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Article

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Spatial mismatch and youth unemployment in US cities: public transportation as a labor market institution

Christof Brandtner*, Anna Lunn, Cristobal Young

Department of Sociology, Stanford University, Stanford, CA, USA

**Correspondence:* cbrandtner@stanford.edu
Anna Lunn and Christof Brandtner equally contributed to this article.

Abstract

Spatial mismatch between homes and jobs within a city can create unemployment despite the presence of unfilled jobs. This is especially problematic among young people who have limited transportation options and high rates of joblessness. Car ownership is a possible solution to spatial mismatch, but private vehicles are expensive and involve negative externalities. Public transportation provides an alternative infrastructure that reduces structural unemployment by matching supply and demand. Using longitudinal models of public transportation in the 95 largest US cities between 2000 and 2010, we test whether better public transit services reduce youth unemployment. Public transportation systems can serve as a labor market institution, but there are two worlds of public transportation in American cities. Improvements in public transit are mostly beneficial in cities that are already less dependent on private automobiles. Path dependence in transportation design means that some cities see little benefits to incremental investments in public transit.

Key words: sociology, economic sociology, unemployment, youth, urban studies, public sector

JEL classification: R4, J6

1. Introduction

The distance between homes and jobs within a city can create high levels of unemployment despite the presence of unfilled jobs (Wilson, 1996; Holzer *et al.*, 2003). This spatial mismatch is a particular challenge for unemployed youth because young people have more limited means of transportation. Previous research has suggested that car ownership can ease spatial mismatch in the labor market by reducing the physical barriers to employment opportunities (cf. Fan, 2012). Yet, encouraging individual transportation— single occupancy vehicles— seems anachronistic in light of the negative externalities of automobiles and cities' commitment to sustainability goals. We investigate how investments in public transportation can address the problems of spatial mismatch and youth unemployment in American cities.

Unemployment is often seen as either an individual problem resulting from workers' lack of skill and social capital, or as a macroeconomic problem attributable to slow economic growth (Mincer, 1993; Hout *et al.*, 2011; Farber, 2015). A wide-ranging consensus among economic sociologists, however, suggests that labor market outcomes are shaped by an array of social forces (Granovetter and Tilly, 1988). Public institutions in particular, including national labor policies, employment protection legislation, unemployment benefit systems and collective bargaining arrangements can mitigate joblessness and its considerable economic costs to workers that do experience unemployment (Kerckhoff, 1995; Streeck, 2005; Gangl, 2006; Dieckhoff, 2011; Gordon, 2014). Most work on how institutions shape unemployment pertains to national legislation and welfare policies, but local labor market institutions at the city and regional levels also play a pervasive role in shaping the socio-economic context of work. As Martin (2001) argues in his study of municipal living wage policies, there is substantial variation in the urban political regimes that determine the context of collective bargaining. Local governments are also less constrained in adopting redistributive policies than is commonly understood, as businesses and wealthy individuals who threaten to move their capital elsewhere are often bluffing (Cox 1997; Carruthers and Lamoreaux, 2016; Young *et al.*, 2016). The ability of local governments to shape local labor market institutions and the differences in city and state labor policies and institutions thus motivate this investigation.

Given the potential for transit services to connect workers to jobs, local planning may, therefore, influence the job opportunities available to vulnerable groups such as youth (Jacobs, 1961; Sampson, 2012). In many cities, affordable housing is not located in the areas that have strong job growth. Entry level jobs are commonly found in suburban areas that also feature high housing costs. In contrast, areas with limited job growth tend to offer more affordable housing. The result is a geographic dilemma that is difficult for many workers to resolve: jobs and housing are regionally disconnected. When unemployed workers must effectively 'restrict their search horizon to their neighbourhood or its close vicinity', a city becomes a patchwork of disconnected labor markets (Gobillon *et al.*, 2007, 2414). Pockets of high unemployment coexist with other 'nearby' areas of unmet labor demand. This mismatch creates a problem of structural unemployment, in which joblessness is higher at every point in the business cycle. In this case, both employers and workers can benefit from a denser transportation system that creates a more integrated metropolitan labor market. Since public transit can play a key role in bridging the distance between jobs and homes in urban economies, municipal public transportation services should be seen as an important local labor market institution.

The spatial mismatch literature in sociology has mostly focused on how the suburbanization of jobs has affected people (predominantly racial minorities) living in the central city. Sociologist William J. Wilson, in his books *The Truly Disadvantaged* (1987) and *When Work Disappears* (1996), pioneered and popularized this perspective. Spatial mismatch is, however, an interdisciplinary area of research with contributions from prominent urban planning scholars and economists, such as Harry Holzer (Holzer, 1991; Holzer *et al.*, 2003) and Edward Glaeser (e.g. Glaeser and Kahn, 2001). One dilemma of 'the [urban] planners' war against spatial mismatch' (Fan, 2012) is that private vehicles create negative environmental externalities (Mayeres *et al.*, 1996; Delucchi, 2000; Maibach *et al.*, 2007), and private vehicles are a costly transportation option for low income earners (Fletcher *et al.*, 2005). Nonetheless, there has been relatively little research specifically on how *public transit systems* affect metropolitan unemployment. Given that roughly 60% of public transit trips are work commutes (Melaniphy, 2012), research in this area is clearly important. High quality public transportation systems can help create integrated urban labor markets in which more workers have access to a greater number of job openings. Public transit services may be particularly crucial for reducing youth unemployment because young people have limited access to private vehicles.

The importance of public transit for decreasing unemployment has been demonstrated in formal theoretical models (Zenou, 2000; Gobillon *et al.*, 2007) and in a number of case studies (e.g. Ong and Miller, 2005; Yi, 2006; Fan *et al.*, 2010). However, there is a need for large scale quantitative evidence that broadly examines the role of public transit as a labor market institution. Drawing on a sample of roughly 100 American cities over a 10-year period, this study tests whether high density public transit systems lead to lower metropolitan unemployment rates for young people. Our contributions to the existing literature are threefold. First, we extend the implications of spatial mismatch theory to a broader but nevertheless economically marginalized group: young workers who tend to face limited employment opportunities and face challenges in finding jobs that lie outside their immediate zone of residency. Second, we focus on public, rather than private, transportation as a potential solution to problems of spatial mismatch. Finally, we scale up from case studies on public transit, providing a longitudinal analysis of youth unemployment and public transportation in nearly 100 of the largest cities in the US. This will help to clarify the role of public transit as an institution that facilitates employment matching and minimizes joblessness in the youth labor market.

2. Background

2.1 Spatial mismatch

The theory of spatial mismatch hypothesizes that geographical distance between homes and jobs creates a friction in the labor market that contributes to unemployment (Ihlanfeldt and Sjoquist, 1998; Fernandez and Su, 2004). As the distance between a worker's home and job increases, the cost and difficulty of finding and commuting to the job also increases. Unemployed individuals often cannot feasibly access more distant job openings, even if they desire the work and have the qualifications that employers want. Spatial mismatch generates a simultaneous condition of both unfilled jobs and unemployed workers in the same city (Logan, 1978, 2012).

Researchers analyzing the effect of job access on labor market outcomes at the city, neighborhood and individual levels generally find that there are substantial distances between the areas in which low skill and minority workers live and the areas where low skill jobs are located (Fernandez, 1994; Stoll *et al.*, 2000). Moreover, individuals that live in areas farther from these jobs are more likely to be unemployed, which suggests that increasing access to jobs would have a positive effect on the employment rates (Holloway, 1996; Raphael, 1998). Of course, an individual's selection into low cost or high cost neighborhoods is related to their employment potential. Controlling for unobserved population characteristics related to employability in each neighborhood, Mouw (2000) demonstrates that there is indeed a direct effect of changing local employment opportunities on unemployment rates. Using panel data on neighborhoods in Detroit and Chicago from 1980 to 1990, he finds that the growing decentralization of manufacturing jobs led to rising unemployment.

2.2 Spatial mismatch and youth unemployment

Unemployment among young people is an important socio-economic issue, both because of the very high rates of youth unemployment, and because of the potential for lasting scars of unemployment that may harm the long-term prospects of young people's careers (Aberg and Hedstrom, 2011; Pedulla and Newman, 2011; Pedulla, 2013). The unemployment rate among young people (17.7%) was more than twice the rate for older workers (7.7%) in 2011.[1] Unemployment is an economically and emotionally straining experience for individuals and can leave lasting scars that extend well beyond the period of unemployment (Burgard *et al.*, 2007; Brand and Burgard, 2008; Young, 2012; Brand, 2015). People who become unemployed or displaced typically find new jobs that pay significantly lower wages (Arulampalam, 2001; Gangl, 2006; Fuller, 2008; Couch and Paczek, 2010), and have poorer working conditions (Brand, 2006; Dieckhoff, 2011) than their previous job. Indeed, studies have found that a 'wage scar' persists even after 12 years or more (Gregg and Tominey, 2005; Mroz and Savage, 2006; Eliason and Storrie, 2009). Moreover, the effect of youth unemployment is associated with high rates of adult unemployment, and therefore may compound itself (Gregg, 2001). Since the negative consequences of unemployment can extend throughout one's career, the impact of unemployment is particularly serious for young people.

2.3 Private versus public transportation

Most research on spatial mismatch focuses on the benefits of private transportation, specifically car ownership, in facilitating job access. The literature generally finds that car ownership enables broader geographic job searches and reduces both the incidence and duration of unemployment (Stoll, 1999; Raphael and Stoll, 2001; Raphael and Rice, 2002; Parks, 2004; Gurley and Bruce, 2005; Kawabata and Shen, 2007; Baum, 2009; Gautier and Zenou, 2010). This is important, as cars are by far the most common mode of transportation for commuting in the US. However, private vehicles are an expensive solution for individual job access. Car ownership requires a high initial investment that youth, in particular, often cannot afford at the beginning of their labor market experience. Owning a car can also lead to high running costs, sometimes described as transportation hardship (Fletcher *et al.*, 2005). One study reported that, 'Nearly half (48%) of the low-income respondents experienced a financial transportation hardship in the past 12 months such as neglecting vehicle repairs, lacking money for gasoline, allowing insurance to lapse, missing a car payment, and/or having a vehicle repossessed' (Fletcher *et al.*, 2005, p. 323). It should, therefore, not come as a surprise that young people use public transit about twice as often as the general population (Pucher and Renne, 2003).

1 The official unemployment rates likely understate the gap as young people, compared to older workers, are more likely to exit the labor force temporarily when they have difficulty finding employment (Ayres, 2013).

Moreover, car ownership generates negative externalities in the form of environmental pollution and increased congestion. Single occupancy vehicles bring individual mobility but also increased problems of air and noise pollution, accidents and traffic congestion (Delucchi, 2000; Litman, 2013). Cutbacks in public transit have been shown to directly increase traffic delays and commuting times on roads (Anderson, 2014). As Tyndall points out, more individual traffic deteriorates the accessibility of metropolitan regions and imposes additional costs on commuters (Tyndall, 2017, 522). Encouraging car ownership also conflicts with environmental planning goals. In a survey among city leaders in 50 of the largest cities in the US, 71% of city administrators indicated a very high or high commitment to sustainability (Portney and Berry, 2010). With growing concerns that cities face over the environment, encouraging private transportation as a solution to spatial mismatch seems anachronistic (Newman and Kenworthy, 1999; Portney, 2013). Policies aiming at connecting people with jobs must take these costs to low income individuals and to the city as a whole into consideration. From a social planner's perspective, the goal is to reduce unemployment with minimum social and environmental cost, which makes public transportation an attractive solution.

2.4 Car dependence as a barrier to public transit

One barrier to public transit as a solution to spatial mismatch is that many US cities have become highly car dependent, both in terms of infrastructure and culture. The effect of improving service levels may well depend on how car dependent a city has already become.

One of the key features of transportation systems is that they need a critical mass to achieve success. Many American cities are characterized and planned around roads with limited sidewalks, extensive interstate highways, car-friendly zoning and miles of parking lots that encourage driving (Jacobs, 1961; Jakle and Sculle, 2004; Jackson, 2015). A majority of Americans support public transit systems in principle, but they do not tend to use it themselves (Manville and Cummins, 2015). This makes it difficult for public transit systems to sustain themselves. Public transportation services are often limited in the US, especially outside of the largest cities.

In many cities, the transit problem is not just low services levels, but also serious issues of urban design and transit governance (Newman and Kenworthy, 1999, 2015). Urban walkability is an important factor in public transit systems. Many US cities have limited sidewalks in large parts of the metro area, which can make walking to and from public transit unsafe. Moreover, many cities do not have regionally integrated services. In Atlanta, for example, many of the counties that make up the metro area maintain separate transit systems that end at county lines. Crossing the city can mean traversing several disconnected transit systems—and a lot of waiting. In cities like Atlanta, taking public transit is stigmatized as a marker of poverty and a sign that one's time is not important. As one sociologist of transportation noted, Atlanta's transit system 'has historically meant transportation for poor people, disabled, the transit-dependent and losers' (Wall, 2006). In New York City, by contrast, the transit system is so widely used and reliable that many middle class adults do not even have a driver's license. Some 31% of New York City households do not own a car, compared to only 7% in Atlanta.

Cities that are highly car dependent may be stuck in a low public transit equilibrium, in which a car-centric culture reacts very slowly to improvements in public transit. In such places, investments in better transit systems take a long time to attract new ridership and become a viable alternative to driving (Urry, 2004). When there is heavy car dependence, incremental improvements in transit service levels may not be enough to change how well the transit system works, without deeper institutional reforms. In places where cars are less central to daily life and transit systems are already functional, expanding or contracting public transit is likely to have a bigger impact on the regional labor market. One goal of this article is to examine this lock-in effect, and see to what extent the effect of public transit depends on the existing levels of car dependence.

2.5 The effect of public transit on youth unemployment

Formal theoretical models of transportation and urban unemployment (Zenou, 2000; Gobillon *et al.*, 2007; Zenou, 2011) clearly lay out the expectation that better public transit should reduce urban unemployment. Empirically, there have been a number of case studies from a collection of American cities: Houston (Yi, 2006), Minneapolis (Fan *et al.*, 2010), Los Angeles (Ong and Miller, 2005), a comparison of Portland and Atlanta (Sanchez, 1999) and a combined analysis of Boston, San Francisco and Los Angeles (Kawabata, 2003). These studies generally find either (a) better transit increases job accessibility, or (b) greater transit accessibility of jobs reduces unemployment. Tyndall (2017) shows that Hurricane Sandy disproportionally damped employment in New York neighborhoods that most frequently used public transit.[2]

What is missing in this literature is large scale evidence that extends beyond a single case study or small handful of cities. The focus on single cities—usually those with higher quality transit systems—leaves a question of generalizability. In particular, these studies do not take into consideration the varying automobile dependence of American cities (Newman and Kenworthy, 1999; Urry, 2004; Low and Astle, 2009; Kimball, 2014). Following a large sample of cities over time while they experience expansion or reduction of their public transportation systems would allow researchers to examine how youth unemployment covaries with these changes in transportation services.

3. Data and measures

We examine the effect of variation between urban public bus services between 2000 and 2010 on unemployment rates for urban youth, as well as within-city variation. Our research design uses a panel data set of large US cities, which allows us to control for each urban areas' unobservable time-invariant characteristics, such as geographic size, early investments in infrastructure, political centralization and cultural attitudes.

3.1 Data

To measure each city's level of public transportation, we use the Department of Transportation's National Transit Database (NTD), which contains annual data on public transportation in each city. Each local transit agency reports the services provided within a

2 The majority of studies draws on cross-sectional (e.g. Sanchez, 1999) or longitudinal data (e.g. Kawabata, 2003; Kawabata and Shen, 2007; Fan *et al.*, 2010) of individuals or neighborhoods in one or a small number of cities. Ong and Miller (2005) and Tyndall (2017) pursue an instrumental variable approach to pin down spatial mismatch as the causal mechanism of this effect.

given Census-defined Urbanized Area (UZA[3]) to NTD as a requirement for receiving federal funding. Agencies report vehicle revenue miles and hours, total operating expenses, fares, passengers and number of trips by transport mode (e.g. bus, light rail and heavy rail). We aggregate the data reported for each type of service by summing each variable across transit services by urban area and year to get annual measures for each city's public transit. The quality of the data improves markedly in 2000, so our analysis uses 2000 as the starting year.

The dataset contains the 95 most populous US cities.[4] We use the years 2000 and 2010 to ensure multiple observations for each urban area over time and to maximize the quality of our data and variation between observations. For our outcome and control variables, we use demographic data on urban areas from the 2000 Census and 2010 American Community Survey (ACS).

3.2 Variables

Our outcome variable, the youth unemployment rate, is defined as the ratio between the number of people between 16 and 24 years of age that are actively seeking jobs but who are not employed and the number of people in that age group that are in the labor force. Our explanatory variable of interest is the density of urban public bus transit, measured as the 'vehicle revenue miles' per capita for each city. Vehicle revenue miles are the annual number of miles that public transit vehicles actually travel while in revenue service.[5] We focus on bus transit services as the central platform for urban transportation, while including controls for the presence of other modes of public transportation, such as heavy rail. Bus services are a cost effective way of expanding public transportation, and youth are more likely to utilize bus services (Pucher and Renne, 2003). Heavy rail transportation (such as metro or subway systems), where they exist, tend to have a different ridership—which is predominantly middle class and professional workers. In cities without a subway system, 75% of public transit services are bus services, and in cities with a subway system, 42% of public transportation are bus services. Still, we include a categorical subway variable (extensive subway system, moderate subway system, no subway system) to control for whether an urban area is served by a subway system to determine whether the relationship differs in cities with a heavy rail system.[6]

3 NDT refers to a Census-designated area with 50,000 residents or more as UZA, the Census abbreviates it as UA. In this article, we simply refer to them as urban areas. The NTD follows these Census boundaries as they collect and report transit data.

4 Our analysis started out with 100 cities, four of which were duplicates due to inconsistencies in the data labels. We are convinced that these four observations were dropped randomly, and therefore did not introduce sampling bias. In addition, we excluded San Juan, PR from our analyses; our analyses are robust to this decision. San Juan was the only city whose Cook's D suggested a possible outlier effect. Our results were also insensitive to significantly reduced sample sizes and the exclusion of cities with a subway system.

5 According to the NTD glossary, this excludes deadhead, training operators, vehicle maintenance tests and charter services: Accessed at http://www.ntdprogram.gov/ntdprogram/Glossary.htm on January 6, 2015.

6 Cities with an extensive subway system (>100 miles) are New York, Chicago, Washington DC and San Francisco. Cities with a moderate subway system (<100 miles) are Baltimore, Los Angeles, Atlanta, Miami, Boston, Philadelphia and Cleveland. We assigned cities with a mass transit system according to the American Public Transportation Association's 2010 Transit Ridership Report.

We also exclude suburban commuter services, which connect individuals that live outside the urban area to the city. Rather than including transportation to the suburbs, which is unlikely to serve youth living in urban areas, we only include transit services within the circumscribed urban area of our analysis. A second reason for excluding commuter modes is data consistency. Before 2007, local service providers that provided transportation in multiple urban areas had the discretion to allocate these services to urban areas as they saw fit when they reported to the NDT, which introduces a source of potential inaccuracy in the measurement of service density of commuter rail lines. Therefore, limiting our analysis to urban bus services maximizes the quality of our data and focuses on the services that are most available to youth seeking jobs in urban areas.[7]

Since we theorize that public transportation bridges the distances between youths' homes and their jobs, we include two measures of within-city spatial mismatch in our models. This allows us to account for variation in the distance between homes and jobs, which may mediate the relationship between public transit density and youth unemployment. First, we use the measure of average commute time in the city. Although this article focuses on public transit, the local commute time for people with private vehicles provides a measure of local job access that incorporates distance, road infrastructure and traffic congestion. Moreover, this measure incorporates information about nearby job openings—if there are more job openings nearby, we expect residents to have shorter commute times. Previous studies measure job access within an area as the average commute time for other low-wage workers in that area who use private vehicles to commute (Ihlanfeldt and Sjoquist, 1990; Ihlanfeldt, 1993). We control for the city population size, and the size (share) of the youth population, defined as individuals between 16 and 24 years of age. Additionally, we include population density in our models, as the geographic distance between commercial and residential areas may be lower in denser cities.[8] By including these two measures of job access—population density and commute times—we are better able to assess whether the level of public transportation also has an effect on youth unemployment across cities with different degrees of spatial mismatch.

Poor public transit could be a proxy for underlying economic and social problems in a city, such as weak economic performance or persistent racial segregation and discrimination.

Accessed at http://www.apta.com/resources/statistics/Documents/Ridership/2010_q1_ridership_APTA.pdf

7 Other city level variables of transit, such as the operating expenses and unique passenger trips, were highly correlated with the vehicle revenue miles (>0.9) and thus not included as predictors. Information on fares was available for 2002–2010, and public transit fares proved to be a statistically insignificant predictor for unemployment in 2010. Affordability (measured as fares per unique passenger trip) is uncorrelated to youth unemployment, though associated with more extensive public transportation systems. Between 2002 and 2010, average per trip fares increased by 32.8% (adjusted for inflation). To ensure that our models are robust to this over time change, we ran additional sensitivity tests imputing fares in 2000 with 2002 fares that yielded practically identical results.

8 We also explored using a dissimilarity index to measure spatial mismatch. A dissimilarity index adapts the common measure of segregation to measure the differences between distribution of jobs and workers across zip codes within a city (see Stoll, 2006 for a discussion of this measure). However, we ultimately did not include this measure because the availability of data the distribution of jobs across cities limits us to measuring the distribution of jobs that are filled, rather than the job openings. Several single city studies have found that proximity to job growth rather than the job workers ratio is negatively associated with unemployment rates (Rogers, 1997; Raphael, 1998).

To address this concern, we include the real per-capita state GDP (2009 USD) as a measure of local economic performance.[9] We used a one-year lag to reduce the possibility of contemporaneous change. We also controlled for racial residential segregation for each major racial and ethnic minority (Asians, Hispanics of any race and blacks) and non-Hispanic whites with data from the US 2010 Census Project.[10] The racial dissimilarity measure represents the proportion of each group that would have to move to a different neighborhood within a city for the distribution of each group to be even throughout the city.[11]

Finally, to measure car dependence in a city, we include the percentage of households that do not own private automobiles (Litman 2013). As noted earlier, car dependence is a focal point of interest for understanding how public transit works. The most car dependent city in the US is Albuquerque, New Mexico, where only 4.7% of households do not own cars. Other representative car dependent cities include San Jose (5.2% of households are without cars), Orlando (5.8%), Houston (6.8%) and Atlanta (7.0%). Car *independent* cities are most strikingly represented by New York—where 32% of households do not own a car—as well as places like San Francisco–Oakland (15% without cars), Boston (14.6%), Baltimore (13.3%) and Chicago (12.9%). It is interesting to note that, at the city level, there is little difference in income between car dependent and car independent places. The car dependence of a city is not driven by its income level. In any event, a key question in this study is whether the effect of public transit depends on the baseline level of car dependence in a city. To capture such interactions between car ownership and transit density we use both multiplicative and split sample interaction models (Brambor *et al.*, 2006). This shows how the effect of improving public transit may differ when a city is more or less dependent on cars.

4. Methods

The outcome variable, youth unemployment, is a continuous variable with a roughly normal distribution. The data are structured such that each urban area ($i = 1, \ldots, n$) is observed at two distinct periods ($t = 1, 2$). In our analyses, we use two types of models on the city level: cross-sectional OLS models and fixed effects models for panel data. The OLS model analyzes variation between the different urban areas for both years. We also include an interaction term between the density of public transit and car ownership in our models. The model is specified as:

$$\text{youth unemp}_i = \beta_0 + \beta_1 \text{transit}_i + \beta_2 \text{non\_car}_i + \beta_3 (\text{transit}_\text{i} \times \text{non\_car}_i) + \boldsymbol{Z}_k \boldsymbol{\delta}_k' + \epsilon_\text{i} \quad (1)$$

where transit_i is per capita vehicle revenue miles, non_car_i is the percent of households

9 A city level measure of GDP would be preferable to a state level measure, but data on GDP for urban areas is unavailable, and data on the GDP for Metropolitan Statistical Areas (MSA) is only available starting in 2001. To check our results using this limited data, we analyzed how MSA per capita GDP affects the relationship between transit density and youth unemployment using data from 2010, and we find similar results (not reported).

10 For more information, see: http://www.s4.brown.edu/us2010/index.htm

11 The dissimilarity formula is: $\frac{1}{2}\sum_{i=1}^{N} \text{abs}\left(\frac{m_i}{M} - \frac{w_i}{W}\right)$, where M_i is the minority population in area (neighborhood) i and M is the total minority population in the city. W_i is the white population in area (neighborhood) i and W is the total white population in the city.

Table 1. Summary statistics for dependent and independent variables pooled for 2000 and 2010, with differences over time

Variable	Mean	SD	$\Delta_{2000–2010}$
Overall unemployment (%)	5.4	2.1	3.6
Youth unemployment (%)	21.3	7.3	10.1
Vehicle revenue miles (in million miles)	16.8	33.5	1.7
Public transit density (in vehicle revenue miles per person)	8.4	4.3	0.3
Carless households (% of total households)	9.7	3.8	−0.9
Average commute time (minutes, for one way)	23.6	3.5	−0.5
Density (one thousand people per square mile)	2.3	1.0	0.1
Total population (millions)	1.6	2.4	0.1
Total population 16–24 (thousands)	202	297	20

Note: For bus modes only. Δ is difference between mean in 2000 and 2010. Data pooled for 2000 and 2010. $N = 192$.
Source: Census (2000), ACS (2010), DoT National Transit Database (2000–2010).

without a private vehicle, Z_k is a set of k controls, with $\delta_k^{'}$ coefficients. The cross-sectional model allows for analyzing the effect of the magnitude of public transit density on the unemployment rate. We use standard errors clustered at the city level and state level when data was pooled across cities and states, respectively, and the consequent violation of the assumptions that all observations are independently and identically distributed (iid).

The second model uses fixed effects to analyze variation within each urban area over time. The fixed effect models predict how a change in the public transit density is associated with a change in the unemployment rate. The model is specified as:

$$\Delta \text{youth unemp}_{it} = \alpha_0 + \beta_1 \Delta \text{transit}_{it} + \beta_2 \Delta \text{non\_car}_{it} + \beta_3 (\Delta \text{transit}_{it} \times \Delta \text{non\_car}_{it}) + \Delta Z_k \delta_k^{'} + \Delta \epsilon_{it} \quad (2)$$

Since fixed effects models control for time-invariant characteristics, idiosyncratic differences in the culture, historical legacy and political system are accounted for in these models to the extent that these factors did not change over time.

5. Results

5.1 Descriptive statistics

We report descriptive statistics for all variables in Table 1. Notably, the youth unemployment rate increased by more than 10 percentage points between 2000 and 2010. In contrast, the overall unemployment rate only increased by 3.6 percentage points. In other words, young people were hit especially hard by the recession. Over the same period, the average density of public transit coverage increased moderately, from an average of 4.85 to 5.16 vehicle revenue miles per capita. Both the population density and the size of the population between 16 and 24 increased in parallel with general urban growth.

Table 2 presents the average levels of youth unemployment and public transit density by city size (based on population) in both 2000 and 2010. Several interesting correlations are apparent. As expected, both youth unemployment and urban transit vary by city size. Youth

Table 2. Average youth unemployment rate and average vehicle revenue miles (per capita) in 2000 and 2010, by city size

Year	Population size	Youth unemployment rate	Public transit density	Number of observations
2000	< 500,000	15.2	6.0	25
	< 1 million	17.1	7.8	33
	< 5 million	16.4	10.7	34
	> 5 million	19.7	11.4	4
2010	< 500,000	24.9	6.1	25
	< 1 million	25.3	7.8	33
	< 5 million	27.6	10.3	33
	> 5 million	29.7	11.2	5

Note: For bus modes of transportation only, $N = 192$.
Source: Census (2000), ACS (2010), DoT National Transit Database (2000–2010).

unemployment is also correlated with city size and grew considerably between the two years of analysis. Larger cities have significantly higher youth unemployment rates. Therefore, we control for city characteristics that might explain this relationship in our regression analyses. And over time, youth unemployment overall increased from 16.5% in 2000 to 26.2% in 2010, so we include a dichotomous variable for year to control for changes in the labor market conditions that were the same across cities and which may be related to increasing youth unemployment.

Second, the data also confirm our intuition about the relationship between public transit density and city size. Figure 1 shows that the amount of public transit per capita is positively correlated with the city's size in both years.

Figure 2 illustrates the city size by population for both car dependent and car independent cities in 2000 and 2010. The median percentage of households without access to a car across both years was 8.9% (vertical line in Figure 2). Given the fact that economically disadvantaged groups have less access to a vehicle, we analyze the relationship between public transit density and unemployment separately for car dependent and car independent cities.

5.2 Cross-sectional models

In Table 3, we first estimate a model for the full sample of 95 cities, in which we included a multiplicative interaction between the public transit density and the percentage of carless households (both mean-centered). We present the findings of the cross-sectional analyses using OLS for both years in Table 3. Model 1 shows that there is a small population effect, but that the effect of public transit density is not significant across the board. In model 2, we show that the effect of public transit density is actually moderated by a city's dependence on cars. In the full model 3, public transit density has a significantly negative effect on youth unemployment. We also find further support for an interaction between public transit density and car ownership, which means that the negative effect of public transit on youth unemployment is higher in cities with fewer cars. When we control for racial segregation and local economic conditions in model 4, the estimated relationship between public transit density does not substantially change, which reassures us that other city level characteristics are not driving this relationship.

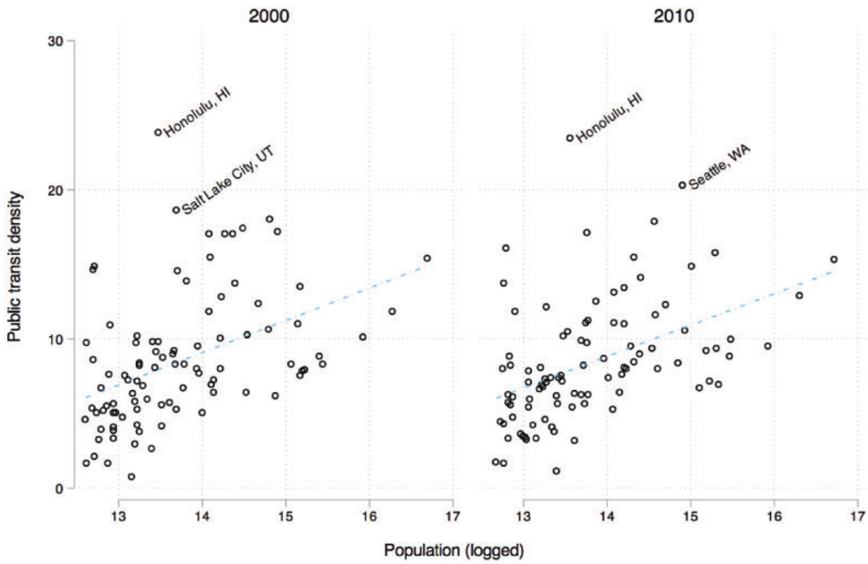

Figure 1. Population size and public transit density, 2000 and 2010.
Source: Census (2000), ACS (2010), DoT National Transit Database (2000–2010).

For illustrative purposes, we interpret this finding for the average of carless households in car independent and car dependent cities: an increase in one vehicle revenue mile per capita decreases the youth unemployment rate by 0.08 percentage points for car dependent cities (mean percentage of carless households in car dependent cities: 7%), but the effect is statistically insignificant. In contrast, an increase in one vehicle revenue mile per capita is associated with a significant decrease of 0.5 percentage points in car independent cities (mean percentage of carless households in car independent cities: 12%).

Figure 3 illustrates the marginal effect of public transit density on youth unemployment as the percentage of carless households in a city grows (model 3). Note that the effect of public transit density is statistically significant at a 5% level only for cities with more than 8.5% of carless households (compared to the median of 8.8% of households without cars among the entire sample). For ease of interpretation, we discuss results for a split sample of car dependent and car independent cities below.

Models 5 and 6 represent the findings of the OLS models for car dependent and car independent cities. Figure 4 shows the predicted youth unemployment rate for different levels of public transit density, depending on whether the city is car dependent or independent. Controlling for all covariates, the slope of the regression line is steeper for car independent cities, which means that the effect of public transit density on youth unemployment is greater in these cities.

We focus our substantive analysis on car independent cities. Three factors can significantly explain variation in the youth unemployment rate: public transit density, population density and the average commute time. Public transit density is a significant predictor for the

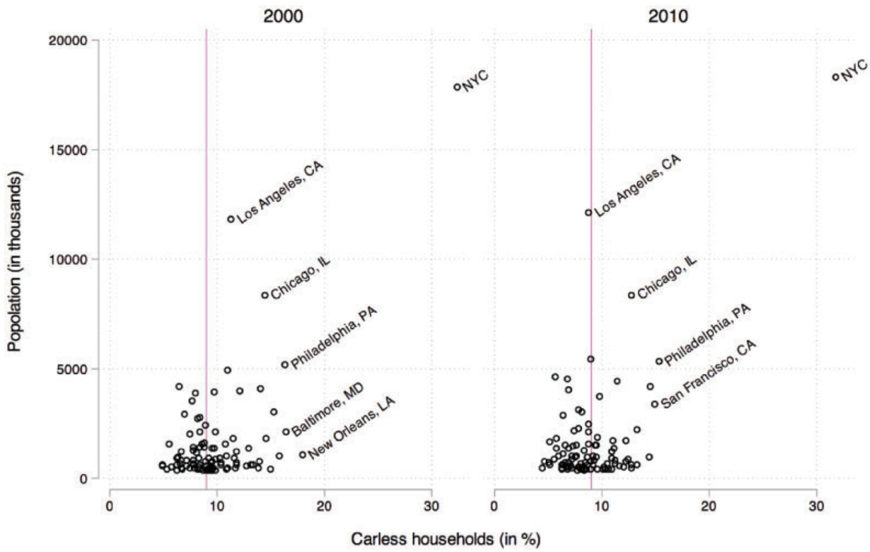

Figure 2. City size and percentage of households without access to a car, 2000 and 2010.
Note: The vertical line is the median of carless households across both observed years. Car dependent cities are on the left side of the line, and car independent cities are on the right side of the line.
Source: Census (2000), ACS (2010).

youth unemployment rate. An increase in the public transit density of one vehicle revenue mile per capita is associated with a 0.5 percentage point decrease of the rate of youth unemployment. There are two ways of thinking about this result. First, holding everything else constant, the model predicts that an increase in public transit density by one standard deviation decreases the youth unemployment rate by two percentage points. Interpreting the result as an elasticity, a 10% increase in the public transit density is associated with a 2 percentage point lower youth unemployment rate. This confirms our hypothesis that youth unemployment is lower in cities with a denser public transit network.

In terms of the other coefficients, we see that population density is associated with higher rates of youth unemployment in car independent cities. According to model 6, a 1,000 person per square mile increase in the population density is associated with youth unemployment rate that is approximately 2.59 percentage points higher in car independent cities. Neither the population size nor the percentage of individuals in the population under 24 years of age are significant predictors of youth unemployment. The percentage of households without access to a car has no additional effect on youth unemployment beyond the significantly different results of the models for the split sample. Note that the subway dummy is insignificant for car independent cities, which have the majority of subway systems. The dummy is significant for car dependent cities, but seems to be picking up an outlier effect: Atlanta, GA (both years) and Los Angeles, CA (2010) are the only car dependent cities with a subway system, and both have above average rates of youth unemployment.

Table 3. OLS models predicting youth unemployment in car dependent and independent cities, with multiplicative interaction between public transit density and percentage of carless households

	Full sample				Car dependent	Car independent
	(1)	(2)	(3)	(4)	(5)	(6)
Public transit density	−0.137	−0.278*	−0.273*	−0.294*	−0.083	−0.564**
	(0.092)	(0.129)	(0.116)	(0.132)	(0.113)	(0.190)
Total population	0.511***	0.386†	−0.051	−0.023	−0.205	−0.170
	(0.147)	(0.215)	(0.221)	(0.236)	(0.240)	(0.287)
% Youth population	0.391	0.361	−0.194	−0.172	0.160	−0.408
	(0.290)	(0.285)	(0.230)	(0.317)	(0.223)	(0.528)
Population density		1.208†	0.678	0.859	−0.146	2.591***
		(0.727)	(0.656)	(0.667)	(0.833)	(0.658)
Carless households		0.107	0.467**	0.486*	1.101*	0.015
		(0.153)	(0.159)	(0.215)	(0.449)	(0.174)
Transit X carless		−0.044*	−0.057**	−0.066*		
		(0.021)	(0.020)	(0.032)		
Avg. commute time			0.383*	0.400*	0.713***	0.173
			(0.162)	(0.157)	(0.121)	(0.254)
Year dummy			1.032***	1.044***	1.202***	0.949***
			(0.064)	(0.104)	(0.118)	(0.176)
Moderate subway (ref = no subway)			−0.612	−1.187	5.577***	−3.983
			(2.069)	(2.318)	(1.199)	(3.090)
Extensive subway (ref = no subway)			−1.908	−1.598		−3.188
			(1.461)	(2.315)		(3.124)
State per capita GDP (Previous Year, $10,000)				−0.175	−0.408	−0.015
				(0.228)	(0.784)	(0.298)
Asian-white Segregation				−0.017	−0.024	−0.053
				(0.048)	(0.056)	(0.078)
Black-white Segregation				0.027	−0.016	0.076
				(0.045)	(0.028)	(0.087)
Hispanic-white Segregation				−0.034	−0.021	−0.010
				(0.033)	(0.044)	(0.053)
Constant	15.261***	13.290**	8.409	8.701	2.425	11.908
	(3.630)	(4.005)	(5.475)	(7.454)	(5.669)	(15.114)
N	190	190	190	190	98	92
R^2	0.04	0.06	0.59	0.59	0.76	0.56

Standard errors in parentheses; †$P < 0.1$, *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.
Note: Models 1–4 are for 95 cities, for years 2000 and 2010. Models 5 and 6 are for 92 observations with above ('car independent') and 98 observations below ('car dependent') median households without access to a vehicle, for years 2000 and 2010. Transit measures include all bus modes, but excludes among others heavy rail and commuter modes.
Source: Census (2000), ACS (2010), DoT National Transit Database (2000–2010).

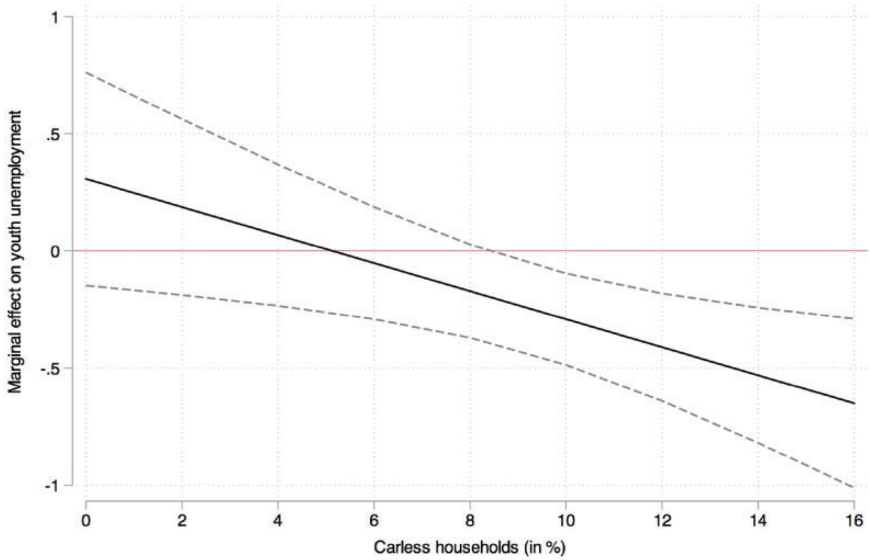

Figure 3. Marginal effects of public transit density on youth unemployment by level of car dependence.
Note: Predicted effect according to multiplicative model 3, Table 3. Dashed lines indicate 95% confidence intervals.
Source: Census (2000), ACS (2010), DoT National Transit Database (2000–2010).

Models 4 and 5 also show that longer commute times in a city are associated with higher rates of youth unemployment in car dependent cities. A common measure of the distance that individuals must travel to work is the average commute time of their local peers who use private vehicles (Ihlanfeldt and Sjoquist, 1991; Ihlanfeldt, 1993; Holloway, 1996; Ihlanfeldt and Sjoquist, 1998). We find that controlling for spatial mismatch as measured by commute time does not decrease the estimated relationship between public transit density and the youth unemployment rate, which supports our argument that public transit alleviates spatial mismatch by increasing job accessibility.

As mentioned above, our model has limited predictive power for car dependent cities, so we cannot report a significant relationship between the density of the public transit system and youth unemployment in cities where cars are more prevalent.

5.3 Longitudinal models

The fixed effects models shown in Table 4 confirm the results of the cross-sectional model while also controlling for time-invariant unobservable city characteristics. Indeed, when we control for the city characteristics, we see that the magnitude of the effect of transit density on youth unemployment in car independent cities increases. The statistical significance of coefficients in the fixed effects models is reduced due to larger standard errors. The fixed effects models show that, for car independent cities, a one vehicle revenue mile per capita increase in the public transit density is associated with a 2.4 percentage point decrease in youth unemployment (model 2). Our model without city fixed effects for car independent cities

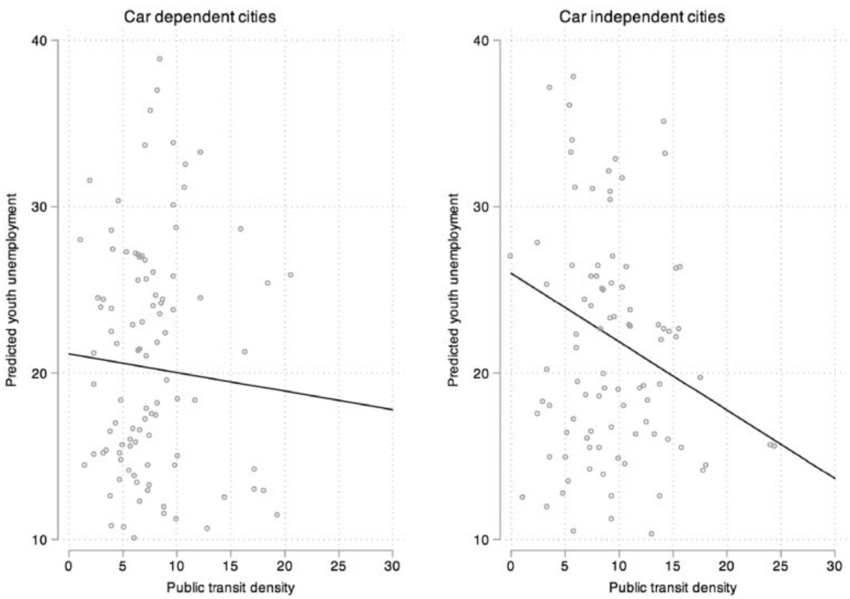

Figure 4. Predicted youth unemployment rate for car dependent and car independent cities pooled for 2000 and 2010

Note: Predicted level according to multiplicative model 3, Table 6. Fitted values for car dependent cities are at the mean of car dependent cities (7% of carless households) and the mean of car independent cities (12% of carless households)

estimates that a similar one-unit increase in public transit density is associated with a .5 percentage point decrease of the rate of youth unemployment (model 6, Table 3). Again, we control for time-variant city characteristics that may proxy for poor public transportation and also affect youth unemployment in models 3 and 4, and we find similar results.

The longitudinal models using fixed effects further support our initial finding that incremental increases in public transit have a differential effect depending on how ingrained a city is in its car dependence. For car dependent cities, the effect of public transit on youth unemployment is not statistically significant, and substantively smaller than in car independent cities. For car independent cities, in which fewer households have access to a vehicle, the efficacy of expanding public transit is statistically significant and five times greater than in car dependent cities. This is controlling for time-invariant characteristics of cities as well as over time changes in population, population density, carless households and average commute time. The results underscore that optimism about the positive economic consequences of public transit may be unjustified in cities whose infrastructure relies heavily on individual transportation. Presumably, the transportation lock-in of these cities can only be overcome with a shift in urban design, major investments in public transit, and the removal of other obstacles to accessibility.

Table 4. Fixed effects models predicting youth unemployment for car dependent and car independent cities

	(1) Car dependent	(2) Car independent	(3) Car dependent	(4) Car independent
Public transit density	0.480	−2.403**	1.032	−2.051*
	(1.163)	(0.819)	(0.931)	(0.817)
Total population	−3.343	9.155	−6.219	13.201
	(20.799)	(16.415)	(15.673)	(16.130)
% Youth population	2.260	4.326†	1.804	3.993
	(2.329)	(2.563)	(2.423)	(3.222)
Population density	33.454†	5.749	26.337	1.151
	(19.945)	(9.495)	(21.614)	(12.012)
Carless households	1.512	0.618	2.325	1.305
	(2.477)	(1.631)	(3.418)	(2.477)
Avg. commute time	−3.676	−0.379	−3.754†	−0.335
	(2.300)	(3.136)	(2.200)	(4.128)
State per capita GDP (Previous Year, $10 000)			4.199	−2.055
			(7.441)	(3.939)
Asian-white Segregation			−0.688	−0.210
			(0.740)	(0.559)
Black-white Segregation			−0.330	−0.836
			(0.490)	(0.619)
Hispanic-white Segregation			0.250	0.503
			(0.564)	(0.556)
Constant	−5.064	−41.628	20.529	−6.123
	(106.635)	(57.922)	(154.332)	(99.280)
N	98	92	98	92
R^2	0.83	0.74	0.87	0.78

Standard errors in parentheses; $^{\dagger}P < 0.1$, $^{*}P < 0.05$, $^{**}P < 0.01$.

Note: Analyses are for 92 observations with above ('car independent') and 98 observations below ('car dependent') median households without access to a vehicle, for years 2000 and 2010. Transit measures include all bus modes, but excludes among others heavy rail and commuter modes.

Source: Census (2000), ACS (2010), DoT National Transit Database (2000–2010).

6. Conclusion: public transportation reduces spatial mismatch

Cities often face challenges in connecting the supply and demand sides of their metropolitan labor market. Unfilled job vacancies can coexist with qualified jobless workers, in sizable part because of a basic spatial mismatch: jobs are often geographically separated from areas with affordable housing. The spatial mismatch is a strain for both workers and potential employers. While the effects of public transit on the labor market are an issue of international importance, it is a particularly sensitive topic in the US. The absence of efficacious public transportation policies since the 1960s—in combination with early mobilization, car-friendly zoning and a lack of tax incentives for public transportation—has made the US more reliant on cars than most other countries (Buehler 2014). Today, inhabitants of German cities are on average five times as likely as urban Americans to use public transportation (Buehler and Pucher, 2012). Given the relatively low usage of public transportation in the US and spatial mismatch in American urban labor markets, this article investigates whether differences in the availability of public transit services in American cities are related to labor market outcomes for young workers. These findings highlight the importance of local level public institutions for socio-economic dynamics. They also have implications for urban planning in contexts in which the availability and uptake of public transportation services is limited.

Improving the geographic mobility of job seekers has the potential to expand their job search and commuting reach, creating a more regionally integrated labor market. Existing research has long shown that unemployment and spatial mismatch can be addressed by private car ownership, reducing 'structural' unemployment in a city. But the proliferation of single occupancy automobiles imposes many negative externalities on a city and its natural environment, producing congestion and pollution (Delucchi, 2000; Litman, 2013). Moreover, privately owned vehicles are very expensive for young workers and job seekers, especially in terms of up-front capital costs, rapid depreciation and unpredictable maintenance expenses. There are many reasons why city architects and urban planners might see public transit as a critical part of the metropolitan labor market for young workers. Drawing on economic sociology and urban economics, we test the potential for public transportation systems to help match supply and demand in the youth labor market.

Our analysis improves upon previous work in two ways. First, our city panel data allow us to control for place characteristics that might systematically affect both transit services and youth unemployment, such as historical infrastructure investments, city design and population preferences. The large scale comparative research design of this study broadens the evidence in an area that so far has tended to focus on case studies in one or two cities. Second, we take into consideration the broad spectrum of American cities and their infrastructure by accounting for variation in car dependence. Recent evidence from car *independent* cities, such as New York City, finds a positive, causal relationship between public transit expansions and economic outcomes (Barton and Gibbons, 2017; Tyndall, 2017). However, it is not clear how well these results extend to cities that are much more car dependent than New York. Our study takes on the challenge of extending the analysis of the relationship between public transportation and labor market outcomes into places with more limited public transit systems that rely more heavily on cars as the baseline mode of transportation.

We find that in car independent cities in particular, public transit has a strong influence on youth unemployment rates. In these places, an increase in the public transit density by one standard deviation is associated with a two-percentage point reduction in the youth unemployment rate. This relationship holds when we take into consideration both time-invariant place characteristics, such as geography and place-specific culture, and a host of control variables, such as cyclical unemployment, racial segregation and car access.

In car independent cities, public transportation becomes a steady bridge connecting unemployed youth to vacant jobs. Investments in public transit services reduce youth unemployment while also creating eco-friendly services. Cities can effectively improve the labor market prospects for low income groups with little access to cars—and help firms fill their labor needs—by treating their public transit systems as labor market institutions.

Our results, however, demonstrate that there are two worlds of urban transit in America. We find that the effect of the quality of public transportation on youth unemployment depends on the current level of car ownership. In cities with high reliance on cars, the public transit system does not significantly affect the youth labor market. As these cities struggle to reduce youth unemployment, incremental investments in public transportation may have little direct payoff. Instead, car dependent cities face deep barriers to making their transit systems work for the labor market; problems of transit management and urban design mean that additional buses on the road alone will likely not solve the problem of spatial mismatch. These cities may also need to address problems of urban walkability and fragmented governance of metropolitan transit. However, there is a silver lining for car dependent cities. While heavy rail and light rail require large capital investments in infrastructure, the excellent road systems in the US eliminate this initial cost for bus services (Hensher, 2007; Tirachini *et al*., 2010). [12] Cities with a network of well-maintained streets—if they can overcome their institutional barriers to public transit use—also have ample opportunities to radically expand their bus systems.

In many cities, public transit can have important long-term benefits by smoothing the school-to-work transition for young people, and therefore diminishing structural unemployment. It can help facilitate attachment to work and economic independence early in young people's employment careers. For employers, better public transit can reduce problems of unmet labor demand that limit their capacity to grow. Alternative solutions, such as incentivizing private car ownership to connect young workers with jobs, are at odds with reducing environmental pollution and transportation hardship on unemployed workers. Our results suggest that investing in the quality and coverage of public transportation services instead of increasing reliance on cars is also an effective strategy for addressing inefficiencies in the labor market at a lower environmental cost. We also show that incremental investments are insufficient to release the positive economic consequences of public transit in cities whose infrastructure and culture are overly reliant on cars. For cities of the 21st century, public transportation is not only an appealing option for increasing urban sustainability, but also an important labor market institution.

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