
# On-Demand Microtransit for Better Transit Station and Job Accessibility

**Dr. Sanggyun Kang**
**Dr. Shima Hamidi**

FINAL REPORT

CENTER FOR TRANSPORTATION EQUITY, DECISIONS & DOLLARS

# ON-DEMAND MICROTRANSIT FOR BETTER TRANSIT STATION AND JOB ACCESSIBILITY

## FINAL PROJECT REPORT

by

Sanggyun Kang
Shima Hamidi
University of Texas at Arlington

Sponsorship
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Center for Transportation Equity, Decisions and Dollars (**CTEDD)**
USDOT University Transportation Center
The University of Texas at Arlington
601 W.Nedderman Dr. Suite 103
Arlington TX 76019-0108 United States
Phone: 817-272-5138 | Email: C-Tedd@uta.edu

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Consisting of a large portion of total transit travel times, the first-last mile segments influence transit patronage. Decreasing travel times of the segments is more effective in improving job accessibility by public transit than improving transit services themselves (e.g., shorter wait time). Few studies have examined this linkage between the first-last mile segments and job accessibility. Further, no studies have examined on-demand microtransit, one of the shared mobility concepts, as a means of improving transit station access/egress and labor market outcomes.

This research consists of three phases. First, we examine various characteristics of the first-last mile travel by GoLink, app-based on-demand microtransit operated by DART, Dallas Area Rapid Transit. We examine travel time of day, wait and in-vehicle travel times, locations of origin and destination, and connections to/from transit stations. Second, we examine the first-last mile travel characteristics by walking, bicycle, and car. We compare the travel patterns across GoLink, walking, bicycle, and car. Third, we examine the number of jobs and workers accessible in 30, 45, and 60 minutes by transit considering for various modes of first-last mile access. Findings of this research will offer the empirical basis for evaluating whether GoLink, as an on-demand microtransit service, is a means of travel that could positively influence first-last mile access to public transit stations as well as jobs and workers in low-density areas.

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## Keywords

Transit accessibility;
Low wage job accessibility;
Modal mismatch;
First-last mile;
On-demand microtransit

# Table of Contents

# 1 Introduction

This paper is organized as follows: Section 2 reviews the recent literature on first and last mile travel patterns. Section 3 presents the conceptual framework and study area. Section 4 presents data with descriptive statistics. Section 5 shows the results of spatial analysis and econometric models. We conclude in section 6 with conclusions and discussion.

# 2 Background

Job accessibility has been studied intensively over the last several decades (Grengs, 2010; Kain, 1968; Kawabata & Shen, 2007; Shen, 2001; Taylor & Ong, 1995). Recently, first-last mile travels by public transit (Chandra, Bari, Devarasetty, & Vadali, 2013; Lesh, 2013; Wang & Liu, 2013) as well as transportation network companies and shared mobility concepts (Clewlow, Mishra, Clewlow, & Kulieke, 2017; Errico, Crainic, Malucelli, & Nonato, 2013; Qiu, Shen, Zhang, & An, 2015; Rayle, Dai, Chan, Cervero, & Shaheen, 2016; Rayle, Shaheen, Chan, Dai, & Cervero, 2014) have been drawing significant attention. Only few studies have examined the linkage between job accessibility and first/last mile transit access (Boarnet, Giuliano, Hou, & Shin, 2017). There are even fewer studies that examined whether the shared mobility concept (e.g., on-demand microtransit) is an effective measure to improve first/last mile transit access as well as job accessibility as an end goal.

Job accessibility concerns the equity implications of transportation accessibility (Kawabata & Shen, 2006, 2007). The spatial mismatch hypothesis – spatially segregated residential locations of racial minority result in disproportionate access to job opportunities – was first conceptualized by Kain (1968) and has been rigorously examined for decades (Holzer, 1991). Further, the modal mismatch hypothesis – differences in travel mode, in most cases between passenger vehicles and public transit, result in disproportionate access to job opportunities – has been tested, and a substantial gap across modes has been documented (Blumenberg & Hess, 2003, p. 200; Blumenberg & Ong, 2001; Kawabata, 2003; Shen, 1998, 2001; Taylor & Ong, 1995). Studies have consistently found inferior job accessibility by public transit, all else equal, because travel time by transit is much longer than by car (Grengs, 2010; Hess, 2005; Kawabata, 2009). Part of the long transit travel time has been attributed to access and egress time (first-last mile) that consist of a significant portion of total travel time (Krygsman, Dijst, & Arentze, 2004). Improving the first-last mile segments positively influences transit patronage as well as use of more active modes of travel (Handy, Boarnet, Ewing, & Killingsworth, 2002; Martens, 2007; Rundle et al., 2007; Wang & Liu, 2013). To improve job accessibility, most policy and planning discussion has focused on improving mobility (e.g., reducing costs to own a car; improving public transit services) (Boarnet et al., 2017). However, in low density areas, public transit services are scarce (e.g., fewer fixed

routes, larger headway, and smaller capacity). Hence, alternative methods have been conceptualized.

Recently, to complement or substitute for fixed route transit services in low density areas, the shared mobility concept (e.g., bikesharing, carsharing, demand-responsive transit services (on-demand microtransit) as well as ridesourcing, transportation network companies (TNCs)) have been proposed and operated (Errico et al., 2013; Qiu et al., 2015). Studies examined whether the shared mobility concept influences travel behavior (Clewlow et al., 2017; Frei, Hyland, & Mahmassani, 2017; Henao, 2017; Rayle et al., 2014); who use it for which reasons (Clewlow et al., 2017; Frei et al., 2017; Hughes & MacKenzie, 2016; Rayle et al., 2016, 2014); and how to improve service availability and user experience (Murphy, 2016). Rayle et al., (2014) found that wait times are shorter for ride-sourcing (TNCs – Uber/Lyft) and more convenient than for taxis. Frei et al (2017) found that the average per-hour cost for "waiting at home" ($11.30) is substantially lower than the cost for "walking to transit" ($25.90). Several studies documented that it may be potentially a good complementary or substitutive form of transportation services in low density areas (Errico et al., 2013; Qiu et al., 2015). However, it mostly depends on the context in which the fixed route public transit service is provided (Clewlow et al., 2017). No studies empirically examined whether the shared mobility concept is a feasible alternative to complement or substitute for fixed route public transit services.

# 3 Research Approach

## *3.1 Research Design*

The purpose of this research is to examine on-demand microtransit, as a means of connecting the first-last mile segments of travel by public transit on urban outskirts with limited access to public transit services. Further, this research aims to examine the extent to which improved first-last mile access to transit by the microtransit influences low-wage job accessibility by public transit. Let us assume all commuters have a limited travel time budget, for instance, 45 minutes. A 10-minute saving in the first mile travel will help the rider make a farther transit travel by 10 minutes. Ten more travel minutes could be translated into two to four further transit stops. Likewise, the rider's job accessibility gets improved by the first-mile travel time savings. The person will have greater access to job opportunities around the additional two to four transit stops. In that perspective, the extent to which job accessibility gets improved will depend on the level of transit services as well as job opportunities available in the neighborhood/region. We compare the accessibility outcomes across various modes of transportation for the first-last mile segments. It includes walking, bicycle, car, and on-demand microtransit. In this research, we only consider temporal budgets, not monetary budgets.

This research consists of three phases. In the first phase, we analyze the characteristics of transit-anchored travels by GoLink. Transit-anchored travels represent all trips that depart from/destined to a transit station. Most of the trips occurred in 2018 and 2019. In order to identify transit-anchored work commute travels, we use travel periods (AM-PM peak or off-peak), land use characteristics of origin and destination (residential, business, or education-oriented), and connection to/from a transit station. Using the information, we understand the typical characteristics of transit-anchored first-last mile work commute travels.

In the second phase, we analyze the characteristics of the first-last mile travel by other travel modes – walking, bicycle, bus, and car (park-n-ride). We use data from 2014 North Central Texas Regional On-Board Transit Survey by NCTCOG data, firstly, to identify all trips originating from and destined to the seven GoLink service area zones and secondly to identify all the first-last mile portions of work commute travels and understand typical first-last mile travels by walk, bicycle, bus, and car.

In the third phase, we examine low-wage job accessibility based on the first-last mile travel patterns. We use Longitudinal Employer-Household Dynamics (LEHD) 2015 dataset in which the employment information is available by three monthly wage categories at the census block level. The wage categories are $1,250 or less, $1,251-3,333, and more than $3,333. These wage levels are by person, neither family nor household. According to the US Bureau of Economic Analysis, annual average per capita personal income in Dallas Fort Worth in 2015 was $50,849 ($4,237 monthly). Despite no direct relevance, we refer to the definition of "very low income" by the Department of Housing and Urban Development (HUD) – 50 percent of a region's median family income. Hence, we use the two bottom categories ($3,333 or less) as low wages.

We calculate job accessibility as the sum of low wage jobs one can reach in a given travel time by transit. We use three travel time thresholds: 30, 45, and 60 minutes. We use the REMIX travel analyst that generates an isochrone – a polygon boundary – that delineates the threshold one can reach by transit, considering for walk time, waiting time, and in-transit time. The calculation is based on the general transit feed specification (GTFS) information. This isochrone is based on the travel time directly from a transit station and excludes the first-mile travel portions. Also, we do not consider the last mile portion at the end of the trip. If there is a set total travel time limit, the time necessary to make the first mile trip from a home to a transit station will directly influence the extent to which one could travel by transit. For example, savings from the first mile travel will influence the extent to which one could travel, which is equivalent to the isochrones REMIX generates. Hence, we produce isochrones from a transit station by multiple travel time (5, 10, 15, 20, 30, 45, 60, and 90 minutes). Considering for first-mile travel times, we will quantify low wage job accessibility.

## 3.2 Study Area – GoLink Service Area Zones

As a case study, we examine GoLink, an app-based on-demand micro-transit service operated by Dallas Area Rapid Transit (DART) in Dallas County, TX. The service is based on the Mobility on Demand (MOD) Sandbox Demonstration Program funded by the Federal Transit Administration (FTA). DART with GoLink aims at "implementing first mile and last mile solutions to improve service and connectivity for customers and provide efficiencies and cost effectiveness within DART's operations" (Cordahi, Shaheen, & Martin, 2018, p. 1). The study area is GoLink service area zones. As of June 2019, DART is operating GoLink services in thirteen service area zones. This study includes only seven service area zones, all on the outskirts of Dallas County where fixed-route public transit services are rare or scarce. With GoLink, DART aims to provide seamless transportation options, particularly for the first/last mile portions of transit travel, that connect travels to/from transit stations or help short-distance travels within the boundary of service area zones. The service is designed in a way any residents can request a ride not only via a smartphone app but also via a call center or walk-in. GoLink is designed to be accessibly by those do not have a bank account or credit card. Also, all GoLink vehicles are ADA compliant. It is operated from 5 AM to 8 PM weekdays, except for holidays. With DART's local day pass ($6), riders have access to other bus/rail lines operated by DART. A reduced day pass ($3) for low-income residents is also available. Other fare passes by DART are also usable. Key partners include public and private entities including transportation network companies (TNCs), technology companies, and a MPO, such as Lyft, Uber, Irving Holdings, Unwire, North Central Texas Council of Government, PayNearMe, DoubleMaps, and Marlene Connor Associates, LLC.

***Table 1: Location and land use/transit service characteristics of GOLINK service area zones***

| Zone | Abbr. name | Service began | Land use characteristics | Transit anchors |
|---|---|---|---|---|
| Legacy West | LEG | 10/02/17 – Lunch pilot began<br>3/26/18 – GoLink zone expands to the entire zone | Business clusters with some residential area | NW Plano Park and Ride |
| Rylie | RYL | 2/26/18 | Low density residential area | Buckner Station (Green line) |
| Kleberg | KLE | 2/26/18 | Low density residential area | Buckner Station (Green line) |
| Inland Port | INL | 2/26/18 | Logistics and transportation activity | UNT Dallas Station (Blue line) |
| North Central Plano | NCP | 3/12/18 – On-call zones converted to GoLink | Mostly residential area with some businesses | Parker Rd Station (Red/Orange line) |
| Rowlett | ROW | 6/25/18 – On-call zones expanded | Mostly residential with some businesses | Downtown Rowlett station (Blue line) |
| Far North Plano | FNP | 8/27/18 | Mostly residential area | Parker Rd Station (Red/Orange line) |

* This table excludes six service area zones: Farmers Branch, Glenn Heights, Lake Highlands, Lakewood, North Dallas, Park Cities. All these zones are located in inner-suburbs of Dallas County. Their GoLink services began on 3/25/19.

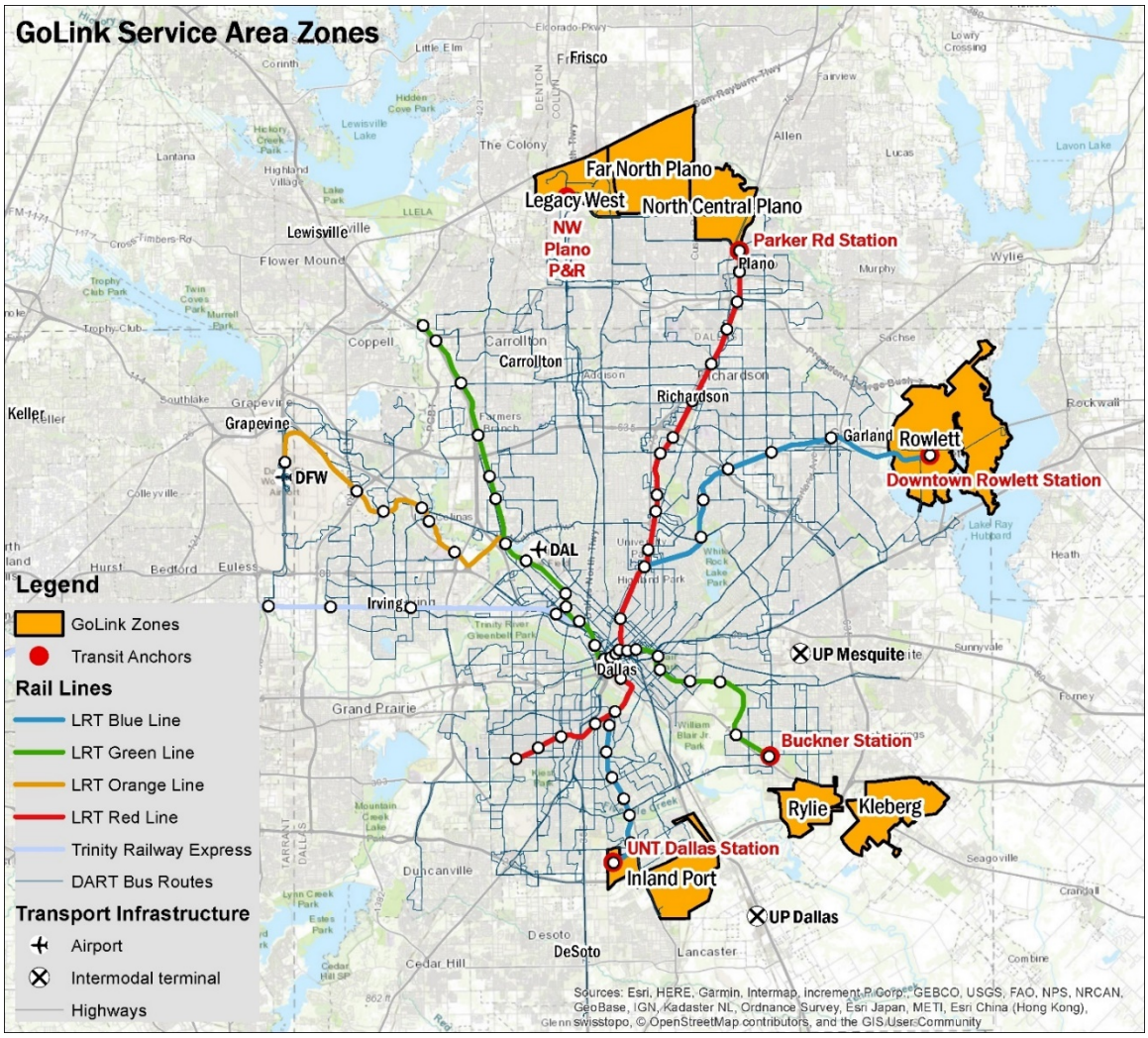



***Figure 1: GoLink service area zones, transit anchors, and DART rail and bus routes***

In Table 1, we summarize land use and transit service characteristics in the GoLink service area zones. In Figure 1, we present the location of GoLink service area zones layered with DART rail and bus service routes/stations. The first GoLink service began with a Plano Legacy Launch Pilot in October 2017. The service expanded to the entire zone, as Legacy West in March 2018. It has NW Plano Park & Ride as its transit anchor. The Legacy West zone has intensive business clusters with high employment densities within and in close proximity. Three southern sector zone services (Rylie, Kleberg, and Inland Port) opened in February 2018. Rylie and Kleberg are low density residential areas with Buckner Station (Green line) as the transit anchor. Inland Port has intensive logistics and transportation sector activity with UNT Dallas Station (Blue line) as the transit anchor. In March 2018, the

on-call zones in North Central Plano were converted to a GoLink zone. The on-call service is a call-based paratransit system: when a rider requests a ride, an operator at DART dispatches a vehicle to the person. Currently, GoLink includes the on-call service and maintains the caller-operator system, so that existing riders who do not have access to the GoLink smartphone application can still receive the on-call ride service. The North Central Plano mostly consists of residential areas with some businesses around Parker Rd Station (Red/Orange line), the transit anchor. Similarly, the on-call service in Rowlett was converted to GoLink in June 2018. Rowlett mostly consists of residential areas with some businesses around Downtown Rowlett Station (Blue line), the transit anchor. Lastly, GoLink began in Far North Plano in August 2018, mostly residential areas with Parker Rd Station (Red/Orange line), as the transit anchor.

## 3.2 Characteristics of the Residents and Low Wage Jobs in GoLink Zones

In Table 2, we provide the socio-economic characteristics of the residents and jobs in the GoLink service area zones. We found significant differences between the zones in Plano (Legacy West, Far North Plano, and North Central Plano) and all other zones (Rowlett, Rylie, Kleberg, and Inland Port). Plano zones have unique characteristics that are different from all other GoLink zones as well as the Dallas-Fort Worth metropolitan area. Plano zones have substantially smaller percentages of African American and Hispanic populations, whereas the percentage for Asian is more than three times higher than the region average. Likewise, the percentage of people who have a bachelor's degree or higher education is two folds of the region average. The percentage of households below poverty, as defined by the American Community Survey, is a half of the region average. Similarly, the percentage of workers with less than $1,250 monthly wage is smaller than the region average. All other zones in Rowlett, Rylie, Kleberg, and Inland Port have more residents who are minority (Hispanic) and with lower education levels (less than a bachelor's degree). Still, all other zones' characteristics are very similar to the region average. Work commute characteristics are similar across all zones – approximately 90% by car, 1.3% by transit, and 1% by walk. In Figure 2, we present the spatial distribution of low wage jobs (monthly earnings less than $3,333) in Dallas, TX. Almost all low wage jobs are located along major highways and DART rail lines. Plano zones have relatively better access to the jobs compared to the other zones. Particularly, the southern sector zones (Rylie, Kleberg, and Inland Port) are quite distant from any of the jobs.

In general, GoLink service area zones do not necessarily have the socio-economic characteristics of typical transit dependent area residents – very low income, minority, low education, and low wage. Plano zones show the opposite characteristics. However, this may lead to the ecological fallacy. Yet, the zones are on the periphery of DART service areas with very limited access to rail and bus services. As explained previously, with GoLink, DART intends to replace bus feeder services completely with GoLink in these peripheral locations.

We do not have access to the demographic characteristics of GoLink users, but we could state that GoLink users are more likely to be similar to transit dependent population rather than personal vehicle users. Hence, we still focus on the specific population group and low wage jobs in the region. All statistics have been derived from American Community Survey (ACS) 2013-2017 and Longitudinal Employer-Household Dynamics (LEHD) 2015. In Appendix Table A 1, we include the definition of all attributes we used in Table 2.

***Table 2: Socio-economic characteristics of the residents in GoLink zone residents***

| Attribute | NCTCOG | All GoLink zones (1)+(2) | Plano zones (1) | All other zones (2) |
|---|---|---|---|---|
| N of block groups | 4158 | 111 | 78 | 33 |
| Area of block groups ($mi^2$) | 9442.1 | 69.4 | 28.3 | 41.1 |
| Total population | 7,095,765 | 209,335 | 132,130 | 77,205 |
| Population density (people / $mi^2$) | 752 | 3,017 | 4,674 | 1,878 |
| **Age characteristics** | | | | |
| Age >65 years | 747,859 | 19,409 | 13,042 | 6,367 |
| % of total pop | 10.5% | 9.3% | 9.9% | 8.2% |
| Workers >16 years | 3,460,674 | 108,460 | 70,565 | 37,895 |
| % of total pop | 48.8% | 51.8% | 53.4% | 49.1% |
| Age >25 years | 4,553,792 | 137,744 | 90,268 | 47,476 |
| % of total pop | 64.2% | 65.8% | 68.3% | 61.5% |
| **Race characteristics** | | | | |
| % African American | 15.4% | 10.6% | 7.8% | 15.6% |
| % Hispanic | 28.4% | 19.7% | 10.5% | 35.4% |
| % Asian | 6.4% | 18.6% | 26.6% | 5.0% |
| **Work commute characteristics** | | | | |
| % by car | 90.6% | 89.2% | 88.0% | 91.3% |
| % by transit | 1.5% | 1.3% | 1.2% | 1.5% |
| % by bicycle | 0.2% | 0.1% | 0.1% | 0.0% |
| % by walk | 1.3% | 0.7% | 0.8% | 0.3% |
| **Education characteristics** | | | | |
| % Low education | 66.2% | 49.8% | 37.5% | 73.1% |
| % High education | 33.8% | 50.2% | 62.5% | 26.9% |
| **Income characteristics** | | | | |
| % HH below poverty | 12.0% | 7.1% | 5.5% | 10.4% |
| % wage < $1,250/mo | 21.0% | 18.3% | 17.1% | 20.7% |
| % $1,250 < wage < $3,333 | 32.1% | 25.4% | 22.4% | 31.3% |
| % wage > $3,333/mo | 46.9% | 56.3% | 60.5% | 48.0% |

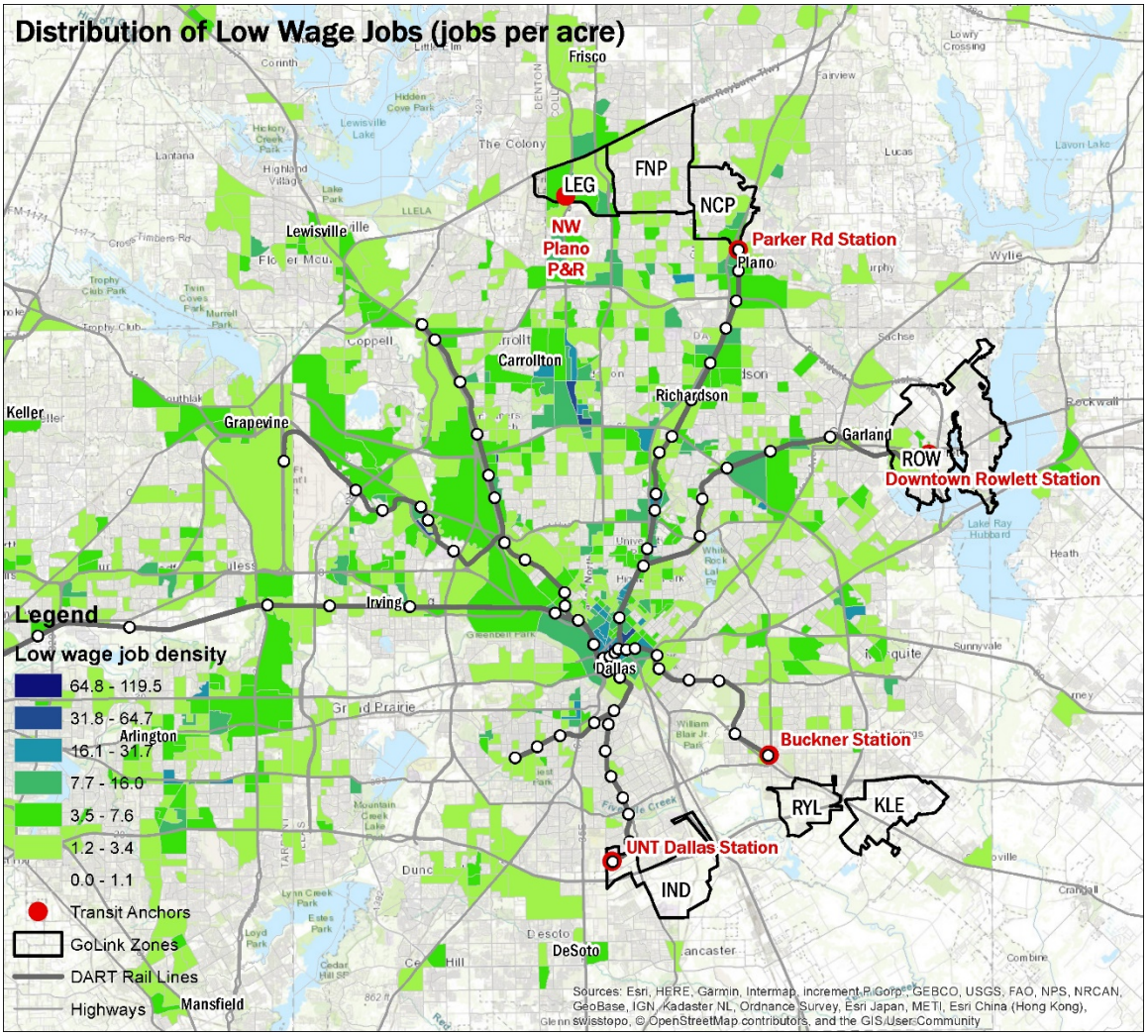



***Figure 2: Distribution of low wage jobs in Dallas, Texas***

# 4 Data

## *4.1 GoLink by Dallas Area Rapid Transit (DART)*

In May 2019, DART provided us with all GoLink travel records from October 2017 to April 2019. They include, requested pick-up time and location (XY Coordinate), requested drop-off time and location, scheduled pickup time and location, actual pick-up time and location, actual drop-off time and location, number of riders, strollers, wheelchairs, child seats, service animals, service area, cancellation time and reason, and with which platform the travel is booked. Users can choose one of three options: a) smartphone application, b) call center, and c) walk-in at the rail station. After data cleaning, we use actual pick-up time and location, actual drop-off time and location, number of riders, ride time, service area, and booked-from.

GoLink services are available for any trips within each service area zone or to/from its transit anchor. We only include all the travel records that have at least one transit anchor as its pick-up/drop-off location. Also, we only include the travel records departing from/destined to a residence. It is because no travel purpose information is available. We cannot identify if a trip from a transit station to a retail mall is for shopping or for a work commute. We also cannot identify if a trip from a home to a transit station is for a work commute or for other purposes. However, regardless of the purpose, all home-based travels explain the characteristics of the home-based first-last mile travel. Thus, we use all trips that have both a residence and a transit anchor as pick-up and drop-off locations. We used parcel-level land use information from the NCTCOG to identify the land use of all trip origin and destination locations. No travel information was available for the trip before departing from/after arriving at a transit anchor. No user information is included in the database. After data cleaning, we have approximately 69,900 records. Figure 3 presents monthly GoLink trips and ridership from April 2018 to March 2019. The figure is derived from "GoLink Program Update" presented at FTA-DART Meeting by Operations Committee, presented by DART on May 14, 2019. Since October 2018, approximately 11,000 riders use the GoLink service monthly.

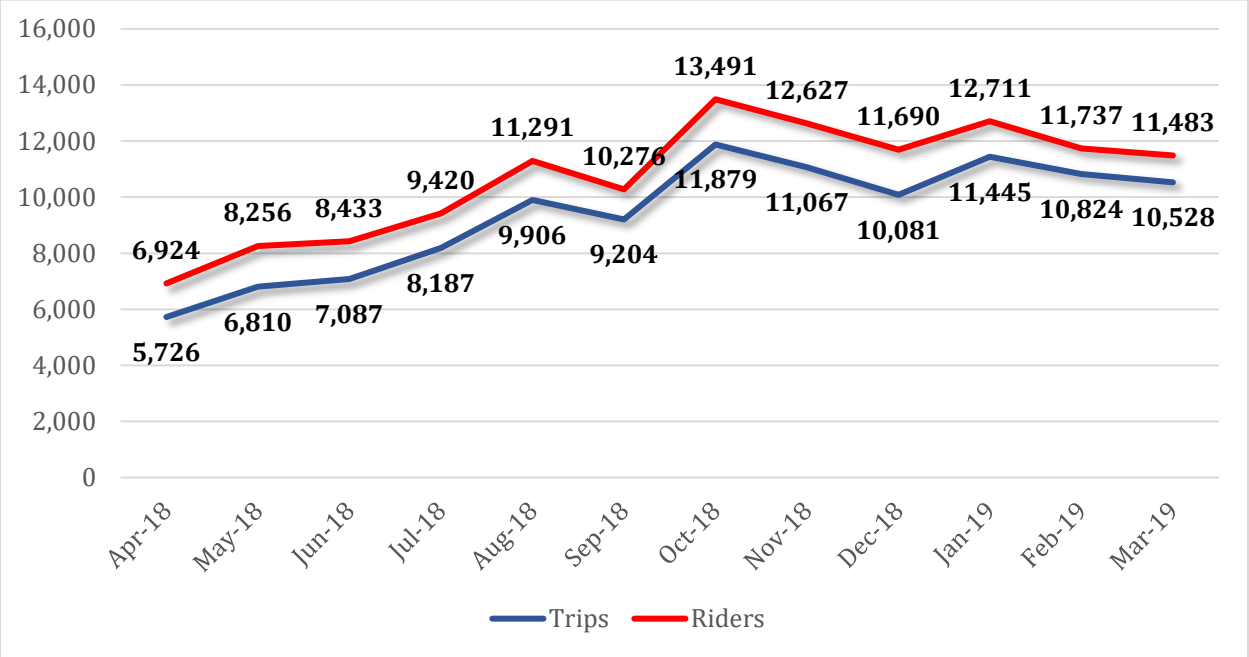



***Figure 3: GoLink trips and ridership (derived from GoLink Program Update, presented at FTA-DART Meeting by Operations Committee, presented by DART)***

## 4.2 2014 NCTCOG Transit Survey

In April 2019, the NCTCOG provided us with 2014 North Central Texas Regional On-Board Transit Survey records. The on-board survey aimed at all rail and bus riders in the Dallas-Fort Worth region, including Dallas Area Rapid Transit (DART), Fort Worth Transit Authority (The T), Trinity Railway Express (TRE), and Denton County Transportation Authority (DCTA). The survey included 83,256 on-to-off survey responses (boarding and alighting patterns) and 36,935 ride survey responses (ride patterns) and examined the rider demographics and travel behavior characteristics.

The on-board survey provides detailed mode and distance information of the first-last travel patterns. The mode includes walked all the way, walked part of the way, bike, dropped-off, drove-alone, drove with others, wheelchair/scooter, shuttle, DART on-call, skateboard, school bus, and cab. The distance was measured by the number of blocks but only for those who walked (less than a block, 1, 2, 3, …, ten or more). Other modes do not have the distance information. It also provides general transit travel patterns, such as time of travel, frequency, vehicle availability, income, and race. Only accounting for home-based work-commute travels by DART's rail services, the database provides first-last mile travel information from 5,669 transit riders.

Table 3 compares home-based work-commute travels between the residents in the entire DART service area and those in GoLink zones. Approximately 44.8% and 51.9% of residents follows the common AM and PM peak commute patterns, respectively. They go to work during AM peak and come back home during PM peak. Proportionally, more people in GoLink zones tend to follow the common peak-time commute patterns. There is almost no difference between DART and GoLink residents in terms the frequency of home-based work trips.

***Table 3 Distribution of time to work***

| Time to work | DART | | | | Residing in GoLink zones | | | |
|---|---|---|---|---|---|---|---|---|
| | Home to work | % | Work to home | % | Home to work | % | Work to home | % |
| Before 6:30 AM | 397 | 13.2% | 67 | 2.5% | 46 | 13.9% | 4 | 1.2% |
| 6:30-9 AM AM peak | 1,351 | 44.8% | 180 | 6.8% | 159 | 48.2% | 24 | 7.4% |
| 9AM-3PM | 739 | 24.5% | 347 | 13.1% | 85 | 25.8% | 39 | 12.0% |
| 3 PM-7 PM PM Peak | 401 | 13.3% | 1,379 | 51.9% | 31 | 9.4% | 189 | 58.2% |
| After 7PM | 126 | 4.2% | 682 | 25.7% | 9 | 2.7% | 69 | 21.2% |
| Total | 3,014 | 100.0% | 2,655 | 100.0% | 330 | 100.0% | 325 | 100.0% |

# 5 Results

## 5.1 First/last mile travel patterns from 2014 NCTCOG Transit On-Board Survey

In the 2014 NCTCOG Transit On-Board Survey, travel records of three anchor stations (Parker Rd Station, Downtown Rowlett Station, and Buckner station) were only available. UNT Dallas Station was opened in 2016, hence was not included in the survey. Figure 4 presents the spatial distribution of survey respondents' home ZIP Codes. Most survey respondents reside in areas near DART rail stations particularly along red and blue lines.

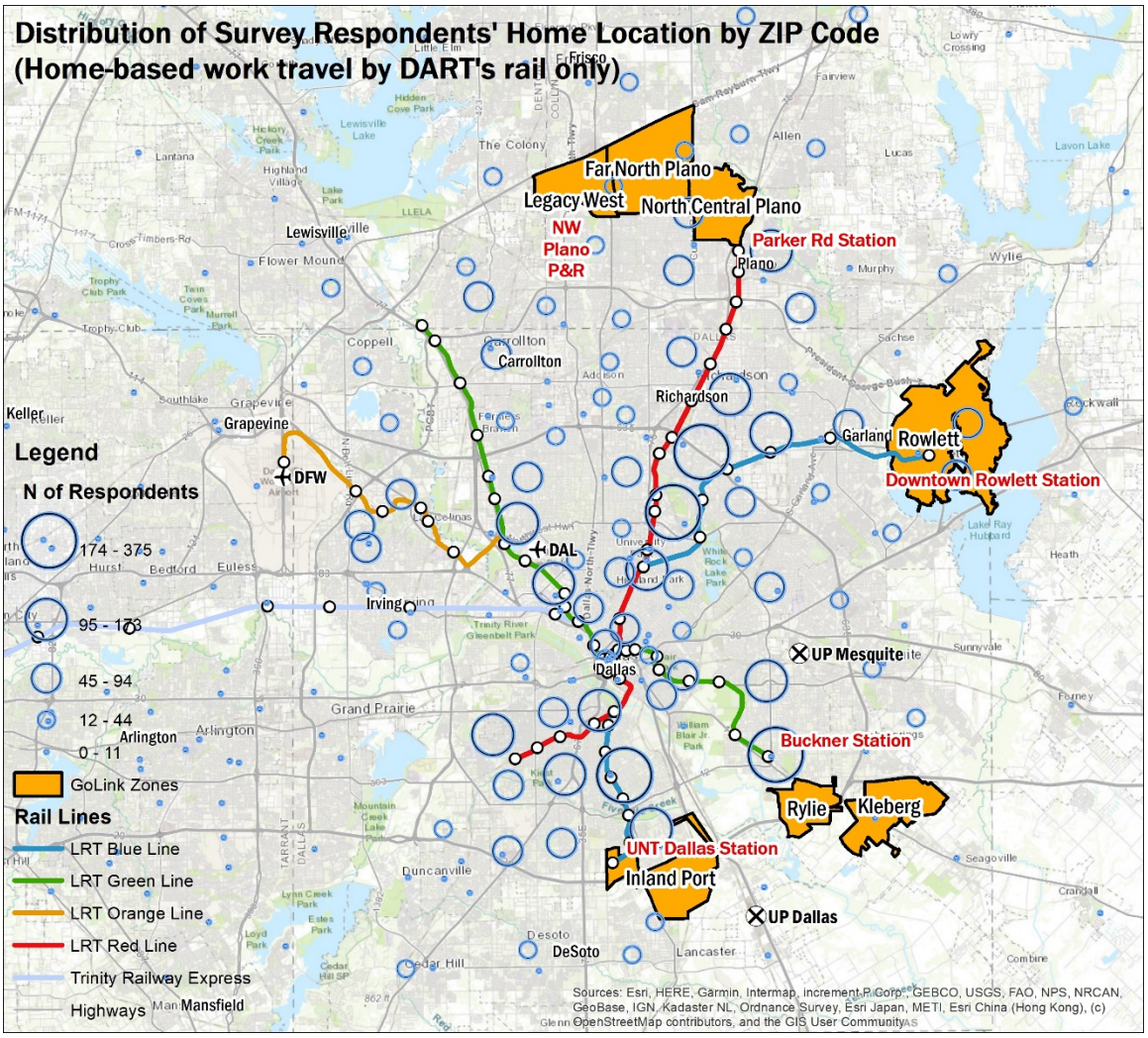



***Figure 4: Distribution of survey respondents' home location by ZIP Code (N=5,669)***

Table 4 presents the distribution of walking distance to a rail station. The distribution show that most of the respondents live close to transit stations and as the distance increases,the number of people who use walk as a mode to access transit, decreases significantly. There was no data available about the time taken from home to reach a transit

station through walking, we used GIS to calculate the walking distance from the residents home location to the nearest anchor station. The walking time calculations show that average walking time for all residents who walk all the way to the station is 34.67 minutes. We discarded the trips with more than 100 minutes of walking because it is rare to walk for over 100 minutes to reach to a transit station. To get an idea of likely GoLink users, we calculated the number of respondents that live within 0.75 miles distance from a transit station and those who live farther than that. This was based on the assumption that people within 0.75 miles distance from an anchor station are likely to walk to access transit while people who are beyond 0.75 miles are likely to switch to a motorized service and use GoLink since it will reduce their access/egress times to a great extent.

***Table 4: Distribution of walking distance by number of blocks (those who walked only)***

| Walking distance to a rail station | DART | | GoLink | |
|---|---|---|---|---|
| | N | % | N | % |
| < 2 blocks | 20844 | 81.16506367 | 101 | 72.6618705 |
| 3-5 blocks | 4117 | 16.03130719 | 26 | 18.70503597 |
| 6-9 blocks | 498 | 1.939176823 | 7 | 5.035971223 |
| 10+ blocks | 222 | 0.864452319 | 5 | 3.597122302 |
| Total | 25681 | 100 | 139 | 100 |

Using the home addresses of residents within GoLink zones, we calculated the network distance from home to the respondent's rail station for commute. According to Table 5, 36% of those who reside within 2 miles walk to a rail station, and 40% drive alone or with others. Even for the residents who live beyond 2 miles from a transit station, there is a large portion that either walk or carpool (drop off/pickup with others). For example, 21% of all trips were either picked up or dropped off. This shows that the residents were already having an informal arrangement of carpooling.

***Table 5: Mode of first-last mile access by distance from home location to a rail station***

| Mode of first-last mile access | 0-2 miles | 2-5 miles | 5-10 miles | > 10 miles | Total |
|---|---|---|---|---|---|
| Walked (all/part) | 76 | 57 | 16 | 0 | 149 |
| % | 36% | 28% | 30% | 0 | 32% |
| Biked | 6 | 0 | 0 | 0 | 6 |
| % | 3% | 0% | 0% | 0 | 1% |
| Dropped off | 45 | 42 | 12 | 0 | 99 |
| % | 21% | 20% | 22% | 0 | 21% |
| Drove (alone/w. others) | 85 | 106 | 26 | 0 | 217 |
| % | 40% | 52% | 48% | 0 | 46% |
| Wheelchair, Shuttle, Cab | 1 | 0 | 0 | 0 | 1 |
| % | 0% | 0% | 0% | 0 | 0% |
| Total | 213 | 205 | 54 | 0 | 472 |
| % | 100% | 100% | 100% | 0 | 100% |

For people who walk to access/egress transit, only 22% (31 out of 139) of respondents live within 0.75 miles of an anchor station while 78% of respondents reside farther than 0.75 miles. Since it become inefficient for people to walk more than 0.75 miles for accessing transit, it is more likely that these people will switch to GoLink for accessing transit.

Table 6 and 7 present the tabulation between number of vehicles available in household and mode to first-last mile access to/from a rail station. Regardless of the residential location in DART's jurisdiction or GoLink zones, number of available vehicles has some correlation with the mode of first-last mile access. Still, a majority of rail riders (57.2%) walk to a rail station. The percentage of the people who drive alone or with others increases as the number of available vehicles increases. The residents who reside in GoLink zones, which are mostly in the urban periphery, tend to use private vehicles more than those residing in DART. Compared to the general DART riders, these results imply that home locations of GoLink zone residents tend to be outside of walking distance and first-last mile mobility options are not available. Hence, they tend to rely more on a private vehicle if it is available in a household.

***Table 6: Tabulation between number of vehicles available in household and mode to access to/from transit***

| Area | Number of vehicles in household | 0 | 1 | 2 | 3 | 4+ | Total |
|---|---|---|---|---|---|---|---|
| DART | Walked (all/part) | 10342 | 9583 | 5182 | 806 | 158 | 26071 |
| | Biked | 180 | 117 | 103 | 19 | 4 | 423 |
| | Dropped off | 658 | 1435 | 1056 | 186 | 39 | 3374 |
| | Drove (alone/w. others) | 133 | 1223 | 1664 | 399 | 148 | 3567 |
| | Wheelchair, Shuttle, Cab | 92 | 16 | 15 | 1 | 0 | 124 |
| | Total | 11405 | 12374 | 8020 | 1411 | 349 | 33559 |
| GoLink | Walked (all/part) | 28 | 57 | 56 | 6 | 2 | 149 |
| | Biked | 0 | 2 | 3 | 1 | 0 | 6 |
| | Dropped off | 17 | 29 | 41 | 10 | 2 | 99 |
| | Drove (alone/w. others) | 6 | 49 | 125 | 35 | 11 | 226 |
| | Wheelchair, Shuttle, Cab | 0 | 2 | 0 | 1 | 0 | 3 |
| | Total | 51 | 139 | 225 | 53 | 15 | 483 |

***Table 7: Proportions between number of vehicles available in household and mode to access to/from transit***

| Area | Number of vehicles in household | 0 | 1 | 2 | 3 | 4+ | Total |
|---|---|---|---|---|---|---|---|
| DART | Walked (all/part) | 90.68 | 77.44 | 64.61 | 57.12 | 45.27 | 77.69 |
| | Biked | 1.58 | 0.95 | 1.28 | 1.35 | 1.15 | 1.26 |
| | Dropped off | 5.77 | 11.60 | 13.17 | 13.18 | 11.17 | 10.05 |
| | Drove (alone/w. others) | 1.17 | 9.88 | 20.75 | 28.28 | 42.41 | 10.63 |
| | Wheelchair, Shuttle, Cab | 0.81 | 0.13 | 0.19 | 0.07 | 0.00 | 0.37 |
| | Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| GoLink | Walked (all/part) | 54.90 | 41.01 | 24.89 | 11.32 | 13.33 | 30.85 |
| | Biked | 0.00 | 1.44 | 1.33 | 1.89 | 0.00 | 1.24 |
| | Dropped off | 33.33 | 20.86 | 18.22 | 18.87 | 13.33 | 20.50 |
| | Drove (alone/w. others) | 11.76 | 35.25 | 55.56 | 66.04 | 73.33 | 46.79 |
| | Wheelchair, Shuttle, Cab | 0.00 | 1.44 | 0.00 | 1.89 | 0.00 | 0.62 |
| | Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

Table 8 shows the tabulation between travel time and distance between residents home location and the nearest anchor station. The travel times were calculated through GIS as there is not travel time data available from the transit survey. Majority of the trips are less under 5 miles distance from the transit stations and have a time spane of under 20 minutes.

***Table 8: tabulation between distance from home to a station and travel time***

| Travel time | Distance between a home to an anchor station | | | | | |
|---|---|---|---|---|---|---|
| | 0-1 miles | 1-2 miles | 2-5 miles | 5-7 miles | > 7 miles | Total |
| 1-5 mins | 70 | 22 | 4 | 0 | 0 | 96 |
| 5-10 mins | 18 | 90 | 98 | 0 | 0 | 206 |
| 10-15 mins | 0 | 16 | 56 | 6 | 0 | 78 |
| 15-20 mins | 0 | 2 | 23 | 6 | 1 | 32 |
| > 20 mins | 0 | 0 | 29 | 23 | 19 | 71 |
| Total | 88 | 130 | 210 | 35 | 20 | 483 |

## 5.3 GoLink travel patterns

GoLink wait time has been approximately 9-10 minutes. It increased to 15 minutes recently. As per DART, it is due to an increase in number of riders. However, riders can internalize it. Figure 5 shows average wait times. The figure is derived from DART's presentation at FTA-DART Meeting.

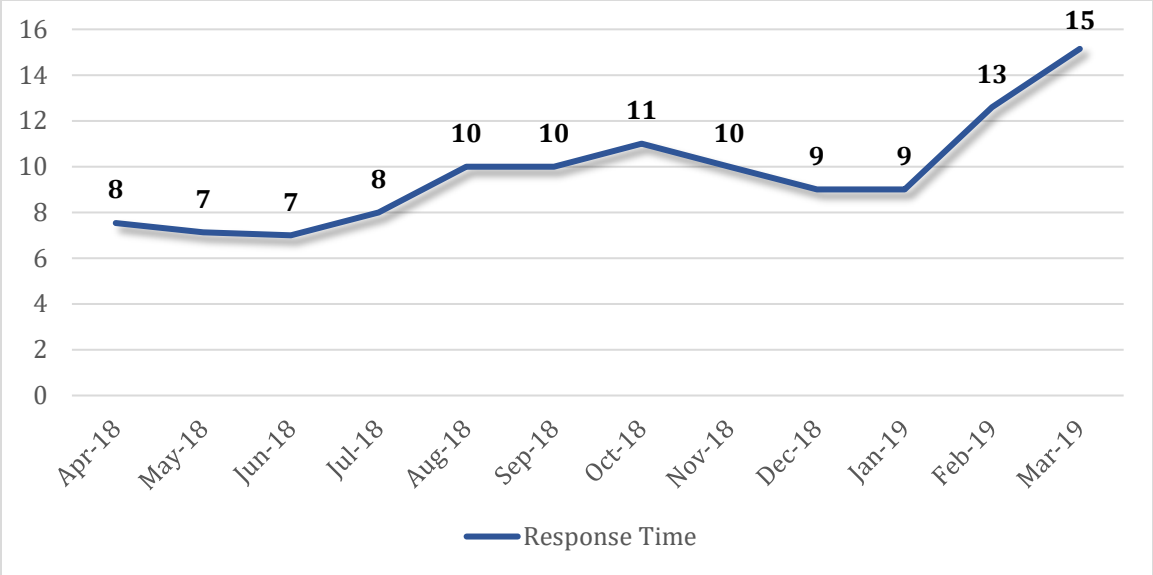



***Figure 5: Average response time in minutes (derived from GoLink Program Update, presented at FTA-DART Meeting by Operations Committee, presented by DART)***

Figure 6 shows average travel time. It is about 12-13 minutes. The figure is derived from DART's presentation at FTA-DART Meeting.

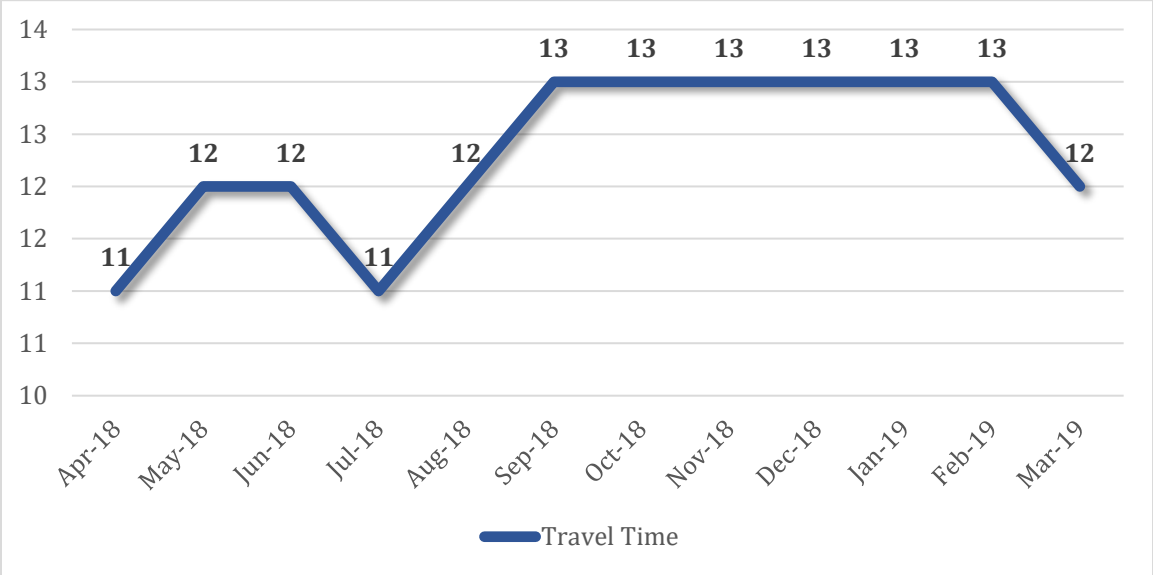



***Figure 6: Average travel time in minutes (derived from GoLink Program Update, presented at FTA-DART Meeting by Operations Committee, presented by DART)***

Table 9 shows distribution of GoLink rides that have both a home location and a transit anchor as the trip's origin/destination locations. These are home-based anchor station trips. Results are very similar to NCTCOG Travel Survey (Table 4). Rather than

analyzing by GoLink service area zones, we use anchor stations. Buckner Station is an anchor station for Rylie and Kleberg zones. Parker Rd Station is an anchor station for Far North Plano and North Central Plano zones. Plano Part & Ride is an anchor station for the Legacy West zone. Downtown Rowlett Station is for the Rowlett zone. UNT Dallas Station is for the Inland Port zone.

***Table 9: GoLink commute patterns: time to travel***

| Time to work | To/from Buckner Station | | | | To/from Parker Rd Station | | | |
|---|---|---|---|---|---|---|---|---|
| | Home to work | % | Work to home | % | Home to work | % | Work to home | % |
| Before 6:30 AM | 1,931 | 22.5% | 58 | 0.9% | 2,294 | 27.1% | 63 | 0.9% |
| 6:30-9 AM AM peak | 3,594 | 41.8% | 500 | 7.6% | 3,150 | 37.2% | 632 | 9.2% |
| 9AM-3PM | 2,417 | 28.1% | 1,760 | 26.7% | 1,967 | 23.2% | 1,322 | 19.1% |
| 3 PM-7 PM PM Peak | 537 | 6.2% | 3,579 | 54.3% | 890 | 10.5% | 4,049 | 58.6% |
| After 7PM | 122 | 1.4% | 699 | 10.6% | 172 | 2.0% | 840 | 12.2% |
| Total | 8,601 | 100.0% | 6,596 | 100.0% | 8,473 | 100.0% | 6,906 | 100.0% |
| Time to work | To/from Plano Park & Ride | | | | To/from Downtown Rowlett Station | | | |
| | Home to work | % | Work to home | % | Home to work | % | Work to home | % |
| Before 6:30 AM | 60 | 19.4% | 6 | 1.2% | 1,406 | 23.9% | 51 | 1.2% |
| 6:30-9 AM AM peak | 202 | 65.4% | 9 | 1.9% | 2,161 | 36.7% | 268 | 6.3% |
| 9AM-3PM | 31 | 10.0% | 28 | 5.8% | 1,741 | 29.6% | 1,070 | 25.1% |
| 3 PM-7 PM PM Peak | 15 | 4.9% | 351 | 72.8% | 523 | 8.9% | 2,101 | 49.2% |
| After 7PM | 1 | 0.3% | 88 | 18.3% | 53 | 0.9% | 777 | 18.2% |
| Total | 309 | 100.0% | 482 | 100.0% | 5,884 | 100.0% | 4,267 | 100.0% |

Table 10 shows average travel time by anchor station. There is a small variation across stations. The statistics are consistent with DART's calculation that includes all trips: approximately 11-12 minutes (Figure 6). Our observations include home-based anchor station trips only and excludes all other trips, such as trips to/from non-residential areas, trips that do not have an anchor station as origin/destination.

***Table 10: GoLink travel time by anchor station***

| Travel time (minutes) | N | Mean | SD | Median | Min | Max |
|---|---|---|---|---|---|---|
| To/from Buckner Station | 15,197 | 12.78 | 4.10 | 12.00 | 4.83 | 23.37 |
| To/from Park Rd Station | 15,379 | 13.75 | 4.57 | 13.30 | 4.82 | 23.37 |
| To/from Plano Park & Ride | 791 | 9.86 | 3.90 | 8.90 | 4.80 | 23.23 |
| To/from Dt Rowlett Station | 10,151 | 11.98 | 4.55 | 11.00 | 4.82 | 23.37 |
| All | 41,518 | 12.89 | 4.46 | 12.07 | 4.80 | 23.37 |

Table 11 shows the tabulation between travel time and distance. Distances do not necessarily correspond to travel distance by GoLink but only indicate how far a home is located from an anchor station. For those who live in a location within 7 miles from an anchor station, most trips are made between 5-20 minutes.

***Table 11: Tabulation between distance from home to a station and travel time***

| Travel time | Distance between a home to an anchor station | | | | | |
|---|---|---|---|---|---|---|
| | 0-1 miles | 1-2 miles | 2-5 miles | 5-7 miles | > 7 miles | Total |
| 1-5 mins | 129 | 121 | 42 | 15 | 4 | 311 |
| 5-10 mins | 1,044 | 3,864 | 5,858 | 1,681 | 16 | 12,463 |
| 10-15 mins | 201 | 1,284 | 10,019 | 4,461 | 227 | 16,192 |
| 15-20 mins | 78 | 520 | 5,773 | 2,338 | 321 | 9,030 |
| > 20 mins | 30 | 171 | 2,179 | 1,003 | 139 | 3,522 |
| Total | 1,482 | 5,960 | 23,871 | 9,498 | 707 | 41,518 |

Table 12 shows the travel time comparisons between the NCTCOG transit survery and GoLink trips. Since most of the trips in both cases were under 20 minutes duration so we compared the travel times before and after GoLink. The distribution shows that the share of trips under 20 minutes increased by more than 6% before and after the GoLink service. If the trips that were taken by foot before GoLink are assumed to be taken using GoLink services, that will add to the travel time savings for transit users in the GoLink zones. Also the large portion of residents who walked to transit stations are located farther than the convenient walking distance and are likely to switch to GoLink.

***Table 12: Travel Time Comparisons***

| Travel Time | NCTCOG Transit Survery | GoLink |
|---|---|---|
| Trips under 20 minutues | 85.3% | 91.52% |
| Trips over 20 minutes | 14.7% | 8.48% |

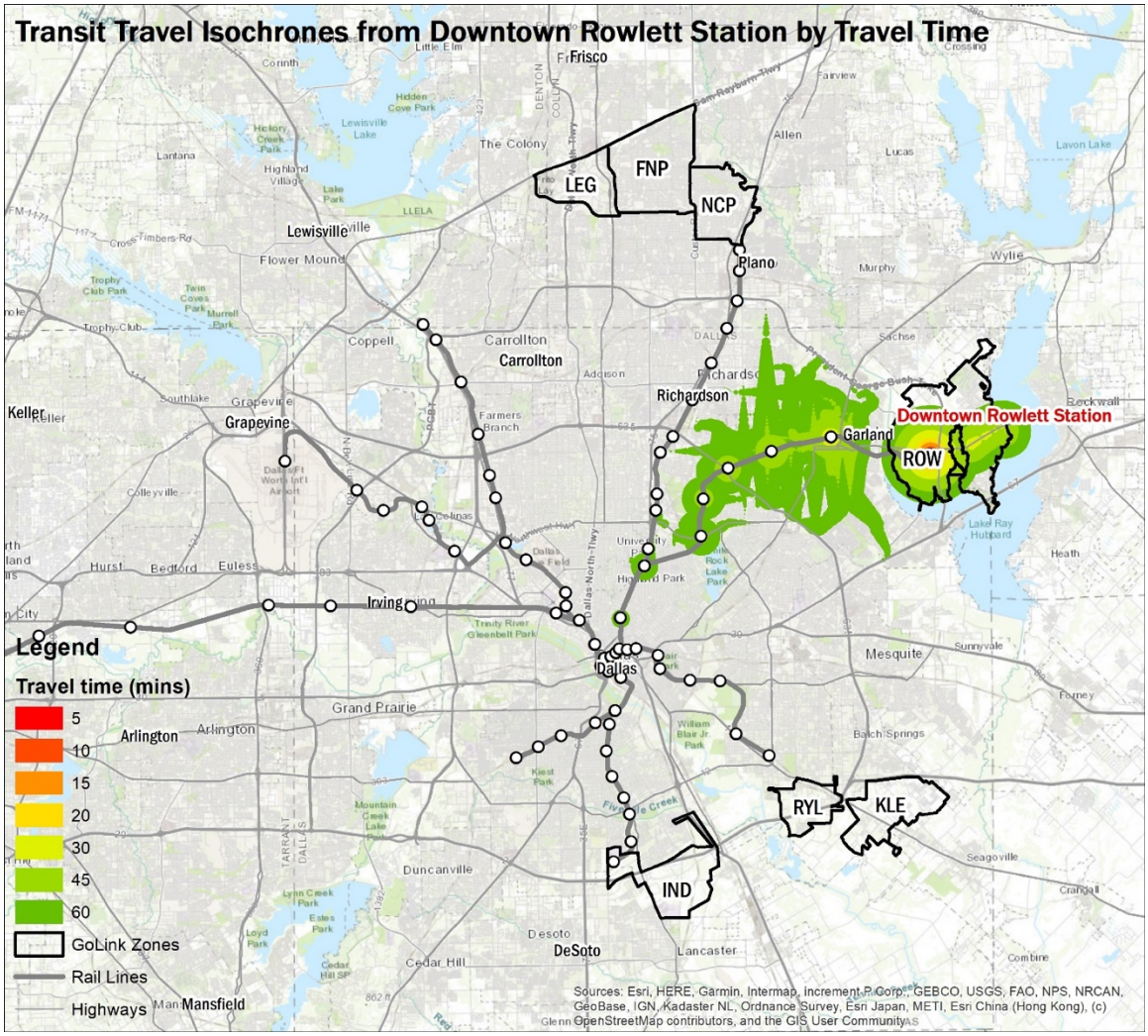
These results can be termed into at least 5 minutues and upto 10 minutes travel time saving for GoLink users. A five-minute saving is not a drastic change but could (1) provide significant incentive to those who use private vehicles from long distances or walk to access transit for more than 0.75 miles from their homes, to switch to GoLink and (2) improve job accessibility to an extent. Then, how many more low wage jobs are accessible if one can reduce first-last mile travel time by 5 minutes?

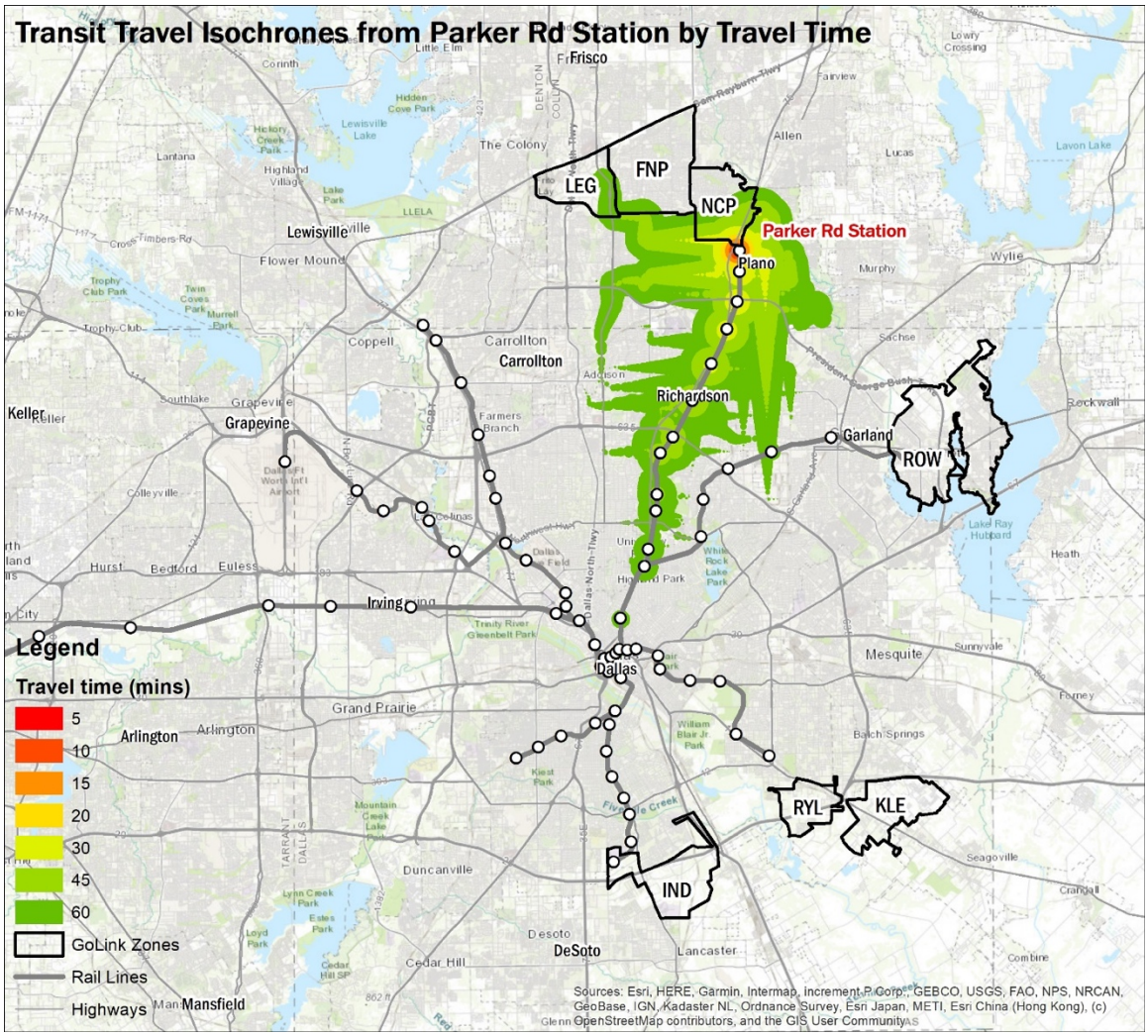
## 5.2 Job accessibility improvement

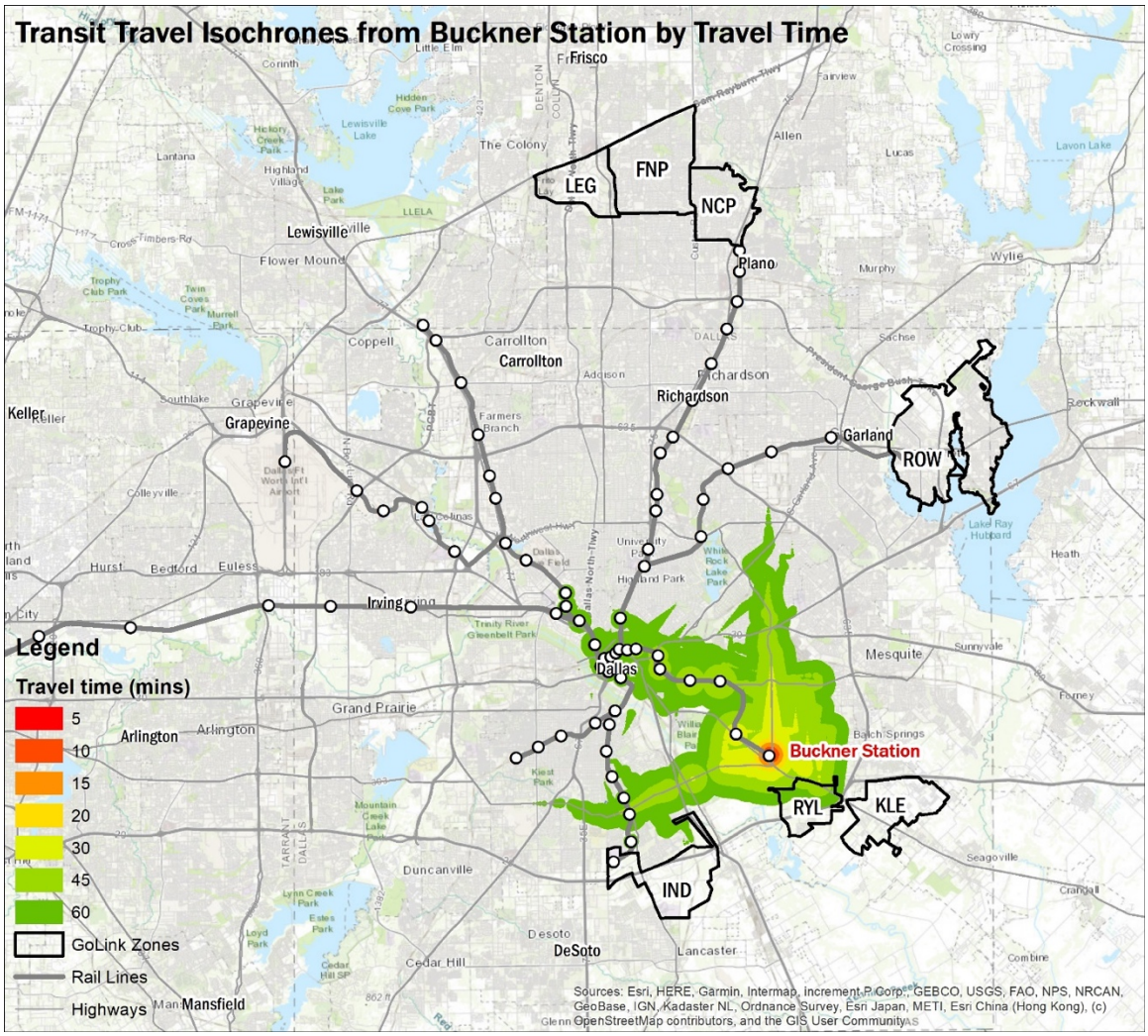
The total number of low wage jobs in the NCTCOG region is 1,714,754.

We do not examine job accessibility improvement at UNT Dallas Station because unlike other stations, most of the GoLink trips from UNT Dallas Stations are work-based commute trips. People residing outside of the Inland Port zone use GoLink to reach their job places in the zone. Most of the job places are warehouses and fulfillment centers. This will be examined in a separate study.

The following maps show REMIX isochrones at various travel time budgets for the travel departing from each of GoLink anchor stations.




Transit Travel Isochrones from Parker Rd Station by Travel Time
Legend
Travel time (mins)
5
10
15
20
30
45
60
GoLink Zones
Rail Lines
Highways
LEG
FNP
NCP
Parker Rd Station
ROW
RYL
KLE
IND
Frisco
Plano
Richardson
Carrollton
Garland
Lewisville
Flower Mound
Coppell
Grapevine
Keller
Irving
Dallas
Arlington
Grand Prairie
Mesquite
DeSoto
Duncanville
Lancaster
Mansfield
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

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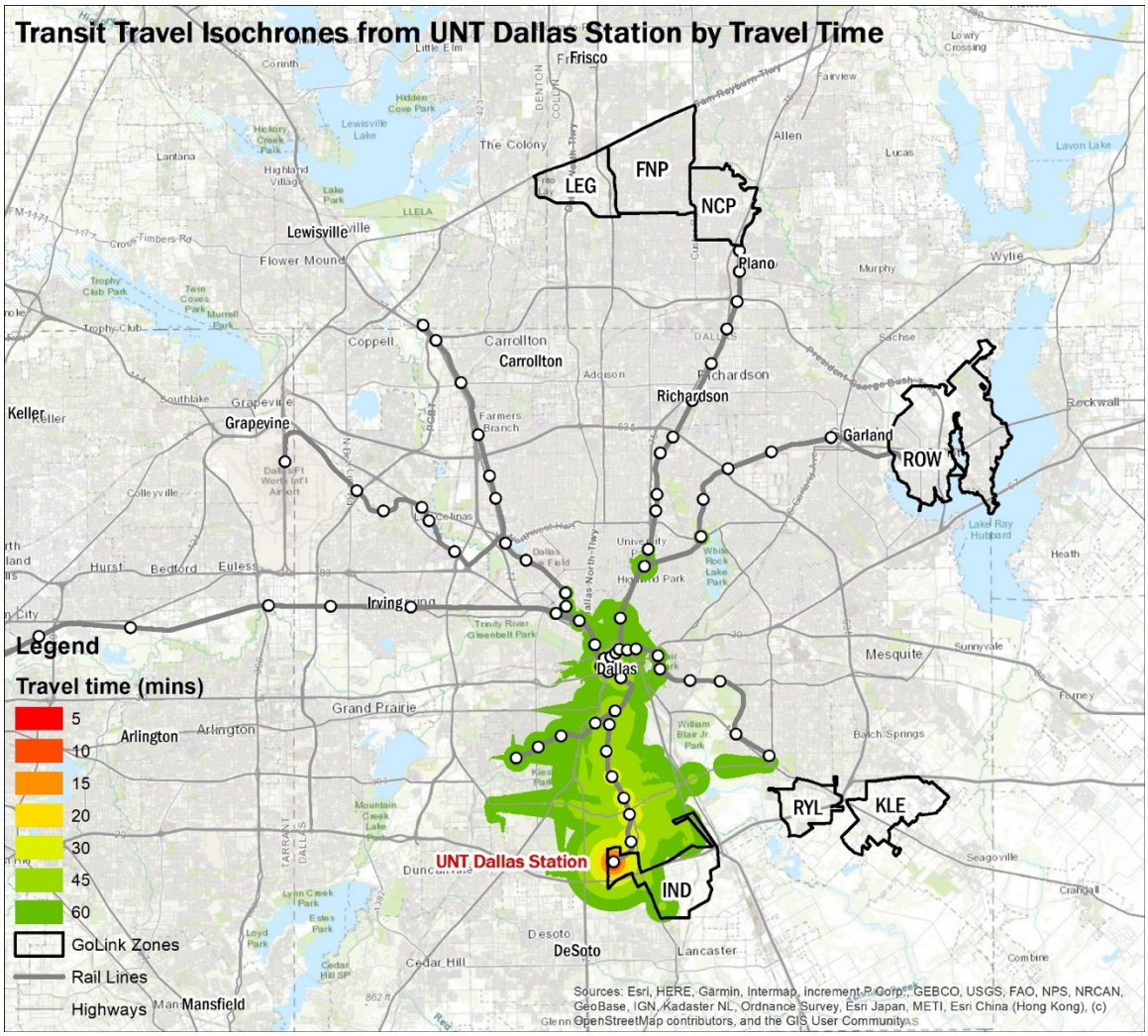


As the travel time increases, the number of accessible jobs increases exponentially. In one hour, rail riders departing from the three anchor stations can reach about 80,000 to 100,000 low wage jobs in an hour, 5-6% of the entire region.

***Table 13: Low-wage jobs accessible in a given travel time by number and percentage***

| Travel time (minutes) | Parker Rd Station | | Rowlett Station | | Buckner Station | |
|---|---|---|---|---|---|---|
| 5 | 0 | 0.00% | 5 | 0.00% | 56 | 0.00% |
| 10 | 313 | 0.02% | 22 | 0.00% | 245 | 0.01% |
| 15 | 831 | 0.05% | 261 | 0.02% | 784 | 0.05% |
| 20 | 2,389 | 0.14% | 455 | 0.03% | 1,661 | 0.10% |
| 25 | 4,498 | 0.26% | 1,474 | 0.09% | 5,683 | 0.33% |
| 30 | 6,606 | 0.39% | 2,492 | 0.15% | 9,705 | 0.57% |
| 35 | 15,072 | 0.88% | 8,185 | 0.48% | 18,460 | 1.08% |
| 40 | 23,537 | 1.37% | 13,877 | 0.81% | 27,214 | 1.59% |
| 45 | 32,003 | 1.87% | 19,570 | 1.14% | 35,969 | 2.10% |

| | | | | | | |
|---|---|---|---|---|---|---|
| 50 | 55,116 | 3.21% | 41,149 | 2.40% | 50,777 | 2.96% |
| 55 | 78,228 | 4.56% | 62,728 | 3.66% | 65,585 | 3.82% |
| 60 | 101,341 | 5.91% | 84,307 | 4.92% | 80,393 | 4.69% |

****REMIX produces travel buffer isochrones for 5, 10, 15, 20, 30, 45, and 60-minute travel times. Isochrones for 25, 35, 40, 50, and 55 minutes are imputed based on a linear interpolation. We tried log-linear regression, but it did not perform better. It may be because jobs are not spatially evenly distributed. Figure 7 shows exponentially increasing patterns of low wage job accessibility for the trips departing from three GoLink anchor stations.*

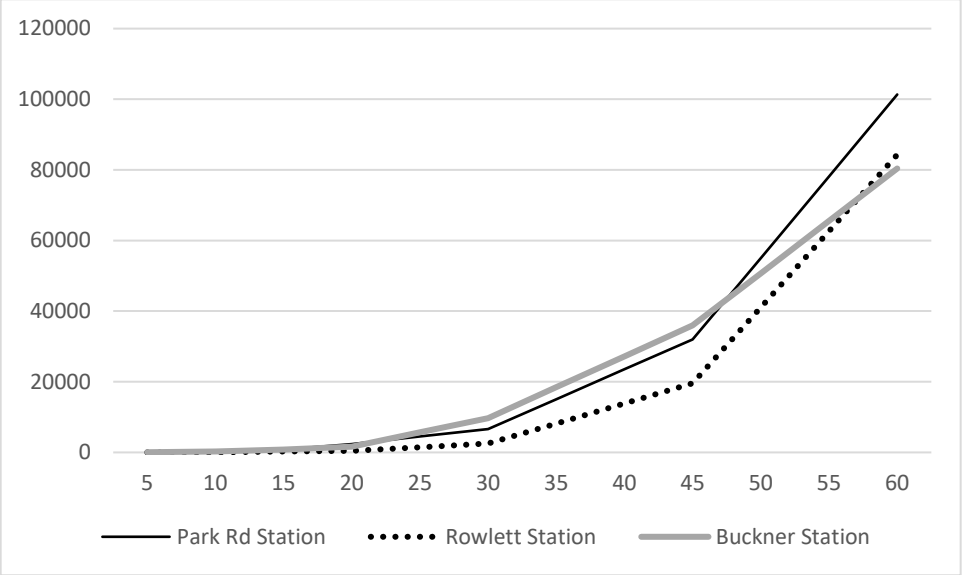


***Figure 7: Low wage jobs accessible in a given travel time by number and percentage***

## *What does a five-minute savings mean?*

For instance, from Parker Rd Station, a person with a 30-minute travel time budget can have access to 6,606 jobs. With 5 more minutes, the person can reach 15,072 jobs. It is an extensive improvement (128.2%) in terms of job accessibility. That way, we calculated the number of jobs that can be gained with five more incremental minutes for each travel time budget and present the results in Table 14 in percentage. With just a 5 more-minute travel budget, GoLink riders can improve their job accessibility significantly. Among the three stations, Rowlett Station shows the most intensive improvement across all the travel time budgets.

***Table 14: Incremental Increase in Job Accessibility per Station***

| Travel time budget in minutes | Park Rd Station | Rowlett Station | Buckner Station |
|---|---|---|---|
| 5 | - | 340.0% | 337.5% |
| 10 | 165.5% | 1086.4% | 220.0% |
| 15 | 187.5% | 74.3% | 111.9% |
| 20 | 88.3% | 223.8% | 242.1% |
| 25 | 46.9% | 69.1% | 70.8% |
| 30 | 128.2% | 228.4% | 90.2% |
| 35 | 56.2% | 69.6% | 47.4% |
| 40 | 36.0% | 41.0% | 32.2% |
| 45 | 72.2% | 110.3% | 41.2% |
| 50 | 41.9% | 52.4% | 29.2% |
| 55 | 29.5% | 34.4% | 22.6% |

# 6 Conclusions and Discussion

Job accessibility have been extensively studies in terms of transportation availability and accessibility. The rise of carpooling services and transportation network companies (shared mobility)are playing a vital role in first/last mile trips. So far no one has looked into the impact of share mobility on first/last mile travel patterns and their impact on job accessibility. This study is one of the first attemps to empirically study the impacts of share mobility on first/last mile transit and jobs accessibility. We used two different sources of data, firstly, NCTCOG's onboard transit survery from 2014 and secondly, GoLink trips data from 2019.

2014 transit suvery data show that a although the majority of residents were using driving as a mode to access/egress the transit stations, there was a significant portion (32%) of the residents that were walking to access transit. The average walk time was 34 minutes. The distribution of travel times into five-minutes segments show that the majority of trips spanned under 20 minutes (85%) in 2014.

In 2019, the proportion of trips under 20 minutes have increased by over 6% to 91%. Also it is likely that a large number of residents who were walking to access transit would now use GoLink service to reduce their trave times for first/last mile.

This increase in the proportion of short span trip may be considered as a proxy to saving travel times. So a five to ten minutes saving in travel times can significantly improve job accessibility.

Since the number of accessible jobs increase exponentially with an increase in the travel times. As the results above show that a 10 minutes increase in the travel budget can

increase the access to jobs from 250% to upto 1000% in some areas. Therefore, we suggest that the share mobility services can serve as important supplements to the existing fixed route transit services and help improve job accessibility for low income residents.

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# Appendix A

***Table A-1: Definitions of socio-economic attributes used to understand the characteristics of GoLink residents***

| Attribute | Definition | Universe | Source |
|---|---|---|---|
| Age >65 yrs | Population 65 years and over | Total population | ACS 2013-2017 |
| Age >25 yrs | Population 25 years and over | Total population | ACS 2013-2017 |
| Workers >16 yrs | Workers 16 years and over | Total population | ACS 2013-2017 |
| Black | Race: Black or African American alone | Total population | ACS 2013-2017 |
| Hispanic | Race: Hispanic or Latino | Total population | ACS 2013-2017 |
| Asian | Race: Asian alone | Total population | ACS 2013-2017 |
| By car | Means of transportation to work by car, truck, or van | Workers 16 years and over | ACS 2013-2017 |
| By transit | Means of transportation to work by public transportation including bus, streetcar, subway, rail, and ferryboat | Workers 16 years and over | ACS 2013-2017 |
| By bicycle | Means of transportation to work by bicycle | Workers 16 years and over | ACS 2013-2017 |
| By walk | Means of transportation to work by walked | Workers 16 years and over | ACS 2013-2017 |
| Low education | Educational Attainment: no education, nursery, K12, GED, some college, Associate's degree | Population 25 years and over | ACS 2013-2017 |
| High education | Educational Attainment: Bachelor's, Master's, Professional, and Doctorate | Population 25 years and over | ACS 2013-2017 |
| HH below poverty | Poverty Status: Income in the past 12 months below poverty level | Total households | ACS 2013-2017 |
| Wage less than $1,250 | Number of jobs with earnings $1250/month or less | Workers 14 years and over | LEHD 2015 |
| Wage between $1,250 and $3,333 | Number of jobs with earnings $1250/month or less | Workers 14 years and over | LEHD 2015 |
| Wage more than $3,333 | Number of jobs with earnings greater than $3333/month | Workers 14 years and over | LEHD 2015 |

| Travel time | Travel distance | | | | | |
|---|---|---|---|---|---|---|
| | 0-1 miles | 1-2 miles | 2-5 miles | 5-7 miles | > 7 miles | Total |
| 1-5 mins | 129 | 121 | 42 | 15 | 4 | 311 |
| 5-10 mins | 1,044 | 3,864 | 5,858 | 1,681 | 16 | 12,463 |
| 10-15 mins | 201 | 1,284 | 10,019 | 4,461 | 227 | 16,192 |
| 15-20 mins | 78 | 520 | 5,773 | 2,338 | 321 | 9,030 |
| > 20 mins | 30 | 171 | 2,179 | 1,003 | 139 | 3,522 |
| Total | 1,482 | 5,960 | 23,871 | 9,498 | 707 | 41,518 |

| Travel time | Travel distance | | | | | |
|---|---|---|---|---|---|---|
| | 0-1 miles | 1-2 miles | 2-5 miles | 5-7 miles | > 7 miles | Total |
| 1-5 mins | 0 | 32 | 13 | 14 | 4 | 63 |
| 5-10 mins | 0 | 777 | 1,844 | 1,677 | 16 | 4,314 |
| 10-15 mins | 0 | 118 | 1,996 | 4,422 | 227 | 6,763 |
| 15-20 mins | 0 | 34 | 626 | 2,039 | 319 | 3,018 |
| > 20 mins | 0 | 8 | 169 | 723 | 139 | 1,039 |
| Total | 0 | 969 | 4,648 | 8,875 | 705 | 15,197 |

| Travel time | Travel distance | | | | | |
|---|---|---|---|---|---|---|
| | 0-1 miles | 1-2 miles | 2-5 miles | 5-7 miles | > 7 miles | Total |
| 1-5 mins | 17 | 36 | 12 | 1 | 0 | 66 |
| 5-10 mins | 233 | 1,574 | 1,818 | 3 | 0 | 3,628 |
| 10-15 mins | 50 | 676 | 5,017 | 38 | 0 | 5,781 |
| 15-20 mins | 15 | 265 | 3,583 | 299 | 2 | 4,164 |
| > 20 mins | 10 | 78 | 1,372 | 280 | 0 | 1,740 |
| Total | 325 | 2,629 | 11,802 | 621 | 2 | 15,379 |

| Travel time | Travel distance | | | | | |
|---|---|---|---|---|---|---|
| | 0-1 miles | 1-2 miles | 2-5 miles | 5-7 miles | > 7 miles | Total |
| 1-5 mins | 13 | 8 | 1 | 0 | 0 | 22 |
| 5-10 mins | 129 | 257 | 85 | 1 | 0 | 472 |
| 10-15 mins | 36 | 56 | 111 | 1 | 0 | 204 |
| 15-20 mins | 18 | 26 | 29 | 0 | 0 | 73 |
| > 20 mins | 2 | 6 | 12 | 0 | 0 | 20 |
| Total | 198 | 353 | 238 | 2 | 0 | 791 |

| Travel time | Travel distance | | | | | |
|---|---|---|---|---|---|---|
| | 0-1 miles | 1-2 miles | 2-5 miles | 5-7 miles | > 7 miles | Total |
| 1-5 mins | 99 | 45 | 16 | 0 | 0 | 160 |
| 5-10 mins | 682 | 1,256 | 2,111 | 0 | 0 | 4,049 |
| 10-15 mins | 115 | 434 | 2,895 | 0 | 0 | 3,444 |
| 15-20 mins | 45 | 195 | 1,535 | 0 | 0 | 1,775 |
| > 20 mins | 18 | 79 | 626 | 0 | 0 | 723 |
| Total | 959 | 2,009 | 7,183 | 0 | 0 | 10,151 |

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