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Bus Rapid Transit Outcomes with Post-Pandemic Implications

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BUS RAPID TRANSIT OUTCOMES WITH POST-PANDEMIC IMPLICATIONS

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This article is the first comprehensive assessment of the extent to which bus rapid transit (BRT) station areas attract jobs, people and households, and influence commuting mode choice as well as real estate values. Research is based on 15 BRT systems between the Great Recession of 2007-2009 and the global COVID-19 pandemic of 2020-2023. The study area extends 800 meters (about 0.50-miles) from BRT stations, which comprise less than one percent of the urbanized land area of the counties within which BRT systems operate. During the study period, BRT station areas added more than 420,000 jobs and accounted for about 24 percent of BRT counties’ growth; however, the shares of jobs fell, indicating station areas lost job concentration during the study period. The population in BRT station areas increased by about 200,000, accounting for nearly 21 percent of BRT counties’ growth, and added more than 90,000 households, about 27 percent of BRT counties’ growth. In contrast to jobs, BRT station areas added people and households at a faster pace than BRT counties. Moreover, BRT station areas overall increased concentrations compared to their counties across all but the eldest of householder age groups as well as all household types. Despite such growth, median household income within BRT station areas fell slightly relative to BRT counties. BRT station areas also accounted for about 39 percent of the BRT counties’ change in renters compared to 14 percent of the change in homeowners. For now, there appears to be little evidence of gentrification overall, although this is occurring among some BRT systems. Of the new workers living in BRT counties, nearly a quarter moved into BRT station areas. They accounted for 36 percent of the increase in the use of transit in work commutes, 45 percent of the change in commuting via walking and biking, and 20 percent of the increase in those working from home. However, the relationship between commercial rents and proximity to transit stations is mixed with mostly negative or statistically insignificant outcomes. These results call into question the efficacy of BRT station planning, location, and design for most transit station systems, assuming one objective is to attract real estate investment. Nonetheless, there are several exemplary BRT systems worth emulating. Results from research reported in this article provide insights into post-pandemic BRT policy and planning, notably that BRT station areas should focus on being places for people.</td></tr>
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BUS RAPID TRANSIT OUTCOMES WITH POST-PANDEMIC IMPLICATIONS

ABSTRACT

This article is the first comprehensive assessment of the extent to which bus rapid transit (BRT) station areas attract jobs, people and households, and influence commuting mode choice as well as real estate values. Research is based on 15 BRT systems between the Great Recession of 2007-2009 and the global COVID-19 pandemic of 2020-2023. The study area extends 800 meters (about 0.50-miles) from BRT stations, which comprise less than one percent of the urbanized land area of the counties within which BRT systems operate. During the study period, BRT station areas added more than 420,000 jobs and accounted for about 24 percent of BRT counties' growth; however, the shares of jobs fell, indicating station areas lost job concentration during the study period. The population in BRT station areas increased by about 200,000, accounting for nearly 21 percent of BRT counties' growth, and added more than 90,000 households, about 27 percent of BRT counties' growth. In contrast to jobs, BRT station areas added people and households at a faster pace than BRT counties. Moreover, BRT station areas overall increased concentrations compared to their counties across all but the eldest of householder age groups as well as all household types. Despite such growth, median household income within BRT station areas fell slightly relative to BRT counties. BRT station areas also accounted for about 39 percent of the BRT counties' change in renters compared to 14 percent of the change in homeowners. For now, there appears to be little evidence of gentrification overall, although this is occurring among some BRT systems. Of the new workers living in BRT counties, nearly a quarter moved into BRT station areas. They accounted for 36 percent of the increase in the use of transit in work commutes, 45 percent of the change in commuting via walking and biking, and 20 percent of the increase in those working from home. However, the relationship between commercial rents and proximity to transit stations is mixed with mostly negative or statistically insignificant outcomes. These results call into question the efficacy of BRT station planning, location, and design for most transit station systems, assuming one objective is to attract real estate investment. Nonetheless, there are several exemplary BRT systems worth emulating. Results from research reported in this article provide insights into post-pandemic BRT policy and planning, notably that BRT station areas should focus on being places for people.

OVERVIEW

This article is the first comprehensive assessment of the extent to which bus rapid transit (BRT) station areas attract jobs, people and households, and influence commuting mode choice as well as real estate values. Observations are also offered with respect to gentrification. Research reported here is based on 15 BRT systems operating wholly or in part between the Great Recession of 2007-2009 and the global COVID-19 pandemic of 2020-2023. The article begins with literature reviews, theoretical perspectives, and research questions relating to the role of BRT station proximity on various economic and demographic outcomes within 800 meters (about 0.50-mile) of transit stations, which is called the "station area." It continues with a framework for analyzing outcomes. This is followed by sections presenting research designs, hypotheses, methods, results, and interpretations relating to the association between BRT station proximity and outcomes with respect to jobs, people, households, commuting, and real estate values. Key findings include the following:

- Within 800 meters, BRT station areas added more than 420,000 jobs during the study period, accounting for about 24 percent of all new jobs in counties with BRT systems. Although BRT station areas lost jobs in education compared to BRT counties, they accounted for 19 percent of the change in industrial jobs, 30 percent of the change in office jobs, 24 percent of the change in health jobs, 28 percent of the change in retail-food-lodging jobs, and 41 percent of the change in arts-entertainment and recreation jobs. Yet, BRT station areas account for less than one percent of the urbanized land area of BRT counites. On the other hand, the pace of new jobs was lower in BRT station areas than in BRT counties, indicating that jobs are dispersing gradually.

- BRT station areas also added more than 190,000 people, accounting for 21 percent of BRT county growth, again on less than one percent of BRT counties' urbanized land area. More than 81 percent of this growth was among non-Whites. Importantly, population growth occurred at a faster pace in BRT station areas than in BRT counties overall.

- BRT station areas accounted for 27 percent of the change in households, mostly because they attracted a third of the BRT counties' growth in single-person households. While the number of households with children fell in the station areas of BRT systems launched before 2010, BRT station areas of systems launched between 2010 and 2019 accounted for nearly 30 percent of their respective BRT counties' share of growth of those households.

- Although the number of householders under 25 years of age fell in BRT counties overall, they increased in BRT station areas. BRT station areas also accounted for 43 percent of BRT counties' growth among householders between 25 and 44 years of age. However, where pre-2010 BRT counties and their station areas lost householders of 45 to 64 years of age, BRT counties of systems launched between 2010 and 2019 increased such households with 53 percent of them added to BRT station areas. BRT station areas overall added householders of 65 years of age or older at about the same pace as the BRT counties.

- Despite BRT station areas attracting more than their proportionate share of growth, household income fell slightly compared to BRT counties overall and among pre-2010 BRT systems and remained about the same compared to BRT systems launched 2010 to 2019.

- Moreover, BRT station areas accounted for 39 percent of the BRT county change in renters compared to 14 percent of homeowners.

- Considering change in household income and tenure, there is little evidence of gentrification overall, although this may be occurring among some BRT systems and may arise in the future without proactive efforts.

- Of the nearly 950,000 new workers living in BRT counties (as opposed to workers with jobs in the county), nearly a quarter moved into BRT station areas. They also accounted for 36 percent of the increase in the use of all transit modes in the commute to work. Between BRT systems launched before 2010 and those launched between 2010 and 2019, there is a large difference in the change of workers commuting via walking and biking, being 29 percent and 49 percent, respectively. Overall, BRT statin areas accounted for 20 percent of the change in workers working from home among BRT counties, but these figures predate the pandemic.

- However, the relationship between commercial rents and proximity to transit stations is mixed with mostly negative or statistically insignificant outcomes. That is, where one would expect proximity to BRT stations to conger a premium on office, retail, and multifamily rents, they do not with respect to most BRT systems. These results call into question the efficacy of BRT station planning, location, and design for most transit station areas if their intent is to achieve the desired real estate investment outcomes. There are several exemplary individual BRT systems worth emulating, nonetheless.

Using insights from research, the article offers lessons for post-pandemic BRT transit policy and planning. Notably, it concludes with a call to make BRT station areas more attractive places for people to live.

What follows is a review of BRT literature and theory along with research questions.

Bus Rapid Transit Station Development Literature, Theories, and Research Questions

Cities and their metropolitan areas are formed and grow in large part by creating agglomeration economies (Glaeser 2011). This occurs in part when the average cost of production falls as firms pool their resources, such as labor, to increase productivity (Anas, Arnott and Small 1998). As more related firms cluster together, average production costs fall as productivity increases. Agglomeration economies can spill over into complementary sectors, thereby creating even more jobs (Holmes 1999). Cities become ever larger when agglomeration economies are exploited (Ciccone and Hall 1996).

Highways make it possible to sustain agglomeration economies by increasing the size of market areas. But increasing demand for highways can lead to congestion which reduces worker productivity and accessibility to markets, thereby undermining agglomeration economies (Glaeser and Kohlhase 2004). Indeed, new highway investments have been shown to reduce agglomeration economies resulting in a net cost to society (Boarnet 1997; Boarnet and Haughwout 2000). A key role of transit is to facilitate agglomeration economies by mitigating the transportation congestion effects of automobile traffic induced by agglomeration. Since public transit is essentially noncongestible, it can sustain agglomeration economies in high-density nodes as well as along the corridors that connect them (Voith1998).

Research shows that public transit enhances economic development, in part because of its role in facilitating agglomeration economies (Graham 2007; Nelson et al, 2009; Litman 2023). Transit thus plays a pivotal role in the development of metropolitan areas, especially near transit stations (Belzer et al., 2011). Not only is job growth facilitated but transit stations also attract households and their workers who seek improved accessibility to jobs as well as other services (Nelson et al. 2015). This can reduce automobile dependence by expanding mobility options.[1] Moreover, transit stations confer proximity rent premiums that increase land and real estate values near them (Higgins and Kanaroglou 2016). But there is an underlying concern that this increase in rental costs near transit stations can lead to gentrification (Padeiro, Louro and da Costa 2019).

In focusing on bus rapid transit (BRT), this section presents literature and identifies theories with respect to the association between BRT station proximity and change in the share of regional jobs, population generally—as well as among Whites/non-Whites, households by type and age—along with their housing tenure and median household income, change in mode choice in the commute to work, and rents for office, retail, and multifamily rent.

[1] See https://tod.itdp.org/what-is-tod/eight-principles-of-tod.html.

Literature, Theory, and Research Questions Relating to BRT Station Proximity and Jobs

In theory, BRT systems should facilitate economic development near BRT stations because they reduce transportation costs and support higher intensity land uses (Shen 2013). Unfortunately, the literature on the association between the change in jobs and jobs by economic sector and proximity to BRT stations is thin.

A key assumption of BRT systems is that they will generate jobs around transit stations. The first study to address this issue generally across several transit modes was conducted by Belzer, Srivastava and Austin (2011). They used Longitudinal Employment-Housing Dynamics (LEHD) data for 34 metropolitan areas for the years 2002 and 2008. "The type, number, and share of jobs were compared between blocks that lay within a half mile of a fixed-guideway transit stop and those in the region as a whole" (p. 18).[2] A transit zone capture rate was calculated as the share of a sector's employment within 0.50 mile (about 800 meters) of a transit station compared to the region. A change in the capture rate from 2002 to 2008 was also estimated. Without differentiating employment shares between types of transit systems, Belzer, Srivastava and Austin found: (1) government employment accounted for 42 percent of all new jobs in the 0.50-mile transit zones; (2) knowledge-based jobs accounted for about 28 percent of the change; (3) only about 14 percent of the change in jobs were in manufacturing; and (4) 17 percent of new jobs were in wholesale trade. Note that this study is based on data mostly preceding the Great Recession of late 2007 through mid-2009.

In the only study focusing on BRT, Nelson et al. (2013) used shift-share analysis to measure the extent to which the number and sector-mix of jobs changed before (2004) and after (2007), when the Eugene-Springfield (Oregon) BRT system was launched. They used InfoGroup data for jobs by sectors for specific firms via address-matching. Nelson et al. found that while the metropolitan area lost jobs between 2004 and 2010, jobs grew within 0.25 mile (about 400 meters) of BRT stations, though not beyond. Notably, they found that of the combined shift of 710 jobs toward BRT station areas, only 12 were in the 0.25–0.50 distance band. Essentially, the entire overall shift in jobs favoring BRT station areas occurred within 0.25 mile. They also speculated that the BRT system may have a resiliency effect. Where the Eugene-Springfield metropolitan area lost jobs between 2004 and 2010, jobs were added within 0.25 mile of BRTs stations.

Focusing on just light rail transit (LRT) systems, Cervero et al. (2004) reviewed development outcomes around LRT stations in several metropolitan areas. They found that in the early 2000s almost all of Portland's LRT stations had seen some new office, retail, and multifamily development. They also found that strong market demand around Dallas Area Rapid Transit LRT stations contributed to the near-term success of that system. In San Diego, Higgins, Ferguson, and Kanaroglou (2014) observe that although the southern end of the Trolley leading to the Mexican border has impressive ridership, development along the line has not occurred likely because of its alignment within an industrial corridor served by freight rail. Otherwise, their review of the academic literature revealed sparse analysis of land use changes around LRT stations and virtually none around BRT stations as of the early 2010s.

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[2] Some literature uses the term "fixed-guideway" or "fixed-route" transit systems to differentiate them from conventional bus service. This article focuses only on the four transit systems noted above.

One impediment to development in transit corridors could be social stigmas. For example, Loukaitou-Sideris and Banerjee (2000) find that unattractive neighborhood characteristics such as low income, high unemployment, and crime, along with physical barriers to transit stations and deteriorating housing stock along Los Angeles' Blue Line created a "derelict and forbidding" (p. 10) climate for investors.

There is some evidence that policies incentivizing development near transit stations makes a difference. Fogarty and Austin (2011) note that new private investment around transit stations in the central areas of Minneapolis and Charlotte is attributable to local policies facilitating development in TODs (transit-oriented developments) combined with growing regional economics, suitable land, and good transit connections at the neighborhood level. But not all TODs have seen desired levels of development. In Denver, development along the Southeast Corridor transit line was hampered by its location within a highway median (Fogarty and Austin 2011).

In Phoenix, Valley Metro (2013) reported that nearly $7 billion in new development had been invested in TODs served by transit stations since 2004. Nonetheless, more development may have been hindered by real estate speculation shortly after station locations were announced (Kittrell 2012) combined by the Great Recession which impacted the metropolitan Phoenix area especially hard. Credit's (2018) later analysis of Phoenix used a pre-post design to measure the change in jobs around light rail stations based on 0.25-, 0.50-, and 1.00-mile (about 400-, 800, and 1,600-meter) buffers, finding increases in knowledge, retail, and service sector jobs.

More recent research has shown that jobs tend to concentrate near rail transit stations in Cleveland (Pasha et al. 2020).

On the other hand, some literature shows insignificant or ambiguous associations between job change and transit station proximity. In a review of four US metropolitan areas with new transit stations between 2000 and 2015, Tyndall (2021) found that rail station proximity reduced employment density. Moreover, in their study of Atlanta's heavy rail transit system, Bollinger and Ihlanfeldt (1997) found only small increases in employment around rail stations.

Lai, Zhou, and Xu's (2024) review of literature conclude that there is limited analysis of the link between employment change and transit stations, and that more studies are needed to close this gap. Indeed, there is no research into the association between job change and proximity to BRT stations, and no research assesses change comprehensively among large numbers of transit systems.

One thing emerges from a review of the literature, however: there is a dearth of research into BRT employment outcomes. This article aims to close the gap. The overarching research questions guiding research are:

> Is there an association between BRT station proximity and an increase in jobs?
>
> If so, does this association vary by groups of jobs in economic sectors?

Literature, Theory, and Research Questions Relating to Transit Station Proximity and Demographic Change and Gentrification

Chapple and Loukaitou-Sideris (2019:91) lament:

> The vast literature on neighborhood change pays little attention to the role of infrastructure, particularly transit, in reshaping areas—and who lives in them.

An early study addressed population and housing change for all transit systems in the United States during the 2000s—the Center for Transit Oriented Development (2014)—but it did not differentiate by type of system or distance from transit stations, nor did it provide details on the race/ethnicity of people, households by age and type and income, or housing based on tenure. With limited focus, Hurst and West (2014) found a significant increase in single-family and multifamily development around LRT stations in Minneapolis which increased population density in those areas. Another study of the LRT system in Dallas found similarly (Al Quhtani and Anjomani 2021).

In their work using the American Community Survey (ACS) for 2013 and 2014, Nelson and Hibberd (2023) provided a national summary of the change in such demographic features as race/ethnicity, household type and age, and tenure for transit systems but provided no data for specific systems. More detailed use of ACS data to measure demographic change over time was used by McKenzie (2015) to evaluate the demographic profiles of rail-accessible neighborhoods in the Washington, DC region. Special reverence to the age profile of people living in transit-oriented developments (TODs) is offered by Wood, Horner, Duncan, and Valdez-Torres (2016). A key finding was that people 65 years and older were a smaller share of the total population residing in TODs in both 2000 and 2010. Their conclusion was that if TODs are intended to help meet the accessibility needs of aging people, more research is needed to learn how to attract them to TODs.

The study and analytic method used by Landis (2016) helps frame the research questions addressed in this article:

> During the study period, did the concentration of population change and, if so, did the demographic composition of the population and households also change terms of household type, householder age, median household income, and housing tenure with respect to BRT station proximity?

The specific role of BRT station proximity in engendering gentrification is addressed next.

There is a large literature exploring the extent to which transit station proximity displaces existing residents and replaces them with higher income ones through a process called "gentrification".

What is "gentrification"? Marcuse (1985) characterized its features as including the arrival of younger, mostly White, highly educated professionals in highly paid jobs. These new households replace older, working-class, lower-income, and minority households in neighborhoods near downtown that are ripe for reinvestment (Bourne 1967). When near transit stations, gentrification can include changes to the socioeconomic composition of existing residents or other changes that shift the racial, ethnic socioeconomic, or housing characteristics of impacted neighborhoods (Delmelle 2017).

Delmelle (2021) presents the conundrum succinctly. An overall goal of transit is to improve mobility, especially of lower-income and minority communities. Doing so elevates the economic opportunities available to residents, such as access to higher-paying jobs (Andersson et al. 2018, Jin and Paulsen 2018). But this can increase the demand for housing near transit stations which raises housing prices. This results in higher income households displacing lower-income ones through a process called "transit-induced displacement and gentrification" (Delmelle and Nilsson 2020). The process is further stimulated when transit-oriented developments (TODs) intentionally create dense, mixed-use and walkable developments near transit stations (Calthorpe 1993). This can lead to the displacement of vulnerable residents (Rayle 2015). Rising housing prices may reduce the supply of housing that is affordable to them near transit stations, thus exacerbating social inequity (Newman and Wyly 2006) especially if transit investments are not proactive in assisting lower-income households to move toward transit opportunities.

However, empirical research is mixed when testing for the presence of gentrification near transit stations. Delmelle (2021) notes several studies found the racial and ethnic composition of neighborhoods remain unchanged after transit stations are introduced (Pollack et al. 2010; Barton and Gibbons 2017; Deka 2017; Nilsson and Delmelle 2018,)

Indeed, as Delmelle (2021) points out, many neighborhoods do not change at all after a transit station is built nearby. If they do change, it is mostly in line with existing trends. Moreover, even with an influx of new households, increasing housing supply need not lead to displacement of existing residents (Dong 2017; Baker and Lee 2019).

Delmelle (2021) concludes that "(t)he current state of the literature increasingly suggests that the impacts of transit on neighborhoods is either marginal or very difficult to quantify" (Delmelle 2021: 184). Qualitative research may be needed to uncover more subtle changes among neighborhoods near transit. Also, given that most studies have focused on system-wide outcomes, including this report, more research is needed at the micro scale of individual transit stations. More long-term research is also needed because neighborhood composition is often slow to change as households occupy their homes for decades, if not generations. Finally, because most studies in this genre did not use micro-scale control areas to measure treatment outcomes in areas near transit stations, this is an area in need of additional research.

Heeding the call in the latter two respects is Qi (2023) who used census block groups (CBG) near transit stations as the treatment regime and compared change over long periods of time with matching control CBGs based on the *MatchIt* algorithm.[3] Based on this research, Qi concludes (with emphases added):

> "… **rail is more likely to induce gentrification than Bus Rapid Transit (BRT)** and that (gentrification) is more evident over long term than over short term for rail-served

[3] See https://gking.harvard.edu/matchit.

> neighborhoods. These findings thus imply that the **BRT could help sustain the transit service to the most vulnerable**." (Qi 2023: 1)

Other research casts doubt on the whole notion that transit station proximity leads to gentrification per se. ACS and several other data sources were used by Baker and Lee (2019) to assess how light rail transit (LRT) impacts gentrification in 14 metropolitan areas, finding little association. A review of relevant studies that evaluate the association between transit station proximity and median household income is offered by Padeiro, Louro, and da Costa (2019). They conducted a review of gentrification outcomes associated with transit proximity among papers published between 2000 and 2018 concluding that gentrification is associated more with local dynamics than transit station proximity. Similarly, Dong's (2017) analysis of development near transit stations in Portland, Oregon, found that housing supply mattered most in either effecting or ameliorating gentrification outcomes based on demographic analysis.

Again, using Landis' (2016) framework, the relevant research questions in this context are:

> During the study period, was there evidence of gentrification with respect to BRT station proximity?

Literature, Theory, and Research Questions Relating to Transit Station Proximity and Change in Commuting Mode

There is scant research into the association between transit station proximity generally and specifically with respect to BRT station proximity addressing the change in commuting mode over time. This avenue of inquiry assesses the association between BRT station proximity and:

- Reduced dependency on commuting to work via the automobile.

Literature, theory, and hypotheses related to each are reviewed below.

Reduced Automobile Dependency

In theory, BRT station proximity should be associated with higher levels of walking, biking, and transit in their journey to work as compared to more distant locations (Renne, 2009; Kwoka, Boschmann, and Goetz 2015; Ewing, Tian, and Lyons 2018). Indeed, households will self-select by moving toward transit stations to gain access to transit, whether they are transportation disadvantaged or prefer that option over others (Lund 2006; Guerra, Li, and Reyes 2022). However, there is no systematic research on how commuting modes vary with respect to proximity to transit stations, including transit (Litman 2023b), walking and biking, or even working at home.

Given the foregoing, this research question is posed:

> Is proximity to BRT stations associated with increasing shares of walking, biking, transit use, and working at home, and if so, is there variation by type of transit system?

As simple as this question appears, there is no literature addressing the proposition.

The theory and literature on the influence of BRT station proximity and real estate rents is reviewed next.

Literature, Theory, and Research Questions Relating to Transit Station Proximity and Real Estate Rents

Real estate markets send important signals about the efficacy of public policy and planning. For instance, locating landfills near residential areas depresses nearby residential property value (Nelson, J. Genereux and M. Genereux 1992). Creating open spaces beyond urban growth boundaries creates amenity value that increases urban residential property value inside the boundary but also creates externality value that depresses farmland value outside of it (Nelson 1986). In the context of transit stations, there can be both positive and negative residential price effects depending on the extent to which transit station externalities are mitigated through planning and design (Nelson and McClesky 1990, Nelson 1992).

The literature begins with J. H. von Thünen (1826) who was the first to formalize the relationship between the center of cities and land value: as distance is reduced land values rise because land capitalizes both transportation cost savings and higher densities lead to more economic exchange. More than a century later, a trio of urban economists—Alonso (1964), Mills (1967) and Muth (1969)—adapted von Thünen's model to create modern urban location theory. By assuming that all jobs are in the central business district (CBD), the "AMM theory" shows that as transportation costs increase from the CBD, land values fall at a declining rate. In the CBD, where transportation costs are the lowest, land prices are thus the highest. Only those land uses that can outbid others secure land in the center, forcing losing bidders to locate farther away in a process known as urban land use invasion and succession (Park et al. 1925).

But urban areas are not "monocentric." As one relaxes the constraints of the AMM monocentric city model, it is possible to imagine the same principles at work only at smaller scales (Hajrasouliha and Hamidi 2017; Bogart 1998). For instance, rail transit stations are often located in or sometimes create small-scale versions of CBDs. Some land uses can realize transportation cost savings if they locate near transit stations and may be willing to pay more for proximity (in the form of rent) compared to other land uses. Numerous studies show negative bid-rent gradients with respect to distance from rail transit stations, meaning that as distance from transit stations increase real estate values fall, *ceteris paribus* (Al-Mosaind et al. 1993; Cervero 1984; Cervero and Duncan 2002; Debrezion et al. 2007; Hamidi et al. 2016; Mulley et al. 2016; Nelson and McClesky 1990; Nelson 1992; Nelson et al. 2015). In effect, station areas can become small scale downtowns. At the regional scale, major centers such as "Edge Cities" may emerge (Garreau 1991).

Refining the Standard Model to Include Externality Value

Theory often becomes messy when confronted with reality. In the case of the standard model of urban land rent, it may not always be the case that the revealed bid rent curve is downward sloping from the center. Instead, it can be upward sloping if the centers or nodes are sources of negative externalities. The concept of externalities as a necessary refinement to urban rent theory was first hypothesized by Richardson (1977) and expanded by Li and Brown (1980). Ten years later, Nelson and McClesky adapted these concepts to their analysis of single-family home values near heavy rail transit stations in Atlanta, Georgia (1990). Externalities can include environmental, physical, social, or other factors that reduce the attractiveness of being at or near the center (Nelson 1992). Their insights are reviewed here.

The urban land market capitalizes both "accessibility" value of rail station proximity as well as "externality" value associated with station noise, lights and glare, vehicle congestion during peak hours, and other nuisances. So long as accessibility value exceeds externality value, the urban land rent gradient will slope downward away from rail transit stations. However, it is possible for externality value to exceed accessibility value for reasons theorized by Richardson (1977), and Li and Brown (1980). Exhibit 1 shows potential relationships between transit stations considering both accessibility and externality value:

> The line R^a shows the land rent (R) curve with accessibility ("a") value from a rail transit station, u_0, outward to a point, u_1, where the accessibility effects of rail transit proximity are negligible, beyond which the overall market rent, unaffected by the presence of the rail transit station, R^m is revealed.
>
> Externality value of rail transit stations are shown in line R^n ("n" for negative externality). As distance from the rail station increases, the externality effects are reduced until they become zero at u^1.
>
> Accessibility and externality effects interact in the market leading to revealed positive or negative bid rent curves with respect to distance from rail transit stations to u_1. Line R^a + $R^n{}_1$ is revealed where overall accessibility effects outweigh externality effects. Line R^a + $R^n{}_2$ is revealed where overall externality effects outweigh amenity effects. Combined effects disappear at u_1 beyond which market rent, R^m ("m" for market) in the absence of accessibility and externality effects is revealed.

The literature addressing the combined effects of accessibility and externality values is inconclusive because it lacks systematic application of theoretical nuances we pose in this article. The theoretical framework presented in Figure 1 can be disaggregated into at least four component parts that are revealed in the market and illustrated in exhibit 2 including:

> *Downward-sloping* relationship where rents fall as distance from stations increases in a liner or curvilinear form without an inflection point. This is the standard von Thünen/Alosno expectation. It reveals itself when there are no externality effects internalized in the market. This is a desirable real estate market outcome.
>
> *Upward-sloping* relationship where rents rise as distance from stations increases in a linear or curvilinear form without an inflection point. This may occur when the station itself is an unattractive location in the real estate market as development wants to position itself away from stations. This is an undesirable real estate market outcome.

> *Concave* relationship where externality value exceeds accessibility value at or near transit stations. As station distance increases, externality value dissipates as accessibility value associated with station proximity increases. At an inflection point, accessibility value exceeds externality value. This is a signal that the market reflects externality value that might be overcome through better planning, station location, and station area design.
>
> *Convex* relationship where rent falls with respect to transit station distance to an inflection point after which it rises. The implication is that transit station accessibility value exceeds externality value but at a declining rate to a point beyond which accessibility value is not revealed in the market.

While these are highly generalized relationships, they help to describe transit station effects on real estate rent in the manner described in more detail later. Next is a review of research into the association between transit station proximity and real estate values, reporting mixed results.

Higgins and Kanaroglou offer the most complete review of studies into this relationship (2016 (see also Berawi et al. 2020; Zhang and Yen 2020). Nearly all studies focus on a particular metropolitan market, usually applied to a single mode, and frequently involving only a few to a few hundred cases. The vast majority of studies address associations between single-family home sales prices and proximity to transit stations even though transit stations are usually located in high intensity commercial and multifamily nodes. Thus, it is difficult to imagine credible transit station area policies and planning relying on just single-family home sales prices, yet this seems to be the case. Very few studies assess the association between transit station proximity and office, retail, or multifamily values and those that do typically use a 0.25-mile (about 400 meters) to 0.50-mile (about 800 meters) buffer around transit stations, assessing outcomes of properties within those circles compared to those outside.

The summary critique is that there is no coherent, systematic analysis of the relationship between BRT station proximity and office, retail, and multifamily values. Research reported below closes this gap by addressing the following research question:

> Is there an association between commercial real estate rent (per square meter) and proximity to BRT stations holding other factors constant?

This is followed by a nuanced question:

> If there is an association, is there evidence of negative externality or amenity effects with respect to BRT station proximity?

The analytic framework guiding this article is presented next.

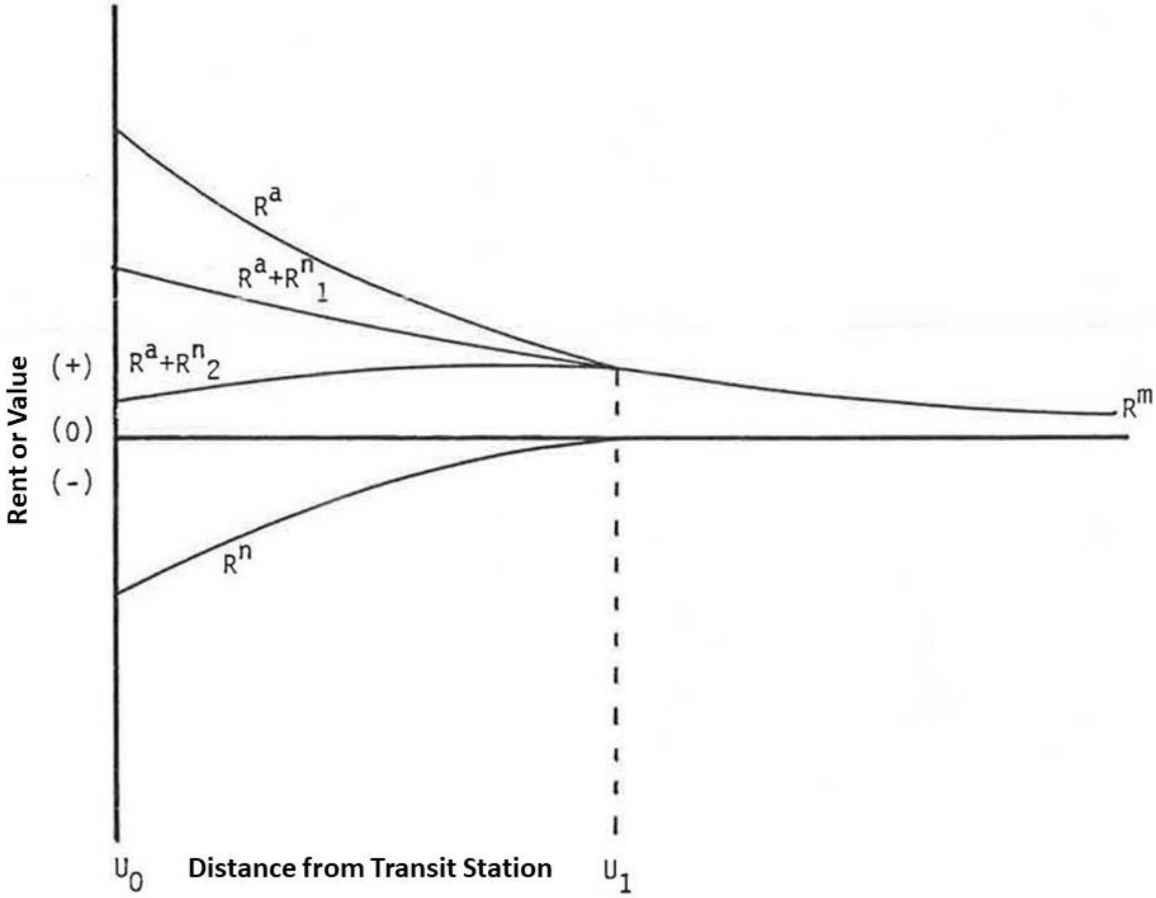

Exhibit 1
Amenity (R^a) and Externality (R^n) influences of transit stations/stops on proximate urban land rent (see text)
Source: Nelson and McClesky (1990).

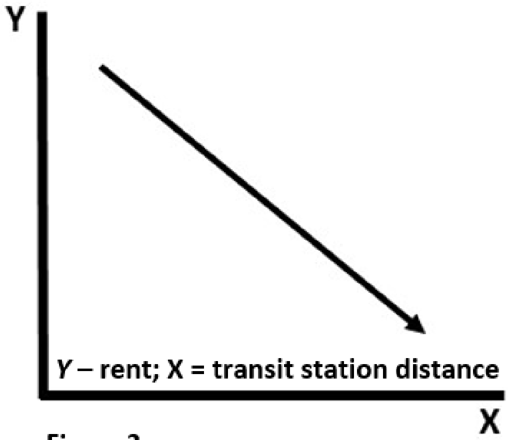

Figure 2a
Downward-sloping relationship where rents fall as distance from stations increases.

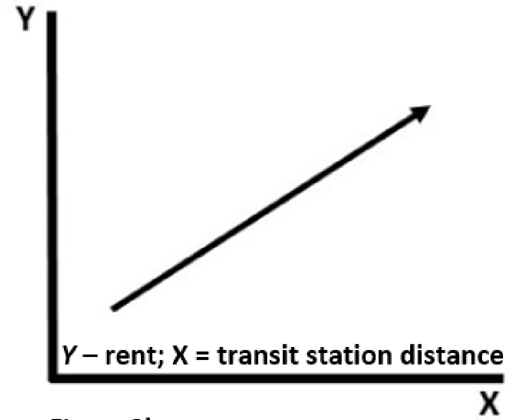

Figure 2b
Upward-sloping relationship where rents rise as distance from stations increases.

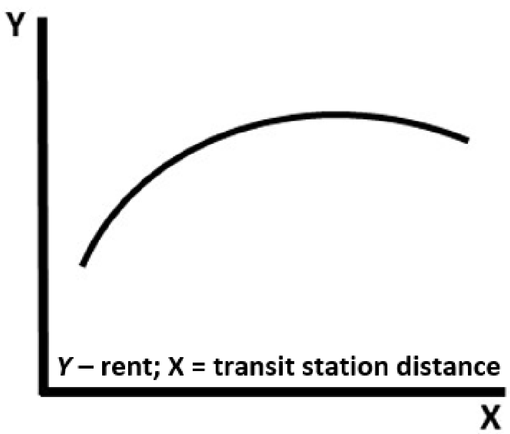

Figure 2c
Concave relationship where rents rise to an inflection point and then fall.

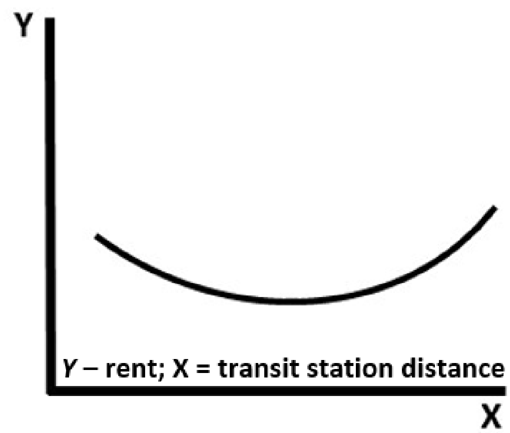

Figure 2d
Convex relationship where rents fall to an inflection point and then rise

Exhibit 2
Four alternative urban rent gradients with respect to transit station proximity
Source: Arthur C. Nelson

ANALYTIC FRAMEWORK

This article assesses how the distribution of jobs, demographic change, household income, housing tenure, and commute mode were influenced by BRT station proximity between 2010 and 2019. This study period is thus between two of the most disruptive events in recent American history. The "Great Recession," which extended from December 2007 through June 2009, was the nation's most severe economic downturn since the Great Depression.[4] This was followed by the COVID-19 global pandemic, , the most severe since the "Spanish Flu" a century ago (Aassve et al. 2021). These twin economic disruptions changed financial markets on the one hand[5] and accelerated work-from-home trends on the other (Peiser and Hugel 2022). While the pandemic reduced transit ridership considerably as people worked from home to avoid crowds, ridership is now recovering with many systems at or near pre-pandemic levels.[6] Indeed, the share of those working from home is also falling[7] although it seems unlikely that it will reach pre-pandemic levels for reasons noted in Peiser and Hugel (2022). Besides, the use of transit for commuting to work has been exaggerated, as non-work ridership is leading much of the transit recovery.[8]

The article also assesses the relationship between transit station proximity and real estate values in 2019, the year before the pandemic.

In all, 15 BRT systems were studied (see exhibits 3 and 4). Eight became operational before 2010 ("pre-2010" BRT systems), the first year of the study period, while seven became operational between 2010 and 2019 ("2010-2019" BRT systems). The study does not include those systems operating in the complex and mature "Megalopolis"[9] (Gottmann 1964) extending from Boston to Washington, DC, or the very large metropolitan areas of Chicago, Los Angles, and San Franciso-Oakland that have complex transit networks that make it difficult to tease out differences between station areas served by overlapping systems. In addition, the selected systems included sufficient rent data allowing for regression analysis described later. The research includes the largest number of BRT systems operating in the largest number of metropolitan areas that have been researched to date.

Exhibit 5 highlights key BRT design and performance features.

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[4] For a review of causes and consequences, see https://www.federalreservehistory.org/essays/great-ecession-of-200709.
[5] For discussion on the longer term effects of the Great Recession on financial markets, see https://www.federalreservehistory.org/essays/great-recession-and-its-aftermath.
[6] Several perspective on COVI-19's effects on transit and recover are offered in https://www.brookings.edu/articles/ensuring-the-intertwined-post-pandemic-recoveries-of-downtowns-and-transit-systems/.
[7] For changing office market trends since COVID-19, see https://www.forbes.com/sites/davidmorel/2023/11/06/future-of-work-is-a-return-to-the-office-inevitable/?sh=6991f7f514fb.
[8] See note 3.
[9] In 2022, Megalopolis was home to about 50 million people occupying an area of land comparable to Iowa, about 56,000 square miles, which in 2022 was home to about 3 million people.

The comparative study areas are called “BRT counties” which are all the counties in a metropolitan area served by the BRT system being studied. Also, BRT systems are labeled after the principal city of the central county in which they are located.

Exhibit 3
Bus Rapid Transit Systems Studied with Metropolitan Abbreviations

Bus Rapid Transit—BRT	Year	Pre-2010	2010-2019
ABQ Albuquerque*	2017		X
AA Arlington/Alexandria	2014		X
CLE Cleveland	2008	X	
ESP Eugene-Springfield	2007	X	
KC Kansas City	2005		
MSP Minneapolis-St. Paul	2016		X
NSH Nashville	2009	X	
PIT Pittsburgh	1977	X	
RNO Reno	2010		X
SLC Salt Lake City	2008	X	
SA San Antonio	2012		X
SD San Diego	2014		X
SJ San Jose	2005	X	
SEA Seattle	2010		X
STK Stockton	2007	X	

*The Albuquerque BRT system started in 2017 but was suspended and restarted in 2019 because of rolling stock issues.
Source: Authors

Exhibit 4
Bus Rapid Transit Systems Studied

Source: Authors

Exhibit 5
Key Features of Bus Rapid Transit Systems

Bus Rapid Transit (BRT)	
Right-of-way	Shared or dedicated lanes
Rolling Stock	Standard and articulated
Station Spacing	1 kilometer or more
Hourly Capacity	6,000-9,000
Typical Seats	75 per bus
Typical Length	2-30 kilometers
Typical Max. Speed	100 kph

Sources: Image from National Institute of Transportation and Communities, Transportation Research and Education Center, Portland State University; BRT features are composites of parameters assembled by the authors.

The individual BRT station study areas are comprised of census blocks (CBs) and census block groups (CBGs), depending on the data used for analysis.

There is a practical consideration for focusing on BRT systems: they are far less expensive to build than rail systems. For instance, one of the authors worked with the Brookings Institution at the University of Nevada, Las Vegas (UNLV) advocating for a light rail system connecting the airport through the UNLV campus to downtown and then to the new medical center. During the study period, the LRT system roughly doubled in price to one billion dollars while the BRT option increased about a quarter and was about a third the cost of LRT. In the end, neither option was selected.

Data for jobs is provided annually by the Longitudinal Employment-Household Dynamics (LEHD) database.[10] These data are reported at the CB level. Demographic, housing, and commuting data are provided through the 5-year samples of the American Community Survey (ACS)[11] at the CBG level.[12] The 5-year samples used are for the periods of 2010-2014 and 2015-2019. Where 2014 or 2019 is just used in the ACS context, it means the respective sampling years.

Based on prior research, the BRT study area is 800 meters (about 0.50-mile) from BRT stations (Guerra, Cervero and Tischler 2012). There are three BRT station bands. Because block groups are comprised of about four to ten census blocks, their spatial extent covers up to the first two city blocks from the station. Although there is no standard size for a city block, a common width is about 300 to 360 feet[13] or roughly 100 meters. The first station band thus extends 100 meters from station centroids. The next two bands extend inclusively 400 (about 0.25-miles) and 800 meters (about 0.50-mile) from BRT stations, respectively. The total area within 800 meters of BRT stations is called the "station area." Any portion of a CB or CBG falling within the closest station band is assigned to it. BRT station area bands comprise very small shares of their BRT counties, being less than one tenth of one percent for the station band, three tenths of one percent for the 400-meter band inclusively, and less than one percent for the entire 800-meter BRT station area.

In addition, proprietary rent data provided from CoStar is used to estimate the market rent premium for BRT station proximity for office, retail, and multifamily rental property for the year 2019, the year before the COVID-19 pandemic. With few exceptions noted below, these data are continuous.

It is acknowledged that this research is not a counterfactual analysis in that one cannot know what would have happened in the absence of BRT station intervention. BRT stations are usually placed in existing, built-up urban and suburban areas. Moreover, BRT stations are not randomly selected but are instead an outcome of a decision-making process that chooses them from among

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[10] https://lehd.ces.census.gov/. For an orientation, see https://lehd.ces.census.gov/.
[11] For a review, see https://www.census.gov/data/developers/data-sets/acs-5year.html.
[12] Census block groups are comprised roughly of four to ten census blocks with considerable variation at the lower and higher end. For a description, see https://www2.census.gov/geo/pdfs/reference/GARM/Ch11GARM.pdf.
[13] See https://www.vintageisthenewold.com/game-pedia/what-is-the-average-size-of-a-city-block.

many options. There is thus a selection bias. Nonetheless, the aim of this analysis is to assess whether there is an association between BRT station areas and outcomes.

As noted earlier, the analysis is based on the period after the Great Recession of 2007–09 and before the COVID-19 pandemic of 2020–23. The study thus avoids analytic complications associated with these disruptive economic and social events. As such, the work may be viewed as the benchmark period that provides context for analysis addressing pandemic and post pandemic outcomes. The nature of market responses to transit station proximity during this period can be used to frame guidance for transit station and land use planning during the post pandemic period.

Except for the regression analyses, descriptive analysis is used where changes are measured numerically and converted into percentages and ratios as the context warrants. All differences in change over the time periods are significant to at least $p < 0.10$ of the two-tailed t-test. Descriptive statistical tests and outcomes are thus not reported for brevity. Significance tests and other performance metrics are reported and interpreted for regression analyses, however.

The next section assesses BRT station area outcomes with respect to jobs.

BRT Transit Station Proximity and Change in Jobs by Economic Group

This section presents results from a national analysis of the extent to which BRT station proximity influences employment near those stations generally and for broad economic groups. It starts with the research design, data, and analytic method, and is followed by results and interpretations along with implications for post pandemic transit policy and planning. To summarize key points made earlier, there is scant research into the association between change in jobs and transit station proximity. The research questions guiding research presented here are:

> Is there an association between BRT station proximity and an increase in jobs?
>
> If so, does this association vary by economic group?

The null hypotheses relating to both questions assert no difference in the concentration of jobs with respect to BRT station proximity during the study period.

Research Design, Data, and Analytic Method

Exhibit 3 shows when BRT systems were launched. When matched with the study period, 2010-2019, these systems fall into two groups for analysis purposes. The first is comprised of BRT systems that were operating before 2010 and the second are those systems that were opened in or after 2010. Outcomes for both groups individually and overall can be evaluated descriptively. Research uses secondary, quantitative data, in an exploratory manner. The data and analytic methods used are reviewed below.

The data come from the LEHD for the years 2010 and 2019. Although data are available at the census block level, they are assembled to the block group level for comparability with ACS 5-year sample data (see above). LEHD data are assembled into economic groups comprised of economic sectors shown in Exhibit 6. These groups were selected because they align with common, large-scale land use categories for planning purposes. As such, they do not include natural resources sectors such as agriculture, forestry, fishing, and mining, or construction, because its employment is transient.

The analytic method uses the location quotient approach to measure the relative change in concentration over time between the base year, 2010, and the end year, 2019. This is called a ***station quotient*** (SQ) because the analysis focuses on change in concentrations over time with respect to BRT station band or the BRT station area. Change in concentration over time is compared to "BRT counties" which are all the counties served by the specific BRT system being studied. Of particular interest is determining whether, over time, the concentration of jobs relative to the BRT counties increase (SQ > 1.0), decrease (SQ < 1.0), or stay about the same (SQ = 1.0).

Results are reported cumulatively for each distance band, meaning the 800-meter band includes data for the station band and the 400-meter band plus the increment to 800 meters. Exhibit 7 reports results for all BRT systems as well as each BRT system for all eight employment groups noted in Exhibit 6. Although statistical tests of significance are not reported in the following exhibits, all differences are significant to at least the 0.10 level of the two-tailed t-test. One reason for this is that the data themselves are not samples but rather actual counts based on data reported by firms.[14]

Results and interpretations are offered next.

Exhibit 6
Assignment of Economic Sectors into Economic Groups for Analysis

NAICS	Economic Sector and Combination into Economic Groups
	Industrial
22	Utilities
	Manufacturing
42	Wholesale Trade
t	Transportation and Warehousing
	Retail, Food, Lodging
44-45	Retail Trade
72	Accommodation and Food Services
	Office
51	Information
52	Finance and Insurance
53	Real Estate and Rental and Leasing
54	Professional, Scientific, and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
81	Other Services (except Public Administration)
92	Public Administration
	Education
61	Educational Services
	Health
62	Health Care and Social Assistance
	Entertainment
71	Arts, Entertainment, and Recreation

Source: North American Industrial Classification System (NAICS).

[14] See https://lehd.ces.census.gov/data/.

Results and Interpretations

Exhibit 7 reports descriptive results of job change by economic groups during the study period for all BRT systems combined, all BRT systems launched before 2010 and all those launched 2010-2019, as well as individual BRT systems for each group in order of year launched. Results are reported in three ways:

- Total numerical BRT county change in jobs overall and for each economic group as well as change in jobs for each of the three station bands;

- Percent share of BRT county change occurring in each of the station bands cumulatively; and

- Station quotients (SQs) for each station band where coefficients SQ <1.0 mean the station band lost share or concentration of jobs compared to the BRT county during the study period while coefficients SQ >1.0 mean the station band gained share or concentration of jobs compared to the BRT county and where SQ = 1.00 means there was no change.

Readers are encouraged to study results for individual BRT systems of interest to them. What follows are highlights of outcomes followed by an overall assessment.

Job Highlights Overall

Overall, BRT station areas accounted for more than 420,000 new jobs or 24 percent of the job growth in BRT counties. This is an impressive outcome considering that BRT station areas comprise less than one percent of their transit regions. On the other hand, with SQs <1/.0, nearly all BRT station bands *lost share* of jobs compared to BRT counties.

BRT station areas for systems launched before 2010 added about 170,000 jobs during the study period or 22 percent of the total change in jobs for respective BRT counties. These systems also lost share of BRT county job change at a faster pace than the pool of all BRT systems. For the most part, individual BRT systems launched before 2010 have similar outcomes but with two exceptions. The first is San Jose in the Silicon Valley where BRT station areas gained share of jobs relative to the BRT county. Indeed, its BRT station area accounted for 31 percent of the growth in jobs compared to the county. At the other end of spectrum is Cleveland where the number of jobs fell across all station bands and the station area. This is surprising considering the accounts of large investments and job growth in the first few years after its opening in 2008.[15]

BRT systems launched 2010-2019 have similar outcomes. In addition to accounting for about 250,000 or 26 percent of the new jobs in BRT counties, the SQs were <1.0 for all station areas. The only SQ of note is for San Diego's first station band, which was 1.07.

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[15] See https://nbrti.org/wp-content/uploads/2017/05/Cleveland.pdf.

Industrial Economic Group Highlights

Inasmuch as industrial activities are usually land-extensive, one would not expect BRT stations to attract many of those jobs, yet they do. Pre-2010 BRT system added about 40,000 jobs within the 800-meter in station areas while 2010-2019 BRT systems added about 30,000 jobs. They accounted for 19 percent and 25 percent of the change in BRT county jobs, respectively.

Two pre-2010 systems are notable. The San Jose BRT system gained large shares of industrial jobs in the second and third station bands, but this may be expected given the prevalence of high-tech firms in the BRT county. The Salt Lake City BRT system has an SQ >1.0 in the first two station bands and its SQ = 1.0 overall. This is an area that added considerable amounts of warehousing and public utilities spaces during the study period.

There are two notable 2010-2019 BRT systems. One is San Diego which has SQs > 1.0 across the entire station area. The BRT station area accounts for 37 percent of the industrial economic group job growth during the study period. The most intriguing BRT system, however, is Arlington-Alexandria where BRT station areas attracted more than 8,000 jobs, which was more than the nearly 4,400 industrial jobs added to the BRT county during the study period. The reason is Amazon, which began adding jobs that are classified technically as industrial because it is principally a warehousing and shipping firm, even though most Amazon's workers occupy offices along the BRT transit corridor.

Office Economic Group Highlights

Offices accounted for the largest share of the job growth at more than half of pre-2010 and nearly 40 percent among the 2010-2019 BRT systems during the study period, which preceded the COVID-19 pandemic. Future research is needed to assess the effect of the pandemic on jobs in BRT station areas. Among just office jobs, pre-2010 BRT station areas accounted for 28 percent of the growth among those jobs in their BRT counties while for 2010-2019 BRT systems the share was 33 percent.

However, with only two exceptions, the share of BRT county office jobs locating within pre-2010 BRT station areas fell during the study period. The exceptions were San Jose, which may be attributable to high-tech jobs locating near BRT stations in the study period, and Cleveland where the SQ for new office jobs at the station band was 1.08.

Among the 2010-2019 BRT systems, San Diego performed best overall with SQs of 1.20 at the station band and 1.07 for the station area. San Antonio had an SQ of 1.13 at the station band while Seattle had a station band SQ of 1.04. Otherwise, the 2010-2019 BRT systems did not perform as well as their counties. The extent to which BRT stations have been resilient in retaining office jobs through the pandemic is worthy of future research (see Nelson, Stoker, Hibberd 2019).

Education Economic Group Highlights

Educational facilities often require large areas of land for buildings, open spaces, parking, and so forth. They also usually need to be close to where students live. These two considerations suggest that jobs in the educational economic group may be expected to decline in station areas, which they did, for both BRT groups.

Among the pre-2010 BRT systems, only San Jose and Salt Lake City added educational jobs. But these are nuanced. San Jose's BRT station areas accounted for 53 percent of the total change in such jobs in the BRT county, but they may be linked to university research and development jobs associated with Stanford University among others. San Jose's SQs for all station bands were >1.0. Salt Lake City's BRT station areas accounted for 8 percent of the BRT county change, and these appear to be a mix of residential serving and higher education facilities. All station band SQs were also >1.0. In all other cases, educational jobs declined.

BRT systems launched 2010-2019 performed about the same as those launched before 2010 with two exceptions. The Seattle BRT system accounted for 72 percent of the entire change in education jobs in the BRT county and its SQs were > 1.0 in all three station bands. Although the Minneapolis-St. Paul BRT system lost jobs in the station band, it gained jobs in the rest of the station area with the SQ > 1.0.

Health Economic Group Highlights

Overall, at a 30 percent share of BRT county gains, gains in health jobs were more robust among the 2010-2019 BRT systems than in pre-2010 BRT systems which accounted for 14 percent of their BRT counties' growth.

Among the pre-2010 BRT systems, Cleveland and Salt Lake City were alone in not adding health jobs. The remaining BRT systems, however, did not perform as well as the 2010-2019 BRT systems. Indeed, among those systems, only San Antonio and Albuquerque had SQs <1.0 in any of the station bands. Otherwise, all 2010-2019 BRT systems increased their concentration of health jobs compared to their BRT counties. Indeed, in the station band, the SQ for Arlington-Alexandria was 5.20, for San Diego it was 1.14, and for Seattle is was 1.05.

Retail-Food-Lodging Economic Group Highlights

Both the pre-2010 and 2010-2019 BRT systems performed about the same with respect to jobs in the rail-food-lodging economic group. The pre-2010 systems accounted for 26 percent of BRT county change while the 2010-2019 BRT systems accounted for 29 percent of the change. Both had comparable numbers of BRT systems with SQs > 1.0 in one or more station bands, and five and four respectively.

Arts-Entertainment-Leasure Economic Group Highlights

Although they accounted for the smallest change in jobs during the study period, jobs in the arts-entertainment-leisure economic groups gravitated toward BRT station areas more so than any other economic group. The share for pre-2010 BRT systems was 50 percent of the growth of BRT counties while the share for 2010-2019 systems was 80 percent.

Except for Eugene-Springfield and Stockton, all pre-2010 BRT systems gained share of arts-entertainment-leisure jobs in at least one station band with Kansas City and Cleveland gaining shares compared to their BRT counties across all station bands. However, the 2010-2019 BRT systems were more robust in having all systems gain share compared to BRT counties in at least one station band with San Diego, Minneapolis-St, Paul and Albuquerque gaining large shares across station bands.

Overall Assessment

There are important differences in the economies of the 15 BRT systems studied. Half of the pre-2010 BRT systems are growing slowly (Pittsburgh, Kansas City, Eugene-Springfield, Cleveland) while the others are growing at about the national grow rate. In contrast, all the BRT systems in the 2010-2019 group are growing with most growing faster than the national growth rate (Reno, Seattle, San Antonio, and San Diego). To some extent, results should be assessed for each system individually, which is encouraged among readers. Nonetheless, with few exceptions among the systems and economic groups, BRT station proximity is associated with growth though often at a pace less than respective BRT counties.

The association between BRT station proximity and change in demographic outcomes is presented next.

Exhibit 7. Bus Rapid Transit Station Area Job Change and Station Quotients by System

[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT Systems	Before 2010	PIT 1977	KC 2005	SJ 2005	ESP 2007	STK 2007	CLE 2008	SLC 2008	NSH 2009	In/After 2010	RNO 2010	SEA 2010	SA 2012	AA 2014	SD 2014	MSP 2016	ABQ 2017
Total Jobs	1,747,466	774,999	36,474	35,542	262,870	74,228	49,624	48,014	159,898	108,349	972,467	37,732	319,263	177,696	21,861	220,424	159,858	35,633
Station	225,925	28,470	(2,724)	6,691	19,143	1,074	1,805	(14,922)	9,734	7,669	197,455	3,330	97,244	31,791	3,037	80,146	(2,398)	(15,695)
400m	353,724	135,950	8,069	4,337	72,959	2,871	2,596	(17,741)	7,512	55,347	217,774	4,287	124,304	34,836	9,115	59,400	(1,087)	(13,081)
800m	420,083	168,271	10,317	7,895	80,913	4,390	5,066	(19,568)	19,529	59,729	251,812	1,513	135,362	42,593	(4,471)	70,437	1,666	4,712
Station Share	13%	4%	NA	19%	7%	1%	4%	NA	6%	7%	20%	9%	30%	18%	14%	36%	NA	NA
To 400m Share	20%	18%	22%	12%	28%	4%	5%	NA	5%	51%	22%	11%	39%	20%	42%	27%	NA	NA
To 800m Share	24%	22%	28%	22%	31%	6%	10%	NA	12%	55%	26%	4%	42%	24%	-20%	32%	1%	13%
Station SQ	0.94	0.86	0.94	0.96	0.92	0.55	0.83	0.82	0.98	0.84	1.00	0.92	1.01	0.98	1.01	1.07	0.79	0.75
400m SQ	0.94	0.92	0.97	0.94	1.05	0.56	0.83	0.83	0.90	1.00	0.96	0.90	0.97	0.94	1.10	0.97	0.86	0.81
800m SQ	0.95	0.92	0.97	0.95	1.04	0.57	0.85	0.83	0.91	1.00	0.96	0.85	0.96	0.95	0.86	0.99	0.90	0.93
Industrial	199,125	83,918	(2,480)	2,440	14,619	8,029	19,964	3,211	23,350	14,785	115,207	9,666	45,587	14,687	4,387	32,255	8,434	191
Station	19,648	(930)	513	(3,356)	(792)	480	611	(3,470)	3,372	1,712	20,578	256	12,380	(2,326)	84	10,816	(359)	(273)
400m	31,503	3,662	(4,637)	(3,225)	4,255	508	1,976	(3,206)	2,990	5,001	27,841	479	12,400	(2,065)	9,124	11,230	(2,625)	(702)
800m	38,548	9,472	(5,736)	(3,324)	3,122	1,028	2,196	(3,432)	9,247	6,371	29,076	471	15,139	(3,017)	8,057	12,042	(2,966)	(650)
Station Share	10%	NA	NA	NA	NA	6%	3%	NA	14%	12%	18%	3%	27%	NA	2%	34%	NA	NA
To 400m Share	16%	4%	NA	NA	29%	6%	10%	NA	13%	34%	24%	5%	27%	NA	208%	35%	NA	NA
To 800m Share	19%	11%	NA	NA	21%	13%	11%	NA	40%	43%	25%	5%	33%	NA	184%	37%	NA	NA
Station SQ	0.96	0.89	1.05	0.64	0.82	0.81	0.72	0.50	1.04	0.88	1.00	0.91	1.00	0.67	0.86	1.02	0.74	0.95
400m SQ	0.96	0.91	0.93	0.71	1.08	0.79	0.77	0.72	1.01	0.95	1.01	0.95	0.97	0.73	4.02	1.01	0.62	0.90
800m SQ	0.96	0.93	0.92	0.73	1.03	0.87	0.77	0.73	1.00	0.97	0.99	0.93	0.97	0.70	2.55	1.02	0.73	0.92
Office	607,355	313,106	22,779	9,229	129,104	22,146	547	29,251	59,850	40,200	294,249	9,527	100,741	65,048	9,383	41,648	52,579	15,323
Station	135,150	22,432	2,935	2,085	9,577	(427)	(789)	8,975	1,479	(1,403)	112,718	1,671	45,708	24,755	1,467	45,408	(2,026)	(4,265)
400m	160,689	72,623	9,436	200	39,853	(751)	(1,729)	3,529	211	21,874	88,066	2,551	44,627	18,487	(1,276)	32,019	(4,019)	(4,323)
800m	183,491	86,567	10,844	3,266	42,767	(405)	(1,828)	2,098	5,425	24,400	96,924	1,815	46,807	22,895	(14,727)	33,743	(3,650)	10,041
Station Share	22%	7%	13%	23%	7%	NA	NA	31%	2%	NA	38%	18%	45%	38%	16%	109%	NA	NA
To 400m Share	26%	23%	41%	2%	31%	NA	NA	12%	0%	54%	30%	27%	44%	28%	NA	77%	NA	NA
To 800m Share	30%	28%	48%	35%	33%	NA	NA	7%	9%	61%	33%	19%	46%	35%	NA	81%	NA	66%
Station SQ	0.98	0.86	0.93	0.96	0.93	0.41	0.95	1.08	0.87	0.79	1.08	0.97	1.04	1.13	1.01	1.20	0.61	0.76
400m SQ	0.95	0.92	0.97	0.94	1.07	0.41	0.91	0.93	0.78	0.97	0.98	0.98	0.95	0.96	0.90	1.07	0.70	0.78
800m SQ	0.96	0.92	0.97	0.97	1.06	0.42	0.92	0.91	0.89	0.97	0.98	0.91	0.95	0.99	0.68	1.07	0.76	1.06

Exhibit 7. Bus Rapid Transit Station Area Job Change and Station Quotients by System—continued
[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT Systems	Before	PIT	KC	SJ	ESP	STK	CLE	SLC	NSH	In/After	RNO	SEA	SA	AA	SD	MSP	ABQ
		2010	1977	2005	2005	2007	2007	2008	2008	2009	2010	2010	2010	2012	2014	2014	2016	2017
Education	59,238	28,050	(5,672)	(4,110)	10,799	5,932	1,243	(4,476)	20,424	3,910	31,188	350	15,033	(58)	3,766	482	14,244	(2,629)
Station	(32,809)	(9,846)	(8,195)	(1,417)	3,993	(166)	(995)	(3,783)	1,215	(498)	(22,963)	77	2,471	(5,404)	80	(5,475)	(414)	(14,298)
400m	(29,378)	(6,986)	(4,954)	(1,396)	4,161	(154)	(1,418)	(3,618)	1,110	(717)	(22,392)	(141)	9,814	(3,662)	41	(17,013)	1,885	(13,316)
800m	(26,007)	(5,727)	(5,668)	(1,252)	5,684	(543)	(1,213)	(3,640)	1,681	(776)	(20,280)	(4,262)	10,799	(1,405)	131	(15,332)	1,889	(12,100)
Station Share	NA	NA	NA	NA	37%	NA	NA	NA	6%	NA	NA	NA	16%	NA	2%	NA	NA	544%
To 400m Share	NA	NA	NA	NA	39%	NA	NA	NA	5%	NA	NA	NA	65%	NA	1%	NA	13%	507%
To 800m Share	NA	NA	NA	NA	53%	NA	NA	NA	8%	NA	NA	NA	72%	NA	3%	NA	13%	460%
Station SQ	0.77	0.83	0.84	0.98	1.02	0.47	0.79	0.85	1.23	0.69	0.72	1.22	1.00	0.64	0.86	0.86	0.79	0.33
400m SQ	0.83	0.87	0.97	1.00	1.01	0.56	0.79	0.86	1.02	0.86	0.80	0.76	1.14	0.80	0.80	0.71	1.03	0.53
800m SQ	0.86	0.89	0.97	1.02	1.04	0.58	0.83	0.87	1.02	0.86	0.83	0.69	1.13	0.95	0.87	0.74	1.01	0.60
Health	357,635	139,435	11,395	11,187	53,767	17,382	11,898	2,099	15,143	16,564	218,200	4,722	47,817	34,827	1,157	64,689	50,956	14,032
Station	26,702	(12,513)	2,787	6,391	422	251	2,687	(20,421)	318	(4,948)	39,215	737	10,175	10,771	704	13,809	375	2,644
400m	68,549	14,464	2,467	6,075	13,625	1,279	3,930	(20,605)	220	7,473	54,085	1,436	18,523	13,270	121	13,407	3,783	3,545
800m	84,230	19,523	5,950	5,747	16,635	1,428	5,527	(20,352)	(3,631)	8,219	64,707	2,732	21,998	13,624	200	15,181	4,553	6,419
Station Share	7%	NA	24%	57%	1%	1%	23%	NA	2%	NA	18%	16%	21%	31%	61%	21%	1%	19%
To 400m Share	19%	10%	22%	54%	25%	7%	33%	NA	1%	45%	25%	30%	39%	38%	10%	21%	7%	25%
To 800m Share	24%	14%	52%	51%	31%	8%	46%	NA	NA	50%	30%	58%	46%	39%	17%	23%	9%	46%
Station SQ	0.85	0.75	0.97	1.12	0.63	0.39	0.95	0.55	0.99	0.59	1.03	1.02	1.05	0.97	5.20	1.14	0.87	0.94
400m SQ	0.91	0.86	0.95	1.09	0.94	0.42	0.98	0.59	0.89	1.07	0.97	0.98	1.00	0.96	1.01	0.97	1.09	0.89
800m SQ	0.91	0.86	0.98	1.02	0.97	0.43	0.97	0.61	0.43	1.08	0.97	1.01	0.98	0.95	1.02	0.98	1.06	0.96
RFL	294,926	116,769	1,002	11,496	30,445	14,339	8,620	7,948	23,478	19,441	178,157	3,192	58,787	49,273	2,765	49,749	7,693	6,698
Station	41,456	15,877	(2,386)	2,251	3,705	820	(131)	1,077	1,853	8,688	25,579	(237)	17,558	2,930	612	4,882	113	(279)
400m	74,357	28,953	582	2,544	6,297	1,445	(820)	2,936	2,068	13,901	45,404	(1,109)	27,319	8,093	968	8,885	231	1,017
800m	81,578	30,474	(340)	2,931	7,403	2,047	(385)	2,227	3,336	13,255	51,104	(601)	25,436	9,948	1,292	13,763	940	326
Station Share	14%	14%	NA	20%	12%	6%	NA	14%	8%	45%	14%	NA	30%	6%	22%	10%	1%	NA
To 400m Share	25%	25%	58%	22%	21%	10%	NA	37%	9%	72%	25%	NA	46%	16%	35%	18%	3%	15%
To 800m Share	28%	26%	NA	25%	24%	14%	NA	28%	14%	68%	29%	NA	43%	20%	47%	28%	12%	5%
Station SQ	0.96	0.95	0.95	0.97	1.02	0.72	0.80	1.07	1.02	1.07	0.97	0.93	1.02	0.87	1.00	0.94	0.97	0.90
400m SQ	0.99	0.98	1.00	0.96	0.98	0.70	0.76	1.23	0.99	1.12	1.00	0.90	1.02	0.97	1.01	0.97	0.98	0.94
800m SQ	0.98	0.97	0.99	0.97	0.98	0.72	0.79	1.12	1.01	1.06	0.99	0.92	0.97	0.98	1.02	1.02	1.02	0.92

Exhibit 7. Bus Rapid Transit Station Area Job Change and Station Quotients by System—continued
[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT Systems	Before 2010	PIT 1977	KC 2005	SJ 2005	ESP 2007	STK 2007	CLE 2008	SLC 2008	NSH 2009	In/After 2010	RNO 2010	SEA 2010	SA 2012	AA 2014	SD 2014	MSP 2016	ABQ 2017
AER	49,751	24,622	3,359	1,043	4,290	1,447	523	5,272	3,373	5,315	25,129	887	8,268	4,636	1,476	947	8,600	315
Station	15,247	7,233	810	458	1,341	(318)	71	3,024	223	1,624	8,014	264	3,243	1,066	107	2,172	279	883
400m	18,087	11,516	2,497	330	1,519	14	88	3,069	222	3,777	6,571	148	2,788	724	196	1,809	379	527
800m	20,491	12,323	2,681	360	1,618	111	65	3,160	437	3,891	8,168	321	3,490	737	609	1,988	620	403
Station Share	31%	29%	24%	44%	31%	NA	14%	57%	7%	31%	32%	30%	39%	23%	7%	229%	3%	280%
To 400m Share	36%	47%	74%	32%	35%	1%	17%	58%	7%	71%	26%	17%	34%	16%	13%	191%	4%	167%
To 800m Share	41%	50%	80%	35%	38%	8%	12%	60%	13%	73%	33%	36%	42%	16%	41%	210%	7%	128%
Station SQ	1.14	1.04	0.93	1.05	1.45	0.21	0.93	1.23	0.90	0.86	1.22	1.11	1.09	1.54	0.96	1.45	2.32	1.52
400m SQ	1.06	1.06	1.02	0.98	1.14	0.50	0.93	1.13	0.89	1.20	1.02	0.96	0.95	0.84	1.14	1.29	1.75	1.17
800m SQ	1.06	1.06	1.01	0.99	1.11	0.55	0.89	1.15	1.06	1.16	1.04	1.05	0.98	0.83	1.38	1.25	1.83	1.11

Comments: The station band ("Station") extends from the station to 200 meters, the 400-meter band ("400m") extends from the station to 400 meters, and the 800-meter band ("800m") includes the entire station area. See Exhibit 3 for BRT abbreviation names. See text for description of Station Quotients (SQs). For clarity of interpretation, station shares (including the 400m and 800m bands) with "NA" means the change in the BRT county and/or in the band was negative. RFL means retail-food-lodging and AER means arts-entertainment-recreation.

TRANSIT STATION PROXIMITY AND DEMOGRAPHIC CHANGE WITH SPECIAL REFERENCE TO GENTRIFICATION

This section presents the association between BRT station proximity and change in several demographic indicators overall and for each BRT system. Observations with respect to gentrification are also made. The relevant research questions in this context are:

> During the study period, did the concentration of population change and, if so, did the demographic composition of the population and households also change terms of household type, householder age, median household income, and housing tenure with respect to BRT station proximity?
>
> In addition, during the study period, were there differences in outcomes between pre-2010 and 2010-2019 BRT systems?

The null hypotheses relating to both questions assert no difference in the concentration over time with respect to BRT station proximity and those features. The next section reviews the research design, data, and analytic methods.

Research Design, Data, and Analytic Method

The research design features noted above for the analysis of jobs apply here as well. Analyses are reported with respect to:

- Change in population in general as well as White (defined as white non-Hispanic) and Non-White persons (Exhibit 8);
- Change in households as well as change in households with children, one or more adult households without children, and single person households (Exhibit 9);
- Change in householder age based on categories of under 25 years of age, 25 to 44, 45 to 64, and 65 years of age of or older (Exhibit 10);
- Change in median household income (Exhibit 11); and
- Change in housing tenure, own or rent (Exhibit 11).

Data come from the ACS 5-year samples for 2010-2014, a period after the Great Recession of 2007-2009, and 2015-2019, the period before the COVID-19 pandemic of 2020-2022. If reference is made to 2010 in this context it means the ACS 5-year period of 2010-2014 and if reference is made to 2019 in this context it means the ACS 5-year period of 2015-2019.

Descriptive analysis is used where changes are measured numerically and change in concentration is measured by SQs (station quotients) as described above. As noted earlier, all differences in change over the time periods are significant to at least $p < 0.10$ of the two-tailed t-test.

Results and interpretations are offered next.

Results and Interpretations

Discussion is offered with respect to population overall as well as White non-Hispanic, “White”, and all other persons, “non-White” (Exhibit 8). Results are reported for the pooled samples of pre-2010 and 2010-2019 BRT systems, as well as for the individual systems. Only certain trends are highlighted below. Readers are encouraged to evaluate results for individual systems of interest to them.

Overall Population

For the pool of all BRT systems, Exhibit 8 shows that BRT station areas added more than 190,000 people or about 21 percent of the growth of BRT counties during the study period. This is the same share of change observed for both the pre-2010 and 2010-2019 BRT systems. These results are impressive because BRT station areas account for less than one percent of the urbanized land area of those counties.

With few exceptions, population SQs were at or >1.0 for nearly all BRT systems, the exceptions being just Albuquerque and Minneapolis-St, Paul among the 2010-2019 BRT systems and Salt Lake City among the pre-2010 systems. Otherwise, the shares of new BRT county residents settling in BRT station areas is impressive such as 58 percent for Kansas City, 27 percent for San Jose, 41 percent for Eugene-Springfield, 49 percent for Stockton, 51 percent for Nashville, 49 percent for Seattle, and 68 percent for Arlington-Alexandria. But two BRT station areas lost sizable populations: Pittsburgh and Albuquerque. While Pittsburgh may be explained because its BRT county also lost population during the study period, there may be different dynamics at work in Albuquerque because the BRT county had a modest increase in population. Perhaps the lengthy BRT construction period followed by about a two-year delay in replacing rolling stock between 2017 and 2019 was a factor.

More interesting is that with the population gaining share of BRT population growth but with jobs losing share, population growth may be displacing jobs in many BRT station areas.

White and non-White Population

Exhibit 8 also shows population change for Whites and non-Whites. Notably, non-White population growth in station areas exceeded 155,000 compared to less than 37,000 for Whites. But station areas accounted for 86 percent of the change in White population, in contrast to just 18 percent for non-Whites. Indeed, the station area SQs for most BRT systems were >1.0 among White residents.

These overall figures are somewhat misleading, however. For instance, Kansas City, Nashville, and Seattle added nearly 55,000 White residents to their station areas while Pittsburgh and Salt Lake City lost about 25,000 White residents. Also, while the San Jose and Cleveland BRT counties lost White residents overall, they gained non-White residents in station areas. Indeed, all but three BRT systems had non-White SQs of >1.0.

Exhibit 8. Bus Rapid Transit Station Area Population Station Change and Station Quotients by System
[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT	Before	PIT	KC	SJ	ESP	STK	CLE	SLC	NSH	In/After	RNO	SEA	SA	AA	SD	MSP	ABQ
	Systems	2010	1977	2005	2005	2007	2007	2008	2008	2009	2010	2010	2010	2012	2014	2014	2016	2017
Total	925,440	236,008	(17,425)	18,049	85,901	18,576	41,553	(20,062)	69,976	39,440	689,432	26,951	249,962	163,755	24,482	132,930	84,923	6,429
Station Area	88,699	24,520	(1,952)	4,892	3,748	1,484	9,007	1,794	355	5,192	64,179	2,180	40,193	7,799	6,321	9,397	(417)	(1,294)
To 400m	134,353	31,858	(3,378)	9,568	9,802	6,276	16,557	2,172	1,326	14,055	102,495	4,578	99,760	23,573	15,099	27,172	(1,546)	(1,962)
To 800m	192,725	49,322	(9,076)	10,452	22,843	7,631	20,215	1,275	343	20,159	143,403	5,532	123,284	29,980	16,728	34,578	518	(3,038)
Station Share	10%	10%	NA	27%	4%	8%	22%	NA	1%	13%	9%	8%	16%	5%	26%	7%	NA	NA
To 400m Share	15%	13%	NA	53%	11%	34%	40%	NA	2%	36%	15%	17%	40%	14%	62%	20%	NA	NA
To 800m Share	21%	21%	NA	58%	27%	41%	49%	NA	0%	51%	21%	21%	49%	18%	68%	26%	NA	NA
Station SQ	1.02	1.00	1.01	1.05	1.00	1.02	1.04	1.16	0.94	0.99	1.05	1.06	1.07	1.03	1.27	1.03	0.94	0.97
To 400m SQ	1.01	1.00	1.01	1.02	0.98	1.05	0.99	1.03	0.95	0.99	1.02	1.01	1.03	1.04	1.16	1.02	0.94	0.99
To 800m SQ	1.01	1.00	1.00	1.02	1.01	1.04	1.00	1.01	0.94	1.00	1.02	1.00	1.03	1.04	1.11	1.02	0.96	0.98
White	42,789	(40,031)	(35,531)	6,044	(19,443)	8,251	(7,810)	(34,649)	26,595	16,512	82,820	8,397	51,518	10,321	8,940	(95)	15,210	(11,471)
Station Area	18,019	3,574	(6,388)	5,637	821	1,018	(642)	1,261	(763)	2,630	14,445	395	9,803	1,680	3,641	(312)	(485)	(277)
To 400m	29,505	5,487	(15,502)	11,643	2,916	3,728	(2,423)	2,623	(2,797)	8,873	24,018	197	26,794	5,115	7,858	2,193	(2,319)	(1,375)
To 800m	36,836	724	(19,265)	10,714	2,961	4,652	(2,224)	2,521	(5,584)	10,523	36,112	913	33,813	7,086	7,653	3,579	(590)	(1,897)
Station Share	42%	NA	NA	93%	NA	12%	8%	NA	NA	16%	17%	5%	19%	16%	41%	NA	NA	NA
To 400m Share	69%	NA	NA	193%	NA	45%	31%	NA	NA	54%	29%	2%	52%	50%	88%	NA	NA	NA
To 800m Share	86%	NA	NA	177%	NA	56%	28%	NA	NA	64%	44%	11%	66%	69%	86%	NA	NA	NA
Station SQ	1.02	1.02	1.00	1.14	1.06	1.04	1.00	1.37	0.94	1.01	1.04	1.02	1.04	1.07	1.27	0.99	0.97	1.03
To 400m SQ	1.02	1.02	1.00	1.09	1.07	1.05	0.97	1.19	0.92	1.03	1.03	0.96	1.03	1.09	1.13	1.02	0.95	1.02
To 800m SQ	1.02	1.01	1.00	1.06	1.05	1.04	0.99	1.13	0.90	1.02	1.03	0.99	1.03	1.11	1.06	1.02	0.99	1.02

Exhibit 8. Bus Rapid Transit Station Area Population Station Change and Station Quotients by System—continued
[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT Systems	Before 2010	PIT 1977	KC 2005	SJ 2005	ESP 2007	STK 2007	CLE 2008	SLC 2008	NSH 2009	In/After 2010	RNO 2010	SEA 2010	SA 2012	AA 2014	SD 2014	MSP 2016	ABQ 2017
Non-White	882,651	276,039	18,106	12,005	105,344	10,325	49,363	14,587	43,381	22,928	606,612	18,554	198,444	153,434	15,542	133,025	69,713	17,900
Station Area	70,680	20,946	4,436	(745)	2,927	466	9,649	533	1,118	2,562	49,734	1,785	30,390	6,119	2,680	9,709	68	(1,017)
To 400m	104,848	26,371	12,124	(2,075)	6,886	2,548	18,980	(451)	4,123	5,182	78,477	4,381	72,966	18,458	7,241	24,979	773	(587)
To 800m	155,889	48,598	10,189	(262)	19,882	2,979	22,439	(1,246)	5,927	9,636	107,291	4,619	89,471	22,894	9,075	30,999	1,108	(1,141)
Station Share	8%	8%	25%	NA	3%	5%	20%	4%	3%	11%	8%	10%	15%	4%	17%	7%	0%	NA
To 400m Share	12%	10%	67%	NA	7%	25%	38%	NA	10%	23%	13%	24%	37%	12%	47%	19%	1%	NA
To 800m Share	18%	18%	56%	NA	19%	29%	45%	NA	14%	42%	18%	25%	45%	15%	58%	23%	2%	NA
Station SQ	1.01	0.98	0.99	0.93	0.96	0.95	1.03	1.03	0.90	0.97	1.05	1.07	1.07	1.02	1.28	1.05	0.89	0.93
To 400m SQ	0.98	0.96	0.99	0.93	0.94	1.06	0.97	0.94	0.93	0.95	1.02	1.03	1.00	1.02	1.20	1.01	0.93	0.96
To 800m SQ	0.99	0.97	0.97	0.96	0.98	1.02	0.97	0.94	0.94	0.98	1.01	0.99	1.00	1.02	1.20	1.01	0.93	0.96

Comments: The station band (“Station”) extends from the station to 200 meters, the 400-meter band (“400m”) extends from the station to 400 meters, and the 800-meter band (“800m”) includes the entire station area. See Exhibit 3 for BRT abbreviation names. See text for description of Station Quotients (SQs). For clarity of interpretation, station shares (including the 400m and 800m bands) with “NA” means the change in the BRT county and/or in the band was negative.
Comments: White means non-Hispanic or Latino and Non-White means all others.

These trends cannot be exaggerated because the non-White residents denominated population change in station areas even if their share of the non-White population change in BRT counties was small. For instance, nearly 90,000 non-White residents were added to the Seattle station areas followed by more than 30,000 in San Diego and about 20,000 each in San Jose, Stockton, and San Antonio.

Households

Unlike Exhibit 8, which shows that some BRT counties lost population during the study period, all BRT counties gained households as seen in Exhibit 9. The reason is that declining household size during the study period means that more households have been formed relative to population. Indeed, despite occupying less than one percent of the BRT county's urbanized land area, BRT station areas attracted 27 percent of all BRT county household growth during the study period with 25 percent among pre-2010 BRT systems and 28 percent among 2010-2019 systems.

Moreover, Exhibit 9 shows that nearly all household SQs are >1.0 across all BRT systems in most bands. Subject to further research, this may be additional evidence that households are displacing jobs within station areas. This has implications for post-pandemic BRT planning and development that are discussed later.

Households by Type

Exhibit 9 shows changes in households with children, households comprised of one or more adults but no children, and single-person households.

Results for households with children are interesting because they are quite different between the pre-2010 and 2010-2019 BRT systems. As a group, pre-2010 BRT station areas saw a reduction in households with children, a pattern consistent with their BRT counties. The only exceptions to this were Eugene-Springfield and Nashville, though Salt Lake City saw an increase in such households to the 400-meter station band.

In contrast, as a group, the 2010-2019 BRT systems saw increases in the number of households with children and they accounted for 29 percent of the overall share of BRT county growth. Moreover, with SQs > 1.0, most 2010-2019 BRT systems gained households with children at a higher rate than their BRT counties. Indeed, 49 percent of the change in Seattle's BRT county households with children were attracted to BRT station areas. There is also an anomaly where all the San Diego BRT station bands gained households with children even though the county lost such households. A clear outlier in this group is Albuquerque, which saw substantial reductions among such households in the county as well as all station bands. Indeed, if Albuquerque is removed, the number of households with children in the station areas of 2010-2019 BRT systems would have increased from about 5,300 to more than 26,200 and the share of BRT county growth overall in this group would have increased to 35 percent. Popular wisdom asserting that transit station areas are not attractive to households with children need to be reconsidered. Indeed, planners might be advised to facilitate opportunities for households with children to live near BRT stations.

Exhibit 9. Bus Rapid Transit Station Area Household Type Change and Station Quotients by System
[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT Systems	Before 2010	PIT 1977	KC 2005	SJ 2005	ESP 2007	STK 2007	CLE 2008	SLC 2008	NSH 2009	In/After 2010	RNO 2010	SEA 2010	SA 2012	AA 2014	SD 2014	MSP 2016	ABQ 2017
Households	351,935	128,699	14,890	14,636	25,501	6,685	11,224	6,244	26,710	22,809	223,236	17,719	95,608	22,955	15,450	41,475	26,049	3,980
Station Area	46,475	17,154	3,304	3,671	1,025	1,042	2,046	1,133	889	4,044	29,321	1,362	17,889	1,321	3,612	4,005	(187)	1,319
To 400m	74,006	25,846	9,707	7,476	2,755	3,791	4,365	2,274	1,738	10,894	48,160	3,157	46,775	5,312	8,548	12,089	(572)	2,172
To 800m	94,351	31,548	9,550	7,816	5,179	3,871	5,293	2,326	1,601	13,066	62,803	3,789	55,054	6,010	9,345	15,796	(90)	2,220
Station Share	13%	13%	22%	25%	4%	16%	18%	18%	3%	18%	13%	8%	19%	6%	23%	10%	NA	33%
To 400m Share	21%	20%	65%	51%	11%	57%	39%	36%	7%	48%	22%	18%	49%	23%	55%	29%	NA	55%
To 800m Share	27%	25%	64%	53%	20%	58%	47%	37%	6%	57%	28%	21%	58%	26%	60%	38%	NA	56%
Station SQ	1.03	1.01	1.00	1.07	0.99	1.10	1.02	1.21	0.98	1.01	1.06	1.06	1.07	1.01	1.26	1.04	0.95	1.03
To 400m SQ	1.02	1.01	1.01	1.03	0.98	1.11	1.00	1.06	0.96	1.00	1.04	1.01	1.04	1.04	1.15	1.03	0.95	1.00
To 800m SQ	1.02	1.00	1.00	1.02	0.99	1.05	1.00	1.03	0.95	1.01	1.03	0.99	1.03	1.03	1.10	1.04	0.97	1.00
HHs w/Children	3,534	(14,797)	(8,056)	567	(5,252)	505	(7)	(9,497)	2,635	4,308	18,331	3,075	22,986	(7,820)	4,976	(202)	3,194	(7,878)
Station Area	925	(1,217)	(1,402)	(528)	(110)	176	471	(60)	15	221	2,142	102	3,720	(21)	25	275	(107)	(1,852)
To 400m	(1,944)	(4,957)	(3,337)	(1,450)	(1,641)	529	(79)	(694)	51	447	3,013	298	8,215	(367)	712	1,094	(195)	(4,602)
To 800m	(1,058)	(6,405)	(4,831)	(1,381)	(1,096)	468	(221)	(1,060)	(279)	778	5,347	275	11,187	(304)	784	1,182	17	(5,652)
Station Share	26%	NA	NA	NA	NA	35%	NA	NA	1%	5%	12%	3%	16%	NA	1%	NA	NA	NA
To 400m Share	NA	NA	NA	NA	NA	105%	NA	NA	2%	10%	16%	10%	36%	NA	14%	NA	NA	NA
To 800m Share	NA	NA	NA	NA	NA	93%	NA	NA	NA	18%	29%	9%	49%	NA	16%	NA	1%	NA
Station SQ	1.01	1.00	1.01	0.91	1.01	1.11	1.04	1.00	0.98	0.96	1.02	0.99	1.08	1.03	0.89	1.02	0.95	0.85
To 400m SQ	0.99	0.98	1.01	0.90	0.96	1.10	0.97	0.84	0.98	0.95	1.01	0.99	1.02	1.01	1.10	1.03	0.97	0.91
To 800m SQ	1.00	0.98	0.99	0.92	1.00	1.04	0.98	0.89	0.97	0.96	1.02	0.97	1.04	1.02	1.02	1.02	1.00	0.93
>1 Adult HHs	264,831	104,742	10,993	7,965	33,029	3,250	7,699	7,558	18,980	15,268	160,089	11,861	68,314	15,227	6,162	39,330	14,704	4,491
Station Area	29,306	11,477	2,632	2,606	1,184	198	781	469	426	3,181	17,829	689	10,909	252	2,382	2,427	(280)	1,450
To 400m	50,748	20,597	6,673	6,098	4,997	858	2,531	1,248	686	8,983	30,151	1,618	29,332	2,269	4,798	8,040	(785)	2,708
To 800m	68,645	27,226	6,696	6,345	8,153	1,250	3,148	1,795	903	10,413	41,419	2,207	35,503	3,142	5,449	10,417	(563)	3,093
Station Share	11%	11%	24%	33%	4%	6%	10%	6%	2%	21%	11%	6%	16%	2%	39%	6%	NA	32%
To 400m Share	19%	20%	61%	77%	15%	26%	33%	17%	4%	59%	19%	14%	43%	15%	78%	20%	NA	60%
To 800m Share	26%	26%	61%	80%	25%	38%	41%	24%	5%	68%	26%	19%	52%	21%	88%	26%	NA	69%
Station SQ	1.05	1.01	1.01	1.18	0.96	1.02	0.99	1.36	0.94	1.07	1.10	1.10	1.11	0.96	1.55	1.03	0.89	1.12
To 400m SQ	1.04	1.02	1.01	1.14	1.00	1.04	1.03	1.15	0.90	1.07	1.06	1.02	1.07	1.06	1.21	1.03	0.90	1.02
To 800m SQ	1.03	1.02	1.00	1.11	1.01	1.04	1.02	1.14	0.91	1.06	1.06	1.04	1.05	1.06	1.16	1.04	0.93	1.01

Exhibit 9. Bus Rapid Transit Station Area Household Type Change and Station Quotients by System—continued
[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT	Before	PIT	KC	SJ	ESP	STK	CLE	SLC	NSH	In/After	RNO	SEA	SA	AA	SD	MSP	ABQ
	Systems	2010	1977	2005	2005	2007	2007	2008	2008	2009	2010	2010	2010	2012	2014	2014	2016	2017
1-Person HHs	83,570	38,754	11,953	6,104	(2,276)	2,930	3,532	8,183	5,095	3,233	44,816	2,783	4,308	15,548	4,312	2,347	8,151	7,367
Station Area	16,244	6,894	2,074	1,593	(49)	668	794	724	448	642	9,350	571	3,260	1,090	1,205	1,303	200	1,721
To 400m	25,202	10,206	6,371	2,828	(601)	2,404	1,913	1,720	1,001	1,464	14,996	1,241	9,228	3,410	3,038	2,955	408	4,066
To 800m	26,764	10,727	7,685	2,852	(1,878)	2,153	2,366	1,591	977	1,875	16,037	1,307	8,364	3,172	3,112	4,197	456	4,779
Station Share	19%	18%	17%	26%	NA	23%	22%	9%	9%	20%	21%	21%	76%	7%	28%	56%	2%	23%
To 400m Share	30%	26%	53%	46%	NA	82%	54%	21%	20%	45%	33%	45%	214%	22%	70%	126%	5%	55%
To 800m Share	32%	28%	64%	47%	NA	73%	67%	19%	19%	58%	36%	47%	194%	20%	72%	179%	6%	65%
Station SQ	1.04	1.02	0.99	1.04	1.01	1.16	1.05	1.19	1.07	1.00	1.05	1.10	1.06	1.00	1.18	1.07	1.00	1.06
To 400m SQ	1.02	1.01	1.00	0.99	0.99	1.17	1.03	1.06	1.05	0.99	1.04	1.03	1.05	1.01	1.13	1.03	0.99	1.02
To 800m SQ	1.01	1.00	1.00	0.98	0.96	1.07	1.02	1.02	1.02	1.00	1.02	1.00	1.03	0.98	1.08	1.05	0.98	1.02

Comments: The station band ("Station") extends from the station to 200 meters, the 400-meter band ("400m") extends from the station to 400 meters, and the 800-meter band ("800m") includes the entire station area. See Exhibit 3 for BRT abbreviation names. See text for description of Station Quotients (SQs). For clarity of interpretation, station shares (including the 400m and 800m bands) with "NA" means the change in the BRT county and/or in the band was negative. ">1 Adult HHs" means households with more than one adult but no children.

At the other end of the spectrum, the concentration of single-person households increased in nearly all station areas with little difference between the pre-2010 and 2010-2019 BRT system groups. The only outlier is San Jose where the number of single-person households fell during the study period. Perhaps the reason is its famously high cost of housing is forcing people to share homes even if they would rather not.

By far the largest share of household change in BRT station areas are households with one or more adults but no children, called ">1 Adult Households". They accounted for 26 percent of the share of change among all BRT counties as well as 26 percent of the pre-2010 and 2010-2019 BRT groups. These households are comprised of married couples, and related and unrelated roommates of all ages. They also span the range from young professionals to downsizing empty nesters and retirees. Many are comprised of unrelated adults who would rather have a place of their own, but price or availability, location, and other constraints limit their options.

Only the Minneapolis-St, Paul BRT station areas lost >1 Adult Households. In nearly all other cases, the SQs for both station bands and station areas were >1.0 meaning that during the study period, they attracted proportionately more households than their BRT counties. Indeed, the 2010-2019 BRT group had a station band SQ of 1.10 while the station area overall had an SQ of 1.06, both considerably higher than the pre-2010 BRT group of 1.01 and 1.02, respectively. The SQs for Arlington-Alexandria are especially impressive at 1.55 at the BRT station band and 1.16 for the station area overall.

Households by Householder Age

Exhibit 10 is especially interesting. Among age groups, BRT station areas as a group mathematically accounted for all new BRT county householders under 25 years of age (because BRT county growth was negative while BRT station area growth was positive), 43 percent of those between 25 and 44 years of age and 17 percent of those 65 years of age and older. The first station band also accounted for all the growth in householders between 45 and 64 years of age. But there are important differences between pre- and post-2010 BRT systems.

Among householders under 25 years of age, only one pre-2010 BRT station area lost concentration relative to their counties (Salt Lake City at SQ = 0.98) while all the others gained. In contrast, four of seven 2010-2019 BRT station areas lost such householders during the study period, following trends of their respective BRT counties.

With respect to householders between 25 and 44 years of age, only the Minneapolis-St. Paul and Albuquerque station areas saw reductions during the study period, though only the Albuquerque BRT county saw a reduction in those households. Otherwise, SQs were >1.0 for most of the station bands and station areas indicating that proportionately more householders in this age group chose to be near BRT stations than elsewhere in the respective BRT counties.

Exhibit 10. Bus Rapid Transit Station Area Householder Age Change and Station Quotients by System
[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT	Before	PIT	KC	SJ	ESP	STK	CLE	SLC	NSH	In/After	RNO	SEA	SA	AA	SD	MSP	ABQ
	Systems	2010	1977	2005	2005	2007	2007	2008	2008	2009	2010	2010	2010	2012	2014	2014	2016	2017
HHs < 25	(16,393)	669	(142)	(105)	824	(620)	(1,547)	1,519	(509)	1,249	(17,062)	652	2,010	(5,008)	1,548	(9,236)	(4,071)	(2,957)
Station Area	2,849	1,914	177	144	166	279	(95)	306	(65)	1,002	935	260	1,067	(233)	150	(202)	(85)	(22)
To 400m	4,178	3,706	917	255	701	933	(276)	666	(80)	2,504	472	638	2,718	(870)	123	(372)	(356)	(474)
To 800m	2,754	2,994	893	180	648	658	(711)	876	(150)	2,514	(240)	743	2,662	(825)	239	(898)	(460)	(766)
Station Share	NA	286%	NA	NA	20%	NA	NA	20%	NA	80%	NA	40%	53%	NA	10%	NA	NA	NA
To 400m Share	NA	554%	NA	NA	85%	NA	NA	44%	NA	200%	NA	98%	135%	NA	8%	NA	NA	NA
To 800m Share	NA	448%	NA	NA	79%	NA	NA	58%	NA	201%	NA	114%	132%	NA	15%	NA	NA	NA
Station SQ	1.14	1.10	1.03	1.05	1.06	1.31	1.13	1.26	0.95	1.25	1.16	1.44	1.12	1.07	1.16	1.19	1.01	1.25
To 400m SQ	1.12	1.11	1.08	1.03	1.11	1.22	1.13	1.08	1.02	1.21	1.12	1.30	1.09	1.05	0.77	1.22	0.96	1.12
To 800m SQ	1.09	1.06	1.06	1.02	1.04	1.13	1.01	1.09	0.98	1.15	1.10	1.14	1.05	1.10	0.85	1.16	0.97	1.10
HHs 25-44	116,733	44,101	10,238	5,827	699	2,926	2,788	1,192	8,619	11,812	72,632	4,783	39,628	7,080	3,775	8,365	9,490	(489)
Station Area	23,183	8,994	2,225	2,460	782	467	559	867	45	1,589	14,189	484	10,715	560	2,234	1,516	(306)	(1,014)
To 400m	40,336	14,692	6,797	5,556	1,551	1,629	908	1,448	55	5,742	25,644	1,471	27,680	2,992	5,092	5,343	(694)	(2,051)
To 800m	50,110	18,451	7,014	6,117	3,054	1,924	1,255	1,463	(182)	6,800	31,659	1,539	32,287	3,241	5,017	6,658	(517)	(2,377)
Station Share	20%	20%	22%	42%	112%	16%	20%	73%	1%	13%	20%	10%	27%	8%	59%	18%	NA	NA
To 400m Share	35%	33%	66%	95%	222%	56%	33%	121%	1%	49%	35%	31%	70%	42%	135%	64%	NA	NA
To 800m Share	43%	42%	69%	105%	437%	66%	45%	123%	NA	58%	44%	32%	81%	46%	133%	80%	NA	NA
Station SQ	1.06	1.04	1.00	1.12	1.05	1.15	1.02	1.46	0.95	0.97	1.08	1.06	1.10	1.02	1.35	1.04	0.90	0.91
To 400m SQ	1.05	1.03	1.02	1.09	1.02	1.16	0.99	1.09	0.95	1.01	1.07	1.08	1.07	1.08	1.21	1.05	0.93	0.96
To 800m SQ	1.04	1.03	1.00	1.09	1.04	1.10	0.99	1.05	0.93	1.01	1.05	1.03	1.06	1.06	1.14	1.05	0.95	0.96
HHs 45-64	1,232	(12,934)	(12,620)	621	4,074	(3,243)	2,392	(10,396)	5,554	684	14,166	1,970	13,219	339	3,918	3,194	(4,906)	(3,568)
Station Area	2,874	(2,488)	(3,284)	(93)	(522)	(93)	538	(210)	446	730	5,362	259	3,550	162	875	323	(442)	635
To 400m	(351)	(6,159)	(8,072)	(923)	(1,821)	(198)	1,155	(287)	965	534	5,808	336	6,859	927	2,290	1,337	(1,179)	600
To 800m	(112)	(7,642)	(9,425)	(1,133)	(1,499)	(567)	1,415	(630)	980	729	7,530	324	8,337	1,310	2,332	1,867	(1,644)	366
Station Share	233%	NA	NA	NA	NA	NA	22%	NA	8%	107%	38%	13%	27%	48%	22%	10%	NA	NA
To 400m Share	NA	NA	NA	NA	NA	NA	48%	NA	17%	78%	41%	17%	52%	273%	58%	42%	NA	NA
To 800m Share	NA	NA	NA	NA	NA	NA	59%	NA	18%	107%	53%	16%	63%	386%	60%	58%	NA	NA
Station SQ	1.02	0.99	0.99	0.98	0.93	1.02	1.03	0.90	1.03	1.05	1.06	1.06	1.07	1.02	1.21	1.01	0.92	1.11
To 400m SQ	1.00	0.98	0.99	0.94	0.93	1.04	1.01	1.04	1.01	0.98	1.03	0.98	1.02	1.05	1.16	1.02	0.94	1.03
To 800m SQ	1.00	0.98	0.99	0.94	0.96	1.00	1.01	1.00	1.00	0.99	1.02	0.98	1.02	1.06	1.09	1.02	0.94	1.03

Exhibit 10. Bus Rapid Transit Station Area Householder Age Change and Station Quotients by System—continued
[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT	Before	PIT	KC	SJ	ESP	STK	CLE	SLC	NSH	In/After	RNO	SEA	SA	AA	SD	MSP	ABQ
	Systems	2010	1977	2005	2005	2007	2007	2008	2008	2009	2010	2010	2010	2012	2014	2014	2016	2017
HHs 65 and over	250,363	96,863	17,414	8,293	19,904	7,622	7,591	13,929	13,046	9,064	153,500	10,314	40,751	20,544	6,209	39,152	25,536	10,994
Station Area	17,569	8,734	4,186	1,160	599	389	1,044	170	463	723	8,835	359	2,557	832	353	2,368	646	1,720
To 400m	29,843	13,607	10,065	2,588	2,324	1,427	2,578	447	798	2,114	16,236	712	9,518	2,263	1,043	5,781	1,657	4,097
To 800m	41,599	17,745	11,068	2,652	2,976	1,856	3,334	617	953	3,023	23,854	1,183	11,768	2,284	1,757	8,169	2,531	4,997
Station Share	7%	9%	24%	14%	3%	5%	14%	1%	4%	8%	6%	3%	6%	4%	6%	6%	3%	16%
To 400m Share	12%	14%	58%	31%	12%	19%	34%	3%	6%	23%	11%	7%	23%	11%	17%	15%	6%	37%
To 800m Share	17%	18%	64%	32%	15%	24%	44%	4%	7%	33%	16%	11%	29%	11%	28%	21%	10%	45%
Station SQ	1.00	0.99	1.01	1.14	0.94	1.05	1.02	1.07	0.98	0.93	1.03	0.97	0.95	1.00	1.13	1.13	1.07	1.15
To 400m SQ	0.99	0.98	1.00	1.07	0.96	1.10	1.01	0.99	0.89	0.94	1.00	0.86	0.99	1.00	1.06	1.02	1.01	1.03
To 800m SQ	0.99	0.98	1.00	1.02	0.94	1.05	1.01	0.98	0.90	0.97	1.01	0.91	0.98	0.96	1.10	1.06	1.04	1.03

Comments: The station band ("Station") extends from the station to 200 meters, the 400-meter band ("400m") extends from the station to 400 meters, and the 800-meter band ("800m") includes the entire station area. See Exhibit 3 for BRT abbreviation names. See text for description of Station Quotients (SQs). For clarity of interpretation, station shares (including the 400m and 800m bands) with "NA" means the change in the BRT county and/or in the band was negative. "HHs < 25," "HHs 25-44," "HHs 45-64," and "HHs 65 and over" means householders under 25 years of age, between 25 and 44 years of age, between 45 and 64 years of age, and 65 years of age or older, respectively.

Skipping to the age group for householders 65 years of age or older, all BRT counties added such householders and indeed they accounted for more than 70 percent of the change in all householders during the study period. Among the BRT groups, the pre-2010 BRT group accounted for 18 percent of the change in such householders compared to 16 percent for the 2010-2019 BRT group. However, while the 2010-2019 BRT group gained share of householder change where SQ > 1.0, the pre-2010 BRT group did not where SQ <1.0. Indeed, more 2010-2019 BRT station bands attracted higher shares of households in this age group than in pre-2010 BRT systems.

Results for householders between 45 and 64 years of age differ substantially between pre-2010 and 2010-2019 BRT groups. Overall, the number of such householders fell by 13,000 in the pre-2010 BRT group during the study period but increased by 14,000 in the 2010-2019 BRT group. In addition, five of the eight pre-2010 BRT station areas saw reductions in these householders. In contrast, only two of the seven 2010-2019 BRT station areas lost such householders: Minneapolis-St. Paul and Albuquerque.

There may be a link between this householder age group and results for households with children that deserve future research. Consider that among householders older than 44, about 30 percent have children living with them.[16] Consider also that as women have children later in life, more children will be part of this householder age group than in the past.[17] Consider further that only the 2010-2019 BRT systems showed gains in households with children during the study period. Could it be that more households with children, especially in the 45-64 age group, would be attracted to BRT station areas if they were more conducive to their needs? This may be an opportunity for BRT planners and policymakers to explore.

Household Income

The top rows of Exhibit 11 show the changes and share of change in household income for all BRT station areas and the 15 individual systems. Overall, BRT station area household income fell slightly compared to BRT counties. Among the pre-2010 BRT systems, the strongest income related influence is in the first station band. Here, SQs are >1.0 for five of the seven systems with Cleveland leading the group at 1.24 followed notably by Pittsburgh at 1.05 and Eugene-Springfield at 1.04. For the most part, pre-2010 SQs range around 1.00 for all station bands.

In contrast, in five of the seven 2010-2019 BRT station areas, household income stayed about the same or increased only slightly relative to BRT counties. With the exceptions noted, overall, household incomes near BRT stations were about the same at the end of the study period as they were at the beginning. As one of the indicators of gentrification is increasing household income over time, this does not seem to be evident overall aside from the noted exceptions.

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[16] Estimated from Source: U.S. Census Bureau, Current Population Survey, 2022 Annual Social and Economic Supplement, Table A3. Parents With Coresident Children Under 18, by Living Arrangement, Sex, and Selected Characteristics: 2022.
[17] See https://www.nytimes.com/2021/06/16/us/declining-birthrate-motherhood.html.

Exhibit 11. Bus Rapid Transit Station Area Median Household Income and Tenure Change and Station Quotients by System
[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT Systems	Before 2010	PIT 1977	KC 2005	SJ 2005	ESP 2007	STK 2007	CLE 2008	SLC 2008	NSH 2009	In/After 2010	RNO 2010	SEA 2010	SA 2012	AA 2014	SD 2014	MSP 2016	ABQ 2017
HH Income	$5,859	$7,027	($3,047)	$329	$33,632	($113)	$12,164	($32)	$346	($458)	$4,942	$523	($188)	$826	$309	$16,931	$129	$273
Station Area	$5,295	$3,793	$28	$21	$29,482	$1,082	$10,106	$6,240	($1,861)	$586	$4,713	($125)	$1,727	($601)	($1,164)	$14,060	$248	$398
To 400m	$5,686	$5,467	$239	$153	$33,696	($4,038)	$9,693	$1,025	($3,964)	$841	$4,822	($217)	$1,223	$226	$931	$15,635	$214	($542)
To 800m	$4,827	$9,650	($4,968)	$87	$34,951	$992	$9,106	$881	($372)	$177	$4,552	($116)	$1,008	$503	($2,451)	$15,780	($30)	$133
Station SQ	0.75	0.97	1.05	0.99	1.00	1.04	1.02	1.24	0.97	1.02	1.00	0.99	1.02	0.97	0.99	0.98	1.00	1.00
To 400m SQ	2.91	1.01	1.05	0.99	1.06	0.94	1.01	1.04	0.92	1.03	1.01	0.99	1.01	1.00	1.00	1.01	1.01	0.98
To 800m SQ	0.82	0.98	0.96	1.00	1.05	1.02	1.00	1.03	0.99	1.01	1.00	0.99	1.01	1.00	0.98	1.01	1.00	1.00
Owner Change	176,015	55,249	6,038	3,077	11,002	3,003	5,835	(6,726)	19,800	13,220	120,766	12,305	54,148	10,964	5,002	21,692	12,557	4,098
Station Area	8,305	2,223	(90)	527	(289)	163	(40)	(6)	190	1,768	6,082	336	4,611	430	948	104	(422)	75
To 400m	15,537	3,125	347	815	(367)	453	(194)	(81)	(212)	4,587	12,412	767	13,548	1,115	2,558	1,231	(689)	(36)
To 800m	25,422	4,600	235	843	(273)	419	224	(310)	(196)	5,881	20,822	1,109	18,110	1,548	2,743	3,473	(234)	155
Station Share	5%	4%	NA	17%	-3%	5%	NA	NA	1%	13%	5%	3%	9%	4%	19%	0%	NA	2%
To 400m Share	9%	6%	6%	26%	-3%	15%	NA	NA	NA	35%	10%	6%	25%	10%	51%	6%	NA	NA
To 800m Share	14%	8%	4%	27%	-2%	14%	4%	NA	NA	44%	17%	9%	33%	14%	55%	16%	NA	4%
Station SQ	0.99	0.99	0.99	1.02	0.94	1.03	0.95	1.01	0.94	1.03	1.02	1.08	1.03	1.04	1.21	0.97	0.91	0.98
To 400m SQ	0.99	0.98	0.99	1.00	0.97	1.01	0.95	1.00	0.90	1.00	1.02	1.00	1.02	1.02	1.17	0.99	0.95	0.97
To 800m SQ	1.00	0.98	0.99	0.99	0.97	0.99	0.96	0.98	0.91	1.01	1.02	1.01	1.02	1.03	1.08	1.02	0.98	0.98
Renter Change	175,920	73,450	8,852	11,559	14,499	3,682	5,389	12,970	6,910	9,589	102,470	5,414	41,460	11,991	10,448	19,783	13,492	(118)
Station Area	38,170	14,931	3,394	3,144	1,314	879	2,086	1,139	699	2,276	23,239	1,026	13,278	891	2,664	3,901	235	1,244
To 400m	58,469	22,721	9,360	6,661	3,122	3,338	4,559	2,355	1,950	6,307	35,748	2,390	33,227	4,197	5,990	10,858	117	2,208
To 800m	68,929	26,948	9,315	6,973	5,452	3,452	5,069	2,636	1,797	7,185	41,981	2,680	36,944	4,462	6,602	12,323	144	2,065
Station Share	22%	20%	38%	27%	9%	24%	39%	9%	10%	24%	23%	19%	32%	7%	25%	20%	2%	-1054%
To 400m Share	33%	31%	106%	58%	22%	91%	85%	18%	28%	66%	35%	44%	80%	35%	57%	55%	1%	-1871%
To 800m Share	39%	37%	105%	60%	38%	94%	94%	20%	26%	75%	41%	50%	89%	37%	63%	62%	1%	-1750%
Station SQ	1.06	1.04	1.02	1.07	1.01	1.12	1.10	1.19	1.06	1.00	1.09	1.08	1.09	1.00	1.28	1.08	0.99	1.08
To 400m SQ	1.04	1.02	1.03	1.02	0.98	1.14	1.04	1.03	1.10	1.01	1.05	1.03	1.05	1.04	1.13	1.05	0.94	1.03
To 800m SQ	1.03	1.01	1.01	1.01	1.00	1.09	1.03	1.01	1.03	1.01	1.04	1.01	1.04	1.03	1.11	1.04	0.95	1.02

Comments: The station band ("Station") extends from the station to 200 meters, the 400-meter band ("400m") extends from the station to 400 meters, and the 800-meter band ("800m") includes the entire station area. See Exhibit 3 for BRT abbreviation names. See text for description of Station Quotients (SQs). For clarity of interpretation, station shares (including the 400m and 800m bands) with "NA" means the change in the BRT county and/or in the band was negative.

Housing Tenure

Exhibit 11 also shows trends in renter and owner tenure. Overall, nearly 39 percent of the BRT county change in renters occurred in BRT station areas, compared to only 14 percent of the change in homeowners. Indeed, only the Minneapolis-St. Paul BRT station area saw a decline in the concentration of renters compared to BRT counties. On the other hand, nearly all the BRT station areas that gained concentration of homeowners were among the 2010-2019 BRT systems. But most of those BRT station areas accounted for even higher changes in the concentration of renters than their respective BRT counties suggesting that rental housing is gaining share of total tenancy over time in the 2010-2019 BRT group.

Implications for Gentrification

Except for San Jose, it may be difficult to assert an association between BRT station areas and the prevalence of gentrification for either pre-2010 or 2019-2019 BRT systems. While many station areas gained share of householders under 25 years of age, which is one indicator of gentrification, many others gained share of households with children which is not a common indicator of gentrification. And while the share of homeowners in BRT station areas increased during the study period, higher shares were gained among renters. Tellingly, aside from the few exceptions noted earlier, the change in household income did not change appreciably between BRT station areas and BRT counties. For the most part, gentrification is not evident in most of the BRT systems studied. This is consistent generally with the findings of Qi (2023) for BRT systems used in the referenced study. But if BRT systems gain popularity in the market, this may become an issue. Concerns about gentrification are discussed in more detail later.

The change in the mode of journey to work, with implications, is presented next.

TRANSIT STATION PROXIMITY AND COMMUTING MODE CHOICE

Theory posits that BRT station proximity is associated with increasing shares of commuting via transit, walking, biking, and working from home. Using ACS data, this section outlines the research design, choice of data, and analytic method. After presenting results, it concludes with implications for post-pandemic transit and land use planning.

Given the literature and theory presented earlier, the research question is:

> Is proximity to BRT stations associated with increasing shares of walking, biking, transit use, and working at home?

The null hypothesis asserts there is no change in the non-auto commute by mode to work with respect to BRT station proximity.

Research Design, Data, and Analytic Method

The same research design features noted earlier apply to the analyses presented here as well. The analyses include the following, all reported in Exhibit 12:

- Change in workers living in BRT station areas as opposed to those working in them (as reported in Exhibit 7)
- Change in workers commuting via automobile;
- Change in workers commuting via transit;
- Change in workers walking or biking to work;
- Change in workers working from home; and
- Combined change in workers using transit, walking or biking, or working from home.

The treatment group is the BRT station areas with respect to BRT counties which is the control. The analysis is applied separately to pre-2010 BRT systems as well as 2010-2019 BRT systems. ACS data are used for descriptive analysis. In all cases, differences are significant to at least the 0.10 level of the two-tailed t-test.

Results and Interpretations

Exhibit 12 reports outcomes for change in workers living in BRT counties and BRT station areas as well as the mode journey to work or working from home.

Workers Living in BRT Station Areas

Overall, the BRT station areas added about 225,000 workers accounting for 24 percent of the change in workers living in BRT counties, on less than one percent of the urbanized land area. Indeed, the concentration of workers living in BRT station areas compared to BRT counties increased during the study period among all BRT systems except Salt Lake City, Minneapolis-St. Paul and Albuquerque.

With those exceptions a pattern is detected in both pre-2010 and 2010-2019 BRT groups: the concentration of jobs with respect to workers living in station areas is increasing across most systems and in most station bands. For instance, with station band SQs of 1.09, 1.13, 1.09, and 1.20 respectively for Kansas City, Eugene-Springfield, Stockton and Cleveland, respectively, those pre-2010 BRT systems gained substantially more than their proportionate growth of growth among workers living in their respective BRT counties. Likewise, station band LQs of 1.10, 1.10, and 1.32, respectively, for the Reno, Seattle and Arlington-Alexandria 2010-2019 BRT systems reveal similar outcomes. In other words, workers are being added to those BRT station bands at a faster pace than their counties. The trends also hold through their station areas. Future research is recommended to assess changes in job-worker balance to determine the extent to which new workers living in station areas also work there.

Workers Living in BRT Station Areas who Commute via the Automobile

At first glance, the increase in commuting via the automobile is not very different for the combined groups or for the pre-2010 and 2010-2019 BRT groups compared to the increase in jobs shown in Exhibit 7. Indeed, Exhibit 12 shows that commuting via automobile increases compared to the increase in jobs. But those figures reflect the mode commute to work for those who live in the study areas whether they work there or not. The extent to which workers who both live and work in the study area needs further research.

Workers Living in BRT Station Areas who Commuting via Transit

By living in an area served by transit, in this case BRT, there is the expectation that the use of transit in the commute to work will increase, and it does. Exhibit 12 shows that, overall, commuting to work via transit increased by 36 percent and it also increased by 30 percent in the pre-2010 group and by 38 percent in the 2010-2019 group. This rate is higher than the increase in workers living in the BRT station areas, which is 24 percent, 28 percent, and 22 percent, respectively. However, because there is wide variation in the change in workers living in BRT station areas and those who commute to work via transit, only broad generalizations can be made. Nonetheless, with few exceptions, commuting via transit increased in the study area for both BRT groups.

Exhibit 12. Bus Rapid Transit Commute to Work Mode Change and Station Quotients by System

[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT Systems	Before 2010	PIT 1977	KC 2005	SJ 2005	ESP 2007	STK 2007	CLE 2008	SLC 2008	NSH 2009	In/After 2010	RNO 2010	SEA 2010	SA 2012	AA 2014	SD 2014	MSP 2016	ABQ 2017
Workers, County	948,324	345,319	24,759	28,124	99,641	17,726	36,671	17,832	69,478	51,088	603,005	29,126	202,192	99,542	15,119	163,709	82,360	10,957
Station Area	92,248	40,664	6,837	6,342	3,976	1,919	7,369	1,086	2,418	10,717	51,584	2,193	33,285	3,528	5,090	7,691	(494)	291
To 400m	164,575	70,455	18,018	14,141	15,876	7,019	16,563	3,322	6,008	30,172	94,120	5,533	86,460	14,916	11,713	25,602	(395)	1,875
To 800m	225,172	95,355	19,180	16,235	26,261	8,667	18,846	3,813	7,804	35,213	129,817	6,900	105,845	19,273	12,449	32,910	1,004	3,020
Station Share	10%	12%	28%	23%	4%	11%	20%	6%	3%	21%	9%	8%	16%	4%	34%	5%	NA	3%
To 400m Share	17%	20%	73%	50%	16%	40%	45%	19%	9%	59%	16%	19%	43%	15%	77%	16%	NA	17%
To 800m Share	24%	28%	77%	58%	26%	49%	51%	21%	11%	69%	22%	24%	52%	19%	82%	20%	1%	28%
Station SQ	1.04	1.02	1.01	1.09	0.98	1.13	1.09	1.20	0.96	1.05	1.06	1.11	1.10	1.00	1.32	1.01	0.89	0.97
To 400m SQ	1.03	1.02	1.01	1.06	1.00	1.15	1.04	1.14	0.96	1.05	1.04	1.07	1.05	1.08	1.18	1.01	0.92	0.99
To 800m SQ	1.03	1.02	1.01	1.06	1.02	1.11	1.02	1.09	0.96	1.04	1.03	1.04	1.05	1.08	1.12	1.01	0.94	0.99
Automobile	686,329	259,904	7,768	25,828	72,035	16,395	34,841	12,833	51,957	38,247	426,425	26,756	111,541	87,838	7,018	124,948	56,946	11,378
Station Area	55,870	30,907	2,494	6,410	2,314	1,143	6,990	907	1,727	8,922	24,963	2,111	14,628	3,207	2,582	3,752	(772)	(545)
To 400m	104,056	52,504	7,227	13,931	10,453	4,958	16,048	2,520	4,397	23,877	51,552	5,129	37,856	13,696	5,654	14,864	(1,283)	599
To 800m	148,973	73,679	8,236	16,243	18,863	6,381	18,292	2,906	5,792	27,873	75,294	6,718	47,827	16,987	6,127	20,732	(132)	1,998
Station Share	8%	12%	32%	25%	3%	7%	20%	7%	3%	23%	6%	8%	13%	4%	37%	3%	NA	NA
To 400m Share	15%	20%	93%	54%	15%	30%	46%	20%	8%	62%	12%	19%	34%	16%	81%	12%	NA	5%
To 800m Share	22%	28%	106%	63%	26%	39%	53%	23%	11%	73%	18%	25%	43%	19%	87%	17%	NA	18%
Station SQ	1.02	1.02	1.01	1.13	0.97	1.08	1.09	1.40	0.96	1.06	1.02	1.17	1.06	1.01	1.34	0.97	0.87	0.94
To 400m SQ	1.02	1.03	1.01	1.08	1.00	1.17	1.05	1.20	0.96	1.05	1.02	1.10	1.03	1.09	1.19	0.99	0.91	0.98
To 800m SQ	1.02	1.03	1.01	1.09	1.03	1.12	1.03	1.12	0.96	1.04	1.02	1.08	1.02	1.08	1.13	1.00	0.94	0.99
Transit	74,510	19,311	4,837	(1,037)	11,466	189	1,431	(1,471)	3,218	678	55,199	(39)	43,698	(34)	2,623	4,463	5,055	(567)
Station Area	13,187	2,277	768	(24)	529	379	281	224	(101)	221	10,910	(60)	8,586	(348)	1,657	928	(157)	304
To 400m	20,669	3,816	2,385	(74)	1,856	660	475	347	(102)	546	16,853	108	21,618	(530)	3,832	2,367	(140)	508
To 800m	27,175	5,825	2,473	(316)	3,311	782	533	467	293	559	21,350	(281)	26,020	(509)	3,607	2,726	34	663
Station Share	18%	12%	16%	NA	5%	201%	20%	NA	NA	33%	20%	NA	20%	NA	63%	21%	NA	NA
To 400m Share	28%	20%	49%	NA	16%	349%	33%	NA	NA	81%	31%	NA	49%	NA	146%	53%	NA	NA
To 800m Share	36%	30%	51%	NA	29%	414%	37%	NA	9%	82%	39%	NA	60%	NA	138%	61%	1%	NA
Station SQ	1.07	0.98	0.97	1.13	0.85	1.90	1.28	1.48	0.76	1.05	1.14	0.90	1.09	0.73	1.30	1.15	0.85	1.49
To 400m SQ	1.04	0.97	0.98	1.13	0.87	1.23	0.88	1.13	0.85	1.03	1.08	1.18	1.02	0.93	1.17	1.09	0.93	1.23
To 800m SQ	1.03	0.98	0.97	1.05	0.93	1.24	0.89	1.14	1.06	1.01	1.06	0.89	1.01	0.96	1.10	1.08	0.96	1.27

Exhibit 12. Bus Rapid Transit Commute to Work Mode Change and Station Quotients by System—continued
[Station Quotients (SQs) > 1.0 mean the station band/area gained a higher share of change than the BRT county 2010-2019.]

Measure	All BRT	Before	PIT	KC	SJ	ESP	STK	CLE	SLC	NSH	In/After	RNO	SEA	SA	AA	SD	MSP	ABQ
	Systems	2010	1977	2005	2005	2007	2007	2008	2008	2009	2010	2010	2010	2012	2014	2014	2016	2017
Walk-Bike	43,634	10,211	791	2	5,526	(673)	(1,177)	1,030	2,414	2,298	33,423	694	21,275	769	1,744	6,068	4,035	(1,162.0)
Station Area	10,862	1,917	1,032	(433)	707	245	(124)	(30)	238	282	8,945	(26)	7,355	158	557	872	155	(126.0)
To 400m	17,488	3,447	1,923	(881)	1,764	744	(363)	426	545	1,206	14,041	(92)	19,141	289	1,463	2,076	507	(398.0)
To 800m	19,443	2,927	1,299	(913)	1,629	866	(417)	342	491	1,547	16,516	(80)	22,380	392	1,497	1,547	351	(626.0)
Station Share	25%	19%	130%	NA	13%	NA	NA	NA	10%	12%	27%	NA	35%	21%	32%	14%	4%	NA
To 400m Share	40%	34%	243%	NA	32%	NA	NA	41%	23%	52%	42%	NA	90%	38%	84%	34%	13%	NA
To 800m Share	45%	29%	164%	NA	29%	NA	NA	33%	20%	67%	49%	NA	105%	51%	86%	25%	9%	NA
Station SQ	1.12	1.02	1.11	0.83	1.05	1.23	1.01	0.93	1.63	0.89	1.20	0.88	1.23	1.05	1.61	1.10	1.02	1.06
To 400m SQ	1.07	1.01	1.04	0.87	0.95	1.18	0.99	1.07	1.64	1.03	1.13	0.87	1.14	1.00	1.32	1.02	1.04	1.05
To 800m SQ	1.03	0.98	0.99	0.87	0.91	1.17	1.01	1.02	1.13	1.09	1.09	0.89	1.11	1.02	1.17	0.95	0.96	1.02
Work at Home	123,648	53,801	12,020	3,890	8,423	1,066	1,810	5,364	12,418	8,810	69,847	2,415	22,846	8,311	2,607	18,201	13,262	2,205
Station Area	10,502	5,375	2,698	352	156	143	279	(24)	713	1,058	5,127	182	2,105	240	245	1,548	232	575
To 400m	18,759	9,924	6,999	930	964	644	544	(101)	1,519	3,800	8,835	589	6,132	784	808	4,003	439	1,207
To 800m	24,583	12,159	7,874	1,111	1,554	464	603	(57)	1,541	4,444	12,424	663	7,392	1,372	1,177	5,095	635	1,217
Station Share	8%	10%	22%	9%	2%	13%	15%	NA	6%	12%	7%	8%	9%	3%	9%	9%	2%	26%
To 400m Share	15%	18%	58%	24%	11%	60%	30%	NA	12%	43%	13%	24%	27%	9%	31%	22%	3%	55%
To 800m Share	20%	23%	66%	29%	18%	44%	33%	NA	12%	50%	18%	27%	32%	17%	45%	28%	5%	55%
Station SQ	1.07	1.04	1.05	0.92	0.89	1.26	1.05	0.70	1.44	0.94	1.08	1.54	1.02	1.04	1.11	1.22	0.88	1.28
To 400m SQ	1.05	1.07	1.08	0.95	0.97	1.32	0.98	0.69	1.19	1.11	1.03	1.96	1.01	1.07	1.19	1.07	0.82	1.11
To 800m SQ	1.03	1.02	1.04	0.96	0.98	1.05	0.96	0.76	1.02	1.08	1.03	1.39	0.98	1.27	1.19	1.09	0.85	1.02
Tran-W/B-Home	241,792	83,323	17,648	2,855	25,415	582	2,064	4,923	18,050	11,786	158,469	3,070	87,819	9,046	6,974	28,732	22,352	476
Station Area	34,551	9,569	4,498	(105)	1,392	767	436	170	850	1,561	24,982	96	18,046	50	2,459	3,348	230	753
To 400m	56,916	17,187	11,307	(25)	4,584	2,048	656	672	1,962	5,552	39,729	605	46,891	543	6,103	8,446	806	1,317
To 800m	71,201	20,911	11,646	(118)	6,494	2,112	719	752	2,325	6,550	50,290	302	55,792	1,255	6,281	9,368	1,020	1,254
Station Share	14%	11%	25%	NA	5%	132%	21%	3%	5%	13%	16%	3%	21%	1%	35%	12%	1%	158%
To 400m Share	24%	21%	64%	NA	18%	352%	32%	14%	11%	47%	25%	20%	53%	6%	88%	29%	4%	277%
To 800m Share	29%	25%	66%	NA	26%	363%	35%	15%	13%	56%	32%	10%	64%	14%	90%	33%	5%	263%
Station SQ	1.07	0.99	1.01	0.89	0.94	1.33	1.08	0.99	1.12	0.93	1.14	0.91	1.12	0.90	1.30	1.14	0.91	1.17
To 400m SQ	1.04	0.99	1.00	0.91	0.93	1.18	0.96	1.01	1.09	1.04	1.08	1.00	1.06	0.95	1.19	1.05	0.92	1.06
To 800m SQ	1.02	0.97	0.97	0.90	0.93	1.13	0.96	0.99	1.05	1.04	1.05	0.89	1.04	1.01	1.12	1.03	0.92	1.03

Comments: The station band ("Station") extends from the station to 200 meters, the 400-meter band ("400m") extends from the station to 400 meters, and the 800-meter band ("800m") includes the entire station area. See Exhibit 3 for BRT abbreviation names. See text for description of Station Quotients (SQs). For clarity of interpretation, station shares (including the 400m and 800m bands) with "NA" means the change in the BRT county and/or in the band was negative.

Workers Living in BRT Station Areas who Work from Home

The role of working from home notes special discussion. For people working from home, access to transit may be attractive if it connects them to shopping, services, and leisure as well as access to airports and long-distance trains. This is one reason why demand for BRT station accessibility may increase in the future even if new residents do not use transit in their commute to work. Indeed, in the post-pandemic world, working from home has become much more prevalent than before, although perhaps not to the degree it was during the pandemic (Peiser and Hugel 2022). Accordingly, the SQs for working from home are likely smaller before the pandemic than going forward afterward. This is clearly an area in need of research in the post-pandemic era. Nonetheless, working from home increased by 20 percent, 23 percent, and 18 percent overall and for the pre-2010 and 2010-2019 BRT groups, respectively. The station area SQs were very similar at 1.03, 1.02, and 1.03, respectively.

Workers Living in BRT Station Areas who use Transit or Walk or Bike to Work, or who Work from Home

The last part of Exhibit 12 aggregates the use of transit or walking or biking in the commute to work or working from home. All BRT systems combined saw an increase in these modes of 29 percent overall during the study period with 25 percent for the pre-2010 group and 32 percent for the 2010-2019 group. However, while the SQs for all systems during the study period was 1.02 and for the 2010-2019 group it was 1.05, for the pre-2010 group it was 0.97. The 2010-2019 BRT group thus resulted in a higher proportion of these modes compared to BRT counties than the pre-2010 group.

The association between BRT station proximity and office, retail, and multifamily rent is addressed next. This is followed by implications for the role of BRT in advancing development.

Transit Station Proximity and Office, Retail, and Multifamily Rents

The last analytic section addresses the extent to which the real estate market values proximity to BRT stations. CoStar commercial rent data are used for analysis. As will be shown, there is considerable variation in the influence of BRT station proximity for each real estate type evaluated. An overall picture emerges to help guide post-pandemic transit and land use planning.

In review, the principal research question is:

> Is there an association between commercial real estate rent (per square meter) and proximity to BRT stations holding other factors constant?

But this question is nuanced as follows:

> If there is an association, is there evidence of negative externality or amenity effects with respect to BRT station proximity?

The research design, hypothesis, data, and analytic method is presented next. This is followed by results and interpretations, and then implications form post-pandemic transit and land use planning.

Research Design, Hypothesis, Data, and Analytic Method

The research questions lend themselves to cross-section analysis that compare changes in real estate rent with respect to BRT station proximity overall and by individual systems. The null hypothesis posits no relationship. However, two outcomes can be revealed, both of which are consistent with theory. The accessibility theory noted earlier would result in a downward sloping rent gradient away from BRT stations because as distance increases, accessibility is reduced. On the other hand, if BRT stations themselves are sources of externalities such as noise, congestion, unattractive urban design and so forth, there would be an upward sloping rent gradient away from stations thereby offsetting the accessibility rent premium. At some point away from BRT stations, the accessibility premium is expected to overcome externality effects (Nelson and McClesky 1990, Nelson 1992). Before that inflection point, however, both outcomes would be consistent with accessibility and externality theories.

The analysis requires data about real estate value. Many studies reviewed earlier used local property tax assessor data mostly for sales or assessed value of single-family residential property. This land use is popular because the number of cases is usually large. However, when evaluating BRT systems in several states where the efficacy of assessor data varies because of state and local regulations as well as data quality, other data are needed. For instance, to get around this limitation in their cross-section analysis of the association between BRT station proximity and single-family home values, Acton, Le and Miller (2022) used CoreLogic home sales data before and after the inauguration of the 15 BRT systems. Their study was limited to sales of single-family homes within or beyond 800 meters (about 0.50-mile) of BRT stations, however.

BRT station areas are often comprised of multiple land uses such as offices, retail operations, and multifamily projects. Unfortunately, there are no large-scale cross-section analyses of the relationship between different types of real estate and BRT station proximity.

This study overcomes limitations of prior work through a national-scale, cross-section analysis of the association between real estate rents for three common types of real estate—office, retail, and residential—and BRT station proximity using fine-grained buffers of 100 meters to 800 meters from stations. The 100-meter buffer is roughly comparable to standard city block widths. It overcomes limitations of continuous functional form approaches such as linear, log, inverse, quadratic models because they mask important interactions between proximity and value close to transit stations. The 100-meter band approach can reveal associations in roughly the first city block around BRT stations and every successive city block outward.

The analysis reported in this article uses CoStar commercial rent data. CoStar is the nation's largest centralized source of commercial real estate data.[18] CoStar rent data are used for office, retail, and multifamily residential rent for 2019, which was the year before the COVID-19 pandemic. CoStar's rent data are converted into dollars per square meter per year.

Rent data are preferred over sales data for two reasons. First, there are many more rent cases than sale cases thus increasing sample size. For instance, whereas there are 71,773 BRT rent cases in this study, analysis using just CoStar sales would include fewer than 3,000 cases. The large number of rent cases thus increases confidence in outcomes and allows for more fine-grained analysis of each system. Second, rent is a better indicator of current market conditions than sales because rent data reflect local economic conditions at the time, not conditions years or decades earlier when properties were sold.

The result is that this study is the nation's largest, most complete assessment of the relationship between BRT station proximity and office, retail, and multifamily residential property values in terms of rent.

Multivariate ordinary least squares analysis is used to tease out the influence of BRT station proximity on office, retail, and multifamily rent per square meter from among various features of properties. Using theoretical and research design foundations reviewed earlier as a guide, the following general model is developed for empirical application (adapted from Nelson 2017).

[18] See https://www.costargroup.com/.

$$\mathbf{R}_{\boldsymbol{i}} = \boldsymbol{f}\,(\mathbf{S}_{\boldsymbol{i}}, \mathbf{SES}_{\boldsymbol{i}}, \mathbf{LU}_{\boldsymbol{i}}, \mathbf{C}_{\boldsymbol{i}}, \mathbf{M}_{\boldsymbol{i}}, \mathbf{DB}_{\boldsymbol{i}}) \qquad (1)$$

Where:

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

S is the set of structural attributes of property *i*;

SES is the set of socioeconomic characteristics of the vicinity of property *i*;

LU is the land use mix of the block group within which property *I* is located;

C is a set of centrality attributes of property *i* in this case being distance to the central business district (CBD) and nearest freeway/expressway ramps;

M is the metropolitan area within which property *i* is located—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; and

DB is the distance band in units of 100 meters of property *i* to a transit station.

Dependent Variable

R is the ***Asking Rent per Square Meter***. The study includes the universe of all office, retail, and multifamily properties from which all data are available as reported by CoStar. As CoStar data come from real estate brokerages participating in its network, its data exclude non-participating brokerages or entities that own properties not for rent such as owner-occupied properties. By logging the dependent variable, the semi-log model allows for coefficients to be interpreted as the percent change in rent attributable to a one-unit change in an independent variable such as an individual 100-meter distance band (Statistical Data Services 2018).

Control Variables

S is the bundle of structure and lease restriction attributes for property *i* reported by CoStar including:

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

Effective Year Built which is the latter year of construction or year of renovation as reported by CoStar with the expectation that newer buildings will command higher rent than older ones.

Vacancy Rate as reported by CoStar with the expectation that the higher the vacancy rates 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*** includes with the expectation that the taller the building the higher the mean rent.

For office real estate, this includes ***Class A*** and ***Class B*** office space which are considered the highest and next highest quality in the office market, commanding rents accordingly. ***Class C*** office space is the referent.

For retail real estate, this includes ***Regional/Community Mall***, ***Power Center***, ***Lifestyle Center***, ***Strip Retail***, and ***General Retail*** as defined by CoStar with the referent being all other retail property.

For multifamily real estate, this includes ***Subsidized*** units such as Section 8 rental vouchers and Low-Income Housing Tax Credit units among others, and ***Restricted*** units such as those for students or persons 55 years of age and older, among others. While one may assume *a priori* that subsidized and restricted units rent for less than market rate units, because the unit of measure is rent per square meter it is conceivable that these units rent for more per square meter than market rate units even if the units themselves rent for less. Accordingly, signs of association cannot be predicted.

The **SES** dimension is comprised of ***Median Household Income*** from the five-year sample of the 2019 American Community Survey (ACS) for the block group within which a CoStar property is located. A positive association is expected with respect to rent (Xiao 2016).

LU is an index of the land-use mix in the block group within which property *i* is located such as the nature of surrounding land uses, street characteristics, and related. This variable is based on work by Ewing and Hamidi (2018) who devised an index comprised of land use and transportation features. The higher the index score, the greater the mix. Higher rents should result because of efficiencies gained in the interaction between land uses. However, if LU mix is associated with congestion, poor urban design and other externalities, a negative association will be revealed. Both directions of association are thus possible (see also Nelson and Hibberd 2021).

Two variables comprise the **C** dimension: distance from the 100 percent corner[19] of the central business district (***CBD***) in meters and distance from the nearest ***Freeway*** ramp also in meters. Both are computed from geographic information systems. Negative associations between rent and CBD and Freeway proximity are expected.

The **M** dimension is comprised of the individual metropolitan areas within which the BRT stations are located. As these are controls which account for idiosyncrasies of metropolitan markets, no direction of associations is predicted.

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[19] For a review of this concept, see https://en.wikipedia.org/wiki/100_percent_corner.

DB is a proxy measure for functional form based on 100-meter distance bands from BRT stations. It is preferred over other functional forms because it gives planners direct information on the extent to which the real estate market responds to transit station proximity in relatively fine-grained distance units. As noted earlier, the alternative linear, semi-log, doble-log, quadratic and other functional forms do not generate the kind of insights planners need to choreograph land uses and infrastructure investment proximate to transit stations. While some studies use distance bands as well, they are usually limited to 0.25- or 0.50-mile distance (400 or 800-meter) bands or occasionally both. But that assumes all relevant interactions which are useful for planners occur only within those large distance bands (Higgins and Kanaroglou 2016; Nelson 2017). The 100-meter distance band approach also allows for fine-grained tests of statistical significance for each distance band separately. Building on prior work by Nelson and Hibberd (2019) and Nelson et al. (2021), the 100-meter distance band approach extends to 800 meters or equivalent to the half-mile circle (Guerra, Cervero, and Tischler 2012). As a reminder, the 100-meter band is equivalent roughly to a typical city block width, although there are variations.

Exhibit 13 summarizes the control and treatment variables, sources of data, measures, and predicted signs.

The database used in this analysis is comprised of nearly 72,000 cases making it the largest cross-section analysis of the association between real estate value and BRT station proximity reported in the literature.

Results and interpretations come next.

Results and Interpretations

Overall results based on the total samples are reported in Exhibit 14 for commercial real estate, Exhibit 16 for retail real estate, and Exhibit 18 for multifamily real estate. Results focusing only on BRT station distance and performance outcomes for specific systems are reported in Exhibits 15, 17, and 19 for those real estate types, respectively.

Although there are no *a priori* expectations of goodness of fit outcomes, literature suggests that ordinary least squares regression analysis usually explains about one fifth to two-thirds of the dependent variable variation with respect to the control and treatment variables. Note that while some analysts are preoccupied with achieving high level regression model coefficients of determination (R^2), too many variables can lead to over-specification. It is best to emphasize that the variables most relevant to the question, along with relevant controls, are sufficient to avoid serious omitted variable bias (a form of endogeneity) in the model.

Because the direction of association with respect to metropolitan controls is not predicted, significance-test outcomes are not reported for them. For other variables where significance is $p < 0.10$ of the one-tailed t-test (because directions of association are predicted), coefficients are highlighted in bold. The bottom of the exhibits reports metrics for mean rent per square meter (“m^2”), the number of cases for each regression, the adjusted coefficient of determination (“R^2”), the standard error of estimate, the F-Ratio, and the mean rent per square meter for the study area.

Exhibit 13
Variables, Data Sources, Measurement Type, and Predicted Associations with Respect to Rent per Square Meter

Variable	Data Source	Measure	Predicted Sign
Dependent Variable			
Rent			
Rent per Square Meter (logged)	CoStar	Continuous	NA
Control Variables			
Structure Controls			
Gross Leasable Area ($100m^2$)	CoStar	Continuous	+
Mean Unit Size ($100m^2$), Multifamily	CoStar	Continuous	-
Stories	CoStar	Continuous	+
Effective Year Built	CoStar	Continuous	+
Vacancy Rate	CoStar	Continuous	+/- *See text*
Structure Controls—Office			
Class A Office	CoStar	Binary	+
Class B Office	CoStar	Binary	+
Class C Office	CoStar	Binary	Referent
Structure Controls—Retail			
Regional/Community Mall	CoStar	Binary	NA
Power Center	CoStar	Binary	NA
Lifestyle Center	CoStar	Binary	NA
Strip Retail	CoStar	Binary	NA
Retail General	CoStar	Binary	NA
All Other Retail	CoStar	Binary	Referent
Structure Controls—Multifamily			
Subsidized	CoStar	Binary	NA
Restricted	CoStar	Binary	NA
All Other Multifamily	CoStar	Binary	Referent
Socioeconomic Control			
Median Household (HH) Income	Census ACS	Continuous	+
Land Use Control			
Land-Use Mix Index	Computed	Continuous	+/- *See text*
Centrality Control			
Distance from CBD	Computed	Continuous	-
Distance from Freeway Ramp	Computed	Continuous	-

Exhibit 13
Variables, Data Sources, Measurement Type, and Predicted Associations with Respect to Rent per Square Meter—continued

Variable	Data Source	Measure	Predicted Sign
Metropolitan Control			
Metropolitan Area Location	Census	Binary	NA
Norfolk excluded from LRT*	Census	Binary	Referent
Tacoma excluded from SCT*	Census	Binary	Referent
Eugene-Springfield excl. from BRT*	Census	Binary	Referent
Portland excluded from CRT*	Census	Binary	Referent
TREATMENT VARIABLES			
Station Distance Band Treatment			
0-100m	Computed	Binary	+/- *See text*
>100m-200m	Computed	Binary	+/- *See text*
>200m-300m	Computed	Binary	+/- *See text*
>300m-400m	Computed	Binary	+/- *See text*
>400m-500m	Computed	Binary	+/- *See text*
>500m-600m	Computed	Binary	+/- *See text*
>600m-700m	Computed	Binary	+/- *See text*
>700m-800m	Computed	Binary	+/- *See text*
Beyond 800 meters	Computed	Binary	Referent

*These systems were selected as referents because they are the smallest of their modes in terms of passenger miles.
Comment: NA means no direction of association is predicted—see text for discussion; "m" means meters and m^2 means square meters; HH means households; LRT means light rail transit; BRT means bus rapid transit; SCT means streetcar transit; and CRT means commuter rail transit.

The bottom of the following exhibits labels two revealed directions of association of rents with respect to BRT station distance bands. The first reports whether there is a significant coefficient for the first 100-meter station band and if so where it is "positive" or "negative."

The second reports the functional form revealed across the first four 100-meter distance bands. The rules for this determination are: (1) there are at least two significant coefficients and (2) at least one of them is for the first or second distance bands. Consistent with theoretical outcomes described earlier and where coefficients meet the rules noted above, there are four functional form choices:

- "Downward" with respect to distance from transit stations thus revealing that accessibility value dominates because value falls as BRT distance increases.

- "Upward" with respect to distance from transit stations thus revealing that externality value dominates because value rises as BRT distance increases.

- "Concave" where the slope starts downward from the station then goes upward after an inflection point revealing accessibility value prevails over externality value beyond the inflection point.

- "Convex" where the slope starts upward from the station and then goes downward after an inflection point revealing externality value prevails over accessibility value beyond the inflection point.

Results and interpretations for office, retail, and multifamily rents with respect to BRT station proximity are presented next.

Results and Interpretations for Office Rents

Overall results for office rents with respect to BRT station proximity reveal modest associations. Controlling for all other influences, rent increases by 2.6 percent above the mean within the first 100 meters of a BRT station and then rises to 17.2 percent in the next 100 meters. Proximity effects are then either ambiguous or small percentages.

Except for the San Jose BRT system, the 12 significant BRT office rent premiums are split evenly between positive and negative associations at the station band. Only the San Antonio and San Jose BRT systems have positive, significant coefficients to at least the fifth distance band although three of the first four distance band coefficients for Kansas City are also positive. Notably. San Jose's coefficients reveal about a 22 percent premium at the station band rising to 68 percent in the second and still averaging about 20 percent through the rest of the distance bands. This outcome may be explained by a combination of Silicon Valley's land constraints and urban planning efforts to encourage office development near BRT stations.

Only the significant coefficients at the station band for Salt Lake City and Seattle are negative, meaning that rents fall as BRT station distance increases—which is consistent with standard urban economic theory. Otherwise, significant coefficients at the station band and usually those beyond are positive, meaning that rents rise with respect to BRT station distance. In effect, externalities at or near BRT stations exist and thus push rents downward. Planning, urban design, or other interventions may be needed to make BRT station proximity attractive and not repulsive.

Results overall and for specific modes and systems are quite different with respect to retail rent outcomes, as will be seen next.

Results and Interpretations for Retail Rents

As seen in exhibits 16 and 17, retail rents are positive across nearly all distance bands for BRT systems. Among the pool of all BRT systems, retail rent premiums start at 2.4 percent in the first 100-meter distance band, rise to 7.1 percent in the second 100-meter band, and remain elevated across most of the rest distance bands to 800 meters.

On the other hand, nine of the individual BRT systems had no significant coefficients at the station band and only San Antonio had positive coefficients from the station band outward through all eight bands to 800 meters, albeit all with single-digit premiums.

A key finding overall from this research is that it is rare for retail real estate to value BRT station proximity. But it also may be that transit and land use planners have not facilitated retail opportunities near BRT stations in a way that responds to market opportunities.

Results and Interpretations for Multifamily Rents

Exhibit 18 shows that, overall, BRT's impact on multifamily rents is not significant near BRT stations, but where coefficients are significant farther away, the impact is negative. It would seem that the multifamily real estate market does not value proximity to BRT stations. On the other hand, it may be that BRT accessibility and externality values offset each other near stations. This is plausible considering that BRT routes tend to be along busy commercial corridors impacted by noise, heavy traffic, and lower-valued real estate.

But there is another interpretation: since there is no association between multifamily rents and BRT station proximity, this may indicate reduced gentrification pressure for lack of demand among younger and higher earning households. Such an outcome would be consistent with demographic findings for BRT station proximity presented above as well as research by Qi (2023).

Specifically, of the 15 BRT systems in the study, Exhibit 19 shows that six have significant coefficients at the station band which are split evenly between positive and negative. Only Cleveland and Kansas City have multiple, positive coefficients among the first four distance bands. Notably, both those systems connect downtowns to major regional centers such as universities, medical centers, conference facilities and mixed-use complexes. None of the other BRT systems in the study served such a mix of major activity nodes.

Insights from the influence of BRT station proximity on real estate rents are offered next.

Exhibit 14. Variation in Office Rents Total Sample with Respect to BRT Station Proximity

BRT Variables	BRT Beta
Constant	**1.709**
Structure Controls	
GLA (1000 m2)	**4.484E-008**
Class A	**0.317**
Class B	**0.096**
Stories	**0.006**
Effective Year Built	**0.001**
Vacancy	**-0.001**
Socioeconomic Control	
Med. HH Inc ($1000)	**1.751E-006**
Land-Use Control	
Land Use Mix	**0.028**
Centrality Controls	
CBD (m)	**-7.439E-007**
Freeway (m)	**-1.403E-006**
Metropolitan Controls	
Albuquerque	-0.237
Arlington-Alexandria	0.461
Cleveland	-0.180
Eugene-Springfield	-0.001
Kansas City	-0.070
Minneapolis-St. Paul	0.097
Nashville	0.235
Pittsburgh	-0.146
Reno	-0.011
Salt Lake City	-0.049
San Antonio	0.195
San Diego	0.346
San Jose	0.771
Seattle	0.373

Exhibit 14. Variation in Office Rents Total Sample with Respect to BRT Station Proximity—continued

BRT Variables	BRT Beta
Station Distance Band Treatment	
0-100m	**0.026**
>100m-200m	**0.172**
>200m-300m	-0.006
>300m-400m	**0.036**
>400m-500m	0.003
>500m-600m	**0.012**
>600m-700m	**0.019**
>700m-800m	**0.030**
Performance Metrics	
R^2	0.663
Standard error	0.240
F-ratio	2354.390
Cases	38,355
Mean Rent/ m^2/year	$266.24
Station Sign	***Positive***
Functional Form	***Concave***

Comments: "GLA" means gross leasable area; "Med. HH Inc." means median household income; "BRT" means bus rapid transit; "m" means meter while "m^2" means square meter; bold coefficients mean $p < 0.10$ for relevant variables (see text).

Exhibit 15. Office Rent with Respect to Bus Rapid Transit Station Proximity

Variable	All	AA	ABQ	CLE	ESP	KC	MSP	NSH	PIT	RNO	SLC	SA	SD	SJ	SEA	STK
Station Distance																
0-100m	**0.026**	**0.003**	**0.071**	**0.030**	0.017	**0.097**	**-0.136**	**-0.065**	-0.009	0.005	**-0.090**	**0.056**	**-0.071**	**0.218**	**-0.010**	**-0.054**
>100m-200m	**0.172**	0.049	0.081	**0.079**	**-0.218**	**-0.083**	**-0.200**	**-0.088**	**-0.033**	**0.058**		**0.113**	**-0.015**	**0.681**	**0.041**	-0.041
>200m-300m	-0.006	-0.005	**0.138**		0.065	**0.156**	**-0.116**	-0.005	**0.065**	**0.138**		**0.030**	-0.001	**0.083**	**-0.042**	-0.047
>300m-400m	**0.036**	0.051	**0.076**	**0.073**	**0.076**	**0.033**	-0.005	**-0.090**	**-0.189**	0.017	0.107	**0.064**	0.049	**0.312**	**-0.059**	**0.151**
>400m-500m	0.003	-0.010	-0.111	**0.081**		0.008	-0.033	**-0.065**	**-0.044**	**0.084**		**0.056**	0.030	**0.231**	-0.006	0.002
>500m-600m	**0.012**	-0.015	**0.938**	0.022	0.037	**0.128**	-0.098	-0.025	**0.048**	**0.129**	0.057	0.021	0.018	**0.115**	-0.004	
>600m-700m	**0.019**	0.027	**0.169**	**0.239**	0.004	**0.195**	**-0.212**	**0.095**	**0.057**	**0.201**	0.114	0.021	**0.111**	**0.148**	**-0.067**	-0.013
>700m-800m	**0.030**	0.044	-0.069	**0.127**	0.087	**0.059**	**-0.120**	**-0.378**	**-0.050**	0.072	0.115	0.018	-0.025	**0.147**	**0.028**	-0.063
Performance																
R^2	0.663	0.187	0.000	0.301	0.207	0.315	0.104	0.442	0.470	0.324	0.267	0.129	0.000	0.441	0.452	0.345
Error	0.240	0.187	0.000	0.183	0.151	0.169	0.253	0.187	0.193	0.168	0.212	0.192	0.000	0.289	0.199	0.203
F-ratio	2354.390	13.421	12.549	61.858	6.305	48.298	22.175	117.447	119.932	34.758	55.095	26.475	125.165	184.143	255.450	18.317
Cases	38,355	867	813	2404	346	1849	3291	2644	2418	1266	2232	3087	4060	4179	5560	559
Rent/m2/year	$266.24	$351.03	$159.52	$165.34	$196.57	$183.88	$227.26	$254.92	$177.85	$198.80	$197.10	$190.83	$295.73	$517.66	$307.83	$186.23
Station Sign	***Positive***	***Positive***	***Positive***	***Positive***		***Positive***	***Negative***	***Negative***			***Negative***	***Positive***	***Negative***	***Positive***	***Negative***	***Negative***
Functional Form	***Upward***		***Upward***	***Upward***	***Upward***	***Concave***	***Concave***	***Down***	***Convex***	***Upward***		***Convex***	***Upward***	***Concave***	***Concave***	***Upward***

Comments: See Exhibit 3 for BRT abbreviation names. Bold coefficients mean $p < 0.10$ for relevant variables (see text). By multiplying by 100, significant coefficients can be interpreted as higher or lower rents per square meter as a percent of the mean. "Station Sign" refers only to significant coefficients that are either ***Positive***, meaning that rents are higher than the mean at the station, or ***Negativ***e, meaning rents are lower than the mean at the stations. "Functional Form" is the shape of association based on at least two significant coefficients among the closest four to the transit station where at least one is first or second closets distance bands. ***Upward*** means upward sloping significant coefficients revealing externality value exceeds accessibility value close to transit stations. ***Down*** means downward sloping significant coefficients from the first distance band revealing accessibility value exceeds externality value close to transit stations. ***Convex*** means upward sloping significant coefficients from the first station band to an inflection point after which significant coefficients are downward sloping revealing accessibility value exceeds externality value beyond the inflection point. ***Concave*** means downward sloping significant coefficients from the first station band to an inflection point after which significant coefficients are upward sloping revealing accessibility value exceeds externality values to the inflection point after which externality value exceeds accessibility value. Blank entries in station distance cells means there were insufficient cases. No functional form noted means there is an ambiguous, non-significant association between rent and transit station proximity revealed within the distance bands used for this determination as noted above.

Exhibit 16. Variation in Retail Rents Total Sample with Respect to BRT Station Proximity

BRT Variables	BRT Beta
Constant	**2.214**
Structure Controls	
GLA (1000 m2)	**-4.990E-003**
Reg/Com Mall	**0.247**
Power Center	**-0.055**
Lifestyle Center	**-0.017**
Strip Retail	**-0.055**
Retail General	**-0.017**
Effective Year Built	**0.000**
Vacancy Rate	**0.000**
Socioeconomic Control	
Med. HH Inc ($1000)	**2.639E-003**
Land-Use Control	
Land Use Mix	**0.063**
Centrality Controls	
CBD (m)	**0.130**
Freeway (m)	**0.251**
Metropolitan Controls	
Albuquerque	-0.515
Cleveland	-0.578
Eugene-Springfield	-0.241
Kansas City	-0.537
Minneapolis-St. Paul	-0.356
Nashville	-0.18
Pittsburgh	-0.468
Reno	-0.335
Salt Lake City	-0.309
San Antonio	-0.218
San Diego	0.096
San Jose	0.255

Exhibit 16. Variation in Retail Rents Total Sample with Respect to BRT Station Proximity—continued

BRT Variables	BRT Beta
Station Distance Band Treatment	
0-100m	**0.024**
>100m-200m	**0.071**
>200m-300m	**0.045**
>300m-400m	**0.095**
>400m-500m	**0.028**
>500m-600m	**0.072**
>600m-700m	0.023
>700m-800m	**0.039**
Performance Metrics	
R^2	0.293
Standard Error	0.282
F-ratio	203.174
Cases	17,627
Mean Rent/m2/year	$194.06
Station Sign	***Positive***
Functional Form	***Convex***

Comments: "GLA" means gross leasable area; "Med. HH Inc." means median household income; "BRT" means bus rapid transit; "m" means meter while "m^2" means square meter; bold coefficients mean $p < 0.10$ for relevant variables (see text).

Exhibit17. Retail Rent with Respect to Bus Rapid Transit Station Proximity

Variable	All	ABQ	CLE	ESP	KC	MSP	NSH	PIT	RNO	SLC	SA	SD	SJ	SEA
Station Distance														
0-100m	**0.024**	0.005	**0.385**	-0.784	0.087	**-0.214**	-0.056	-0.037	0.075	-0.083	**0.076**	-0.126	0.158	**-0.098**
>100m-200m	**0.071**	0.028	0.155	-0.016	**0.201**	**0.338**	0.100	-0.057	0.093	**-0.291**	**0.083**	-0.001	0.065	0.086
>200m-300m	**0.045**	-0.029	-0.021	0.126	0.039		0.051	**0.433**	0.276	-0.194	**0.054**	0.084	**0.236**	0.024
>300m-400m	**0.095**	-0.027	0.008	0.420	0.284	**0.369**	**-0.296**	**0.324**	0.100	-0.294	**0.087**	0.399	0.285	**0.206**
>400m-500m	**0.028**	-0.009	**0.713**		**0.206**		-0.159		-0.168	0.027	**0.030**	**0.303**	0.012	0.185
>500m-600m	**0.072**	0.004		0.285	**0.356**	**1.051**	-0.112	**0.182**	0.198		**0.078**	0.036	0.177	0.176
>600m-700m	0.023	0.000	-0.280		0.087	-0.139	-0.015	-0.092	0.198	-0.349	**0.046**	-0.099	**0.673**	-0.093
>700m-800m	**0.039**	**0.106**	**-0.382**	-0.243	0.239	**-0.466**	0.063	0.169	-0.143	**0.617**	**0.044**	-0.004	**0.314**	-0.103
Performance														
R^2	0.293	0.047	0.116	0.107	0.152	0.079	0.211	0.251	0.140	0.163	0.157	0.125	0.101	0.208
Error	0.282	0.226	0.362	0.548	0.319	0.280	0.450	0.393	0.564	0.389	0.231	0.430	0.466	0.403
F-ratio	203.174	3.811	3.028	0.776	3.398	9.440	2.904	5.557	2.033	4.373	96.542	4.268	2.601	6.618
Cases	17,627	1,080	295	38	256	1680	136	260	122	331	10,241	459	285	430
Rent/m2/year	$0.00	$143.04	$140.51	$206.97	$144.15	$171.92	$227.86	$167.29	$211.85	$193.04	$190.83	$292.73	$376.47	$270.53
Station Sign	*Positive*		*Positive*			*Negative*					*Positive*			*Negative*
Functional Form	*Convex*					*Upward*					*Convex*			*Upward*

Comments: See Exhibit 3 for BRT abbreviation names. Because the COVID-19 pandemic occurred when Alexandria-Arlington and Stockton BRT retail data were to be collected, they are excluded from analysis. Bold coefficients mean $p < 0.10$ for relevant variables (see text). By multiplying by 100, significant coefficients can be interpreted as higher or lower rents per square meter as a percent of the mean. "Station Sign" refers only to significant coefficients that are either ***Positive***, meaning that rents are higher than the mean at the station, or ***Negativ***e, meaning rents are lower than the mean at the stations. "Functional Form" is the shape of association based on at least two significant coefficients among the closest four to the transit station where at least one is first or second closets distance bands. ***Upward*** means upward sloping significant coefficients revealing externality value exceeds accessibility value close to transit stations. ***Down*** means downward sloping significant coefficients from the first distance band revealing accessibility value exceeds externality value close to transit stations. ***Convex*** means upward sloping significant coefficients from the first station band to an inflection point after which significant coefficients are downward sloping revealing accessibility value exceeds externality value beyond the inflection point. ***Concave*** means downward sloping significant coefficients from the first station band to an inflection point after which significant coefficients are upward sloping revealing accessibility value exceeds externality values to the inflection point after which externality value exceeds accessibility value. Blank entries in station distance cells means there were insufficient cases. No functional form noted means there is an ambiguous, non-significant association between rent and transit station proximity revealed within the distance bands used for this determination as noted above.

Exhibit 18. Variation in Multifamily Rents Total Sample with Respect to BRT Station Proximity

BRT Variables	BRT Beta
Constant	**-3.452**
Structure Controls	
GLA (1000 m2)	**3.309E-007**
Stories	**-0.001**
Average Unit Size	**0.002**
Subsidized	**0.025**
Restricted	**0.005**
Effective Year Built	**-0.113**
Vacancy Rate	**-0.244**
Socioeconomic Control	
Med. HH Inc ($1000)	**2.703E-006**
Land-Use Control	
Land Use Mix	**0.080**
Centrality Controls	
CBD (m)	**-8.871E-007**
Freeway (m)	**-3.370E-006**
Metropolitan Controls	
Albuquerque	-0.477
Arlington-Alexandria	0.110
Cleveland	-0.451
Eugene-Springfield	-0.312
Kansas City	-0.462
Minneapolis-St. Paul	-0.207
Nashville	-0.251
Pittsburgh	-0.314
Reno	-0.314
Salt Lake City	-0.322
San Antonio	-0.379
San Diego	0.133
San Jose	0.326
Seattle	0.076

Exhibit 18. Variation in Multifamily Rents Total Sample with Respect to BRT Station Proximity—continued

BRT Variables	BRT Beta
Station Distance Band Treatment	
0-100m	-0.016
>100m-200m	-0.009
>200m-300m	-0.028
>300m-400m	**-0.021**
>400m-500m	-0.004
>500m-600m	**-0.025**
>600m-700m	**0.044**
>700m-800m	0.012
Performance Metrics	
R^2	0.545
Standard Error	0.303
F-ratio	575.118
Cases	15,791
Mean Rent m2/year	$222.39
Station Sign	*Ambiguous*
Functional Form	*Ambiguous*

Comments: "GLA" means gross leasable area; "Med. HH Inc." means median household income; "BRT" means bus rapid transit; "m" means meter while "m^2" means square meter; bold coefficients mean $p < 0.10$ for relevant variables (see text).

Exhibit 19. Multifamily Rent with Respect to Bus Rapid Transit Station Proximity

Variable	All	AA	ABQ	CLE	ESP	KC	MSP	NSH	PIT	RNO	SLC	SA	SD	SJ	SEA	STK
Station Distance																
0-100m	-0.016	-0.005	-0.141	**0.224**	-0.126	**0.096**	-0.049	-0.008	-0.022	-0.039	-0.024	**0.118**	**-0.063**	**-0.146**	**-0.040**	NA
>100m-200m	-0.009	-0.094	0.027	**0.222**	**-0.223**	**0.124**	0.008	0.019	-0.005	-0.085	0.123	**-0.050**	0.010	0.010	**-0.055**	0.139
>200m-300m	-0.028	-0.053	0.053	**0.119**	-0.001	**0.119**	-0.050	0.001	0.030	0.012	-0.156	-0.011	**-0.046**	-0.018	**-0.086**	0.197
>300m-400m	**-0.021**	**0.440**	**-0.064**	0.052	0.050	**0.172**	-0.068	0.017	0.025	0.040	-0.091	-0.034	**-0.064**	-0.052	**-0.056**	-0.302
>400m-500m	-0.004	-0.002	**-0.104**	0.020	0.096	**0.190**	-0.043	-0.040	0.089	-0.072	**-0.176**	0.046	-0.002	0.027	-0.013	**-0.530**
>500m-600m	**-0.025**	-0.304	-0.019	**0.137**	0.099	**0.230**	-0.018	0.023	**-0.150**	0.020	-0.047	0.032	**-0.085**	**0.146**	**-0.042**	-0.373
>600m-700m	**0.044**	**4.593**	-0.021	**0.594**	-0.143	**0.136**	-0.052	0.005	**0.274**	**0.120**	-0.058	0.003	**-0.060**	0.032	0.002	-0.055
>700m-800m	0.012	0.076	**-0.071**	0.051	0.166	**0.270**	-0.010	0.032	-0.017	-0.049	-0.043	-0.008	-0.023	0.071	-0.026	0.594
Performance																
R^2	0.545	0.316	0.460	0.337	0.316	0.454	0.344	0.572	0.359	0.492	0.387	0.412	0.350	0.319	0.507	0.041
Error	0.303261495	0.468	0.188	0.245	0.302	0.236	0.214	0.229	0.277	0.216	0.211	0.173	0.259	0.311	0.267	1.032
F-ratio	575.118	7.310	16.700	25.024	5.057	25.632	61.707	32.560	24.720	16.833	16.281	32.317	100.603	44.800	160.722	1.656
Cases	15791	233	351	900	168	563	2200	450	806	312	461	850	3515	1778	2955	249
Rent/m2/year	$222.39	$134.71	$129.41	$130.10	$148.37	$126.33	$167.14	$166.09	$160.38	$148.72	$146.37	$146.63	$228.16	$313.79	$247.99	$199.72
Station Sign				*Positive*		*Positive*						*Positive*	*Negative*	*Negative*	*Negative*	
Functional Form				*Down*		*Upward*						*Down*	*Convex*		*Convex*	

Comments: See Exhibit 3 for BRT abbreviation names. Bold coefficients mean $p < 0.10$ for relevant variables (see text). By multiplying by 100, significant coefficients can be interpreted as higher or lower rents per square meter as a percent of the mean. “Station Sign” refers only to significant coefficients that are either ***Positive***, meaning that rents are higher than the mean at the station, or ***Negativ***e, meaning rents are lower than the mean at the stations. “Functional Form” is the shape of association based on at least two significant coefficients among the closest four to the transit station where at least one is first or second closets distance bands. ***Upward*** means upward sloping significant coefficients revealing externality value exceeds accessibility value close to transit stations. ***Down*** means downward sloping significant coefficients from the first distance band revealing accessibility value exceeds externality value close to transit stations. ***Convex*** means upward sloping significant coefficients from the first station band to an inflection point after which significant coefficients are downward sloping revealing accessibility value exceeds externality value beyond the inflection point. ***Concave*** means downward sloping significant coefficients from the first station band to an inflection point after which significant coefficients are upward sloping revealing accessibility value exceeds externality values to the inflection point after which externality value exceeds accessibility value. Blank entries in station distance cells means there were insufficient cases. No functional form noted means there is an ambiguous, non-significant association between rent and transit station proximity revealed within the distance bands used for this determination as noted above. “NA” means there are no cases in the distance band.

Insights From Rent Analyses

Regression results are mostly disappointing. In theory, BRT stations must influence real estate markets by increasing the value of real estate nearby. However, except for office development near most transit stations in the study, BRT stations do not appear to be positive attractors of retail or multifamily development. Instead, negative or ambiguous results suggest the market is responding in undesirable ways that need to be overcome by mitigating externalities (see Nelson and McClesky 1990). In particular, since post-pandemic office demand is unlikely to return to pre-pandemic levels over the next several years (Peiser and Hugel 2022), planners and policymakers may no longer be able to depend on meeting the demand for offices as a reason for making new BRT investments. Something else is needed.

Results for multifamily rent are especially disappointing. This seems incongruous with results reported earlier showing substantial population and household growth near BRT stations, because growth near BRT stations should affect rent premiums. On the other hand, such growth was not associated with significantly higher incomes, which could help explain the lack of multifamily rent premiums with respect to BRT station proximity.

Despite disappointing results, there are lessons to be learned based on the outcomes associated with individual BRT systems. For instance, the San Antonio BRT system is unique in conferring positive rent results on retail real estate across the entire 800-meter study area. Planners might study how that city's BRT planning and urban design led to this outcome. Likewise, given their positive BRT outcomes with respect to multifamily rent premiums, systems in Cleveland and Kansas City should be studied.

SUMMARY OF FINDINGS WITH IMPLICATIONS FOR POST-PANDEMIC BRT PLANNING AND DEVELOPMENT

This concluding section summarizes key findings and offers approaches to meeting the market demand for living near transit stations while also addressing potential gentrification concerns. Concluding observations for post-pandemic BRT planning and development are also offered.

Key Findings

Overarching findings of this research are offered with respect to BRT station proximity and jobs, people and households, commuting mode, and real estate rental premiums.

Jobs

The change in jobs during the study period (2010 and 2019) was measured with respect to cumulative distance bands from BRT stations to 200 meters—called the "station band", then to 400 meters cumulatively, and finally to 800 meters cumulatively. All bands comprise the "station area". Despite the 800-meter transit station areas occupying less than one percent of their BRT counties' urbanized land area, these BRT station areas accounted for 24 percent of the job growth in their respective counties.

Overall, nearly all station bands added jobs in all economic groups. The strongest group gaining the most jobs was the office economic group, but this was before the pandemic. Future research should address the extent to which offices were more, or less, resilient during and after the pandemic than other economic groups. Surprising strength was seen in the industrial economic group. The weakest group was the educational group perhaps because it is more dependent on large areas of land that would seem to be expensive near transit stations. The arts-entertainment-recreation group was the strongest in terms of attracting more than its proportionate share of BRT county jobs but the overall job gains are small.

However, the station bands and station areas account for the smallest shares of job change over time. Indeed, despite impressive outcomes noted above, most distance bands for most economic groups lost share of jobs relative to their transit regions. One reason may be that people and households are pushing jobs outward.

People and Households

This article explored the change in demographic composition with respect to BRT station bands and station areas in terms of population generally as well as among Whites and non-Whites, households by type and age, household income, and housing tenure (own or rent).

During the study period, most BRT counties lost White residents. Among all BRT systems, non-White persons accounted for the largest share if not all the change. In BRT counties that added Whites, they tended to congregate within transit station areas at a rate disproportionate to non-Whites. Except for Cleveland, this was more the case among 2010-2019 BRT systems than pre-2010 systems. However, in absolute numbers, non-Whites accounted for overwhelming share of population change in BRT station areas.

Consistent with population change, households overall and by type grew at a faster pace within the BRT station areas compared to their counties. Recall that although jobs were added to the station areas, the share of job change was below the pace of BRT county growth overall. This finding bolsters the notion that people and households may be displacing jobs near BRT stations. One surprise is that households with children were attracted to some BRT station areas to a greater extent than their respective counties. Planners may need to consider facilitating demand for households with children as part of future BRT station planning and development.

A key indicator of gentrification is the extent to which the change in households is dominated by younger householders. Results are mixed, however because among pre-2010 BRT systems, younger householders (under 25 years of age) were added to all BRT station bands as well as overall while in 2010-2019 BRT systems the number of such households fell in the station area overall. On the other hand, both pre- and 2010-2019 BRT systems added householders between 25 and 44 years of age at 42 percent and 44 percent, respectively. Still, results among householders aged 45 to 64 are quite different with the number of such householders falling in pre-2010 BRT systems (following those BRT county trends) but rising in 2010-2019 BRT systems (also following those BRT county trends)—accounting for 53 percent of the growth in those BRT county trends.

Importantly as it is an indicator of gentrification, analysis shows that BRT station area household income did not change compared to BRT counties for nearly all BRT systems. This finding is consistent with Qi (2023) for BRT systems.

Change in housing tenure is another gentrification indicator. Overall, rental housing tenure accounted for 39 percent of the share of the change in rental homes during the study period, compared to 14 percent among owner-occupied homes.

The evidence reveals that gentrification is not widespread. The lone exception is San Jose in the heart of Silicon Valley. Nonetheless, as BRT systems mature, gentrification pressures are likely to accelerate. In their recent *Cityscape* article, Nelson and Hibberd (2024) offer approaches to anticipate and then manage gentrification pressures when they arise.

Commuting Mode Choice

Analysis shows that commuting via transit and walking or biking with respect to BRT station proximity increased at a faster pace than for BRT counties as a whole. However, even before the pandemic, the share of workers working from home increased more rapidly in BRT station areas than in BRT counties. One reason may be that for people working from home, access to transit may be attractive, especially if it connects them to shopping, services, and leisure as well as to airports and long-distance trains. Indeed, BRT station areas are usually comprised of mixed land uses within walking distance of them. For those people looking for places to work from home but want to live in a community where destinations are walkable, BRT station areas may be attractive to them. This is clearly an area in need of more research in the post-pandemic economy.

Real Estate Markets

The final analysis presented evaluates the association between office, retail, and multifamily rents with respect to BRT station proximity. This is the largest and most comprehensive analysis reported in literature.

The association between commercial rents and proximity to BRT stations is mixed and is mostly negative or ambiguous where there is no statistically significant outcome. Although office rents reveal a higher number of positive associations with respect to BRT station proximity than retail or multifamily real estate, for most BRT systems, office results are not positive. The outcomes are less impressive for multifamily property. Overall, these results call into question the efficacy of BRT station planning, location, and design to achieve desired results in the real estate market. Nonetheless, there are several exemplars among individual systems to warrant their use as models for other systems to emulate. Moreover, given the shift in office workplace dynamics after the pandemic, policymakers and planners may need to shift priorities to make transit more attractive to retail and multifamily real estate investment. This is discussed in more detail next.

The article concludes with observations moving forward in a post-pandemic world.

Concluding Observations for Post-Pandemic Transit Policy and Planning

The COVID-19 pandemic changed everything, or so it seems, especially the role of BRT systems. For the most part, BRT systems are designed mostly to carry workers to downtowns and secondary office nodes. In a post-pandemic world, reliance on offices served by transit needs to be rethought. Research reported in this article may provide some insights on this and the rationale to do so.

Consider findings by Nelson and Hibberd (2024) in *Cityscape* showing that more than half of American households want to live in walkable communities that include mobility options. Yet, only about 13 percent live in such communities (Koschinsky and Talen 2015). By one reckoning, if all new homes that were built were in walkable communities, it would take 35 years just to meet current demand, let alone future demand. Maybe the time has come to recast BRT systems to serve people primarily. But how?

Consider the BRT stop shown in Exhibit 20. Its unattractiveness is an all-too-common site. One reason may be that this BRT among scores of others nationally does not appear to prioritize attractiveness to people. BRT stations and their immediate areas need to be designed as attractive places for people such as that illustrated in Exhibit 21, which shows a BRT station area amidst an area of mixed uses.

Next, consider planning along transit corridors. Although local governments may want BRT systems to serve people this is undermined when transit corridors are over-supplied with non-residentially zoned land and undersupplied with land zoned for residential uses. One reason is that many local governments mistakenly believe non-residentially zoned land generates more property tax and other revenue than residentially zoned land. Another assumption is that people living along transit corridors will cost more to serve than the new revenues they generate, which is a myth (for example, see Ives-Dewey 2007 and Gallagher 2016). Instead, over-supplying land for non-residential land uses depresses real estate values that can lead to localized blight and further depress values in the vicinity (Schilling and Pinzón 2016). On the other hand, undersupplying land for multifamily housing along transit corridors pushes the market to meet housing needs farther away often at lower densities and at higher public costs per unit (Burchell et al. 2002), not to mention greater automobile dependence (Mattson 2020).

Perhaps local government does not know the demand for housing along transit corridors and within BRT station areas. The evidence seems compelling that the demand is substantial and unmet. For instance, despite comprising less than one percent of BRT counties, BRT station areas accounted for very large shares of the growth of all households for all age groups and household types. How many more people and households would be attracted to BRT station areas through enhanced urban design and planning?

Furthermore, it is not as if wholesale urban renewal is needed. Instead, BRT station areas and the transit corridors along which they are located have vast supplies of vacant land, under-invested buildings, and buildings that are beyond their useful life (see Nelson 2013, 2014 for details on national trends). For instance, in one study, the authors estimate that the land area comprising the half mile (roughly 800-meter) circle of all light rail transit and streetcar transit station areas in the Albuquerque, Denver, Phoenix, Salt Lake City, and Tucson metropolitan areas are comprised mostly of parking lots and aging one- and two-floor structures beyond their economic useful life (Nelson and Hibberd 2021). Much of this area has a floor area ratio of about 0.25, meaning the structure is equivalent to 25 percent of the land area while 75 percent or more of the land area is a parking lot. The authors' analysis estimated that all projected growth over a thirty-year period in those metropolitan areas could occur on existing parking lots and the low-rise structures that need to be repurposed or replaced anyway. Such development can create walkable communities dominated by "middle housing" (Parolek with Nelson 2020) with multimodal access.

There is another opportunity for BRT station areas of the future. The COVID-19 pandemic showed that reliance on offices in BRT station areas and elsewhere should be downplayed. Peiser and Hugel (2022) express surprise that offices played as large as role as they did before the pandemic given technological advances allowing people to work remotely. The pandemic corrected for over-reliance on traditional offices and accelerated work-from-home. On the other hand, work-from-home includes working in "third places" such as local coffee shops, libraries, and open-air venues, among others that can be key elements of BRT station areas.[20] An additional benefit is the potential for BRT station area planning and design to enhance opportunities to walk and bike within and between them. Canepa (2007) suggests that doing so can extend the proverbial half-mile circle (about 800 meters) to even to a mile (about 1,600 meters) or more. It also advances public health (Ewing and Hamidi 2016).

There is another aspect with respect to offices. While for many firms, central offices are no longer needed, workers who prefer not to work from home or in third places could work in dispersed coworking offices supported by their employers.[21] Ideally, these would be accessible in BRT station areas and easily accessed via walking, biking, or a short transit ride. These coworking offices could include retrofits of strip retail centers as well as conversions of malls into mixed-use redevelopments. Another source can include office conversions into residential units with some original office areas set aside for co-working spaces. Office conversions, however, are more difficult and costly than many assume (Gupta, Martinez and Van Nieuwerburgh 2023).[22]

As successful as BRT station areas are in attracting jobs and people in such a small area of land relative to their regions, research into the influence of BRT station proximity on real estate values challenges the efficacy of BRT station area planning and design. In the post-pandemic economy, BRT station area planning and design cannot be an after-thought. BRT station areas need to be developed proactively into places that attract people and connect them to destinations. When that happens, markets will respond favorably as needs will be met.

[20] See https://www.brookings.edu/articles/third-places-as-community-builders/ and https://www.thebalancemoney.com/great-places-to-work-outside-your-home-office-1794789.
[21] See https://hbr.org/2023/02/research-how-coworking-spaces-impact-employee-well-being.
[22] See https://www.brookings.edu/articles/myths-about-converting-offices-into-housing-and-what-can-really-revitalize-downtowns/.

Exhibit 20
Bus Rapid Transit stop in suburban Salt Lake County, Utah
Source: Google,

Exhibit 21
Bus Rapid Transit stop serving mixed use area in San Antonio, Texas
Source: VIA Metropolitan Transit rendering.

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