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How buses alleviate unemployment and poverty: Lessons from a natural experiment in Clayton, GA

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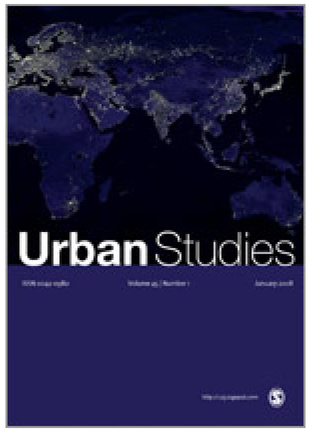

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Abstract

Many studies have documented the linkage between public transportation and economic outcomes, though there is relatively little empirical evidence on the consequences of losing existing transit services, especially bus services, which disproportionately serve low-income populations. We investigate the impacts of bus access on poverty and employment using a natural experiment in Clayton County, GA, where the local bus transit was terminated between 2010 and 2015. Using a difference-in-difference approach, we find substantial increases in poverty and unemployment rates in affected neighbourhoods during the five-year period. Our findings suggest both the spatial mismatch hypothesis, which predicts the reduction in transit access can lead to reductions in job accessibility and employment, and the residential sorting hypothesis, which states that poor households gravitate toward neighbourhoods with better transit access, could be at play. Overall, we find strong evidence that disruptions in bus transit could have significant adverse impacts on neighbourhood economic outcomes. Our findings underscore the need for federal and local public transportation funding to help improve job access, alleviate poverty, and maintain neighbourhood stability.

Keywords

Public transportation, bus transit, poverty, unemployment, neighbourhood change

Introduction

Lack of access to jobs, and the subsequent unemployment or underemployment, can be a major driver of urban and suburban poverty (Preston and McLafferty, 1999; Gobillon and Selod, 2021).

Despite the automobile dependence in most U.S. cities, many still ride transit to work, especially minority, lower-paid workers who are more susceptible to poverty and unemployment (Burrows et al., 2021; Clark, 2017). Access to public transportation (or lack thereof), therefore, could have an important role in expanding access to jobs and alleviating poverty (Grengs, 2010; Lyons and Ewing, 2021; Sanchez, 2008).

Many studies have explored the linkage between public transportation and economic outcomes (Lyons and Ewing, 2021; Pasha et al., 2020; Sari, 2015; Sanchez, 1999; Sanchez, 2008), though few examined the causal effects of losing existing transit, especially bus services, on unemployment and poverty. Since transit disruptions caused by natural disasters or public safety crisis are often accompanied with confounding factors influencing economic activities, it can be methodologically challenging to evaluate their economic impacts.

We examine the causal link between bus access, poverty, and unemployment using a natural experiment in Clayton County, Georgia. Clayton's local bus service was abruptly terminated in 2010 due to county budget shortfalls (Fausset, 2010), leaving most residents with no transit access until 2015. Using a difference-in-difference (DID) approach and propensity score matching, we find that the termination of local buses led to significant increases in poverty and unemployment rates in affected areas in 2010-2014. Our findings make an important contribution to the literature and policy debates on the role of public transportation in job access and poverty.

Background

Bus transit in Clayton County

Clayton is one of the core counties in the Atlanta metropolitan region, lying adjacent to the city of Atlanta to the south. The Hartsfield Jackson International Airport, in Clayton's northwest corner, is the southern terminus of Metropolitan Atlanta Rapid Transit Authority (MARTA)'s heavy rail line, but the rail station is inaccessible from outside the airport. Therefore, buses are the primary form of public transportation serving the county. A local bus system, C-Tran, served Clayton County and connected its residents to MARTA and Atlanta from 2001 to 2010. In March 2010, C-Tran ended all bus routes due to county budget shortfalls (Fausset, 2010). On November 4, 2014, voters in Clayton County passed a referendum with an 74-26 percent split to join MARTA and dedicate a one-cent sales tax to expanding MARTA services to the county (Laing, 2014; Karner and Duckworth, 2019). MARTA started operating bus routes in Clayton in March 2015 (MARTA, 2015).

Clayton County is a working-class suburb with one of the highest concentrations of racial minorities in the Atlanta region. Black residents represented 60.6% of the county's population in 2005-2009 (US Census Bureau, 2021). By the time the county commission voted 4 to 1 to end C-Tran service in October 2009, the bus routes had been an essential service for transit dependent commuters in Clayton County (Fausset, 2010). Prior to the termination in 2010, C-Tran operated five bus routes with over 2 million trips annually. 4% of the workers in Clayton County commuted by transit in 2005-2009, the third highest in metro Atlanta following Fulton and DeKalb, the two counties forming the City of Atlanta (US Census Bureau, 2021). A few private companies attempted to fill the gap after the termination of C-Tran, often with limited service and higher fares, though these attempts were largely unsuccessful and short-lived (Rankin, 2012; Martinez, 2011; Feigenbaum, 2014). The five-year gap in local bus service could have had tremendous impacts on transit riders in Clayton County.

Figure 1 shows the bus routes in Clayton County in 2007 (C-Tran) and 2016 (MARTA). The census tract encompassing the airport (shaded area in Figure 1) is the only tract in Clayton with direct access to MARTA rail, though it contains no residential population and is excluded from our analysis. Six of the 50 census tracts in Clayton are also served by Georgia Regional Transportation Authority (GRTA) Xpress, a regional commuter coach service throughout the Atlanta region (Figure 1). Xpress was not affected by the decision to end C-Tran, and these tracts maintained some regional bus access during 2010-2014. In robustness tests described in *Findings*, we test the hypotheses without these tracts. Including or excluding these six tracts has no substantial effects on our results.

Please insert Figure 1 here

A conceptual framework

We draw from several groups of literature to form two theoretical links between bus access and poverty or unemployment. The first one, based on the spatial mismatch theory and the transport justice literature, posits that losing bus access will negatively impact the labour market and economic outcomes of affected residents. The second link, drawing from the neighbourhood change literature and the poverty decentralisation hypothesis, suggests that the lack of bus transit may also lead to lower rates of poverty and unemployment via inter-neighbourhood migration and residential sorting.

Spatial mismatch, transport justice, and equitable accessibility. The spatial mismatch theory, started in the 1960s in the U.S., links inner-city poverty to the separation of people and jobs in suburbanization (Kain, 1968). Subsequent research extends the model to other countries and contexts, with emphases on residential segregation and jobs-housing imbalance (Fan et al., 2014; Gobillon and Selod, 2021; Holzer, 1991; Cervero, 1989). The focus on physical distance or travel time often assumes commuting by car, thus overlooking the role of public transportation in job accessibility (Grengs, 2010; Kain, 1992). Some researchers further attribute poor job accessibility to lower levels of car ownership and advocate expanding access to automobiles for vulnerable populations to address the "modal mismatch" (Grengs, 2010; Blumenberg and Manville, 2004; Taylor and Ong, 1995; Patacchini and Zenou, 2005; Blumenberg and Pierce, 2014).

While many consider public transportation inadequate in bridging the job access gap, researchers find linkages between transit access and employment, although more empirical evidence focuses on rail than bus transit. Sanchez (1999) finds that labour participation rates are negatively associated with distance from rail or bus stops in Portland and Atlanta. Sari (2015) and Mayer and Trevien (2017) report evidence from Bordeaux and Paris that new construction and extension of public transit lead to increased employment. In a natural experiment similar to our study design, Tyndall (2017) examines the effect of the R Train closure in New York City following Hurricane Sandy, though the transit disruption was limited to one train route in a transit rich city and a much shorter time frame. One year after the hurricane, Tyndall (2017) finds significant increase in unemployment rates along the R Train, suggesting the R Train closure had an adverse impact on commuters and job searchers in these neighbourhoods. An inter-city cross-sectional analysis by Lyons and Ewing (2021) argues that transit may affect unemployment and poverty indirectly by supporting compact urban forms.

A broader literature on transport justice further establishes the importance of transit in ensuring equitable accessibility, including access to economic and employment opportunities (Tiznado-Aitken et al., 2021; Adli and Chowdhury, 2021; Liu and Kwan, 2020). Jiao and Dillivan (2013) use "transit deserts" to describe areas where transit services do not meet transit demand. Cai et al. (2020) find 11% of low-income commuters in Wuhan, China live in transit deserts. In Atlanta, Wyczalkowski et al. (2020) find low transit connectivity in poor, minority concentrated neighbourhoods. The reimplementation of bus transit in Clayton County was a public response to transit inequity and move towards transit justice (Karner and Duckworth, 2019).

The residential sorting and poverty decentralisation hypotheses. Transit has long been seen as a potential driver of rising property values (Stokenberga, 2014; Bowes and Ihlanfeldt, 2001; Hess, 2005; Grass, 1992) and gentrification (Dawkins and Moeckel, 2016; Grube-Cavers and Patterson, 2015; Baker and Lee, 2019), which may lead to the displacement of low-income residents. As in the spatial mismatch literature, more attention has been paid to rail and bus rapid transit (BRT) than regular bus, although the latter forms the bulk of public transit systems in the U.S. (APTA, 2019). The few studies finding a positive linkage between bus transit and property values are largely from outside the U.S. (Ibeas et al., 2012; Yang et al., 2019), likely reflecting the higher share of racial minorities among American bus riders and the related stigma and poor service quality (Clark, 2017). Taking service frequency into account, Pasha et al. (2020) find increased bus access is associated with increased employment as well as poverty but not increased rental values in Cuyahoga County, Ohio, suggesting buses have not caused displacement of poverty.

Other studies showing a positive association between transit and poverty point to the importance of transit access in poor households' residential choices (Brueckner and Rosenthal, 2009; Glaeser et al., 2008). Glaeser et al. (2008) argue that the concentration of poverty in cities is largely attributable to better transit access. Likewise, recent research on suburbanization of poverty suggests the expansion of transit may have played a role in housing decisions of the poor. Wang and Woo (2017) report increasing racial and income diversity in suburban transit rich neighbourhoods in metro Atlanta. Moreover, they find a stronger association between poverty and transit ridership in suburban transit rich neighbourhoods than those in downtown or inner-city. Pathak et al. (2017) examine the longitudinal changes in suburban poverty in metro Atlanta in relation to the expansion of bus transit, concluding that growing transit coverage has expanded the housing options of the poor and facilitated the decentralisation of poverty.

These theoretical models have various implications on the termination of C-Tran in Clayton County. On one hand, the spatial mismatch hypothesis predicts increased poverty and unemployment due to diminished job accessibility, implying that low-income workers have low residential mobility due to the limited availability of affordable housing. The poverty decentralisation hypothesis, on the other hand, suggests decreased poverty due to residential sorting. The two processes could work in tandem, with the transit disruption first worsening the economic outcomes of transit riders in affected neighbourhoods and then forcing some of them to relocate to areas with better transit access.

Methodology

The difference-in-difference (DID) approach

The termination of C-Tran, caused by fiscal deficits arguably exogenous to the public transit system and with contained effects on Clayton County residents, constitutes an ideal setting for a quasi-experimental examination of the impacts of losing bus transit on poverty and unemployment rates. If all other factors were held equal, we can expect poverty and unemployment to increase or decrease in Clayton after the bus termination in 2010 and then regress to their baseline levels following the reinstatement of bus routes in 2015. However, those "other factors" rarely stay constant in real-world settings and could confound our analysis. Notably, the study period of 2005-2019 coincides with the Great Recession and subsequent economic recovery. Even if the transit disruption had no effects, we can still expect to see poverty and unemployment rates rise in 2010 and subside after 2015. It is therefore important to situate any observed changes in the macroeconomic environment to isolate the transit impacts.

The difference-in-difference (DID) approach addresses this issue and identifies causal effects by comparing observed temporal changes in “treated” versus “control” areas (for a more detailed discussion of DID, see Lechner, 2011). Specifically, in this study “treated” areas are census tracts in Clayton County that lost bus access in 2010, and “control” areas are census tracts from the rest of the Atlanta region that were not affected by the termination of C-Train but otherwise similar to the treated tracts. We compare poverty and unemployment rates in three five-year periods:

- Period 1 (*P1*): 2005-2009, when C-Tran operated in Clayton.
- Period 2 (*P2*): 2010-2014, during which Clayton had no local public bus services while other counties only experienced marginal or incremental changes in transit coverage.
- Period 3 (*P3*): 2015-2019, when MARTA implemented new bus routes in Clayton.

The effects of the termination of C-Tran will be observed in P2.

Figure 2 demonstrates the DID approach in three hypothetical scenarios. In Figure 2(a), with no linkages between transit access and unemployment or poverty, both treated and control tracts follow the same macroeconomic trend in three time periods. Figure 2(b) illustrates the scenario where the spatial mismatch theory was dominant, i.e., the termination of bus services led to an increase in poverty or unemployment in P2 *in addition to* that caused by the Great Recession (as seen in control tracts). The widened gap between treated and control tracts in P2 represented the effects of the transit disruption. In Figure 2(c), residential sorting was a stronger force, and treated tracts saw a smaller increase (or even decrease) in poverty or unemployment as compared to control tracts. In all three scenarios, controlling for macroeconomic trends using the DID approach helps identify the impacts of the transit disruption.

Please insert Figure 2 here

The study area

Following the Atlanta Regional Commission[1], we define the Atlanta region as the 11-county area including Cherokee, Clayton, Cobb, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Henry, and Rockdale counties. In addition to the 2007 C-Tran map, we obtained transit maps for the 11-county Atlanta region in 2010 and 2016, including MARTA, GRTA Xpress, and local transit services in other counties, such as Cherokee Area Transportation System (CATS), CobbLinc or Cobb Community Transit (CCT), and Gwinnett County Transit (GCT). Since no large-scale expansion or termination of transit services occurred outside Clayton County between 2005 and 2014, we use the 2010 maps to derive bus access measures for both P1 and P2.

We develop two measures for bus access: 1) a binary indicator, *HASSTOP*, with 1 indicating at least one bus stop within the census tract and 0 indicating none, and 2) a continuous variable, *PCTBUS*, measuring the percentage of land area in a census tract within a 0.5-mile buffer from any bus stop. The continuous measure complements the binary indicator and allows us to differentiate tracts with extensive bus coverage from those with minimal coverage. The Atlanta region has limited rail coverage only in Fulton and DeKalb, with rail stations and surrounding neighbourhoods all well served by buses. Therefore, our bus access measures would also capture rail transit access where it exists.

We are primarily interested in areas affected by the termination of C-Tran, so we exclude all census tracts outside Clayton County that experienced *substantial changes* in bus access between 2010 and 2016 from the panel dataset. We define a substantial change as either 1) having no bus stops in 2010 and one or more bus stops in 2016, or 2) having one or more bus stops in 2010 and no bus

[1] https://atlantaregional.org/atlanta-region/about-the-atlanta-region

stops in 2016. In other words, *HASSTOP* is time invariant in all control tracts in our panel dataset. We further use propensity score matching to select control tracts, as explained in the following section.

Propensity score matching

Propensity score matching (Rosenbaum and Rubin, 1985) is a statistical technique widely used in quasi-experimental studies for constructing control groups comparable to the treatment group. Matching is based on the "propensity" for treatment as predicted by a set of covariates, thus balancing these covariates between the treated and control subjects. We create two matching scenarios: one defines all census tracts in Clayton County as treated, and the other defines only Clayton tracts with one or more bus stops (i.e., *HASSTOP* = 1) in P1 as treated. Table 1 shows the matching variables, including the two dependent variables, the two measures of bus access, and a number of control variables. All variables were measured in P1 for matching purposes.

Please insert Table 1 here

For each of the two scenarios, we use nearest neighbour matching to create three matched samples, containing one, three, and five matches for each treated tract. Nearest neighbour is a matching algorithm that identifies the closest control unit(s) in propensity scores (based on the matching variables in Table 1) for each treated unit. Table 2 compares the means of all matching variables between the treated and control tracts in P1, as well as all untreated tracts in the Atlanta region, for each of the six matched samples. As Table 2 shows, propensity score matching significantly improves the comparability between treated and control tracts, especially in the two 1:1 matching samples. Figure 3 shows the locations of these matches in relation to the treated tracts, as well as tracts excluded due to substantial changes in bus access. Most of the matched controls are geographically close to the treated tracts or in similar suburban locations of the Atlanta region, although geographical proximity is not considered in the matching process.

Please insert Table 2 here

Please insert Figure 3 here

Model Specification

Equation (1) shows our main model specification:

$$y_{it} = \beta BUS_{it} + X_{it}\theta + u_i + \varepsilon_{it} \qquad (1)$$

where y_{it} is the outcome variable (*POVERTY* or *UNEMPLOYMENT*) in census tract *i* and period *t*, BUS_{it} represents one of the two measures of bus access in tract *i* and period *t*, X_{it} is a vector containing all control variables in Table 1, and u_i is a full set of census tract fixed effects so we can isolate temporal changes in poverty and unemployment within tracts. The parameter β captures the association between bus access and poverty or unemployment. A positive β will indicate that the termination of C-Tran has led to reduced poverty and unemployment, and a negative β suggests the opposite.

To test the residential sorting hypothesis more directly, we use a slightly modified set of models to examine neighbourhood change and residential mobility in the affected tracts. These models use the following dependent variables:

- Total population (natural log);
- White population (natural log)
- Black population (natural log);
- % population that moved into their current units (at the time of survey) within five years;

- % population that moved within the same MSA in the past 12 months;
- % population under poverty that moved in the past 12 months.

The first three variables test socio-demographic changes as related to the termination of C-Tran. We use population counts instead of percentages to examine population growth and inter-neighbourhood migration. Unlike poverty or unemployment status, race typically does not change over time, so changes in the number of whites or Blacks in five years would be a stronger indicator of residential sorting than changes in poverty or unemployment rates. The last three variables test residential mobility. The model takes a similar form to Equation 1:

$$P_{it} = \gamma BUS_{it} + H_{it}\delta + u_i + \varepsilon_{it} \quad (2)$$

where P_{it} is the one of the neighbourhood change or residential mobility variables, and H_{it} is a reduced set of control variables, including only housing costs (*LNRENT* and *LNVALUE*) and age (*H30OLD*) as factors of residential choices. According to the theory that the poor and disadvantaged gravitate to transit rich neighbourhoods, we should see positive estimates of γ for Blacks and negative estimates for whites. If, on the contrary, the termination of C-Tran has diminished the desirability and economic vitality of the affected neighbourhoods, we expect to see the opposite signs in γ.

The three residential mobility measures have inherent limitations due to the design of the American Community Survey (ACS). None of them distinguish movements within census tracts from those between census tracts, so increased mobility does not necessarily suggest population inflows from other tracts. Moreover, as the ACS estimates only describe people living in a census tract at the time of the survey, these measures cannot capture people who have moved out of the tract. Still, if the disruption in bus access has led to substantial socio-demographic changes through migration, we expect to see more movements in affected neighbourhoods, or a negative γ in those models.

Findings

No matching

Table 3 presents the results of Model 1 without matching, i.e., using all census tracts in the Atlanta region other than those excluded in Figure 3. All four models show a strong negative relationship between bus access and the dependent variables. Specifically, losing all bus stops in a census tract leads to a 5.1 percentage point increase in the poverty rate and a 4.5 percentage point increase in the unemployment rate. These are significant effect sizes, considering the baseline levels of poverty and unemployment in Clayton were 14.9% and 10.9%, respectively, in P1. Most of the control variables are also strong predictors of poverty and/or unemployment. Overall, these results lend strong support to the spatial mismatch or job access hypothesis.

Please insert Table 3 here

Propensity score matching

We then proceed to test the four models in Table 3 using each of the six matched samples illustrated in Table 2 and Figure 3, generating 24 sets of estimates. Figure 4 summarises the key coefficients in these models along with the 95% confidence intervals.[2] Bus access consistently demonstrates a negative association with poverty and unemployment in the six matched samples, with an average effect size of 4.6 percentage point increase in the poverty rate and 3.7 percentage point increase in the unemployment rate in tracts affected by the termination of C-Tran.

[2] Full modelling results available upon request.

Please insert Figure 4 here

Clayton-only analysis

A second strategy of accounting for potential confounding factors, or systematic differences between treated and untreated tracts, is to limit the analysis to Clayton County only. The Clayton-only analysis considers only those tracts with bus access in P1 as treated, and tracts within Clayton that either never had or maintained (via GRTA Xpress) bus access from P1 through P3 as controls. While these control tracts may be ranked lower in propensity score matching, this analysis allows us to rule out the possibility of unobserved factors unique to Clayton County influencing the previously reported results. We run the same four models for the Clayton-only sample, including all census tracts in Clayton except the airport and one with missing *LNVALUE*. Considering the smaller number of tracts (37 “treated” and 11 control tracts) in this sample, we test the models both with and without census tract fixed effects, with standard errors clustered by tract in all models. Table 4 presents the results.

The relationship between bus access and poverty or unemployment persists within Clayton County, suggesting the previous findings are not driven by county-specific factors. Interestingly, the last two models in Table 4 show counterintuitive relationships between the unemployment rate and some of the control variables. The percentage of non-white population (*NONWHITE*) and 25+ adults without a high school diploma (*HSDROP*), often linked with higher unemployment (including in Table 3), are negatively associated with unemployment rates in these models. These associations disappear or become statistically insignificant in models without census tract fixed effects (Models 5 and 6 in Table 4), indicating they are largely driven by temporal changes within census tracts, not cross-sectional variations between census tracts. In other words, decreases in *NONWHITE* or *HSDROP* had concurred with increases in unemployment rates in certain census tracts. These observations, in addition to the strong evidence suggesting the termination of C-Tran caused higher poverty and unemployment, lead us to further investigate the socio-demographic changes and residential mobility in treated tracts.

Please insert Table 4 here

Socio-demographic changes and residential mobility

Figure 5 illustrates key results from models on socio-demographic changes and mobility.[3] We do not find strong evidence that losing bus access is associated with a decline or slower growth of the overall population (the top left panel of Figure 5), with only one coefficient significant at the 0.05 level and one marginally significant ($p = 0.081$). This is further corroborated in the residential mobility models for the population as a while (the top and middle right panels of Figure 5), which show no effects of the transit disruption on overall residential mobility in the past five years or 12 months. The two race models (the middle and bottom left panels of Figure 5), however, paint a different picture: reduced bus access, especially the continuous measure of bus coverage, is associated with a net increase of whites and a net decrease of Blacks in a census tract. These findings are consistent with the residential sorting hypothesis (Pathak et al., 2017; Glaeser et al., 2008), which nevertheless runs counter to our findings regarding poverty and unemployment.

Interestingly, the residential mobility among those living under poverty (% moved within the past 12 months) seems to have slightly increased in census tracts that lost bus access (the bottom right panel of Figure 5). More frequent moving among the poor could be evidence for the residential sorting hypothesis, corroborate the racial changes discussed above or the counterintuitive associations between *NONWHITE* or *HSDROP* and *UNEMPLOYMENT* in Table 4. Specifically,

[3] Full modelling results available upon request.

the termination of C-Tran could have led to increased housing instability for the poor, including an exodus of Blacks and those with lower levels of educational attainment, *as* poverty and unemployment rates rose due to worsening economic outcomes of the low-income residents who stayed in the neighbourhood, creating a spurious positive association between the two processes. Nevertheless, as aforementioned, the residential mobility models should be interpreted with caution, since these measures do not differentiate movements within the census tract or from other census tracts, nor can they reflect displacement from the treated tracts.

Please insert Figure 5 here

Robustness tests

To further test the robustness of our results, we exclude the six census tracts in Clayton County that were served by GRTA and therefore maintained regional bus services during P2, as described in the *Background* section, leaving only those served by local bus routes as "treated" tracts. A new set of matched samples is generated for this subset of treated tracts. In regression analyses like those presented in Figure 4, 23 of the 24 models show significant negative relationships between bus access and poverty or unemployment rates, with a consistent effect size averaging -0.047 on *POVERTY* and -0.039 on *UNEMPLOYMENT*. We also test the models with spatial autocorrelation in dependent variables or residuals. Neither spatial lag nor spatial error models report significant spatial autocorrelation, with key estimates consistent with those reported.[4]

Discussion and Conclusion

Public transit provides an essential service for lower income individuals to access jobs and other opportunities. Even in low-density, automobile-dependent American cities and suburbs, better

[4] All modelling results not fully presented here are available upon request.

transit coverage expands housing opportunities for transit riders and mitigates residential segregation. To date, more research attention has been focused on rail and Bus Rapid Transit (BRT), although in the U.S., bus systems serve the vast majority of low-income transit riders (APTA, 2019). Bus transit, meanwhile, is more vulnerable than rail to disruptions and service cuts due to financial, environmental, and public health crises such as the COVID-19 pandemic. To better understand the implications of bus access and disruptions in bus services on poverty, unemployment, and neighbourhood change, we examine a natural experiment in Clayton County, Georgia, where the local bus service was terminated between 2010 and 2015.

Using a difference-in-difference approach and propensity score matching, we find that the termination of local buses led to substantial increases in poverty and unemployment in affected neighbourhoods, supporting the spatial mismatch theory that lack of public transportation can limit access to jobs, especially for low-income workers. Most of our models suggest that the termination of local buses had a greater impact on the poverty rate than on the unemployment rate, indicating that the economic impact of transit disruptions could go beyond those workers who lose their jobs – for example, to their dependents or those who have to work fewer hours or accept lower pay due to longer commute or reduced employment options. These findings are robust to alternative measures of bus access and matching schemes. While some of the census tracts retained regional bus services during this period, excluding these tracts does not qualitatively change our conclusion.

We find that the termination of local buses also led to an increase in the number of whites and a decrease in the number of Blacks. As poverty and employment status can and do change over time, we consider racial composition a stronger indicator of inter-neighbourhood migration. These findings are consistent with the residential sorting hypothesis that racial minorities and disadvantaged groups tend to live closer to transit (Pathak et al., 2017; Glaeser et al., 2008), though it would not explain the strong linkage between bus access and poverty or unemployment we find in the opposite direction. We also observe an increase in residential mobility among the poor with no significant changes among the population as a whole, although the residential mobility measures do not capture emigration from the neighbourhood and could simply indicate increased housing instability for the poor, which can be an additional adverse effect of the transit disruption.

Our findings suggest that both theoretical models on the relationship between transit and poverty or employment could be at play. While transit access can be an important factor in low-income households' residential choices, losing existing bus service predominantly impacts transit-dependent riders in the area, leading to net increases in poverty and unemployment, at least in the relatively short term of a five-year period. Moreover, the potential exodus of low-income households in seeking of better transit access, which is not captured in our analysis, would only add to the adverse consequences of the transit disruption in Clayton County. While suburban communities in Atlanta often oppose public transit for its connection with the poor (Givens, 2017), the termination of C-Tran in Clayton County had most definitely not attracted enough affluent residents to offset the negative economic impacts on affected neighbourhoods.

This study uses strong quasi-experimental design to provide solid evidence on the causal effects of bus access on poverty and unemployment. The significance of bus transit in job access and poverty has important policy implications. On one hand, it calls for federal and state investments and improvements in bus transit to reduce the accessibility gap. On the other hand, it highlights the risks of transit disruptions for low-income communities. The widespread transit disruptions and service cuts during the COVID-19 pandemic, for example, likely exacerbated the economic impacts of the pandemic on vulnerable populations. Maintaining consistent public transit access, particularly for low-income communities, should be a policy priority in future disasters and crises.

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Conflict of interest

Fei Li declares no conflicts of interest. **Christopher Wyczalkowski** is an employee of the Metropolitan Atlanta Rapid Transit Authority (MARTA), the public transit authority in metro Atlanta. Other than providing bus transit maps, MARTA has no direct involvement in the research. All views and opinions are our own.

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Table 1. Variables definition.

Matching Variables		Description
Dependent Variables	*POVERTY (%)*	Poverty rate
	UNEMPLOYMENT (%)	Unemployment rate
Independent Variables (Bus Access)	*HASSTOP (%)*	Whether there is any bus stop within the census tract
	PCTBUS (%)	% of the census tract within a 1/2 mile radius from a bus stop
Control Variables+	*POPDEN ('000s)*	'000s of people per square mile
	NONWHITE (%)	% non-white population
	HSDROP (%)	% population 25 and over with less than high school diploma
	COLLEGE (%)	% population 25 and over with a bachelor's or higher degree
	LNRENT	the natural log of median rent (2019 dollars)
	LNVALUE	the natural log of median housing value (2019 dollars)
	H30OLD (%)	% housing units built 30 or more years earlier++

+ All control variables are derived from American Community Survey (ACS) 5-year estimates. The 2005-2009 estimates (P1), based on 2000 census tracts, are reweighted to 2010 census tracts for consistency with the other two periods using the relationship file from the Census Bureau.[1]

++ Age of the housing stock is included as a factor of income-based sorting, as suggested by Brueckner and Rosenthal (2009) and Pathak et al. (2017).

[1] https://www.census.gov/geographies/reference-files/time-series/geo/relationship-files.2010.html.

Table 2. Key variables for the "treated" tracts, all other tracts in the Atlanta region, and matched tracts in P1 (2005-2009).

(a) All Clayton County tracts as "treated"

VAR	Clayton County Census Tracts	All Other Tracts	Nearest Neighbour Matches		
			1:1	3:1	5:1
N	49	673	49	147	245
POVERTY (%)	14.9	13.4	15.8	16.2	15.7
UNEMPLOYMENT (%)	10.9	8.4***	10.8	11.2	10.9
HASSTOP (%)	67.3	61.1	67.3	67.3	62.9
PCTBUS (%)	41.0	47.1	42.5	44.6	45.2
POPDEN ('000s)	2.6	3.0	2.4	2.6	2.6
NONWHITE (%)	75.5	45.2***	73.8	68.8**	65.7***
HSDROP (%)	17.0	12.6***	16.0	17.4	16.5
COLLEGE (%)	16.9	38.4***	19.5*	20.7***	22.7***
LNRENT	7.0	7.1**	7.0	7.0	7.0
LNVALUE	11.9	12.5***	12.0	12.0***	12.1***
H30OLD (%)	45.4	39.2*	42.6	42.6	41.7

(b) Clayton County tracts with *HASSTOP* = 1 in P1 (2005-2009) as "treated"

VAR	Treated Tracts	All Other Tracts	Nearest Neighbour Matches		
			1:1	3:1	5:1
N	33	689	33	99	165
POVERTY (%)	16.3	13.3**	20.4*	18.9	19.6**
UNEMPLOYMENT (%)	11.3	8.4***	12.5	12.2	12.4
HASSTOP (%)	100.0	59.6***	100.0	100.0	100.0
PCTBUS (%)	58.6	46.1***	62.2	65.8	71.2**
POPDEN (00s)	47.2	52.1	2.9	3.0	3.3*
NONWHITE (%)	77.9	45.8***	79.5	77.7	76.9
HSDROP (%)	18.0	12.7***	19.7	19.4	18.9
COLLEGE (%)	16.1	37.9***	16.0	19.1**	20.8***
LNRENT	7.0	7.1***	6.9	7.0	7.0
LNVALUE	11.9	12.4***	11.9	12.0***	12.0***
H30OLD (%)	50.6	39.1***	54.9	49.9	52.4

Two tailed t-test between treated and matched/other tracts: ***: $p<0.01$; **: $p<0.05$; *: $p<0.1$.

Table 3. Poverty, unemployment, and bus access in Atlanta region (2005-2019).

	Model 1	Model 2	Model 3	Model 4
DV	POVERTY RATE		UNEMPLOYMENT RATE	
HASSTOP	-0.051***		-0.045***	
	(0.014)		(0.008)	
PCTBUS		-0.064***		-0.059***
		(0.019)		(0.013)
POPDEN	0.003	0.004	-0.003*	-0.003*
	(0.003)	(0.003)	(0.002)	(0.002)
NONWHITE	0.075***	0.075***	0.023	0.023
	(0.021)	(0.021)	(0.018)	(0.018)
HSDROP	0.216***	0.217***	0.085*	0.085*
	(0.059)	(0.059)	(0.047)	(0.048)
COLLEGE	-0.101***	-0.098***	-0.128***	-0.125***
	(0.031)	(0.032)	(0.024)	(0.024)
LNRENT	-0.038***	-0.038***	0.000	0.001
	(0.011)	(0.011)	(0.008)	(0.008)
LNVALUE	-0.086***	-0.087***	-0.041***	-0.042***
	(0.008)	(0.008)	(0.007)	(0.007)
H30OLD	-0.011	-0.011	-0.099***	-0.098***
	(0.010)	(0.010)	(0.008)	(0.008)
N	2112	2112	2112	2112
R^2	0.236	0.234	0.239	0.237

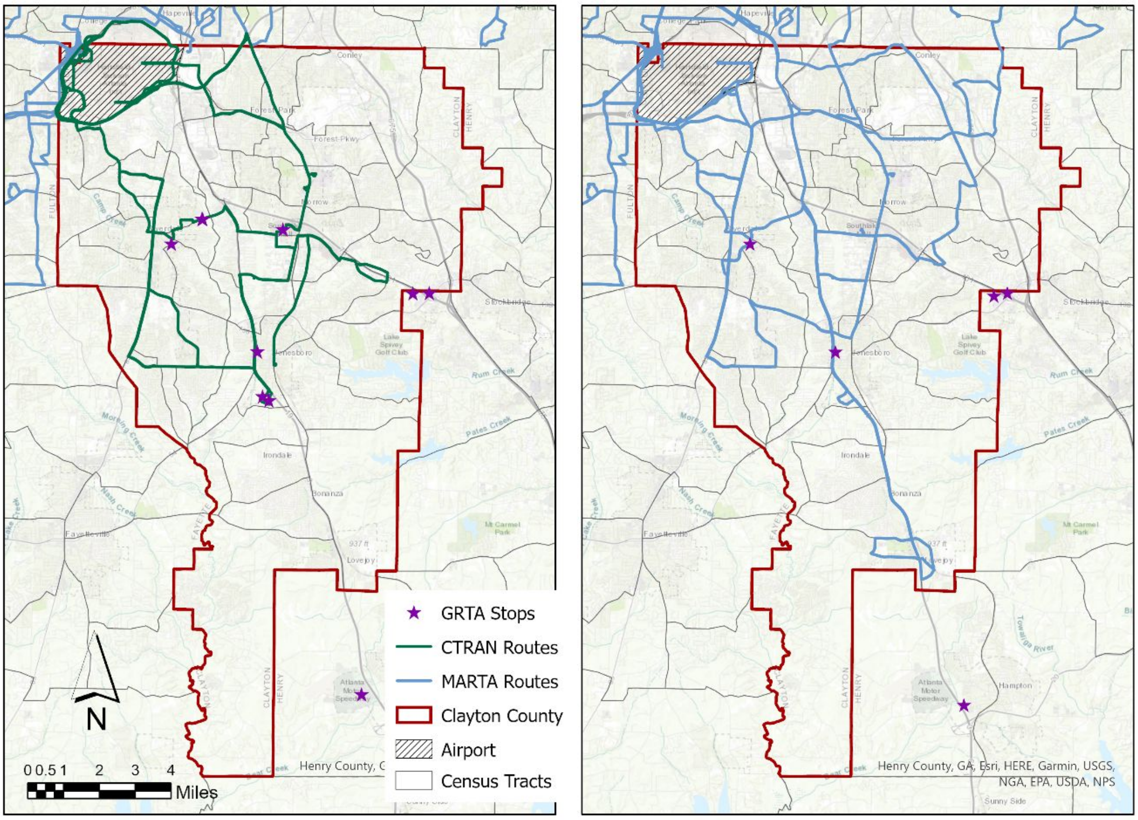
***: p<0.01; **: p<0.05; *: p<0.1. All models include census tract fixed effects. Figures in parentheses are cluster-robust standard errors.

Table 4. Poverty, unemployment, and bus access in Clayton County (2005-2019).

Model	1	2	3	4	5	6	7	8
DV	POVERTY RATE				UNEMPLOYMENT RATE			
HASSTOP	-0.043*** (0.012)		-0.061*** (0.015)		-0.049*** (0.008)		-0.053*** (0.009)	
PCTBUS		-0.071*** (0.021)		-0.122*** (0.028)		-0.077*** (0.013)		-0.092*** (0.016)
POPDEN	0.002 (0.008)	0.003 (0.008)	0.001 (0.016)	0.007 (0.013)	0.007 (0.004)	0.008* (0.004)	-0.002 (0.011)	0.002 (0.010)
NONWHITE	0.152** (0.074)	0.152** (0.073)	0.042 (0.119)	0.079 (0.117)	0.039 (0.049)	0.038 (0.049)	-0.117* (0.067)	-0.092 (0.063)
HSDROP	0.161 (0.125)	0.145 (0.127)	0.101 (0.147)	0.021 (0.158)	-0.110 (0.077)	-0.125 (0.085)	-0.205** (0.079)	-0.266*** (0.086)
COLLEGE	-0.172 (0.116)	-0.216* (0.125)	0.015 (0.175)	-0.057 (0.167)	-0.333*** (0.082)	-0.379*** (0.094)	-0.178* (0.098)	-0.239** (0.092)
LNRENT	-0.215*** (0.040)	-0.232*** (0.044)	-0.212*** (0.072)	-0.213*** (0.060)	-0.015 (0.027)	-0.033 (0.025)	0.056 (0.046)	0.054 (0.052)
LNVALUE	-0.047* (0.026)	-0.045* (0.027)	-0.054** (0.021)	-0.056*** (0.019)	0.002 (0.018)	0.003 (0.017)	-0.026 (0.017)	-0.030* (0.016)
H30OLD	0.031 (0.030)	0.034 (0.031)	0.022 (0.049)	0.034 (0.047)	0.006 (0.021)	0.007 (0.021)	-0.084*** (0.029)	-0.086*** (0.026)
Constant	2.121*** (0.343)	2.230*** (0.355)			0.250 (0.275)	0.367 (0.275)		
Census tract fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
N	144	144	144	1445	144	144	144	144
R^2	0.515	0.515	0.455	0.502	0.300	0.285	0.502	0.519

***: p<0.01; **: p<0.05; *: p<0.1. Figures in parentheses are cluster-robust standard errors.

Figure 1. Bus routes in Clayton County in P1 and P3



(a) Period 1 (2007) (b) Period 3 (2016)

Figure 2. Conceptual models of the difference-in-difference (DID) estimation

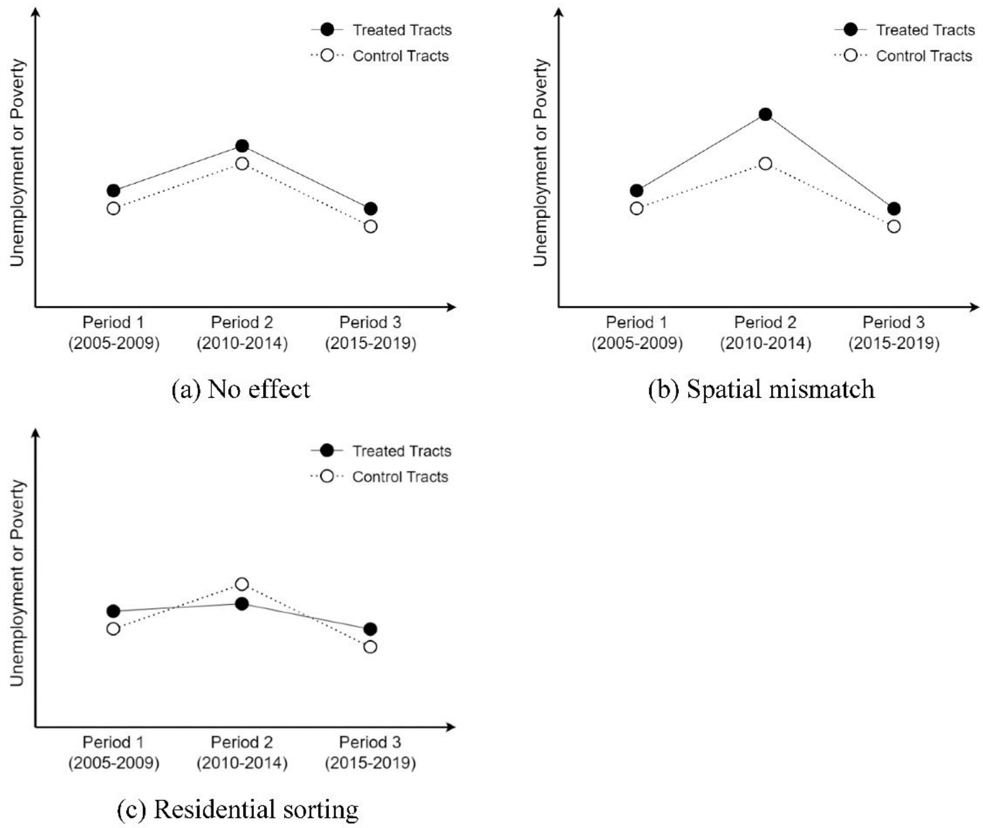
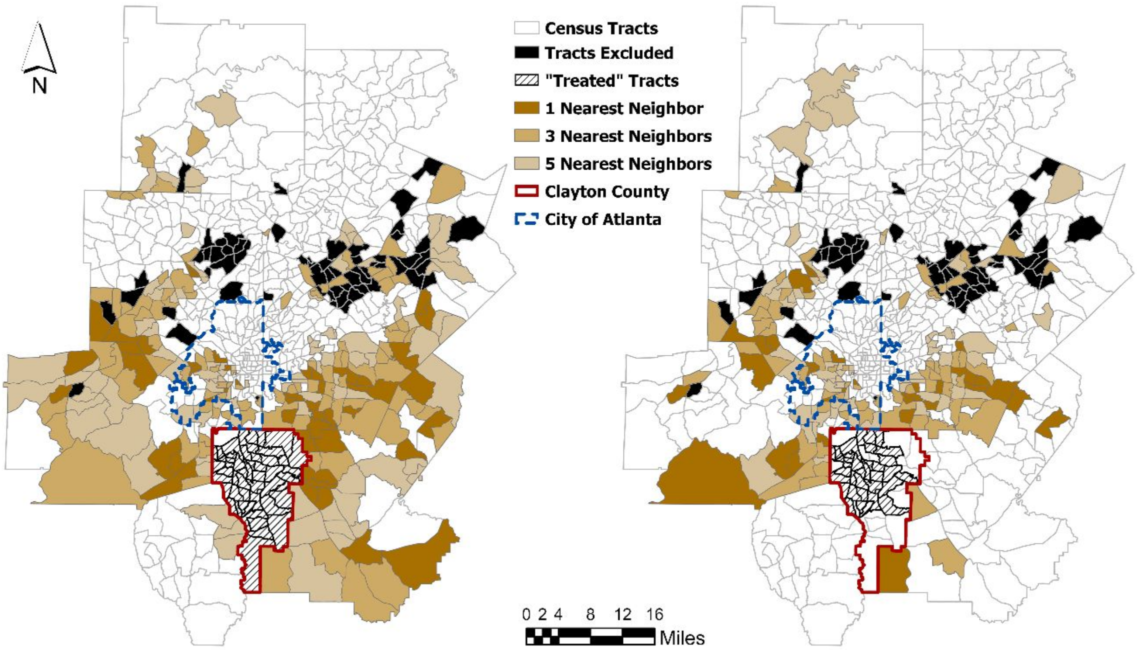


Figure 3. Treated tracts and matches in the two matching scenarios.



(a) All Clayton tracts as "treated" (b) Clayton tracts with bus stops in P1 as "treated"

Figure 4. Regression coefficients on bus access across the six matched samples

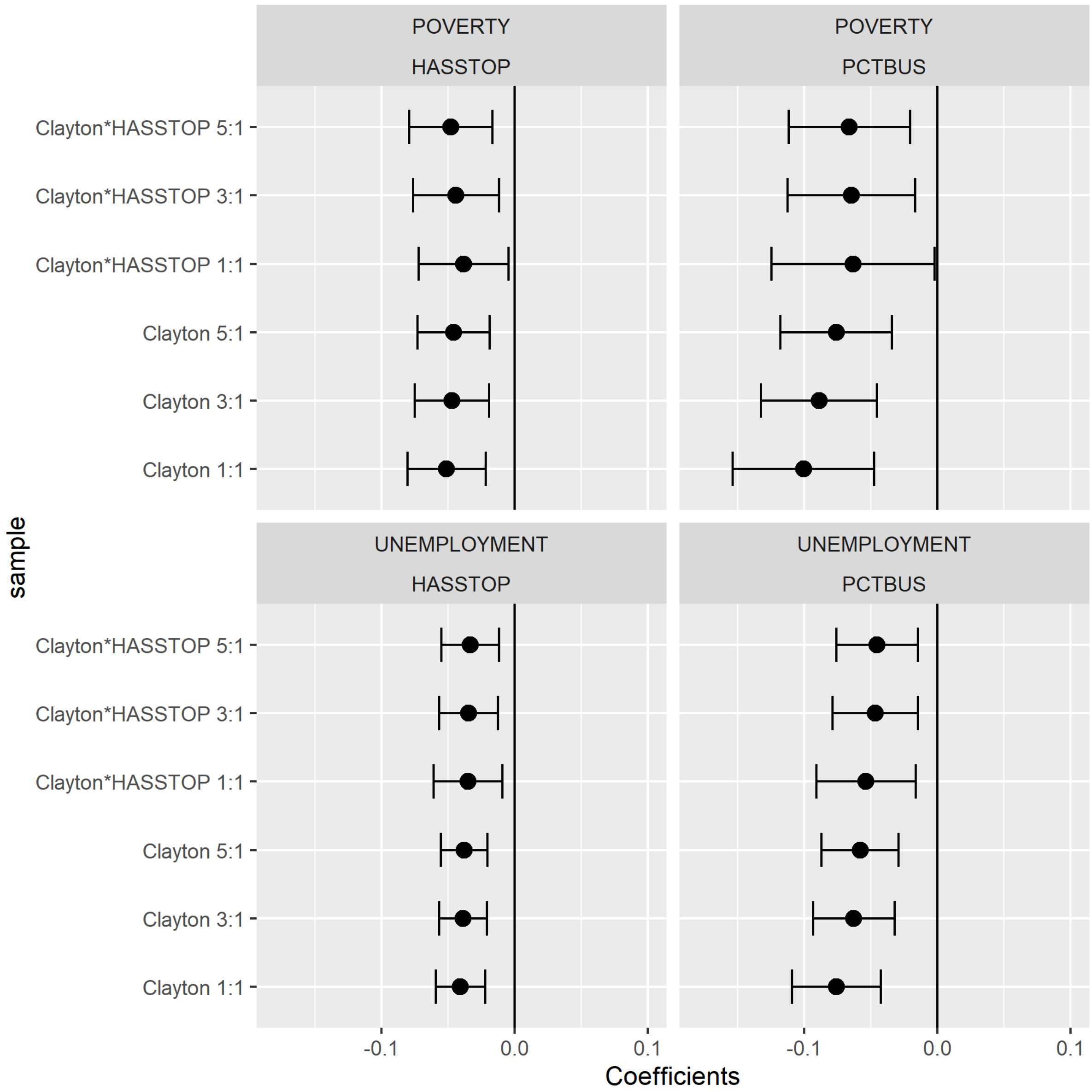


Figure 5. Bus access, socio-demographic changes, and residential mobility, 2005-2019.