PUBLIC TRANSPORTATION INVESTMENTS AND THEIR RELATION TO FOOD CONSUMPTION PATTERNS

By

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ABSTRACT

Urban policy and traffic patterns can influence how people eat, as public transportation improvements can alter the transaction costs associated with choosing unique food outlets. Despite the history of research on infrastructure improvements, few studies have explored these linkages between public transportation investment and consumer food choices, creating a research gap in this area. This study uses a novel dataset to investigate how U.S. transportation investments alter foot traffic patterns in food-away-from-home retail establishments, specifically looking at restaurants and other eating places. We hypothesize that new public transportation reduces consumer transaction costs and leads to an increase in observed demand, as well to a choice substitution effect between different categories of food establishments. To test this hypothesis, we match three TIGER grant awardees to SafeGraph foot traffic data in the areas surrounding the awarded projects. Our awardeesof interest are the Milwaukee Hop, the Omaha Rapid Bus Transit, and the Virginia Pulse; three public transportation systems representing a diverse set of cities and regions. Using two-way fixed effects models, we estimate the effects of each public transportation investment on local foot traffic. Of particular interest is how the new infrastructureinvestments changed foot traffic outcomes in full and limited-service establishments differently. We then compare our results to a placebo city (Savannah, Georgia) as a robustness test. Estimatesvary substantially by city. Contrary to our hypothesis, we fail to find a positive effect on attendanceof these infrastructure investments in two of the three treated cities. In some cases, the infrastructure investments might have decreased foot traffic in the investment region. Wealso fail to confirm our choice substitution effect hypothesis between full-service and limited- service restaurants, finding counter-intuitive outcomes in one of the three cities studied as well asin our Placebo test city. These findings suggest that public infrastructure projects are not a panacea,as they don’t translate into immediate spillover effects to the food system.

Para María del Refugio Beltrán López y Víctor Hugo Quintero Ron

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Esta página me es insuficiente para incluir agradecimientos personales, haré una sección especial para ellos al final del documento; sepan que estoy inmensamente agradecido con el pueblo que me dio el regalo de mi educación, con mi familia, mis profesores, compañeros, amistades y equipo personal. Más sobre ello al final. Muchas gracias a todas y todos.

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INTRODUCTION

Urban policy mechanisms can significantly influence food consumption behaviors, as public transportation investments hold the potential to alter the transaction costs that drive the decision-making process between food outlets. Understanding how such investments impact food choices is essential for public infrastructure enhancement planning. Instead of focusing on how transportation investments might create these changes in the developed world, the prior literature has typically explored relationships between public improvements in transportation infrastructure and reduced transaction costs in other contexts (Adam et al., 2012; Baulch, 1997; Hine et al., 1983). Consumer behavior and marketing scholars have studied purchasing activities, including foot traffic patterns; urban studies have explored city arrangements and development; and the agricultural economics literature has studied the comprehensive impacts of transportation infrastructure investments on the food system. This thesis bridges all these disciplines' approaches and tests the potential for causal links between transportation investments and retail food choices.

Our primary objective is to explore changes in food choices due to public transportation investment, supported in part by the federal government, through the lens of transactions costs theory, which posits that changes in the accessibility and cost of transportation can significantly alter the transaction costs associated with food purchases. As these costs decrease due to improvements in public transportation, consumers may access more diverse food outlets, potentially leading to changes in their eating patterns and food choices. In a "frictionless" local economy with zero transaction costs, more meals are purchased than are observed, where transaction costs for food can be nontrivial. For example, to eat at a downtown restaurant, a household must not only be willing to pay the cost of the meal but also be willing to incur transactions or travel costs for driving, cabs, parking, and/or other transportation-related factors.

It may also be that public transportation investments increase the willingness to pay for retail food proximate to a public transportation investment via, for example, increased downtown revitalization. Hence, we hypothesize that new public transportation investments reduce consumer transaction costs, increasing demand for food establishments in the area.

We test our hypothesis using data at the food establishment level to estimate the effect of public transportation investments on proximate foot traffic. Specifically, we match three U.S. Department of Transportation (USDOT) Transportation Investment Generating Economic Recovery (TIGER) grant awardees to SafeGraph foot traffic data in dining establishments within and outside various distance radii around the awarded projects. Established in 2009, these awards aimed to enhance public improvements of transportation infrastructure by investing in road, rail, transit, and port projects. We examine the effect of the Milwaukee Hop (streetcar), the Omaha Rapid Bus Transit (BRT), and the Virginia Pulse (BRT) as they represent a diverse set of cities and regions in the United States. To test whether our results are an artifact of some underlying macroeconomic trend, we also compare our results to those of a placebo city (Savannah, Georgia), which applied for TIGER funding for a similar project, but not only they did not receive the grant, they lost an existing streetcar system they were trying to improve with the funds.

This research contributes to the literature in three ways: first, by developing a conceptual framework for how transportation investments affect dining establishment choice; second, we link changes in the overall volume of foot traffic in dining establishments to TIGER investments; and third, we test how new infrastructure investments affect foot traffic at full-service and limited-service restaurants.

The thesis proceeds as follows: we begin with a literature background on food access, food security, and prior studies on economic impact of transportation infrastructure investments. Next, we provide a comprehensive background or the TIGER/BUILD investment program, including details on the specific projects of interest. Subsequently, we present our conceptual framework for understanding the effect of these investments on demand for full- and limited-service restaurants. We then detail our methods and estimates for analyzing the effect of these investments on foot traffic for full-service and limited-service restaurants. Finally, the thesis concludes with a summary of policy implications.

BACKGROUND

The development economics' literature contains many examples where infrastructure spending improves food access, though fewer studies have explored this phenomenon in the economically developed world. Indeed, the earliest studies on transportation improvements focused on the general welfare effects of transportation infrastructure investments in developing economies (Owen, 1959; Johnston and Mellor, 1961; Oguike, 1962; Cole, 1968). These studies highlighted the role of government, political leadership, and disruptive events in decision-making for transportation infrastructure investments and their impact on the food economy. For example, Owen (1959) suggested that improving transportation infrastructure can lead to economic progress in underdeveloped countries by preventing food transportation delays and reducing losses related to weather conditions or a lack of commercial capacity. Similarly, Johnston and Mellor (1961) argued for public efforts that improved transportation infrastructure as it could lead to agriculture development, input technology adoption, cropping decisions, and marketing purposes.

Following these early efforts, later studies characterized how transportation costs are linked to prices throughout the food system. For example, Hine et al. (1983) categorized transportation costs as a specific subset of transaction costs, arguing that the cost is a function of the quality of the road. Building from a similar conceptual framework of transportation costs, Barret and Baulch (1996) and Minten and Kyle (1999) used econometric methods to estimate the probability of inter-market arbitrage conditions via exogenous transaction cost data. At the same time, other studies focused on the producer side of the analysis, as Jayne (1994) and Omamo (1998) explored how variation in transportation expenses shaped suppliers' decisions in Zimbabwe and Kenya. Similarly, Gardner and Brooks (1994) and Minten and Kyle (1999) explored how transportation costs could prevent market integration, reduce marketing margins, and restrict regional economies.

More recent studies have focused on linking transportation investments and the comprehensive food system's transformation. Coyle (2005), Pingali (2006), Kassali et al. (2012), Adam et al. (2012), and Shively and Thapa (2016) examined the effects of transportation investments on informal outcomes such as food culture, habits, choices, and decision patterns. Studies have also examined transaction costs' role in the food system. Frank and Henderson (1992) found that transaction costs motivate the use of nonmarket arrangements to coordinate production vertically, and Okoye et al. (2016) found that high transaction costs prevent small farmers from entering the market. Cechin et al. (2021) explored the role of transaction costs in consumers' preferences, choices, and behavior. They found that assortment and the number of establishments that sell organic products increase transaction costs, significantly impacting willingness to pay. Together, these studies highlight the importance of infrastructure spending in improving food access and the complex interplay of transportation costs in shaping food systems.

While prior literature has documented the relationship between transportation infrastructure and the movement of goods and services, the impact of transportation infrastructure on health and nutrition is less studied. A lack of access to sufficient and nutritious food, more commonly known as "food insecurity," is a persistent problem affecting 10.2 percent of U.S. households in 2021, including 3.8 percent with very low food security (Coleman-Jensen et al., 2022). The problem is particularly acute for households with children, women living alone, and elderly Americans living alone.

Food insecurity is generally associated with many health problems. In adults, food insecurity is associated with a higher risk of depression, diabetes, obesity, hypertension, hyperlipidemia, and other ailments that can be improved with good nutrition or worsened by poor nutrition (Gundersen and Ziliak, 2015). For children, food insecurity is linked to an increased risk of congenital disabilities, anemia, lower nutrient intake, cognitive problems, anxiety, and other negative health outcomes (Gundersen and Ziliak, 2014). Children with low food security have twice the odds of tooth decay compared to children with full food security, and those aged between 12 and 15 years in households with food insecurity have a 2.95 times higher risk of iron deficiency anemia than those who are food secure. Moreover, food-insecure mothers have 2.2 times higher rates of mental health problems than fully food-secure mothers, and food-insecure individuals have approximately twice the odds of experiencing diabetes compared to their food-secure counterparts (Gundersen and Ziliak, 2015).

Infrastructure spending in the United States may help address food insecurity, as improved public transit might reduce the impacts of "food deserts." Bitler and Haider (2011) explored the empirical literature on food deserts, highlighting the importance of supply issues and demand-side constraints in determining food access in a given area. Some studies have used geographical approaches to identify spatial access to food, forming the basis for studies looking at food deserts (Larsen and Gilliland, 2008; Strome, Johns, Scicchiatano, and Shelnutt, 2016). Prior research has also found that access to new stores increases consumption of fruits and vegetables, and further research has addressed space-time access to food retailers, the role of transportation, and more specifically public transportation, in food insecurity, and human activity patterns in their food environment (Chen and Clark, 2016; Baek, 2016; Lee and Kwan, 2011). Thus, it may be that investing in infrastructure to address transportation and access to food retailers, including dining establishments, in areas with insufficient supply or demand could reduce food insecurity in the United States.

That said, the prior literature indicates that policy can make food more accessible by reducing the cost of the healthy option by improving the ease of access (Just and Byrne, 2020).

Previous studies have shown that the food environment plays a significant role in the disparity of access and relations to food choices at the individual level (Chen and Yang, 2014). More relevant to our conceptual framing is Byrne and Just (2022), who evaluated the economic value of food pantry access, finding that food pantry clients gain value from decreased travel costs to and from their local food pantries.

A study conducted in Burkina Faso by (Ruijs, Schweigman, and Lutz, 2004) provides further nuance to this discussion, finding that isolated reductions in transportation and transaction costs have a small and non-significant effect on food prices and availability. However, simultaneous reductions in transportation and transaction costs lead to significant benefits for consumers and suppliers. Building from these studies, we explore the impact of public transportation investments on transaction costs and their potential to influence food purchasing choices while also considering their impact on traffic patterns that are closely tied to the operating hours of the public transportation system.

Changes in transport and transaction costs are directly linked to food prices and availability. In the context of the relationship between travel costs and purchasing patterns in dynamic food environments, recent research suggests that households shift their food expenditures towards retailers who accept SNAP benefits, highlighting the significant influence of travel costs on households' food purchasing choices (Byrne et al. 2023). Additionally, some stores increased their inventory of fresh foods to meet the demand of SNAP recipients, further emphasizing the importance of travel costs in shaping food access.

The TIGER/BUILD Program

Though dense literature surrounds transportation investments in developing countries, fewer studies have explored these investments in economically developed countries. One such program worth exploring is the Transportation Investments Generating Economic Recovery (TIGER) grant program, which was later renamed the Better Utilizing Investments to Leverage Development (BUILD) program. The TIGER program is a competitive discretionary grant program under the U.S. Department of Transportation (DOT) initiated during the 2007-2009 recession to improve transportation infrastructure and stimulate economic activity. Its origins can be tracked back to the American Recovery and Reinvestment Act of 2009 (ARRA; P.L. 111-5), where it was referred toas "national infrastructure investment."

The primary objective of the TIGER/BUILD program is to fund transportation projects ofnational, regional, and metropolitan significance, with a focus on regional and metropolitan areas. Eligible projects include highway, bridge, or other road projects; public transportation projects; passenger and freight rail transportation projects; port infrastructure investments, including inlandport infrastructure and land ports of entry; and intermodal projects. Eligible applicants include state and local governments, including U.S. territories, tribal governments, transit agencies, port authorities, metropolitan planning organizations (MPOs), and other political subdivisions of stateor local governments.

Over the years, certain allocation criteria have evolved. For instance, in the first year, no more than 20% of the total program budget could be allocated to a single state. That share was raised to 25% from 2010 to 2015, reduced to 20% in 2016, and reduced again to its current level of no more than 10% of the program budget to a single state. A 20% rural-80% urban project allocation was set in 2015. That share was raised to 30% in 2018, and currently, no less than 50%

of the program budget can be focused on projects in rural areas. A project will be designated as rural if it is located in an urban area that had a population less than 200,000 in the 2020 Census, or identified outside of any Census-designated urban area.

Furthermore, the project investment caps have changed over the years. In 2009, no more than $300 million could be allocated to one project, reduced to $200 million from 2010 to 2015, then further decreased to $100 million in 2016, and is currently set at $25 million per grant from 2017 to date. The DOT requires grantees to develop performance plans and measures for each project, starting before construction and continuing for years after completion. However, there is no requirement for comparability of the measures across projects. The sponsor of each project is responsible for setting up performance measures considered relevant to its project.

Critics of the TIGER/BUILD program have pointed out several shortcomings. One main criticism received from evaluations (Congressional Research Service, 2019) (Feigenbaum, 2012) is its sustainability, as it relies heavily on discretionary funds and is subject to the whims of changing administrations and political priorities. This uncertainty makes it challenging for states and local governments to plan long-term transportation projects and investments. Additionally, the competitive nature of the program means that many worthwhile projects may not receive funding due to limited resources or other factors, leading to disparities in transportation infrastructure across different regions and populations.

Another critique centers on the lack of a clear performance measurement system, making it difficult to assess the effectiveness of the funded projects. While grantees are required to develop performance plans and measures for each project, there is no standardized or comparable method for evaluating the success of different projects. This lack of accountability has led some to question whether the program is achieving its goals of improving transportation infrastructure and generating economic activity. Additionally, some have argued that the program's focus on larger-scale projects may neglect smaller, community-based transportation needs, further exacerbating disparities in access to transportation. (Congressional Research Service, 2019) (Feigenbaum, 2012)

However, the TIGER/BUILD program has also offered benefits, allowing regional and local governments to apply directly to the federal government for funding and providing states with additional funding beyond their annual highway and public transportation formula funding. The program has supported a diverse range of transportation projects across the United States, contributing to economic development and improving transportation infrastructure. We now review each of our three funding recipients of interest, with Table 1 (see appendix) providing a summary.

CASE STUDIES

The Hop – Milwaukee Streetcar

In 2015, The Hop Streetcar project was approved for the city of Milwaukee, Wisconsin, during the seventh round of TIGER grant funding. The Hop Streetcar is a passenger vehicle that operates on fixed-rail guideways on public streets, and its fleet consists of five vehicles that can accommodate around 150 passengers each, standing and sitting. One of the benefits of the Hop Streetcar is that it can operate in shared traffic, which helps preserve most of the on-street parking. The Hop provides free public transportation service, operating from 5 a.m. to midnight on weekdays, 7 a.m. to midnight on Saturdays, and 7 a.m. to 10 p.m. on Sundays. Its route spans 2.1 miles through some of Milwaukee's busiest neighborhoods, including the Historic Third Ward, East Town, and the Lower East Side. A round trip on the route takes approximately 40 minutes. Users ride the Milwaukee Hop for no charge to move around the downtown area.

The Hop Streetcar project was awarded $14.2 million from the TIGER program, which represented a contribution of 11.46% of the total project budget. This amount was an increase of around 2.4% of Milwaukee's 2015 city budget. The project aimed to construct the Milwaukee Streetcar Lakefront Line expansion, covering 0.4 route miles, and purchase one additional streetcar vehicle. The project took approximately three years from the TIGER grant approval to its inauguration.

Omaha Rapid Bus Transit (ORBT) Metro – Omaha BRT

The Omaha Rapid Bus Transit (ORBT) is an 8-mile Bus Rapid Transit (BRT) corridor that serves major retail locations, the University of Nebraska-Omaha, three major medical complexes, and a recently developed dense urban area known as Midtown Crossing. BRT is a high-quality bus-based transit system that delivers fast, cost-effective services with dedicated lanes and off-board fare collection. The corridor must be at least 3 km long with specific characteristics to be considered BRT. Omaha's ORBT rides were free at the beginning of the service, but one-ride fare rates were raised to $1.25 with 25-cent transfers on October 1, 2021.

The ORBT project received $14.97 million from TIGER grant funds in 2014, representing 1.89% of the city of Omaha's budget and 40.46% of the project costs. It took around six years from approval to starting service on November 18, 2020. Studies indicated that 16% of the households within ¼ mile of the proposed BRT route lacked access to a private vehicle and would benefit the most from the project. The benefit-cost analysis estimated that transit-dependent populations would realize 6.2 million USD in benefits over a 20-year period.

GRTC (Greater Richmond Transit Company) Pulse – Richmond BRT

The Greater Richmond Transit Company was granted $24.9 million in the sixth round of the 2014 TIGER program to expand its public transit system by adding 'Pulse,' a bus rapid transit line (BRT). The project aimed to construct a 7.6-mile BRT corridor connecting Richmond with growth areas in Henrico County. The BRT line includes off-board fare collection, TSP, 14 stations, and dedicated BRT vehicles connecting to 35 of the 37 GRTC routes. The BRT line provides frequent service, with buses arriving at each station every 10 minutes during peak hours on weekdays and every 15 minutes during off-peak hours and weekends, with late-night service every 30 minutes. Richmond's GRTC Pulse used to charge $1.5 for a single ride, but the service became free on March 19, 2020. The project aimed to benefit minority populations, with 41% of the city of Richmond population identified as African American. The project received 38% of its total cost from TIGER funds.

CONCEPTUAL FRAMEWORK

Drawing on the theory of demand shocks and existing literature on consumer behavior, we conceptualize the inauguration of a new public transportation system as a demand shock; this demand shock results from reduced transportation costs and increased available income for expenditure on various goods, including food-away-from-home. We examine the short-term effects on dine-in (full-service) and fast-food (limited-service) establishments as own and substitute goods, respectively. We assume that transportation is a normal good, and its demand follows standard price elasticity behavior. Additionally, we consider introducing the new public transportation system to reduce the overall transportation costs for the population in the city, thereby increasing available income for expenditure on other goods, including food. We explore the impact of this change on consumer behavior and its effects on full- and limited-service establishments. Specifically, we investigate how this change may affect consumer choices in the short term, focusing on dine-in establishments as an own good and fast-food as a substitute good. Our analysis considers the possibility that more people can now attend dine-in establishments due to reduced transportation costs. In contrast, fast-food establishments, which often receive heavy drive-thru traffic, may experience lower demand due to the increased availability of dine-in options.

Dine-in establishments as Own Goods (Figure A1)

Figure A1 (see appendix) illustrates the short-term effects of the opening of a new public transit system on dine-in establishments from an own good perspective. The figure begins with a market equilibrium before the project intervention. After the inauguration of the new public transportation system, a demand shock occurs, shifting the demand curve to the right. This shift implies that consumers are willing to purchase more of the product at every given price, increasing the demand for dine-in establishments, ultimately leading to an upward shift in quantity and price levels.

Limited-service establishments as Substitute Goods (Figure A2)

Figure A2 (see appendix) presents the short-term effects of a substitute good, whereby the starting point is the same market equilibrium level as in the previous scenario, except for a decrease in transaction costs for the substitute good. This reduction in transaction costs increases the attractiveness of the alternative consumption, causing a leftward shift in the demand curve for the substitute good, indicating that consumers demand less of the product at every given price. This reduced demand for fast-food meals decreases quantity and price levels, causing a new equilibrium price and quantity at lower levels.

Hypotheses

Given this conceptual framework, we hypothesize that (1) public transportation investments increase the overall demand (as measured by foot traffic) in the vicinity of the transport investment stops; and that this overall increase in the vicinity of the transport investment stops includes (2) an increase in the demand for full-service restaurants; and (3) a decrease in demand for limited-service restaurants.

However, public transportation investments might not significantly influence transaction costs, which would lead to no change in food purchase activities. Public transportation investments might actually decrease food establishment foot traffic if the transportation cost reduction incentivizes substitute recreational activities. The foundation for these consumer-side alternative hypotheses is that research has shown public infrastructure impacts transaction costs depending on their regime and delivery, as well as direct transaction cost effects on competitive markets' participation (De Schepper, Elvira, and Michael, 2015; Pingali, Khwaja, and Meijer, 2005).

METHODS

We test our hypotheses by exploring foot traffic changes in full- and limited-service restaurants related to investments in three public transportation projects across the United States that received funding from the TIGER grants program: streetcars in the cities of Milwaukee, WI, and BRT systems in the cities of Omaha, NE and Richmond, VA.

Data Description

We use SafeGraph's 2018-2023 pattern dataset to map the establishments, their North American Industrial Classification System (NAICS) code, and their locations in the surrounding area of the public transportation system. SafeGraph Patterns is a dataset including commercial brick-and-mortar points-of-interest (POI) with anonymized counts of how many people from their panel visit these POI each week. SafeGraph Patterns is aggregated from a panel (sample of the population measured longitudinally) of ~40MM mobile devices (e.g., smartphones) in the United States. Members of the SafeGraph panel opt in by accepting the terms of service of various mobile apps. SafeGraph Patterns measures foot-traffic patterns to 3.6MM commercial points of interest from over 45MM mobile devices in the United States. These patterns allow us to keep track of the amount and type of foot traffic at food establishments.

To measure the distance from each point of interest to the infrastructure investment, we individually mapped the longitude and latitude of the stops for each infrastructure investment. The SafeGraph data contains the latitude and longitude of every point of interest, so we can precisely measure the distance from each point of interest to the nearest stop. The data also contains the North American Industry Classification System (NAICS) industry code for points of interest, so we limit the sample to full-service restaurants (NAICS 722511) and limited-service restaurants (NAICS 722513).

Figures A3-A8 (see appendix) show the foot traffic trends for full-service versus limited-service restaurants within half-a-mile of a transportation investment stop. We summarize these descriptive trends findings here.

Foot traffic patterns per city

Milwaukee

When examining Figures 3 and 4 for Milwaukee, several important observations emerge. First, full-service restaurants located near the transit system's stops witnessed an increase in foot traffic following the inauguration of the transit system. Second, full-service restaurants were disproportionately affected by the COVID-19 pandemic lockdown. Additionally, in the long term, we can potentially identify spillover effects where the introduction of the transit system correlates with higher traffic at full-service restaurants compared to limited-service restaurants. However, it may take several years for this effect to become noticeable.

Richmond

Figures 5 and 6 for Richmond similarly highlight some important effects of the transit system. First, similar to the Milwaukee case, the effects on restaurants near the transit investment may take years to realize increased foot traffic. Second, during the COVID-19 pandemic lockdown, full-service restaurants near the transit system experienced a comparatively greater impact. In the long run, we can potentially identify spillover effects whereby establishing the transit system is associated with increased traffic at full-service restaurants compared to limited-service restaurants. However, this effect becomes more apparent after a recovery following the pandemic lockdown.

Omaha

Similar to the other studied cities, Figures 7 and 8 for Omaha show that full-service restaurants located near the transit system's stops were impacted during the COVID-19 pandemic lockdown;

these restaurants experienced a greater negative impact than other establishments. Secondly, regarding long-term effects, it may be challenging to easily identify spillover effects associated with the inauguration of the transit system in Omaha. When comparing Omaha to Richmond and Milwaukee, where the transit system projects were implemented longer ago and not amidst a pandemic, it becomes apparent that the necessary time for these effects to materialize may not have yet occurred in Omaha. Additionally, both full-service and limited-service restaurants in Omaha exhibit higher volatility. This volatility could be attributed to smaller-scale economic activities such as opening and closing establishments and fluctuations in customer demand.

Estimation Strategy

We use a "two-way fixed effects" (TWFE) estimator to handle a linear model that considers both unit- (establishment) and time-fixed effects. By incorporating place-of-interest fixed effects into our linear regression, we eliminate unit-specific time averages as well as control for unobserved heterogeneity across entities, capturing factors that may persistently influence their outcomes. While time-fixed effects help address systematic changes in the economic environment that affect all units similarly, it also considers time-varying shocks or trends that affect all entities in the sample, reducing the risk of omitted variable bias (Wooldridge, 2021). We estimate each city separately so that each point of interest receives the same treatment simultaneously, avoiding more recent concerns related to using a TWFE estimator in the context of time-varying treatment.

We thus use the following estimation model,

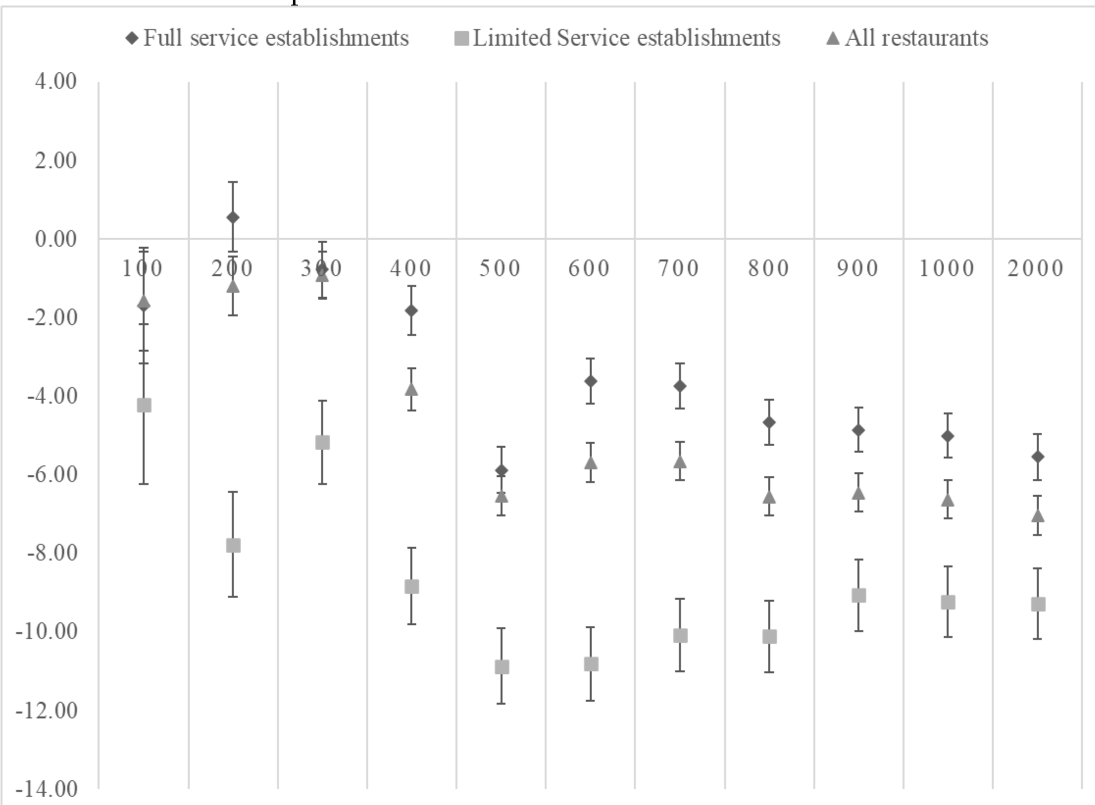
$$y_{it} = \beta_1 Post + \beta_2 Treat\_M + \beta_3 Post \cdot Treat\_M + \gamma_i + \rho_t + u_{it} \quad (1)$$

where y_{it} is foot traffic at the point of interest i in week t, $Post$ is an inauguration time indicator that equals 1 after the inauguration date, $Treat\_M$ is the treatment indicator that equals 1 when a point of interest is within a specified meter radius of the nearest transportation stop, γ_i is the place of interest fixed effects, ρ_t are week fixed effects, and u_{it} is the error term. β_3 hence becomes the coefficient (treatment effect) estimate of interest. Because there is no apriori theoretical reason to assume effects end at a specific distance from a transportation investment, and for sensitivity analysis purposes, the estimation is performed at 11 different area treatment levels: radii of every 100 meters from 100 to 1000 meters and at 2000 meters. Testing various distances also allows us to examine the potential for distance decay in the average effects. We conduct tests of each of the three projects, a placebo robustness check, and a pooled estimate with all restaurants and other eating places accounted for.

RESULTS

Richmond

Figure 1. TWFE coefficient plot for Richmond

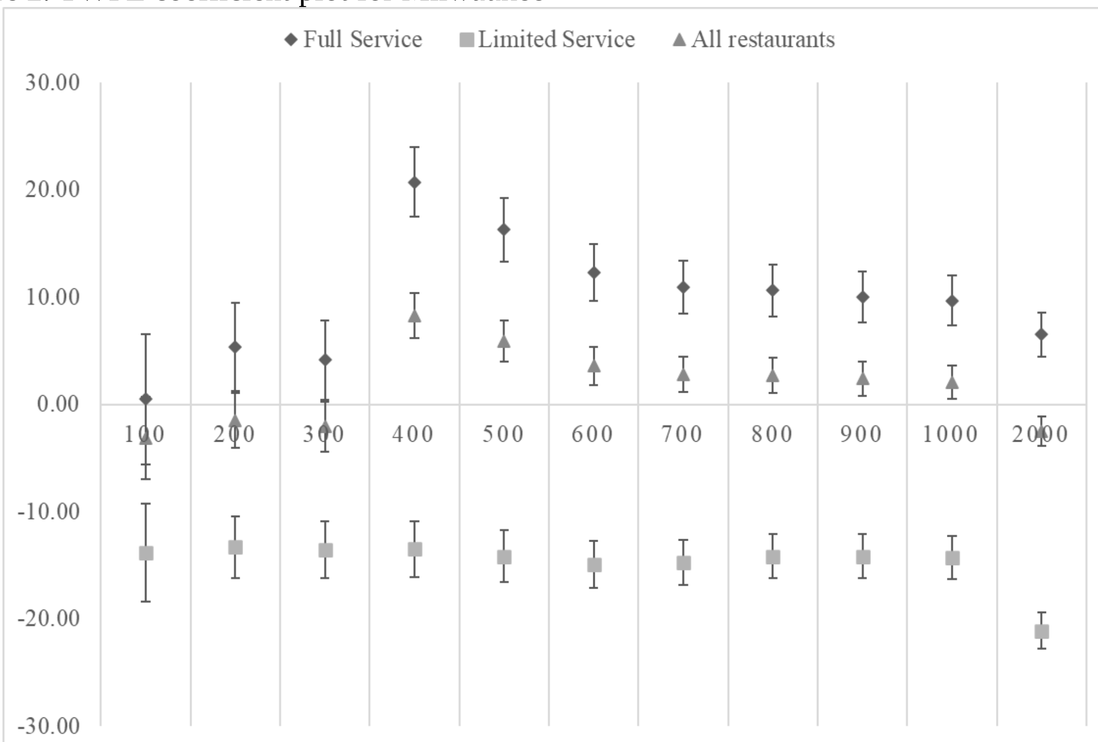


Notes: Plot provides coefficient estimate and 95% confidence intervals for full service, limited service, and all restaurants for the treatment effect as estimated using equation (1). Estimates are provided by defining treatment as within a specified radius, setting the radius as every 100 meters from 100 to 1000, and 2000. Tables of regression results are provided in the appendix.

Among the three cities in this study, Richmond was the first city to inaugurate its transit project. Interestingly, we have insignificant results for full-service establishments in the immediate vicinity (100-300 meters) of the project, having an inflection point at the 300-meter radius level, from where the further you get from the transit system, the greater the negative effect on foot traffic is experienced. Limited-service restaurants follow a similar increasingly negative pattern, though the coefficients are always statistically significant and larger in magnitude.

Milwaukee

Figure 2. TWFE coefficient plot for Milwaukee

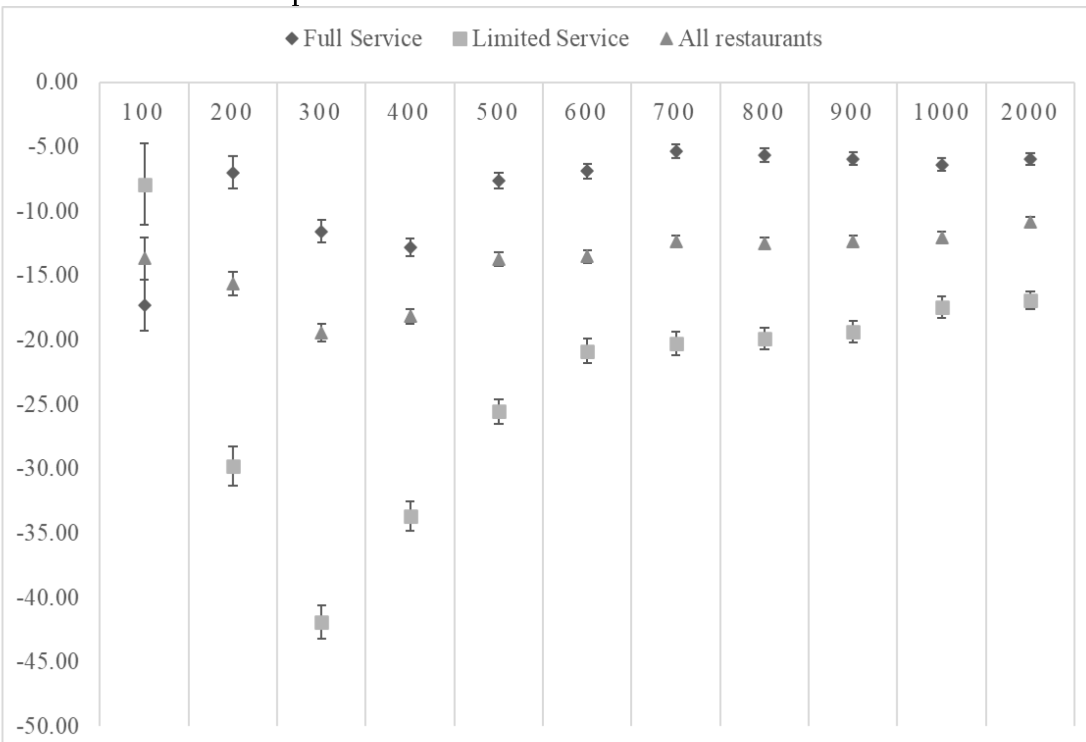


Notes: Plot provides coefficient estimate and 95% confidence intervals for full service, limited service, and all restaurants for the treatment effect as estimated using equation (1). Estimates are provided by defining treatment as within a specified radius, setting the radius as every 100 meters from 100 to 1000, and 2000. Tables of regression results are provided in the appendix.

Figure 2 provides the analogous coefficient plot for Milwaukee, showing treatment effect estimates when defining treatment at various radii around the nearest transportation stop. These results are more consistent with our hypothesis, with foot traffic decreasing at limited-service restaurants and increasing at full-service restaurants. Although small until 400 meters, there is a positive relationship between the inauguration of the Milwaukee Hop streetcar and foot traffic at proximate full-service, with the average effect diminishing as we extend the radius farther. We find the opposite for limited-service establishments, with a negative relationship between the inauguration of the streetcar and foot traffic at all treatment distance levels. Finally, when running the pooled model for all restaurants, we find an estimated effect closer to a null effect in the middle of limited-service and full-service restaurants.

Omaha

Figure 3. TWFE coefficient plot for Omaha



Notes: Plot provides coefficient estimate and 95% confidence intervals for full service, limited service, and all restaurants for the treatment effect as estimated using equation (1). Estimates are provided by defining treatment as within a specified radius, setting the radius as every 100 meters from 100 to 1000, and 2000. Tables of regression results are provided in the appendix.

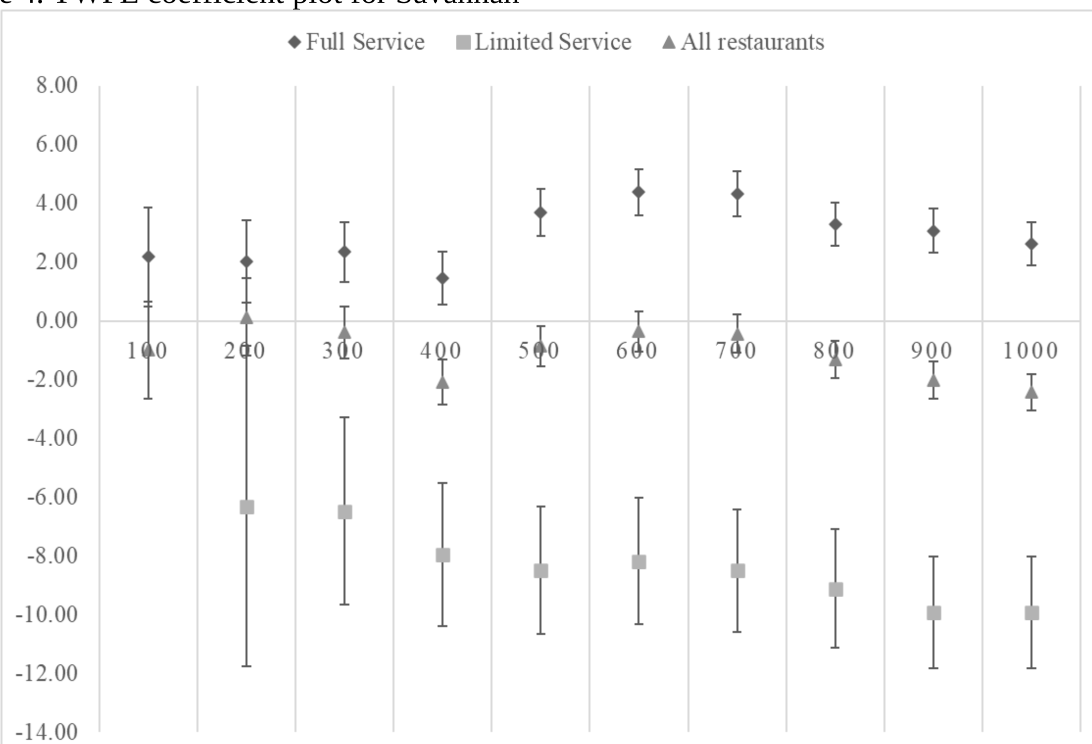
Figure 3 shows a coefficient plot defining treatment at various radii for Omaha's ORBT. We find a negative relationship between foot traffic and inauguration for both full- and limited-service restaurants (and restaurants overall), with the effect diminishing in magnitude as we increase the treatment radius. Given the consistency after 100 meters, it may be that the limited number of restaurants within 100 meters of the nearest stop is leading to noise in those estimates.

PLACEBO TEST

To add a layer of robustness, we performed a placebo test on the city of Savannah in the area where a streetcar used to be in place and where Savannah applied for a TIGER grant but was not awarded a TIGER grant. The streetcar ended operations before the observation period. We chose Savannah because the city applied for TIGER funds around the same time as Richmond, so we can assume the same inauguration date for the placebo Savannah investment as was observed in Richmond.

Results

Figure 4. TWFE coefficient plot for Savannah



Notes: Plot provides coefficient estimate and 95% confidence intervals for full service, limited service, and all restaurants for the treatment effect as estimated using equation (1). Estimates are provided by defining treatment as within a specified radius, setting the radius as every 100 meters from 100 to 1000, and 2000. Tables of regression results are provided in the appendix.

Placebo test results show the relationship between the placebo inauguration counterfactual streetcar and foot traffic at different types of restaurants near the transit area. The Savannah results complicate our general results even further as the placebo investment appears to cause a significant increase in foot traffic for full-service restaurants and a decrease for limited-service restaurants.

DISCUSSION AND CONCLUSIONS

The hypotheses of the present study were tested using a set of TWFE regressions that included distance sensitivity analysis and a placebo test. While the results indicate some evidence that full-service restaurants were at least less negatively affected by transportation investments, the overall findings lead us to conclude there is no sufficient evidence for a positive or negative relationship between TIGER-grant public transportation projects' awardees and restaurant foot traffic in the vicinity of the public transit systems.

Evidence from Milwaukee suggests a positive effect from the inauguration of the transit system and foot traffic on food establishments near the streetcar, driven by more foot traffic in full-service food establishments. However, the evidence from Richmond's BRT system's inauguration shows effects in which full-service restaurants had less reduced foot traffic than limited-service ones. Finally, Omaha's ORBT experience shows a similar story to Richmond's, in which the effect of the inauguration is negative for all food service establishments, though full-service restaurants had a less negative effect.

The placebo test further emphasizes the need to interpret these results with caution. Savannah did not get approved funds from the TIGER program. Yet, results show statistically significant changes near the counterfactual investment system, similar to the Milwaukee (real) investment inauguration.

For these reasons, we can conclude that, from the experience of Milwaukee, Richmond, and Omaha, TIGER-grant funds are not a panacea, as they do not always lead to an increase or decrease in the economic vibrancy of a corresponding area where public transportation systems are inaugurated, as measured by visits to food establishments. Changes in foot traffic on food establishments are inconsistent when testing for different types of restaurants, different distances from the stop, different kinds of transit systems, and different cities.

The study raises important questions about the factors driving economic vibrancy in urban food environments. Understanding this relationship requires more comprehensive investigations, considering additional factors that influence consumer behavior in response to public transportation investments.

High-cost transportation infrastructure investments do not solve problems or immediately translate into benefits when looking at local effects on food establishments. These findings result in a counterintuitive conclusion worthy of further exploration. For example, what other factors drive the economic vibrancy of urban food environments? This question is especially important as our current study represents only a first step toward understanding the relationship between transportation costs and consumer behavior in the urban United States. The impact of a demand shock on the welfare of consumers and producers could hypothetically be determined by comparing the relative magnitudes of the gains and losses. However, due to the lack of price change data, it is not feasible to calculate the welfare effects for this study. If data were available in the long run, analyzing changes in consumer welfare and producer surplus resulting from public transportation investments would be possible. In addition, it would be possible to observe changes in the availability and prices of different types of foods and evaluate how the accessibility of food markets has been influenced by public transportation. By examining these outcomes, it would be possible to gain insights into the long-term effects of public transportation investments on food access and consumer behavior.

A second important limitation of the present study includes a clear shock to demand, and supply driven by the COVID-19 pandemic, where differentiated measures and enforcement were taken in different geographies. Although we controlled for week fixed effects, which should hypothetically control for this time-specific shock, we implicitly assumed COVID-19 affected all areas of a city equally; of course, it may be that where these transportation investments occur (downtown) is confounded by areas of a city differentially affected by the COVID-19 pandemic. Similarly, it may be that COVID-19 affected people's desire to use public transportation more generally. A negative effect on foot traffic (like the one we find) would be consistent with such confounding. Further research is needed to understand what behavioral and economic factors influenced during this period at these locations. Additionally, the type of cities (e.g., in terms of industry, tourism, commuting patterns, etc.) relative to the location of these transportation investments may cause heterogeneous effect between cities. Finally, there is also the potential for heterogeneous effects by demographic and socioeconomic measures, but SafeGraph's patterns dataset does not contain this information, and thus we cannot test this policy- and equity-relevant aspect.

This study serves as an initial step in exploring the complex relationship between transportation costs, urban policy, and consumer behavior in the United States. Further research is needed to unravel the intricate dynamics between transportation investments, food access, and food consumption patterns.

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APPENDIX

Figures

Figure A1. Conceptual framework: short-term effects of the opening of a new public transit systemon full-service restaurants

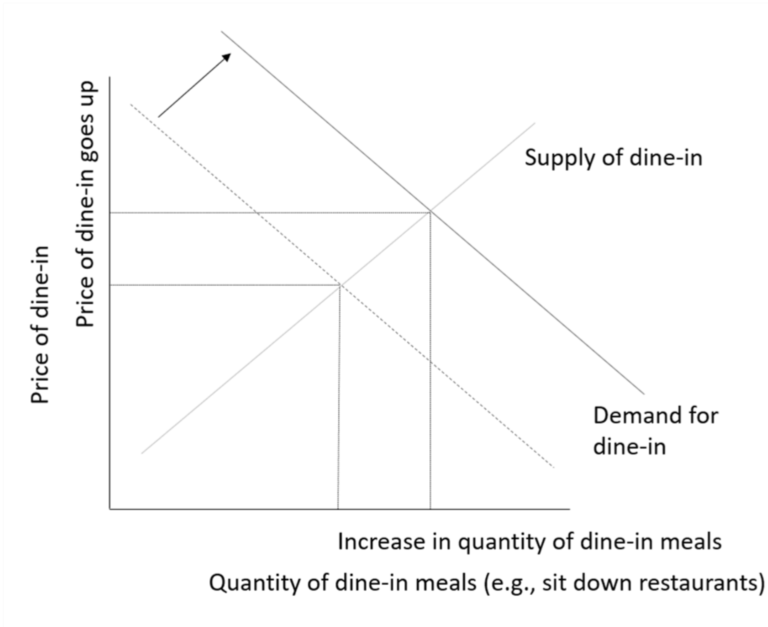


Figure A2. Conceptual framework: short-term effects of the opening of a new public transit systemon limited-service restaurants

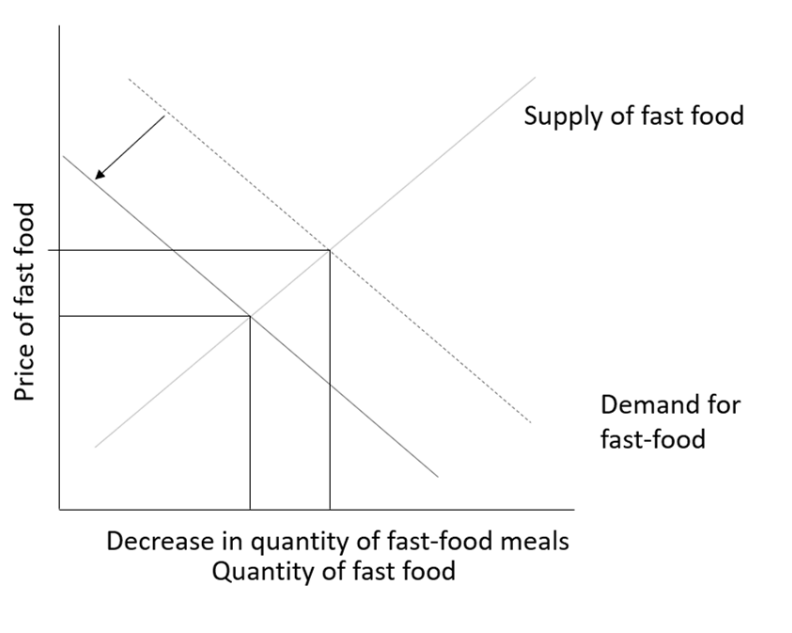
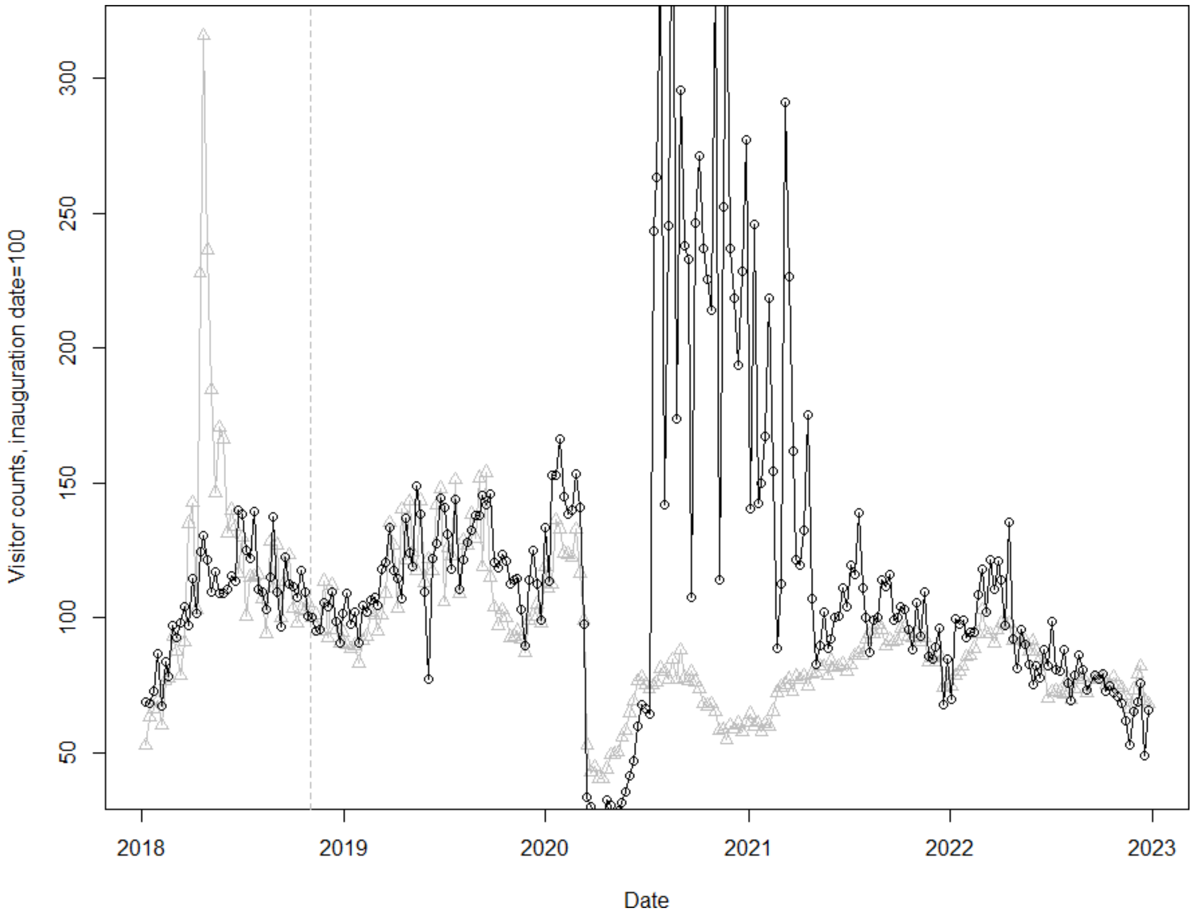
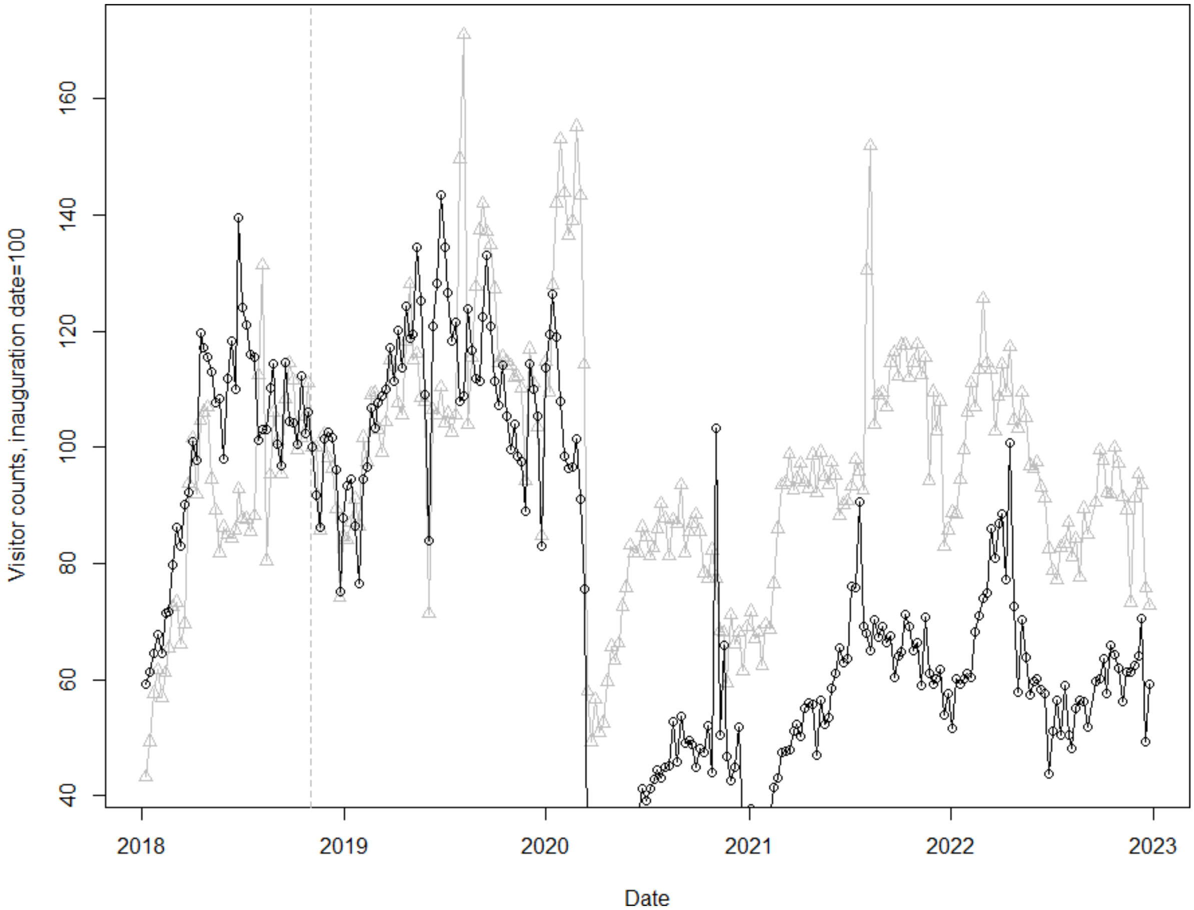


Figure A3. Milwaukee Full-service restaurants within and outside half a mile of a transit stop.



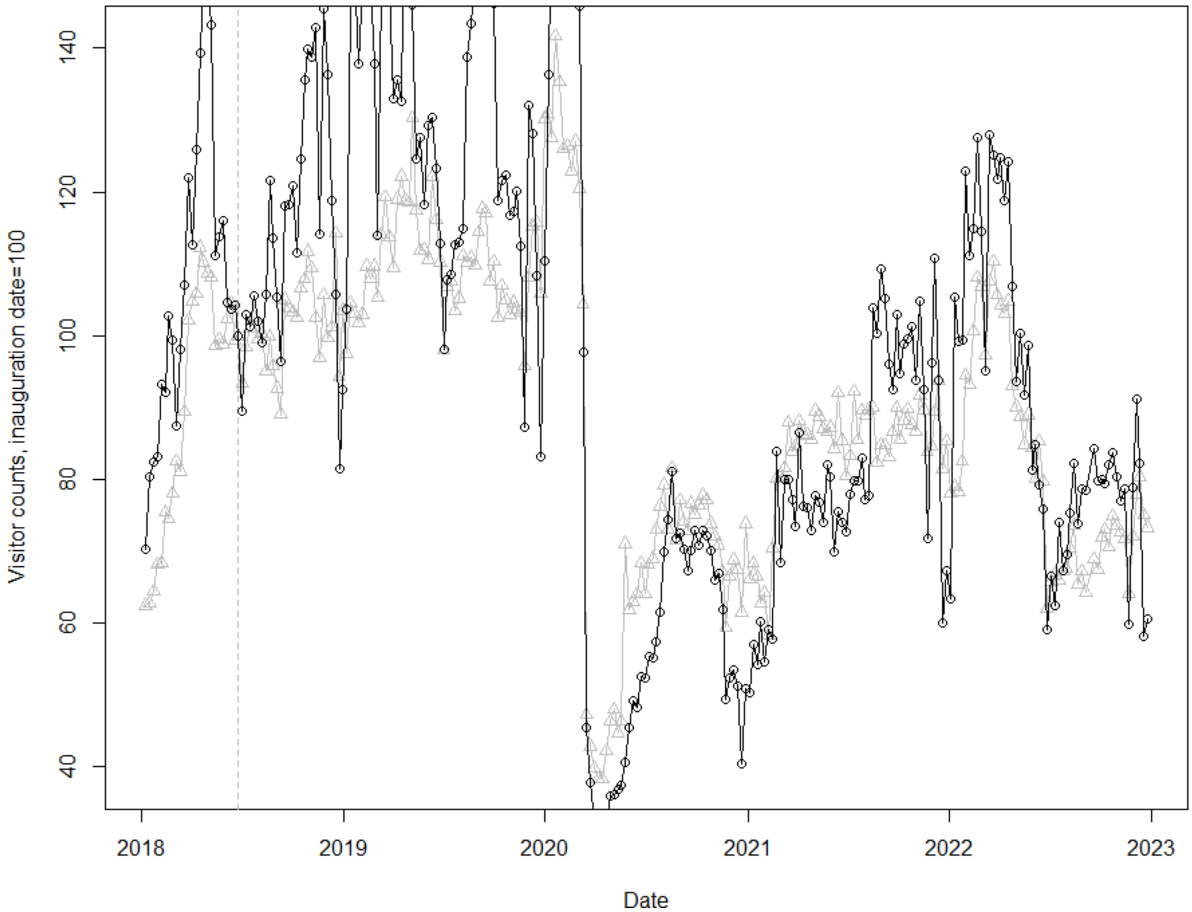
Note: Black (gray) indicates foot traffic in restaurants within (outside) half a mile of any transit stops. Dotted vertical line indicates the inauguration date.

Figure A4. Milwaukee Limited-service restaurants within and outside half a mile of a transit stop.



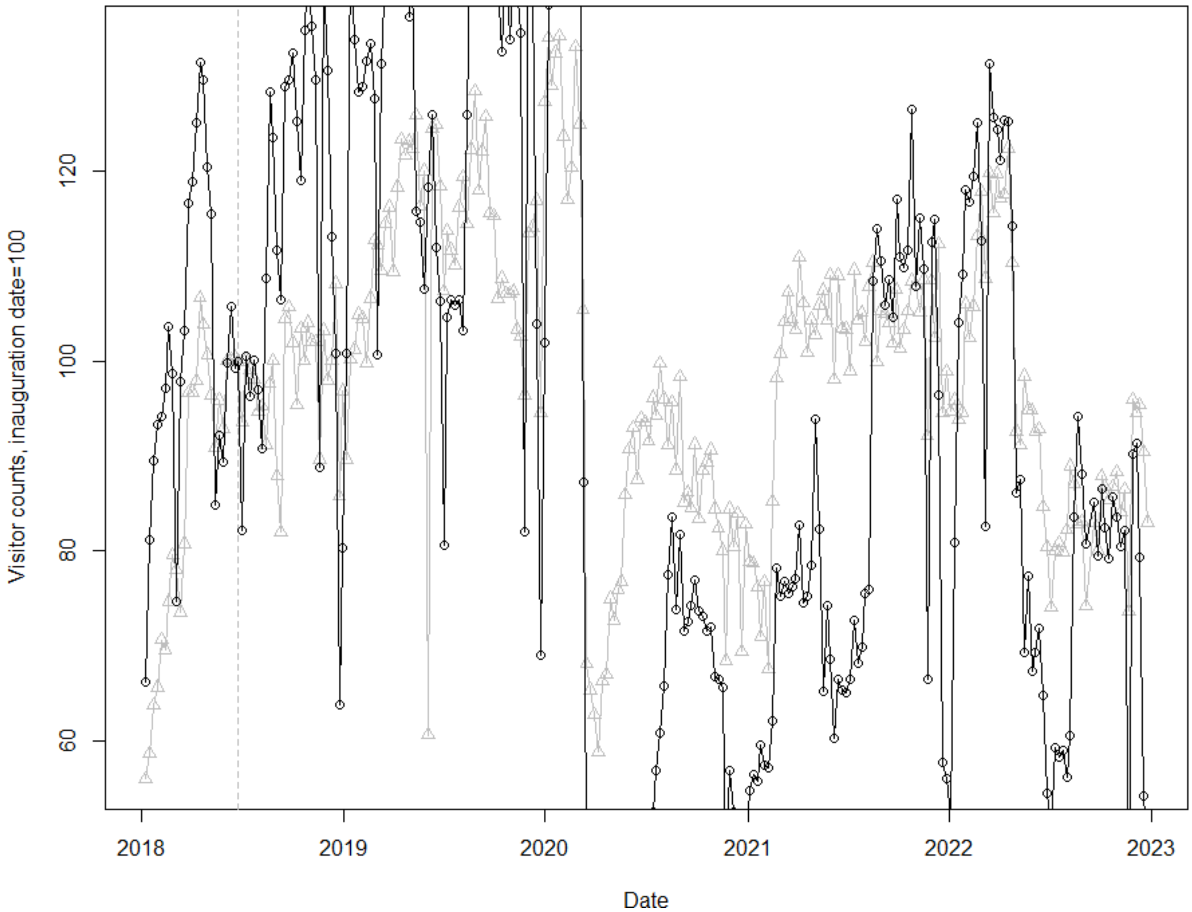
Note: Black (gray) indicates foot traffic in restaurants within (outside) half a mile of any transit stops. Dotted vertical line indicates the inauguration date.

Figure A5. Richmond Full-service restaurants within and outside half a mile of a transit stop.



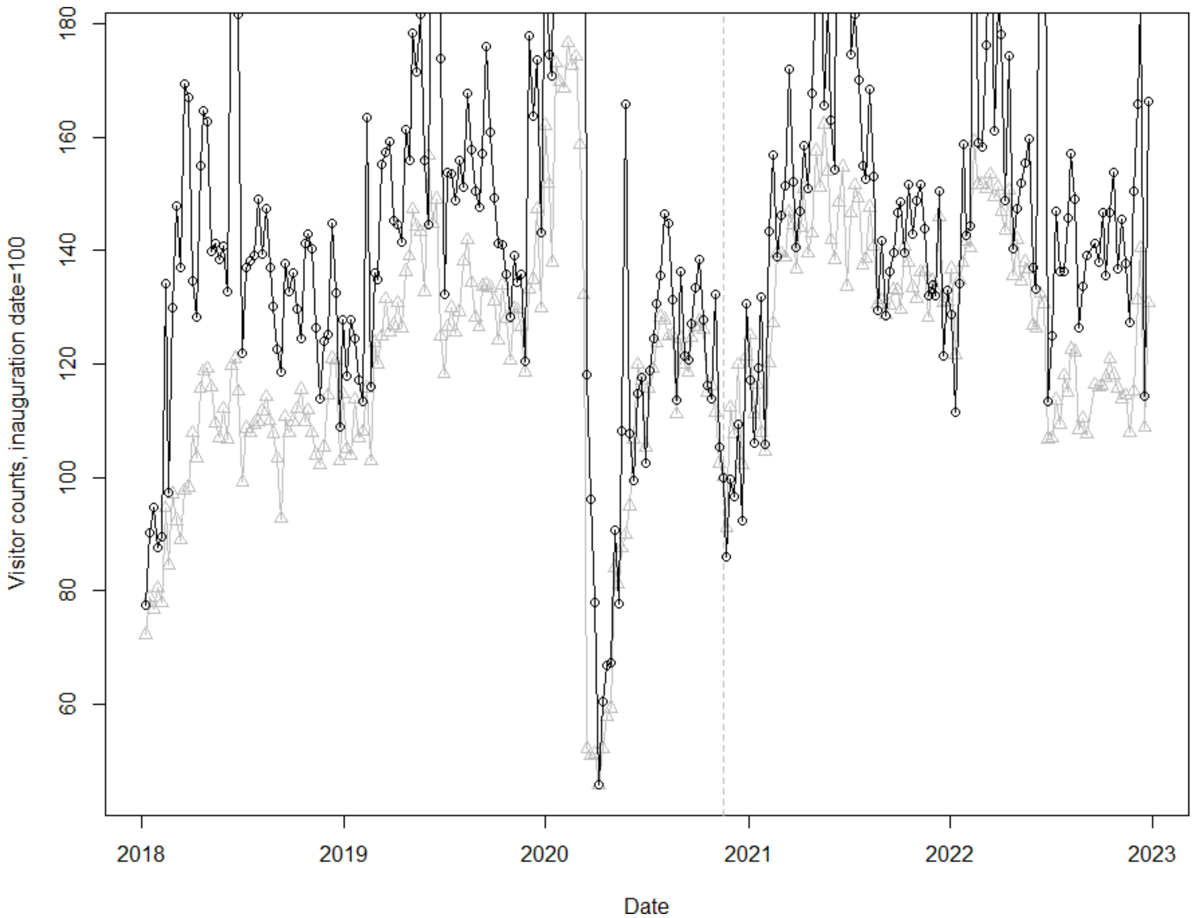
Note: Black (gray) indicates foot traffic in restaurants within (outside) half a mile of any transit stops. Dotted vertical line indicates the inauguration date.

Figure A6. Richmond Limited-service restaurants within and outside half a mile of a transit stop.



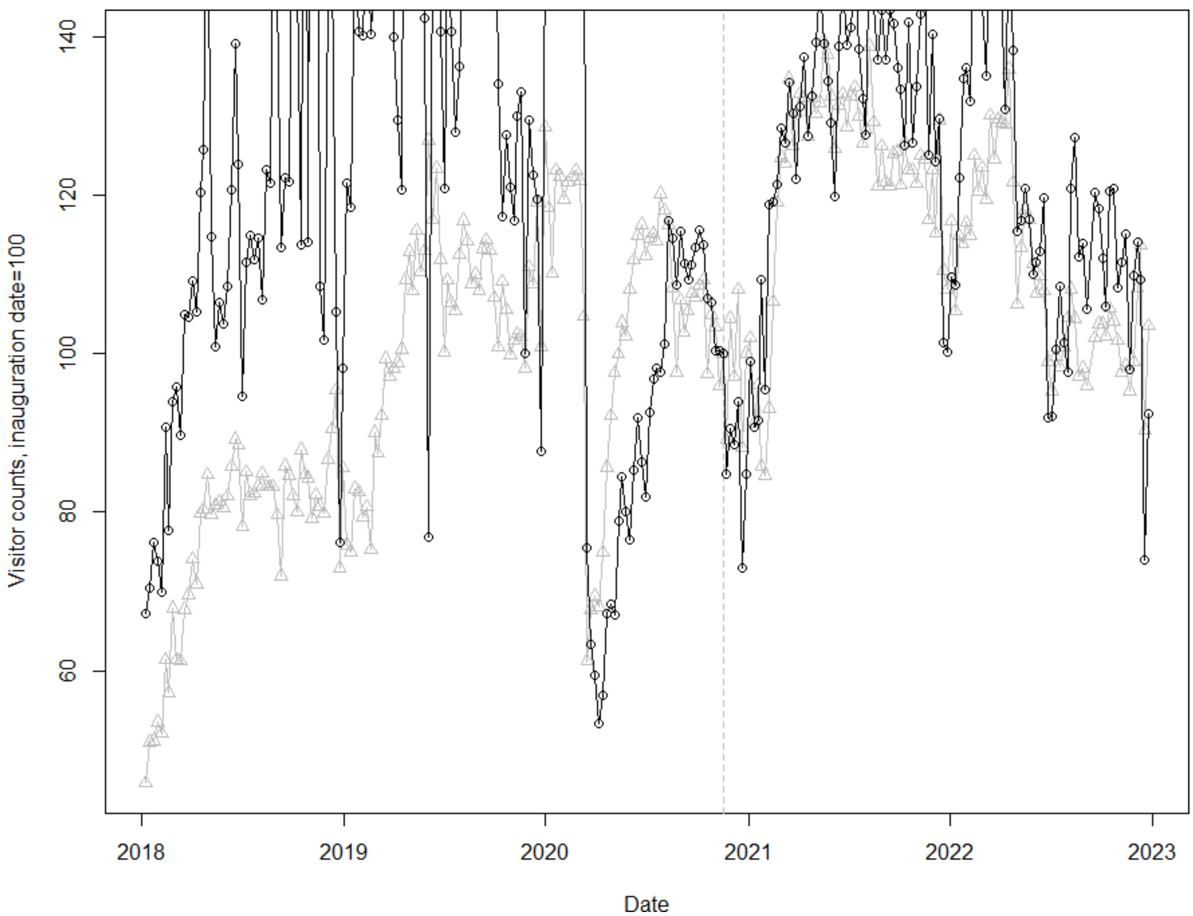
Note: Black (gray) indicates foot traffic in restaurants within (outside) half a mile of any transit stops. Dotted vertical line indicates the inauguration date.

Figure A7. Omaha Full-service restaurants within and outside half a mile of a transit stop.



Note: Black (gray) indicates foot traffic in restaurants within (outside) half a mile of any transit stops. Dotted vertical line indicates the inauguration date.

Figure A8. Omaha Limited-service restaurants within and outside half a mile of a transit stop.



Note: Black (gray) indicates foot traffic in restaurants within (outside) half a mile of any transit stops. Dotted vertical line indicates the inauguration date.

Tables

Table 1. Comparison between projects

Case study projects comparative table

City	Milwaukee	Omaha	Richmond
State	Wisconsin	Nebraska	Virginia
Award amount (millions of USD)	14.2	14.97	24.9
Total project funding (millions of USD)	123.9	37	65
Share of project budget from TIGER	11.46%	40.46%	38.31%
Location	Latitude 43.0463 Longitude -87.8971	Latitude 41.261291 Longitude -95.983343	Latitude 37.617495 Longitude -77.524338
TIGER grant date	2015 round 7	2014 round 6	2014 round 6
Inauguration date	11/02/2018	11/18/2020	06/24/2018
Time from award to inauguration	3 years	6 years	4 years
City budget at year of award (millions of USD)	590.70	792.55	760.53
Share of city budget increase by grant	2.40%	1.89%	3.27%
Type of public transportation project funded	Streetcar	BRT: Bus Rapid Transit	BRT: Bus Rapid Transit
Metro area population at award year ('000 of people)	1406	771	1017
Median area annual household income at award year	$ 64,323	$ 65,901	$ 69,807
Average household size (persons)	2.40	2.40	2.20
Per capita income at award year	$ 26,801	$ 27,459	$ 31,730
Median age (years)	38.5	35.6	34.8
Race/ethnicity %			
White	64	64	41
Black	16	11	43

Table 1 (cont'd)

Native american	0	0	0
Asian	4	4	2
Two or more races	3	4	5
Hispanic/Latinx	12	15	8
Other	0	1	1

Table 2. Weekly visitors summary statistics

	Richmond	Milwaukee	Omaha
Mean visitor count			
Full service	28.21	35.15	48.4
Limited service	45.83	56.08	67.66
All restaurants	33.05	41.83	55.68
Total restaurants	1629	1788	1869

Notes: Table provides summary statistics for the three cities with show average (mean) visitor counts per week in each type of establishment, as well as total number of establishments.

Estimation Outcomes

Table 3. TWFE Outcomes for Richmond

Distance (mts)	Full Service	Limited Service	All Restaurants
100	-1.70 (1.47)	-4.21** (2.04)	-1.58 (1.26)
200	0.56 (0.89)	-7.77*** (1.33)	-1.18*** (0.75)
300	-0.78*** (0.71)	-5.17*** (1.07)	-0.92*** (0.60)
400	-1.81*** (0.63)	-8.83*** (0.98)	-3.82*** (0.53)
500	-5.87*** (0.59)	-10.87*** (0.96)	-6.53*** (0.51)
600	-3.61*** (0.58)	-10.81*** (0.95)	-5.68*** (0.50)
700	-3.75*** (0.57)	-10.08*** (0.92)	-5.65*** (0.49)
800	-4.67*** (0.57)	-10.11*** (0.92)	-6.56*** (0.49)
900	-4.85*** (0.57)	-9.06*** (0.91)	-6.45*** (0.48)
1000	-5.01*** (0.56)	-9.23*** (0.90)	-6.62*** (0.48)
2000	-5.54*** (0.59)	-9.27*** (0.89)	-7.03*** (0.50)

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level

Table 4. TWFE outcomes for Milwaukee

Distance (mts)	Full Service	Limited Service	All Restaurants
100	0.49	-13.83***	-3.12
	(6.11)	(4.56)	(3.87)
200	5.37	-13.30***	-1.45
	(4.09)	(2.85)	(2.56)
300	4.17	-13.55***	-2.06
	(3.69)	(2.66)	(2.34)
400	20.73***	-13.49***	8.29***
	(3.25)	(2.56)	(2.12)
500	16.29***	-14.16***	5.90***
	(2.93)	(2.43)	(1.94)
600	12.28***	-14.91***	3.60**
	(2.66)	(2.22)	(1.77)
700	10.93***	-14.76***	2.83*
	(2.47)	(2.10)	(1.65)
800	10.64***	-14.14***	2.74*
	(2.44)	(2.04)	(1.63)
900	10.04***	-14.14***	2.43
	(2.36)	(2.04)	(1.60)
1000	9.67***	-14.27***	2.09
	(2.32)	(2.02)	(1.57)
2000	6.51***	-21.08***	-2.48*
	(2.07)	(1.71)	(1.40)

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level

Table 5. TWFE outcomes for Omaha

Distance (mts)	Full Service	Limited Service	All Restaurants
100	-17.32*** (1.96)	-7.94** (3.16)	-13.67*** (1.66)
200	-7.01*** (1.24)	-29.80*** (1.50)	-15.65*** (0.91)
300	-11.58*** (0.87)	-41.89*** (1.31)	-19.41*** (0.69)
400	-12.82*** (0.69)	-33.67*** (1.15)	-18.16*** (0.57)
500	-7.62*** (0.61)	-25.56*** (0.98)	-13.72*** (0.51)
600	-6.90*** (0.58)	-20.86*** (0.93)	-13.52*** (0.47)
700	-5.33*** (0.54)	-20.26*** (0.90)	-12.37*** (0.45)
800	-5.69*** (0.53)	-19.89*** (0.87)	-12.48*** (0.44)
900	-5.92*** (0.52)	-19.37*** (0.86)	-12.34*** (0.43)
1000	-6.39*** (0.51)	-17.45*** (0.84)	-12.03*** (0.42)
2000	-5.98*** (0.45)	-16.92*** (0.69)	-10.83*** (0.37)

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level

Table 6. TWFE outcomes for Savannah

Distance (mts)	Full Service	Limited Service	All Restaurants
100	2.19 (1.69)		-0.99 (1.64)
200	2.02 (1.40)	-6.31 (5.45)	0.14 (1.31)
300	2.35** (1.01)	-6.47** (3.19)	-0.38 (0.88)
400	1.46 (0.89)	-7.96*** (2.44)	-2.08*** (0.77)
500	3.70*** (0.82)	-8.49*** (2.17)	-0.86 (0.69)
600	4.39*** (0.79)	-8.17*** (2.14)	-0.36 (0.67)
700	4.34*** (0.77)	-8.50*** (2.07)	-0.43 (0.66)
800	3.30*** (0.74)	-9.11*** (2.01)	-1.30** (0.64)
900	3.07*** (0.74)	-9.92*** (1.91)	-2.02*** (0.63)
1000	2.62*** (0.74)	-9.92*** (1.91)	-2.42*** (0.63)

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level

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Chapingo merece un reconocimiento particular; 14 escalones, muchísimo aprendizaje, mucho crecimiento y un centro cardinal de mi educación y mi persona. Sin arrogancia y más allá de juicios estandarizados, Chapingo es la mejor universidad que hay en México y sin duda la mejor casa académica que he tenido. La herencia de la UACh para con México, latinoamérica, y el sector agroalimentario la llevaré conmigo siempre. Eternamente agradecido estoy con mi alma mater, mis profesores y mis compañeros.

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