earth, we identified the central most point of each downtown.

The second location control is *Distance from Freeway* which is defined as the nearest freeway or expressway ramp. Because freeway ramps can be considered nuisances in addition to being an accessibility benefit, no signs of association are predicted.

DB is used in two ways, one for location in a distance band from the nearest XBT station and the other for the distance band nearest to a combined XBT and another FRT station.

For XBT location, *distance band* is the location of the multifamily property within 0.125-mile (1/8th mile) distance bands of the nearest XBT station to 1.00-mile. We note this as the DXBT variable. We use closest distance, calling it the “front door”, assuming that, over time, structures will orient themselves to be close to transit stations/stops. (We anticipate future research will address network distance.) We also measure straight line distance; future research will measure network distance. The 1.00-mile distance is used because that is the distance within which the largest share of market premiums associated with FRT station proximity occurs (31, 32).

The same 0.125-mile distance band measures are used for multifamily properties within 0.50 mile of where XBT and other LRT stations/stops intersect. These are called DBXBT+LRT, stations/stops.

Both sets of DB variables are binary for 0.125-mile to 1.00-mile mile distance bands with cases beyond 1.00-mile DB being the referent.

The **M** dimension is comprised of the individual metropolitan areas within which the LRT systems we used for the XBT analysis operate. As these are controls which account for idiosyncrasies of metropolitan markets, no direction of associations is predicted. We use San Diego as the referent.

We used the General Transit Feed Specification (GTFS) platform to identify XBT systems (33). It is the most commonly used format for specifying public transit systems. We also double checked XBT systems identified in the GTFS with a review of transit agency web sites to confirm.

Though XBT and BRT services are different, as we note above, prior BRT research can shed light on our research expectations. For the most part, prior research has found positive albeit small associations between single family residential values and proximity to BRT stations/stops (13, 14, 34). Prior research found that multifamily rents were 3.0 percent higher than the regional mean within the first one-half mile of BRT stations/stops and 1.7 percent higher in the next one-half mile distance band (8). Using a much larger database, however, more recent research has found that multifamily rents rise with respect to distance from BRT stations/stops suggestion the presence of negative externalities at BRT stations/stops (35). Prior research on BRT influences on nearby multifamily rents is thus mixed.

We address the research questions with three sets of regression analyses. We first estimate the association between multifamily rents per square foot and proximity to XBT and LRT stations/stops in the same equation. We then estimate the association between rent and proximity to combined XBT+LRT stations/stops. We finally estimate the association between rent and distance from XBT stations/stops for those cases more than 1.0 mile from the nearest LRT station. Table 1 reports our variables, data sources, measurement type, and predicted association between the dependent variable (logged rent per square foot) and the independent ones.

We acknowledge that our model does not include any transit service-related factors such as the number of bus routes at a station, station spacing, headway, service span and so forth. These quality of service measures may reveal incremental willingness to pay higher rent with respect to distance to specific stations/stops. It is an area ripe for future research mostly because it has never been done in the context of real estate transit value added. Part of that research may include efforts to improve open data standards to meet the needs of transportation researchers, as discussed below. Second, as in all prior real estate value transit added research, our theory is based on incremental change in value (rents) with respect to transit station proximity, not with respect to level and quality of service. Finally, like all real estate transit valued added research, our aim is to determine central tendencies, directions of association, and proximate as opposed to precise estimates of value added with respect to transit station proximity.

With 27,847 cases, our model includes many times more data than used in most prior studies (see 14 for comparison). While we have no *a priori* expectations of goodness of fit outcomes, literature suggests that ordinary least squares hedonic (regression) analysis usually explain about one fifth to two-thirds of the variation in the observed rent for cases. Some analysts may be preoccupied with achieving high levels of regression model explanation. Yet, too many variables can lead to over-specification. It is best to emphasize the variables most relevant to the question along with relevant controls sufficient to avoid serious omitted variable bias (a form of endogeneity) in the model. Our model is based on both theory and a large body of prior empirical work.

Our key interest is the association between rents per square foot and distance band with respect to the nearest XBT station/stop as well as nearest combined XBT+LRT station/stop. While a positive association is expected between **DB**s and XBT stations/stops, negative associations can signal externality effects noted above. For instance, areas very near stations/stops may have nuisances such as traffic, noise, and poor urban design that offset positive effects of proximity. But **DB**s farther away may reveal positive rent coefficients. Finally, the **DB** approach allows us to estimate how far away from transit stations/stops the market values proximity, which is important for transit and land use planning. In the regression results reported below, significant **DB** coefficients, where $p < 0.10$ of the two-tailed test, are noted in **bold** in Table 1. Theory allows for both positive and negative signs, with negative signs indicating negative externalities associated with XBT and LRT stations/stops and nearby MF real estate.

INSERT TABLE 1 ABOUT HERE

Transit Data Challenges

Use of secondary data is considered an easy, low resource way to quantitatively analyze social phenomena. Yet data quality issues frequently arise due to lack of adherence to best practices, or due to need for further development of those practices. Challenges appear when the original design of the data standard does not anticipate and thus serve the needs of diverse researchers. The GTFS data model and standard – a revolutionary source in expanding general access to transit data – has provided a remarkable tool for the present study. More than 2,000 transit agencies have provided data through the GTFS. However, the agencies and app developers do not always format and manage it consistently, notwithstanding the standard's underlying paradigm of uniformity of data (36).

The present study is a representative case, in which the GTFS standard fails to require consistent categorization of bus systems to distinguish between "bus rapid transit" or "express bus" among the vaguely defined "bus" category in the standard. When that information is provided, it is because the transportation authority decided to provide it, rather than the GTFS standard requiring it. The current relational model for the GTFS further increased the challenge of its use through greatly compounding data size and processing time, reducing computational capacity given the size of the resulting tables.

Finally, GTFS could be augmented with additional data describing transit system funding sources, boarding and alighting counts, headway, and station operational start dates. The former data would be of great value in such research efforts as discerning the market's involvement, response to, and investment return on various funding sources. The latter is often used in the literature to analyze temporal patterns of development around transit, such as how the market responds to the announcement of a new transit route.

Nonetheless, we matched the XBT routes reported in Table 1 with the inventory of BRT systems reported in other research (13) and found no overlap between them. We invite readers to identify any XBT systems in Table S-1 that may function as BRT systems to refine future research. Nonetheless, because of the size of our database, even if some XBT lines may function as BRT systems, central tendencies and directions of association are not likely to change and approximate orders of magnitude will not change appreciably.

3. RESULTS AND DISCUSSION

Table S-2 reports the descriptive statistics for the first two regression analyses. (Because the descriptive statistics relevant to the third analytic approach—XBT stations/stops that are more than 1.0 mile from the nearest LRT stations—were substantially the same, those statistics are not reported for brevity.)

Table 2 reports results the three regressions used to address the two research questions as follows:

The first regression estimates the association based on proximity to XBT stations/stops that includes LRT stations in the same equation.

The second regression reports the estimates of rent premium proximity with respect to XBT and LRT stations/stops in the same location, which we hypothesize as creating a combined XBT+LRT interaction.

The third regression tests for proximity associations for only those cases that are more than 1.0 mile from the nearest LRT station. This avoids potential interactive associations that are addressed in the second regression.

Future research will explore different ways in which to control for interactive effects between transit modes based on types of modes, distances between stations/stops, and types of stations/stops such as park-and-ride versus a downtown multimodal center.

For all three equations: the coefficients of determination (R^2) show that the equations explain more than half of the variation of rents and the F-ratios show the equations outcomes to be considerably beyond chance.

We now review results for the control variables first and then those for the station/stop proximity treatment variables. As expected among the control variables (excluding metropolitan controls):

Rent increases as the size of a multifamily complex increases reflecting amenities that are more commonly offered in larger complexes than smaller ones;

Rent decreases as the average size of an apartment unit increases reflecting declining marginal value to renters;

As building height increases reflected by the number of floors or stories, mean rent increases reflecting elevation away from the hustle and bustle of the ground level as well as views and perhaps improved air flow;

As the effective year in which the structure was built (or renovated) increases (more recent years have a higher value than earlier years), rent increases;

As the structure vacancy rate increases rent also increases though only slightly—normally, higher vacancy rates might be associated with lower rents but in many markets landlords will push rents as units turn over as they capture renters' increasing willingness to pay for housing;

On average rents for units restricted to seniors decrease in part because subsidies may limit rents but also in part because seniors may impose less wear and tear on units which is reflected in lower rents;

On average rents for units restricted to students decreases in part because their high turnover and large periods of vacancy during summer months lowers the annual average monthly rent;

As the median household income of the block group (BG) in which the multifamily structure is located increases, so does rent;

As the ratio of jobs located in the block increase proportionate to the number of BG residents who are in the labor force, the higher the rent;

Rent increases as employment mix also increases;

As distance from the downtown increases rents fall; and

As distance from the nearest freeway ramp increases rents also fall.

We note that as controls for metropolitan-specific market characteristics, the coefficients for the metropolitan variables are not directly relevant to the interpretation of results with respect to transit stations/stops. Since we use Virginia Beach as our referent, the coefficient for Seattle indicates only that the mean rent per square foot in the Seattle market is 33.6 percent higher than the mean rent in Virginia Beach. In contrast, the mean rent for the St. Louis market is actually 14.0 percent lower than the mean rent in the Virginia Beach market.

Results for proximity effects on MF rent per square foot are reviewed next. Figure 4 illustrates all four of the proximity-related rent associations that are estimated:

Distance from XBT stations/stops and Distance from LRT stations (XBT, LRT in Table 2);
Distance from combined XBT+LRT stations/stops (XBT+LRT); and
Distance from XBT stations/stops for those cases beyond 1.0 mile from the nearest LRT station (XBT-1mile-LRT).

INSERT FIGURE 4 ABOUT HERE

INSERT TABLE 2 ABOUT HERE

XBT Station/Stop Rent Proximity Associations

We first look at the rent premium with respect to XBT station/stop proximity. All distance band coefficients are positive and statistically significant. Rents rise from 4.6% above the mean in the first (0.125-mile) distance band to 6.7% in the second (0.25-mile) distance band, then decline gradually to 1.0 mile. Because rents rise from the XBT station/stop outward to the second distance band, the implication is that negative externalities affecting MF rents may exist at or near the XBT station/stop. Externality sources can be noise, traffic, and poor urban design.

LRT Station Rent Proximity Associations

Relationships are somewhat different with respect to proximity to LRT stations. Here we find an ambiguous (though positive) premium relationship in the first (0.125-mile) distance band with bumpy, positive premium relationships through the remainder of the study area, from 4.0% in the second (0.25-mile) to about the same premium at 3.9% to the last (1.0-mile) distance band. Although the ambiguous effect at or near LRT stations is contradictory to theory, it was found in more than half of all LRT stations studied individually by Nelson et al. (35). They surmised that inadequate planning and/or urban design may be the cause, as we do here.

Combined XBT+LRT Station/Stop Rent Proximity Associations

We next consider synergistic effects; that is, we test for the association between MF rents per square foot with respect to proximity to combined XBT+LRT stations/stops. Three observations are offered:

Firstly, all rent premium coefficients are statistically significant and for the most part are the highest of all rent premiums estimated for each distance band. Indeed, the rent premium at the second (0.25-mile) distance band is 14.0% higher than the mean, the highest estimated in our study.

Secondly, like all other relationships we found, the rent premium rises from the first (0.125-mile) distance band to the second (0.25-mile) distance band before falling steady to the study area boundary at 1.0 mile. The persistence of this upward rent premium from the first to the second (0.125- to 0.25-mile) distance bands signals the presence of negative externalities that may be addressed in future transit and land use planning in ways that we outline below.

Third, we surmise that there is an important synergistic effect between XBT and LRT stations/stops sharing the same area or platform. Reasons may include that presence of these two modes, XBT and LRT, provide accessibility to more destination opportunities throughout the metropolitan area than just one would, and potentially even if both modes serve the same destination, scheduling options are expanded.

XBT Station/Stop Rent Proximity Associations beyond 1.0 Mile of LRT Stations

We now consider XBT rent premium effects when XBT stations/stops are at least 1.0 mile from the nearest LRT station. We note than the number of cases is reduced from 27,847 observations to 18,929, reflecting the elimination of cases falling within the 1.0-mile LRT station buffer area. Here we see that compared to the mean rent among those cases, the XBT rent premium proximate to XBT station/stops starts at 2.2% at or near the station/stop in the first (0.125-mile) distance band, rises to 2.3% in the second (0.25-mile) distance band, then after an ambiguous though positive coefficient for the third (0.375-mile) distance band, peaks at 3.9% in the seventh (0.875-mile) distance band before falling to 2.4% in the last (1.00-mile) distance band. This is an interesting finding because the analysis removes much of the potential influence of LRT station proximity on MF rents, leaving bare underlying associations. MF rent proximity associations are smaller than the others but they also rise mostly through the study area before falling farther away. We surmise that though XBT proximity is valued, negative externalities at or near XBT stations/stops are evident.

We observe that more than half of the coefficients for the metropolitan controls are significant. That may be an indication that those metropolitan areas are different enough from the referent (Virginia Beach) to warrant individual examination. For instance, recall from Figure 1 that there can be vast differences in the types of express busses used between metropolitan areas. This may affect real estate values and rents. Our ongoing research will disaggregate the data into metropolitan area specific analyses to include the kind of rolling stock used among other factors we raise in the next section.

In review, we produce three sets of estimates for XBT proximity effects on rent. In all cases, the outcomes were similar; that is, rent rises with respect to distance from XBT (and XBR+LRT) stations/stops to some distance away before declining. We infer that the inverted U reveals the presence of negative externalities at or near stations that dissipate at some distance (usually by the second, 0.25-mile distance band). This leads to implications for express bus transit and land use planning that we discuss next.

4. IMPLICATIONS FOR EXPRESS BUS TRANSIT AND LAND USE PLANNING

Until now, research into the effects of transit on commercial property such as multifamily rental real estate has been limited to rail transit and BRT stations/stops (12, 13, 14). In this study, we extend analysis to assess how multifamily rents may be influenced by proximity to express bus transit (XBT) stations/stops. We also analyze how XBT stations/stops combined with light rail transit (LRT) stations influence multifamily (MF) rents. Several lessons are offered for express bus transit and land use planning.

We note overall that the market is signaling the desirability of proximity to XBT stations/stops. That is, after controlling structural, socioeconomic, urban form, centrality and metropolitan location influences, multifamily rents capitalize proximity to XBT stations/stops positively. As no literature advances the real estate benefits of XBT systems, perhaps transit and land use planners may have unwittingly overlooked an opportunity to maximize economic returns to XBT investments.

We also note that MF rents rise as distance from XBT stations increases between the first (0.125-mile) and second (0.25-mile) distance bands, signaling that externalities may be present at or near XBT stations/stops. This is also the case for combined XBT+LRT stations. However, for XBT stations more than 1.00-mile away from LRT stations, the externality effect may extend beyond 0.50-mile. Finally, externality effects appear in the first (0.125-mile) distance band from LRT stations in the form of a statistically ambivalent coefficient (though still positive). While, on the one hand, this is inconsistent with theoretical expectations for only a smoothly declining slope with respect to transit station distance using linear, semi-log or double-log functional forms (14), on the other it is consistent with theoretical expectations for negative externalities that are revealed only through quadratic or, in our case, distance band functional forms (25, 26).

There are two key lessons from these results for express bus transit and land use planning. First of all, more might be done to encourage multifamily residential development close to XBT stations/stops. One reason this might not be happening is the assumption among policy makers that proximity to XBT stations/stops does not convey the kind of market premiums studies that have shown for other types of FRT systems (12, 13, 14). This assumption may be especially prevalent in suburban jurisdictions where XBT service is the only long-distance transit option for many thousands of workers.

The other lesson is that more might be done to reduce negative externalities associated with transit stations/stops. While our analysis applies only to XBT and LRT and combined XBT+LRT stations/stops, externality effects have been found in other studies (14, 35). There may be station planning and urban design ways in which to minimize station/stop externalities. Nelson and McClesky's (25) insights for heavy rail transit stations in Atlanta, Georgia in residential areas suggest such XBT station/stop features as:

- Planting extensive landscaping around the perimeter of stations/stops and their parking lots, especially adjacent or near to residences.
- Directing lighting, which can be crucial for safety, onto the station areas directly. Although stations/stops might be visible, the glare or illumination into nearby residences can be avoided.
- Designing sound systems (if needed) to broadcast into the platforms and not into parking areas or nearby residences. This may not completely eliminate sound effects but it can reduce them.
- Designing traffic flow to avoid residential areas, or design new residential developments to orient away from station traffic flows where feasible.

More comprehensive station/stop urban design features relating to transit streets, transit oriented development, context-sensitive urban design, and related design features are offered by the Center for Transit Oriented Development (37) and the National Association of City Transportation Officials (38).

These lessons may also be applied to other combinations of XBT with such systems as heavy rail transit, street car transit, bus rapid transit, and commuter rail transit. Indeed, this is the focus of ongoing research.

Our over-arching perspective is that future economic returns to local economies and local government resources may be maximized by increasing development opportunities near XBT stations/stops. For instance, while there has been a concerted effort to create transit oriented developments (TODs) across the nation, they tend to focus on rail systems, and recently bus rapid transit systems. We are not aware of any express bus TODs—maybe the time has come. In any event, transit and land use planners would be advised to assess the development potential for multifamily investment and other land uses near XBT stations/stops. Transit and land use planners might also consider rethinking drop-off/park-and-ride lots for their development potential while retaining those options.

Our analysis suggests that because of positive market responsiveness to XBT station/stop proximity, transit agencies may consider expanding XBT services as well as creating more synergies between XBT systems and other transit modes. Though our analysis was of XBT stations/stops within metropolitan areas served by LRT systems, our research suggests that more US metropolitan areas may benefit from them, and those with XBT systems may consider adding to their inventory.

We concede that more research is needed to understand how to maximize the real estate market benefits of XBT systems. In-depth, longitudinal case study research could be especially useful to understand the nature of ridership and land use changes associated with features of particular XBT systems, such as frequency of service, features of origin (typically suburban) and destination (typically urban or suburban activity center) stations/stops, and even comforts (seating, Wi Fi, food and beverage, and related).

The bottom line is that express bus transit systems may have been overlooked for their role in influencing real estate markets and by extension development patterns. It is time to reconsider their role in shaping metropolitan development patterns.

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FIGURES

Figure 1
Wide Spectrum of Express Busses
Express busses come in many different types. The top image is an express bus operating in Tucson, Ariz. It is little more than a conventional bus with express bus routes. (Image courtesy of Koren Manning.) The bottom image is an express bus (with one trailing in the distance) operating in Seattle, Wash. It is an articulated bus that is designed for customer convenience such as comfortable high-back reclining seats, overhead storage, and other amenities. (Image from https://www.soundtransit.org/get-to-know-us/our-brand/photography.)

Figure 2
Amenity (R^a) and Negative Externality (R^n) influences of transition stations/stops on proximate property values
Source: Nelson and McClesky (25).

Figure 3
Metropolitan study areas with both light rail transit and express bus transit Systems used in analysis.
Source: Authors.

Figure 4
Percent multifamily rent per square foot change from mean with respect to proximity from Express Bus Transit (XBT) station/stop, Light Rail Transit (LRT) station, combined XBT+LRT and XBT station/stop more than 1.00-mile from LRT stations.

TABLES

Table 1
Variables, Data Sources, Measurement Type, and Predicted Association with Respect to Rent per Square Foot

Variable	Data Source	Measure	Predicted Sign
Rent			
Rent per Square Foot (logged)	CoStar	Continuous	na
Structure Controls			
Gross Leasable Area, Square Feet	CoStar	Continuous	+
Unit Size, Square Feet	CoStar	Continuous	-
Stories	CoStar	Continuous	+
Effective Year Built	CoStar		+
Vacancy Rate	CoStar	Continuous	-
Occupancy Control			
Senior	CoStar	Binary	+
Student	CoStar	Binary	-
Socioeconomic Control			
Median Household (HH) Income	Census ACS	Continuous	+
Land Use Mix Controls			
Workers per Labor Force Member	LEHD, ACS	Continuous	+
Employment mix	LEHD	Continuous	+
Location Controls			
Distance Downtown Center	Computed	Continuous	+
Distance Freeway Ramp	Computed	Continuous	+/-
Distance Band			
1/8 mile bands to 1.0 mile	Computed	Categorical	+/-
Metropolitan Area			
Metropolitan Area Location	Census	Binary	na

Table 2

Association between XBT, LRT and XBT+LRT Station/Stop Proximity and Multifamily Rent per Square Foot

Variable	XBT, LRT	T-score	XBT+LRT	T-score	XBT-1mile LRT	T-score
Constant	-3.537	-24.462	-3.660	-25.384	-3.950	-20.853
Structure Controls						
Gross Leasable Square Feet.	**3.180E-007**	23.914	**3.233E-007**	24.409	**2.621E-007**	18.174
Average Unit Size, Square Feet	**-1.000E-003**	-72.047	**-0.001**	-71.794	**-0.001**	-57.619
Stories	**0.024**	31.116	**0.022**	28.134	**0.039**	29.532
Effective Year Built	**0.002**	26.282	**0.002**	27.296	**0.002**	20.890
Vacancy Rate	**0.004**	21.101	**0.004**	20.947	**0.004**	16.364
Senior Restricted*	**-0.058**	-7.326	**-0.057**	-7.159	**-0.037**	-4.157
Student Restricted*	**-0.050**	-2.803	**-0.051**	-2.908	**-0.052**	-2.188
Socioeconomic Control						
Median HH Income	**4.000E-003**	53.217	**0.004**	53.522	**0.003**	33.547
Urban Form Controls						
BG Labor Force Balance	**-5.858E-006**	-2.674	**-8.596E-006**	-3.927	**0.003**	17.503
Employment Mix	**0.088**	11.960	**0.090**	12.267	**0.082**	9.819
Centrality Controls						
Distance Downtown	**-1.047E-006**	-23.720	**-9.180E-007**	-20.724	**-6.179E-007**	-11.453
Distance Freeway Ramp	**-5.85E-007**	-1.993	**-9.966E-007**	-3.461	**-6.306E-007**	-2.094

Table 2

Association between XBT, LRT and XBT+LRT Station/Stop Proximity and Multifamily Rent per Square Foot Continued

Variable	XBT, LRT	T-score	XBT+LRT	T-score	XBT-1mileLRT	T-score
Metropolitan Controls**						
Buffalo	2.500E-002	1.106	0.032	1.415	0.014	0.539
Charlotte	-9.100E-002	-4.498	-0.083	-4.138	-0.078	-3.543
Dallas	0.082	4.548	0.070	3.890	0.081	4.026
Denver	0.271	14.831	0.266	14.656	0.270	13.173
Houston	-0.032	-1.770	-0.040	-2.219	-0.032	-1.583
Minneapolis St. Paul	0.103	5.679	0.104	5.813	0.095	4.737
Phoenix	-0.053	-2.933	-0.061	-3.390	-0.023	-1.169
Pittsburgh	0.011	0.557	0.003	0.145	0.010	0.470
Portland	0.184	10.064	0.186	10.267	0.164	7.841
Sacramento	0.122	6.487	0.110	5.920	0.192	9.008
Salt Lake City	-0.030	-1.428	-0.033	-1.562	-0.013	-0.500
San Diego	0.474	26.349	0.463	26.015	0.497	24.855
San Jose	0.607	32.789	0.595	32.254	0.692	33.009
Seattle	0.336	18.763	0.333	18.698	0.347	17.391
St. Louis	-0.140	-7.228	-0.151	-7.800	-0.149	-6.810

Table 2

Association between XBT, LRT and XBT+LRT Station/Stop Proximity and Multifamily Rent per Square Foot

Continued

Variable* **	**XBT, LRT**	**T-score**	**XBT+LRT**	**T-score**	**XBT-1mileLRT**	**T-score**
XBT <0.125 mile	**0.046**	6.187				
XBT >0.125 to <= 0.250 mile	**0.067**	8.985				
XBT >0.250 to <= 0.375 mile	**0.049**	6.114				
XBT >0.375 to <= 0.500 mile	**0.050**	6.150				
XBT >0.500 to <= 0.625 mile	**0.034**	3.943				
XBT >0.625 to <= 0.750 mile	**0.042**	4.875				
XBT >0.750 to <= 0.875 mile	**0.046**	5.268				
XBT >0.875 to <= 1.000 mile	**0.041**	4.575				
LRT <0.125 mile	0.005	0.446				
LRT >0.125 to <= 0.250 mile	**0.040**	4.647				
LRT >0.250 to <= 0.375 mile	**0.019**	2.378				
LRT >0.375 to <= 0.500 mile	**0.037**	4.678				
LRT >0.500 to <= 0.625 mile	**0.029**	3.626				
LRT >0.625 to <= 0.750 mile	**0.038**	4.477				
LRT >0.750 to <= 0.875 mile	**0.024**	2.867				
LRT >0.875 to <= 1.000 mile	**0.039**	4.629				
XBT+LRT <0.125 mile			**0.099**	8.418		
XBT+LRT >0.125 to <= 0.250 mile			**0.140**	13.390		
XBT+LRT >0.250 to <= 0.375 mile			**0.117**	10.781		
XBT+LRT >0.375 to <= 0.500 mile			**0.117**	10.329		
XBT+LRT >0.500 to <= 0.625 mile			**0.096**	7.727		
XBT+LRT >0.625 to <= 0.750 mile			**0.085**	7.171		
XBT+LRT >0.750 to <= 0.875 mile			**0.083**	6.864		
XBT+LRT >0.875 to <= 1.000 mile			**0.080**	6.169		

Table 2
Association between XBT, LRT and XBT+LRT Station/Stop Proximity and Multifamily Rent per Square Foot
Continued

Variable***	**XBT, LRT**	**T-score**	**XBT+LRT**	**T-score**	**XBT-1mileLRT**	**T-score**
XBT1miLRT <0.125 mile					**0.022**	2.603
XBT1miLRT >0.125 to <= 0.250 mile					**0.023**	2.377
XBT1miLRT >0.250 to <= 0.375 mile					0.010	0.888
XBT1miLRT >0.375 to <= 0.500 mile					**0.016**	1.545
XBT1miLRT >0.500 to <= 0.625 mile					**0.021**	1.945
XBT1miLRT >0.625 to <= 0.750 mile					**0.036**	3.226
XBT1miLRT >0.750 to <= 0.875 mile					**0.039**	3.564
XBT1miLRT >0.875 to <= 1.000 mile					**0.024**	2.237
Performance Metrics						
Mean Monthly Rent/Sq.Ft.	$1.45		$1.45		$1.39	
Cases	27,847		27,847		18.929	
Adjusted R^2	0.570		0.573		0.590	
Standard Error of Estimate	0.256		0.255		0.241	
F-Ratio	858.747		1067.871		779.588	
Binary Variable Referents						
*All Other Renters						
**Virginia Beach						
***Cases >1.00 mile						
p <0.10 two-tailed test						

Table S-1

Express Bus Transit Routes in Metropolitan Areas outside the Northeast and Great Lakes Regions with Light Rail Transit and Express Bus Systems

City	Rte ID	Route Name	City	Rte ID	Route Name
Buffalo		AIRPORT -DOWNTOWN EXPRESS	Minneapolis	674	Express - Maple Plain -Orono - Wayzata - Mpls
Buffalo	44	LOCKPORT	Minneapolis	675	Express - Mound - Wayzata - Ridgedale - Mpls
Buffalo	54	MILITARY	Minneapolis	677	Express- Mound - Orono - Plymouth Rd - Mpls
Buffalo	60E	Enhansed Express Route 64 - Lockport	Minneapolis	679	Express - Co Rd 73 - Mpls
Buffalo	64E	Enhanced Express Route 60 - Niagara Falls	Minneapolis	756	Express- Hwy 55 - Mendelssohn Rd - Boone Av
Buffalo	67	CLEVELAND HILL	Minneapolis	758	Express - Douglas - MnDot P&R - Noble - Mpls
Buffalo	69	ALDEN	Minneapolis	760	Express - Zane Av - 63rd Av - 65th Av P&R - Mpls
Buffalo	70	EAST AURORA	Minneapolis	761	Express - Brooklyn Park - Xerxes - 49th Av - Mpls
Buffalo	76	LOTUS BAY	Minneapolis	763	Express - 85th Av - Brookdale Dr - Humboldt - Mpls
Charlotte	40x	Lawyers Road Express	Minneapolis	764	Express - Winnetka Av - 42nd Av - Mpls
Charlotte	41x	Steele Creek Express	Minneapolis	765	Express - Target - Hwy 252 and 73rd Av P&R - Mpls
Charlotte	45x	Carmel Road Express	Minneapolis	766	Express - Champlin - Noble P&R - West River Rd
Charlotte	46x	Harrisburg Road Express	Minneapolis	767	Express - 63rd Av P&R - 65th Av P&R - Mpls
Charlotte	48x	Huntersville Express	Minneapolis	768	Express - Noble P&R - Downtown
Charlotte	52x	Idlewild Road Express	Minneapolis	850	Express - Riverdale P&R - Foley P&R - Mpls

Charlotte	53x	Northlake Express	Minneapolis	852	Express - Anoka - Coon Rapids - Northtown - Mpls
Charlotte	54x	University Research Park Express	Minneapolis	854	Express - Paul Pkwy - Northdale - Northtown - Mpls
Charlotte	61x	Arboretum Express	Minneapolis	860	Express - Riverdale - Northtown - St Paul
Charlotte	62x	Rea Road Express	Minneapolis	865	Express - Blaine - Ham Lake - East Bethel
Charlotte	63x	63X Huntersville Express Huntersville CTC/ Northcross Park and Ride	Phoenix	520	Tempe Express
Charlotte	64x	Independence Blvd Express	Phoenix	521	Tempe Express
Charlotte	65x	Matthews Express	Phoenix	522	Tempe Express
Charlotte	74x	Union County Express	Phoenix	531	Mesa/Gilbert Express
Charlotte	77x	North Mecklenburg Express	Phoenix	533	Mesa Express
Charlotte	80x	Concord Express	Phoenix	541	Chandler Express
Charlotte	82x	Rock Hill Express	Phoenix	542	Chandler Express
Charlotte	85x	Gastonia Express	Phoenix	562	Goodyear Express
Charlotte	88x	Mountain Island Express	Phoenix	573	Northwest Valley Express
Cincinnati	12X	Madisonville Express	Phoenix	575	Northwest Valley Express
Cincinnati	14X	Forest Park Express	Pittsburgh	12	McKnight
Cincinnati	15X	Mt Healthy Express	Portland	92	South Beaverton Express
Dallas	205	ADDISON TC EXPRESS	Sacramento	3	aka 103 on the internet RIVERSIDE EXPRESS
Dallas	206	GLENN HEIGHTS EXPRESS	Sacramento	7	aka 107 on the internet POCKET EXPRESS
Dallas	210	JACK HATCHELL EXPRESS	Sacramento	51X	W/X
Dallas	278	REDBIRD EXPRESS	Sacramento	109	HAZEL EXPRESS
Dallas	282	MESQUITE/LAWVIEW STATION	Salt Lake City	2X	200 SOUTH EXPRESS
Dallas	283	LAKE RAY HUBBARD EXPRESS	Salt Lake City	307	COTTONWOOD HEIGHTS FAST BUS
Dallas	987	RAPID RIDE	Salt Lake City	313	SOUTH VALLEY / U OF U FAST BUS

Dallas	211	LEGACY/TOYOTA	Salt Lake City	320	HIGHLAND DRIVE FAST BUS
Dallas	MAX	UTA EXPRESS	Salt Lake City	354	SANDY / U OF U FAST BUS
Dallas	208	NORTHWEST PLANO PARK & RIDE	Salt Lake City	451	TOOELE EXPRESS
Denver	FF1	Flatiron Flyer	Salt Lake City	456	OGDEN/UNISYS/ ROCKY MTN. EXPRESS
Denver	FF2	Flatiron Flyer	Salt Lake City	472	OGDEN - SALT LAKE EXPRESS
Denver	FF3	Flatiron Flyer	Salt Lake City	473	SLC - OGDEN HWY 89 EXPRESS
Denver	FF4	Flatiron Flyer	Salt Lake City	650	OGDEN FRONTRUNNER / WSU FAST BUS
Denver	FF5	Flatiron Flyer	San Diego	280	
Denver	FF6	Flatiron Flyer	San Diego	290	
Denver	FF7	Flatiron Flyer	San Jose	101	CAMDEN & HWY 85 - PALO ALTO
Denver	104X	104X	San Jose	103	EASTRIDGE - PALO ALTO
Denver	116X	116X	San Jose	104	PENITENCIA TRANS CTR - PALO ALTO
Denver	120X	120X	San Jose	122	SOUTH SAN JOSE - LOCKHEED MARTIN
Denver	122X	122X	San Jose	140	FREMONT BART - M.COLLEGE & MONTAGUE
Denver	LNX	LNX	San Jose		GILROY TRANS CTR - SAN JOSE DIRIDON
Denver	LX	LX	San Jose	180	GREAT MALL/MAIN - FREMONT BART
Denver	RX	RX	San Jose	181	SAN JOSE DIRIDON - FREMONT BART
Eugene	79x	79x	San Jose	182	PALO ALTO - IBM/BAILEY AVE
Fort Worth	60		San Jose	185	GILROY TC - MOUNTAIN VIEW
Fort Worth	61		Seattle	101	
Fort Worth	63X	North Park and Ride Xpress	Seattle	150	
Fort Worth	64X	North Texas Xpress	Seattle	177	
Fort Worth	65X	South Park and Ride Xpress	Seattle	178	
Fort Worth	66X	Candleridge/Altamesa Xpress	Seattle	190	

Fort Worth	SPUR		Seattle	50	
Houston	137	NORTHSHORE EXPRESS	Seattle	540	Kirkland University District
Houston	151	WESTPARK EXPRESS	Seattle	545	Redmond Seattle
Houston	152	HARWIN EXPRESS	Seattle	550	Bellevue Seattle
Houston	153	HARWIN EXPRESS	Seattle	554	Issaquah Seattle
Houston	160	MEMORIAL CITY EXPRESS	Seattle	555	Issaquah Northgate
Houston	161	WILCREST EXPRESS	Seattle	556	Issaquah University District Northgate
Houston	162	MEMORIAL EXPRESS	Seattle	102	
Houston	170	MISSOURI CITY EXPRESS	Seattle	542	Redmond University District
Minneapolis	94	Express - Mpls - St Paul	Seattle	541	Overlake P&R to U-District
Minneapolis	156	Express - 58th St - 56th St - Diamond Lake - Mpls	Seattle	500	Federal Way
Minneapolis	250	Express - St Josephs P&R - 95Av P&R - Mpls	Seattle	510	Everett - Seattle
Minneapolis	261	Express - Shoreview - Roseville - Mpls	Seattle	511	Ash Way - Seattle
Minneapolis	263	Express - Rice St Park and Ride - Roseville	Seattle	512	Everett - Seattle
Minneapolis	264	Express - Co Rd C Park and Ride - Roseville	Seattle	513	Everett - Seattle
Minneapolis	265	Express - White Bear Lake - Maplewood - St Paul	Seattle	532	Everett - Bellevue
Minneapolis	270	Express - Mahtomedi - Maplewood - Minneapolis	Seattle	560	Bellevue - Sea-Tac - W. Seattle
Minneapolis	272	Express - Maplewood - Roseville - U of M	Seattle	566	Auburn - Overlake
Minneapolis	275	Express - Forest Lake- Running Aces - St Paul	Seattle	567	Kent - Overlake
Minneapolis	288	Express - Forest Lake - Mpls	Seattle	574	Lakewood - SeaTac
Minneapolis	294	Express - Oakdale - Stillwater - St Paul	Seattle	577	Federal Way - Seattle
Minneapolis	351	Express - Woodbury - St Paul	Seattle	578	Puyallup - Seattle

Minneapolis	353	Express - Woodbury - St Paul - Mpls	Seattle	580	Lakewood to Puyallup
Minneapolis	355	Express - Woodbury - Mpls	Seattle	586	Tacoma - U. District
Minneapolis	361	Express - Cottage Grove - St Paul	Seattle	590	Tacoma - Seattle
Minneapolis	365	Express - Cottage Grove - Mpls	Seattle	592	Olympia/DuPont - Seattle
Minneapolis	375	Express - Oakdale - Mpls	Seattle	594	Lakewood - Seattle
Minneapolis	452	Express - West St Paul - Mpls	Seattle	596	Bonney Lake - Sumner
Minneapolis	467	Express - Lakeville-Minneapolis	St. Louis	40X	I-55 Express
Minneapolis	552	Express - 12th Av - Bloomington Av - Mpls	St. Louis	57X	Clayton Rd
Minneapolis	553	Express - Bloomington - Portland Av - Mpls	St. Louis	58X	Twin Oaks Express
Minneapolis	554	Express - Bloomington - Nicollet Av - Mpls	St. Louis	174X	North Express
Minneapolis	558	Express - Southtown - Lyndale Av - Penn Av - Mpls	St. Louis	410X	Eureka Express
Minneapolis	578	Express - Edina - Southdale - Mpls	St. Louis	2X	Waterloo-Columbia
Minneapolis	579	Express - U of M - Southdale	St. Louis	12X	Metrolink Station Shuttle
Minneapolis	587	Express - Edina - Valley View Rd - Mpls	St. Louis	17X	Lebanon - Mascoutah
Minneapolis	589	Express - West Bloomington - Mpls	St. Louis	21X	Scott AFB-East Base Shuttle
Minneapolis	597	Express - West Bloomington - Mpls	St. Louis	22X	Sauget Industrial Parkway
Minneapolis	649	Express - Louisiana Av - Cedar Lake Rd- Mpls	St. Louis	3X	Muny Trolley
Minneapolis	652	Express - Plymouth Rd - Co Rd 73 P&R - U of M	Virginia Beach	918	MAX SILVERLEAF-NSA/JOINT FORCE STAFF COLLEGE/LAFAYETTE RIVER ANNEX
Minneapolis	663	Express - Cedar Lake Rd - Mpls	Virginia Beach	919	MAX SILVERLEAF/NAVAL STATION NORFOLK

Minneapolis	664	Express - Co Rd 3 - Excelsior Blvd - Mpls	Virginia Beach	922	MAX GREENBRIAR/INDIAN RIVER/NAVAL STATION NORFOLK
Minneapolis	667	Express - Minnetonka - St Louis Park - Mpls	Virginia Beach	960	MAX VIRGINIA BEACH-NORFOLK EXPRESS
Minneapolis	668	Express - Hopkins - St Louis Park - Mpls	Virginia Beach	961	MAX NEWPORT NEWS/HAMPTON/NORFOLK
Minneapolis	672	Express - Wayzata - Minnetonka - Mpls	Virginia Beach	965	MAX PATRICK HENRY/PENINSULA TOWN CENTER/NAVAL STATION NORFOLK
Minneapolis	673	Express - Co Rd 73 P&R - Mpls	Virginia Beach	966	MAX SILVERLEAF/NEWPORT NEWS SHIPBUILDING
Minneapolis	674	Express - Maple Plain -Orono - Wayzata - Mpls	Virginia Beach	967	MAX VIRGINIA BEACH-NEWPORT NEWS EXPRESS

Source: Authors.

Table S-2

Descriptive Statistics of Variables Used in the Analysis of the Association between XBT and Combined XBT+LFRT Station/Stop and Multifamily Rent per Square Foot

Variables	Cases	Minimum	Maximum	Mean	Std. Deviation
Structure Controls					
Mean Rent per Square Feet	27,847	$0.41	$14.92	$1.45	0.657
Gross Leasable Square Feet	27,847	850	2,711,782	105,032	141103.949
Average Unit Size, Square Feet	27,847	97	3,000	800	203.048
Stories	27,847	1	51	2.81	2.377
Effective Year Built	27,847	1871	2022	1977	25.076
Vacancy Rate, percent	27,847	0.00%	100.00%	5.45%	7.8083648
Senior Restricted, percent	27,847	0%	100%	4%	0.200
Student Restricted, percent	27,847	0%	100%	1%	0.087
Socioeconomic Control					
Median HH Income, dollars	27,847	$5,491	$250,001	$52,996	26.544
Urban Form Controls					
BG Labor Force Balance	27,847	77	13,321	1,282	759.786
Employment Mix	27,847	0.000	0.929	0.226	0.213
Centrality Controls					
Distance to Downtown, feet	27,847	37	210,794	49,796	43,892
Distance to Freeway Ramp, feet	27,847	54	116,696	6,737	6,277

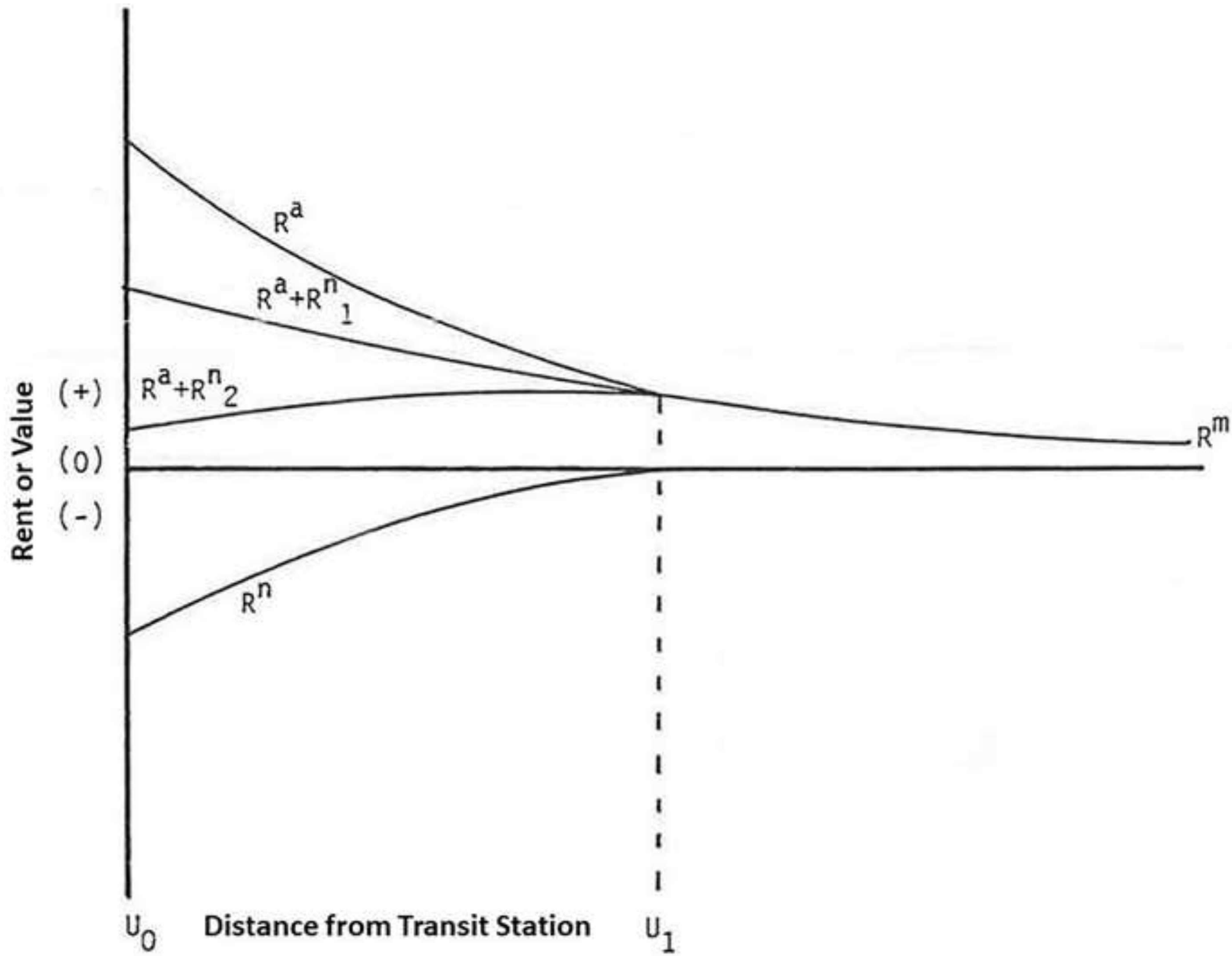
Table S-2
Descriptive Statistics of Variables Used in the Analysis of the Association between XBT and Combined XBT+LFRT Station/Stop and Multifamily Rent per Square Foot—continued

Variables	Cases	Minimum	Maximum	Mean	Std. Deviation
Metropolitan Controls					
Buffalo	27,847	0	1	1%	0.105
Charlotte	27,847	0	1	2%	0.146
Dallas	27,847	0	1	12%	0.326
Denver	27,847	0	1	7%	0.253
Houston	27,847	0	1	8%	0.276
Minneapolis-St. Paul	27,847	0	1	8%	0.277
Phoenix	27,847	0	1	9%	0.283
Pittsburgh	27,847	0	1	3%	0.167
Portland	27,847	0	1	7%	0.257
Sacramento	27,847	0	1	4%	0.206
Salt Lake City	27,847	0	1	2%	0.127
San Diego	27,847	0	1	13%	0.334
San Jose	27,847	0	1	6%	0.244
Seattle	27,847	0	1	13%	0.340
St. Louis	27,847	0	1	3%	0.169

Table S-2
Descriptive Statistics of Variables Used in the Analysis of the Association between XBT and Combined XBT+LFRT Station/Stop and Multifamily Rent per Square Foot—continued

Variables	Cases	Minimum	Maximum	Mean	Std. Deviation
Transit Station/Stop Treatment					
XBT <0.125 mile	27,847	0%	100%	6%	0.2290
XBT >0.125 to <= 0.250 mile	27,847	0%	100%	5%	0.2200
XBT >0.250 to <= 0.375 mile	27,847	0%	100%	4%	0.2010
XBT >0.375 to <= 0.500 mile	27,847	0%	100%	4%	0.1960
XBT >0.500 to <= 0.625 mile	27,847	0%	100%	3%	0.1830
XBT >0.625 to <= 0.750 mile	27,847	0%	100%	3%	0.1820
XBT >0.750 to <= 0.875 mile	27,847	0%	100%	3%	0.1810
XBT >0.875 to <= 1.000 mile	27,847	0%	100%	3%	0.1770
LRT <0.125 mile	27,847	0%	100%	2%	0.1320
LRT >0.125 to <= 0.250 mile	27,847	0%	100%	4%	0.1890
LRT >0.250 to <= 0.375 mile	27,847	0%	100%	4%	0.2060
LRT >0.375 to <= 0.500 mile	27,847	0%	100%	4%	0.2000
LRT >0.500 to <= 0.625 mile	27,847	0%	100%	4%	0.1990
LRT >0.625 to <= 0.750 mile	27,847	0%	100%	4%	0.1880
LRT >0.750 to <= 0.875 mile	27,847	0%	100%	4%	0.1880
LRT >0.875 to <= 1.000 mile	27,847	0%	100%	4%	0.1870
XBT+LRT <0.125 mile	27,847	0%	100%	2%	0.1400
XBT+LRT >0.125 to <= 0.250 mile	27,847	0%	100%	2%	0.1520
XBT+LRT >0.250 to <= 0.375 mile	27,847	0%	100%	2%	0.1450
XBT+LRT >0.375 to <= 0.500 mile	27,847	0%	100%	2%	0.1380
XBT+LRT >0.500 to <= 0.625 mile	27,847	0%	100%	2%	0.1250
XBT+LRT >0.625 to <= 0.750 mile	27,847	0%	100%	2%	0.1310
XBT+LRT >0.750 to <= 0.875 mile	27,847	0%	100%	2%	0.1280
XBT+LRT >0.875 to <= 1.000 mile	27,847	0%	100%	1%	0.1190


103X INA RD


Rent or Value
(+)
(0)
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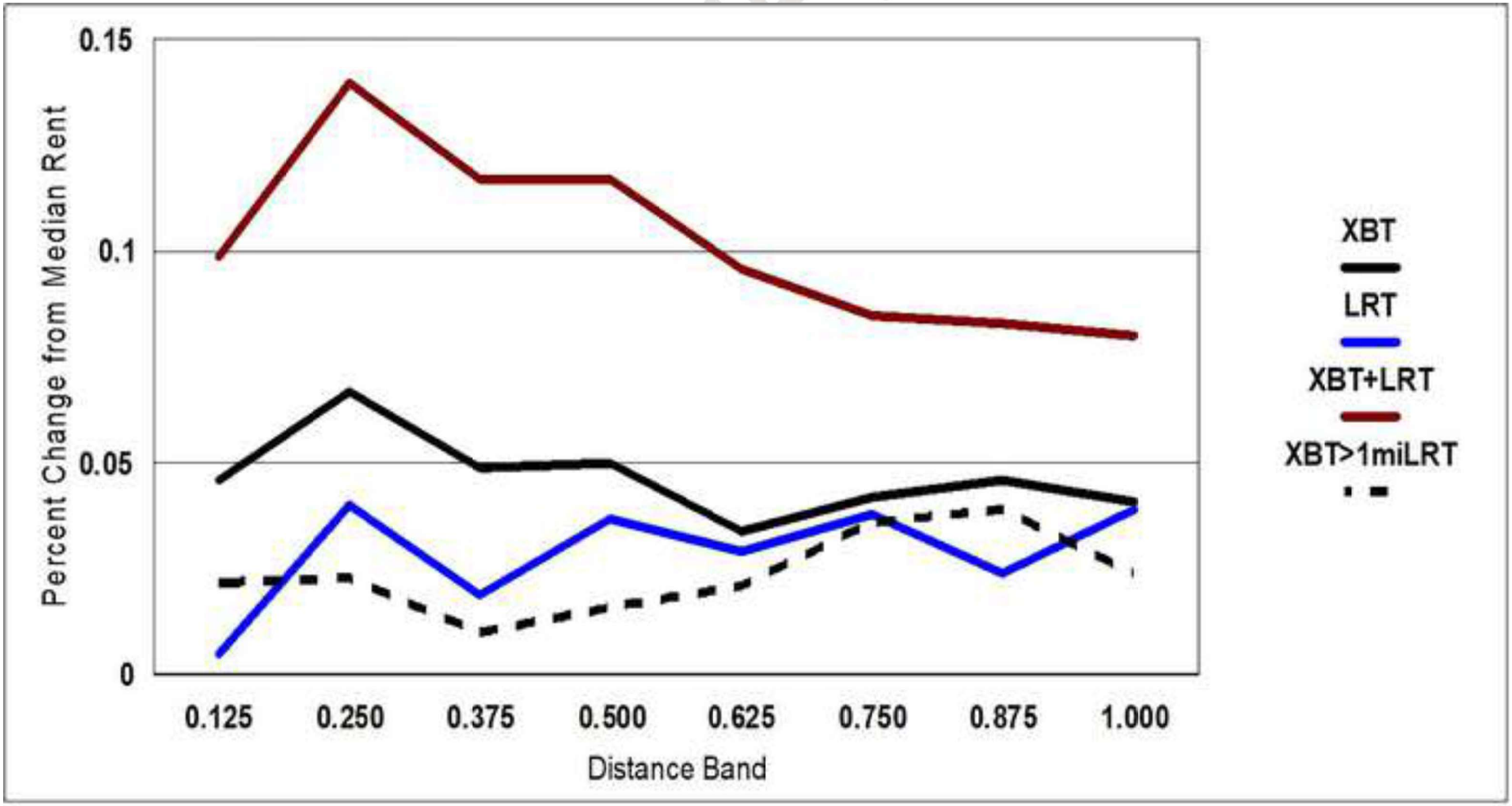
R^a
$R^a+R^n_1$
$R^a+R^n_2$
R^n
R^m
U_0
Distance from Transit Station
U_1

Figure


0.15
0.1
0.05
0
Percent Change from Median Rent
0.125
0.250
0.375
0.500
0.625
0.750
0.875
1.000
Distance Band
XBT
LRT
XBT+LRT
XBT>1miLRT