If You Build It
Bus Rapid Transit with High Levels of Service
They
Discretionary Riders
Will Come
Especially If You Give Them Free Parking

New bus ridership patterns in Connecticut’s Capitol Region following the introduction of bus rapid transit

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By: J. Logan Clark
Advisor: David King
Reader: Floyd Lapp
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ABSTRACT

This thesis investigates the impacts of the introduction of Bus Rapid Transit ("BRT") on transit ridership and usage patterns in the greater Hartford region. CTfastrak marks a significant upgrade by the state of Connecticut to modernize the capitol region’s transit system, and has been hailed as a success by the state government. However, the system’s detractors maintain that the system is a costly burden on state finances with limited use by the broader population. This thesis seeks to answer some of the questions regarding the system effectiveness and distributional effects. First, how have the system upgrades affected the travel behaviors of the pre-existing transit ridership? Secondly, what groups of people have become transit riders because of CTfastrak? Finally, how do these two groups access and utilize the system differently? The answers to these questions have important implications for the future of CTfastrak in particular, but also more broadly bus rapid transit in the United States on the whole. The Hartford region’s dispersed land use pattern and autocentricity pose challenges familiar to many American cities. Results from the survey suggest that previous riders have increased the amount of travel and trips that they make over a monthly basis. Additionally, the system is attracting new riders, many of whom have higher incomes. The diversification of the transit system’s ridership provides an opportunity for the region to encourage a shift away from autocentric development patterns.
INTRODUCTION

The transportation of people is one of Planning’s biggest questions. In a capitalist political economy, who has access to different modes of transportation, like all other goods, is determined by personal wealth. Those with greater access to wealth will have greater access to modes with greater mobility, and vice versa. Therefore, the question planners must concern themselves with is one of distribution of access to mobility. The perennial question “For whom are we planning?” deeply influences the types of transportation systems we build, and where they are built. Transportation networks have a dialectic relationship with the physical and social form of cities, both responding to and shaping the surrounding land use and socioeconomic structures. In the United States, the widespread adoption of transportation infrastructure built around mass ownership and unimodal usage of the automobile has exacerbated the divide between the haves and have-nots, limiting lower income residents’ access to jobs and enabling economic segregation.

The deep-seated American preference for the automobile came at the price of building a more equitable transportation system. Long years of disinvestment have relegated public transit systems to being the sole provenance of those that cannot afford any other mode of travel. With middle and higher income populations securely ensconced in the automobile, pressure on policymakers for improved transit remains limited in its scope in many metropolitan areas. Yet, the ill-effects of this system are not isolated to low income communities. Autocentricity has generated a multitude of new challenges for cities and the suburbs they support. Cities struggle to cope with peak hour congestion, and an ever-increasing amount of land is consumed by the parking facilities. The automobile has removed the people from the city streets, effectively removing the life from previously vibrant downtowns.

The greater Hartford region is no stranger to these problems. Downtown Hartford suffers from a glacially paced quotidian exodus of suburban commuters, leaving the city conspicuously empty after 5PM and on the weekends. Surface level parking lots and garages dominate acre after acre of the city causing a significant stirring in Jane Jacobs’ grave. On the socioeconomic side, it is a city still struggling with the dark consequences of 1960s-era Urban Renewal initiatives and redlining that left a legacy of social fragmentation and a hollowed tax base.

Yet, it is the challenges posed to the suburban travelers and struggling city coffers that have created a renewed interest in traditional human scale patterns of development, and have driven many municipalities to rethink their public transit strategies. Walkable downtowns and functioning transit systems have come into vogue with cities looking to attract millennials and disposable income. The growing demand for these renewed urban typologies provides an opportunity for city to build lasting transportation infrastructure that more equitably distribute the benefits of mobility.

This thesis concerns itself with such an opportunity.

Bus Rapid Transit

The concept of dedicated bus lanes is nothing new in the United States. The first dedicated lane for buses was built in 1939 in Chicago, and several other proto-BRT lanes were built through the 1970s in LA, Washington, Pittsburgh, and New York (Weinstock et al 2011). The XBL across the Lincoln tunnel proved to be an early success for this model, carrying 8.7 million passengers by the end of its first year of operation in 1971 (Port Authority of New York and New Jersey). However,
a more extensive BRT system was first introduced more broadly in Curitiba, Brazil in 1974 by Mayor Jaime Lerner (Wright, Hook et al. 2007). The system, called the *Rede Integrada de Transporte* ("RIT", or Integrated Transportation Network) introduced not only dedicated bus lanes, but an integrated off-board payment system and multiple door boarding, which dramatically increased the speed of the city’s transit system. At the time, Curitiba could not afford a much more expensive subway or light rail system, yet the RIT achieved similar transportation benefits for a fraction of the cost. Other global cities began to take note of Curitiba’s success in the early 2000s. *Transmilenio*, a similar BRT system opened in Bogota in 2002. The success of these systems, combined with greater encouragement from the Federal Transit Administration prompted several cities to undertake BRT projects after the turn of the millennium (FTA 2010).

BRT can achieve high ridership on with generally smaller per mile costs than rail infrastructure. Cities in North America like Cleveland and Ottawa have successful implement BRT systems and leveraged them for transit-oriented development (Hook, Lotshaw et al. 2013). The lure of bus rapid transit is that municipalities can place them only already existing road infrastructure with some level of modification, rather than installing new rail lines, which allows BRT to be constructed at less than one half of the cost of a light rail system (Hook, Lotshaw et al. 2013). The lower infrastructure costs make it especially attractive in this age of smaller federal investment in state and local projects.

The basic premise of bus rapid transit is to separate the bus from traffic and install other improvements to make a bus-based system function more like a light rail or subway system. A true BRT system has either a dedicated lane or separated guideway that allows it to bypass or minimize its interaction with other street traffic. Other common improvements include off-board fare purchasing, loading at platform level, greater distances between stops and signal priority (ITDP 2014). These design elements and the role they play in providing value to riders will be explored further in the literature review.

**The Connecticut Context**

*The Capitol*

Hartford is a small city of approximately 125,000 residents and serves as the capital of the state. Like many older east coast cities, its economy was traditionally centered on industrial manufacturing, including firearms, hand tools and other goods. The city is also home to many professional and finance services, earning it the nickname of the Insurance Capital of the World. Many of the lower skill manufacturing jobs have left the city, though high end precision engineering jobs remain. As the state capitol, government services (and their attendant lawyers and lobbyists) also contribute significantly to the local economy.

In the post-war period Hartford, like many American cities changed considerably. The construction of two highways passing through its downtown split the city along racial and economic lines. Manufacturing jobs began leaving the city and the surrounding suburbs absorbed wealthier white residents, leading the city into decline. The city’s population peaked in 1950 just shy of 180,000 residents. As a result, Hartford has become a commuter city that is busy from nine to five during the workweek, but few residents live in the downtown business district. The majority of the population of the city lives outside the central core and is mostly a low income minority population.
This pattern of development focused on serving the suburbs and restricting growth in the city led to steadily increasing congestion on the interchange over the years. In 2014 the state earned a dubious distinction of having the 4th highest congestion costs per highway mile according to an APTA study. The interchange of I-91 and I-84 was ranked as the 18th worst bottleneck in the entire country (CBIA 2014). The congestion has been estimated to cost the residents of the state $5.1 billion in lost time, traffic accidents and increased maintenance (HBJ 2015).

**Building the Busway**

Given these conditions the Capitol Region Council of Governments (CRCOG), the regional MPO, in conjunction with the FTA, produced a feasibility study in the late 1990s focused on ameliorating these traffic conditions. The study explored several options for the I-84 corridor, including expanded highway infrastructure and rail infrastructure. The study came out in favor of building a BRT system that utilized a separated busway along an unused rail right of way. The initial cost was expected to be $75.3 million as opposed to nearly $100 million for either light or commuter rail.

A Final Environmental Impact Statement was approved in 2001 citing construction costs between $145 and $160 million, whereupon the Connecticut General Assembly passed enabling legislation for the project. Delays in the start of the project led to increasing costs and in between 2005 and 2007 the FTA issued several warnings to the state over the project. However, in 2011 the FTA announced the approval of a $275 million grant from the New Starts project that finally pushed the state to initiate the project. The final capital cost was assessed at $567 million, with the federal government paying for eighty percent of the total. The large increase in costs stems mostly from an increase in land and construction costs (Frisman 2012).

Although the enabling legislation had already become law long before he came into office, Governor Dannel Malloy (D) had made the project the priority of his first term. Following the Bond Commission meeting during which the state funding for the project was approved, Republican members of the House and Senate attempted to kill the project through the passage of numerous amendments to budget bills and filibustering other transportation items. Sen. Joe Markley of Southington and Rep. Whit Betts of Bristol led the opposition to the busway in their respective chambers, both citing the high per mile cost and frequently referring to it as a “boondoggle.” Sen Markley was quoted as saying: “They’ve got a bus already from New Britain to Hartford. A dollar–25 round trip, twice an hour and it’s carrying a dozen people at a time. What are we going to do with twenty of them an hour, 16 hours a day?” (Stacom 2011)

At $567 million for 9.4 miles of busway, their concerns certainly were valid. Average per mile costs were estimated by the GAO in 2001 as being in between $200,000 and $55 million per mile depending on the level of features in the BRT (GAO 2001). At approximately $60 million per mile, CTfastrak greatly exceeded its initial cost expectations and places it among the costlier BRT projects in the United States. However, the Republican-led opposition to the busway generated more noise than action given the Democratic dominance of both chambers of the General Assembly and the Governor’s office. Construction finally began in 2012, eleven years after the approval of the FEIS.

**Actors**

The role of the federal government in the project has been advisory and monetary, and federal dollars are largely responsible for the construction of the busway. Eighty percent of the total construction budget was supplied by the Federal Transit Administration. Additional funds
through the Bus Livability Grant program have been delivered to the state as well. The FTA signed off on the FEIS for the project in 2001, and urged the state to make improvements to the project throughout the planning and design process.

Several state actors have played and continue to play critical roles in the busway’s development and implementation. Given the long time period between approval and project completion, three governors have had their hands on the project. The project was initially proposed and approved in 2001 under Rowland, had funding approved by Rell, and the project was finally completed under Malloy’s tenure. Governor Malloy in particular has hailed the system as a critical piece of infrastructure despite numerous bipartisan attacks. Under his direction the state Office of Policy and Management’s Bond Commission approved the final bonding necessary to finance the project.

Other key members at the state level include members of the Connecticut General Assembly. Republican members of both the House and the Senate introduced amendments throughout the 2012 and 2013 legislative sessions that would have limited the amount of state funding available for the project.

As a regional system CTfastrak passes serves numerous municipalities. The local governments of these towns and cities have generally supportive of transit-oriented development. However, the residents and municipal government of Newington, through which CTfastrak runs, have expressed concerns with TOD, mostly due to complaints over multi-family housing (Hoffman 2015). The municipalities along the separated busway have also raised questions about local control and the new development authority.

Several other key players are involved in the project. The busway was designed around connecting traditionally large anchor employers, such as medical educational facilities. There is a stop at Central Connecticut State University, and a new UConn campus will be opening up in downtown Hartford in the coming years. Manchester Community College is also being linked in via feeder routes. The UConn Health Center in Farmington, which also hosts Jackson Labs, a genomic medicine testing facility, is linked to the busway by a feeder route. Another large employer is Westfarms Mall, which again is linked in by a feeder route.

Finally, the Capitol Region Council of Governments has been responsible for shepherding the project through the design and implementation project. As the regional MPO, they were responsible for the initial proposal and advising throughout.
System Overview

Design

As noted previously, the hallmark of CTfastrak is its 9.4-mile-long separated busway, which begins in New Britain and has its terminus in Hartford. Figure 1 on the next page details its route and stops. All of the CTfastrak branded routes make stops along the busway, though some only make stops at a singular station. The stations are characterized by a sleek, modern design that match the overall branding scheme of the new system.

CTfastrak utilizes hybrid diesel-electric single buses for smaller routes and articulated buses along the main flagship routes. The single buses have an entrance at the front and the rear, while the articulated buses have a third entrance in the middle. This speeds up the loading process and decreases the amount of time spent in each station. The single buses seat 40 passengers, and the articulated buses seat 60, though both have room for standing passengers.
### Table 1: Available Parking at Stations

<table>
<thead>
<tr>
<th>Town</th>
<th>Location</th>
<th>Total Spaces</th>
<th>Handicap</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Busway Parking</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Britain</td>
<td>Szczesny Municipal Garage</td>
<td>723</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>East Street Station</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>Newington</td>
<td>Newington Junction</td>
<td>27</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Cedar Street Station</td>
<td>45</td>
<td>2</td>
</tr>
<tr>
<td>West Hartford</td>
<td>Elmwood Station</td>
<td>27</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Flatbush Avenue Station</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>Hartford</td>
<td>Parkville</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>885</strong></td>
<td><strong>12</strong></td>
</tr>
<tr>
<td><strong>Park &amp; Rides</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Britain</td>
<td>Corbin P&amp;R</td>
<td>227</td>
<td>5</td>
</tr>
<tr>
<td>Waterbury</td>
<td>Hamilton Ave P&amp;R</td>
<td>178</td>
<td>6</td>
</tr>
<tr>
<td>Cheshire</td>
<td>Rt 70 P&amp;R</td>
<td>146</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Cheshire/Milldale P&amp;R</td>
<td>118</td>
<td>6</td>
</tr>
<tr>
<td>Southington</td>
<td>Southington P&amp;R</td>
<td>102</td>
<td>4</td>
</tr>
<tr>
<td>Bristol</td>
<td>Lake Ave P&amp;R</td>
<td>143</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Todd St P&amp;R</td>
<td>200</td>
<td>4</td>
</tr>
<tr>
<td>Manchester</td>
<td>Spencer St P&amp;R</td>
<td>245</td>
<td>7</td>
</tr>
<tr>
<td>East Hartford</td>
<td>East Hartford P&amp;R</td>
<td>255</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1614</strong></td>
<td><strong>52</strong></td>
</tr>
</tbody>
</table>

Parking is provided at seven stations along the busway. Table 1 above shows the total number of parking spaces available along the route and at linked park and ride facilities. Parking costs three dollars per day at the Szczesny Garage in New Britain for CTfastrak riders, but is free at the other stations along the busway. The reduced rate at the New Britain parking garage is not broadly advertised, and at the time of this research appeared only on a small, handwritten sign at the exit to the garage. Alternatively, the cost of parking in a garage in Hartford is approximately sixteen dollars per day. However, CTfastrak is planning on expanding the number of parking spaces available throughout 2016, and is currently in negotiations to provide free parking during the weekdays at the New Britain garage (CTfastrak 2016). The parking facilities are also augmented by kiss and ride drop off points at each facility.
An important aspect of the station design was the construction of pedestrian and streetscape infrastructure. Prior to the construction of CTfastrak many of the lots that the stations sit on were vacant or underutilized. Images on CTfastrak’s website emphasize before and after images, that have turned those vacant lots into more attractive and used spaces. The project included the construction of sidewalks and surface treatments for crosswalks. Additionally, the stations include seating and benches for riders and passing pedestrians to rest on.

A Multi-Use Trail runs along five miles of the busway. The trail provides serves both to increase access to CTfastrak and provide a recreational facility for local residents. One of the main reasons this was included in the design of the system was to encourage active transportation and intermodalism. This is augmented by bicycle infrastructure on-board the CTfastrak buses, each of which has space for two bikes.
Another critical part of the design that separates CTfastrak from the regular CTtransit system is shorter headways and high frequency of service during peak hours. During rush hour, headways for the main routes are in between seven to ten minutes. Even during off-peak times, the pure number of routes that run along portions of the busway still maintain higher frequencies for riders, even if individual routes increase their headways.

**Routes and Destinations**

Route 101 is the main route that runs along the busway, from New Britain to Hartford. It provides riders access to the main central business districts of both cities and also passes through southeastern West Hartford and northwestern Newington. This grants riders access to many of the large employers in the downtown Hartford area, including Aetna, The Hartford, and state government offices. Route 102 runs a nearly identical route to the 101, but rather than finishing in New Britain it continues to Bristol, which establishes it as a regional connection.

Route 121 serves one of several hospitals that lie within the service area. The new UConn Health Center/Jackson Labs campus in Farmington has a 224 bed inpatient capacity and employs approximately 5,000 people. Route 121 connects it with southwestern and downtown Hartford through Capitol Avenue, as well as Manchester Community College (MCC). The Capitol Ave connection is important as many state offices are located there. Additionally, the Bushnell Center for the Performing Arts and the Wadsworth Atheneum, two critical cultural keystones of the city, are located along the route.

The most important stop along Route 128 is the Westfarms Mall. The mall has 1.3 million square feet of leasable retail space, four large anchor tenants, and is the largest upscale retail destination along the I-91 corridor between New Haven and Springfield, Massachusetts. The mall has 6,500
parking spaces for shoppers and employees. Route 128 links the mall to the Downtown New Britain terminal, and re-enters the busway at Flatbush Ave in southwestern Hartford.

Route 140 runs shuttle service to Central Connecticut State University (CCSU) in New Britain through two stops on the busway. CCSU has a student population over 12,000 (only 23 percent of whom reside on campus) and over 400 full time faculty, making it a large regional trip generator. The campus is easily accessible by CTfastrak as it lies adjacent to the busway and the multi-use trail.

Several routes pass through the busway at one stop but provide critical access to several important employers in the region. Route 144 makes a stop at Cedar Street, but serves as an important East-West route connecting Westfarms Mall and Brittany Farms Nursing Home to the center of Newington and Wethersfield. Route 153 makes only one stop on the busway at Flatbush Ave. The route extends through to West Hartford Center which is densely populated and also a walkable retail destination and terminates at the Cigna campus to the north. At the eastern terminus it connects riders to Walmart and other big box stores along Flatbush Ave. Finally, Route 161 connects two important health centers, St. Francis Hospital and Hartford Hospital, and links into the busway at Sigourney street.
Since Opening

After three years of construction, CTfastrak opened on March 28th, 2015. The system was heralded by the governor and transit supporters as a transformative piece of the region’s infrastructure.

Figure 2: CTfastrak Corridor Ridership May 2015 to March 2016. Source ConnDOT.

Figure 2 shows ConnDOT’s ridership numbers from the opening through March 2016. Ridership on CTfastrak generally has exceeded initial forecasts and expectations, averaging in between 16,000 and 17,000 rides on a weekday. However, over the same period of time, CTtransit numbers have dropped. Which leads to the question, has CTfastrak’s apparent success simply been a shift of old ridership to a new route? This is not to say that such a shift would not have a benefit to the rider, but it would likely be construed as a much more limited success. Additionally, the growing ridership also comes along with a 75% increase in the overall operating budget, most of which was focused on level of service improvements (Stacom and Kauffman 2015). Statements from ConnDOT indicate that the additional feeder routes and reliability of services are seen as critical to the system’s success. Officials and proponents of the system frequently tout its high level of service, and the fact that the bus trip from New Britain to Hartford was cut from a full hour to twenty minutes.

In order to coordinate and funnel development in the transit corridor, the state has established the Connecticut Transit Corridor Development Authority (CTCDA). It is given the power to use eminent domain, though this has caused serious concern in the state, especially given the example of Kelo v. New London in the not-so-distant past. In 2005, Kelo sparked backlash in the state after eminent domain was used to acquire the land in a residential neighborhood to make way for an expanded Pfizer campus in New London. The use of eminent domain in the case was upheld by
the Supreme Court as falling within the definition of public use within the takings clause of the Fifth Amendment. Shortly after, many states adopted legislation or amended their constitutions to prevent such a case from occurring. It should be noted that following the state’s exercise of eminent domain and razing of the residential neighborhood, the project fell through and Pfizer eventually left the state (Somin 2015). Given these circumstances, municipalities in Connecticut have exercised caution in their use of eminent domain, and viewed its possible expansion through a state authority with suspicion. Following its proposal in the General Assembly, numerous municipalities submitted testimony opposing the eminent domain powers enumerated in the bill (CGA 2015).

While bills establishing the authority had been proposed in the past, they had not garnered sufficient support to pass in the legislature. In 2015 a reworked version that addressed several of the issues that concerned municipalities passed through both houses in the General Assembly. However, due to budgetary constraints the authority has not yet been established. Once again, a reworked version of the bill that would fund the authority is currently working its way through the legislative process, though it faces an uphill battle for funding in a year in which the state is significantly cutting back spending (Stacom 2016).

Despite, the troubles of the CTCDA, there has generally been support for TOD in communities adjacent to the busway. New Britain received an FTA Bus Livability Grant for urban design improvements around the stations, and several new businesses have opened downtown next to the station (Fortier 2016). TOD proposals have also been approved in West Hartford and Hartford (HBJ 2015). However, Newington residents expressed concern about higher density housing around the stations. Several residents in particular raised concerns about more school age children and expressed a preference for increased commercial development (Hoffman 2015, Whipple 2015, Pazniokas 2016).

Questions remain about the system’s impact on congestion. Despite being one of the primary reasons cited for undertaking the system, new numbers on the level of traffic on I-84 have not been released. This has led to criticism from some journalists and Republican lawmakers that the system is creating the promised reductions in car travel (Kaufman and Stacom 2015). While, there are reasons to be skeptical about congestion reduction claims, like induced demand, the questions surrounding the justifications of the busway remain outside the primary focus of this study.

**Research Questions**

Given this context, this study looks to critically assess the how CTfastrak has changed the travel behaviors of residents in the Capitol Region. The main research questions are as follows:

1. How have previous riders changed their behavior in response to the new system?
2. Has CTfastrak created new ridership, or has it simply shifted previous riders to new routes?
3. If new ridership exists, how do they differ demographically and behaviorally from previous riders?
LITERATURE REVIEW

My literature review aims to establish the scholarly background behind these research questions. This thesis centers itself around the mode of transportation choices made by consumers, and how their behavior is shaped by transit modes. Their decisions are inherently economic, and is therefore best understood as the elastic interactions between the cost of supply and the travel demand of consumers. The supply cost of transportation is composed of various component costs, both fixed and variable. Understanding how these component costs are affected by both policy and design is critical to understanding why consumers choose one mode over another. As such, this literature review investigates the scholarship surrounding the various design and policy issues that affect consumers’ transportation costs in the Connecticut area. For a driver, important costs to consider are the price of gasoline, the price and supply of parking, and the cost of time spent in traffic. For a transit user, important costs are the fare price, cost of time, reliability of service, the accessibility of the transit network, and its convenience.

Additionally, this literature review addresses how the interactions of these costs affects the mode choices of various populations of differing socioeconomic statuses. This is an additional hurdle to overcome in attracting transit ridership, especially for bus-based services, as transit is often stigmatized as the domain of the poor and disenfranchised. Car trips contrast with transit trips as car trips are generally unimodal. By their nature transit trips are generally multimodal, and may require other modes, whether that be car, walking, biking or another form of transit to complete or start a trip.

Bus Ridership

Central to this thesis is the literature surrounding mode choice. Mode choice depends heavily upon socioeconomic factors (Ewing and Cervero 2010). Minorities and lower income residents are more likely to be use transit, particularly buses than wealthier white populations (Racca and Ratledge 2004). Riders can be classified as either discretionary (those who choose to ride), or captive (those who have no other option) riders (Krizek, K., & El-Geneidy, A. 2007). Several writers have argued that the effectiveness of BRT should be enough to entice wealthier riders to become discretionary bus riders, but it has been shown that this is not always the case (Maciag 2014). Part of this failure can be explained in part by value of time research suggests that wealthier individuals value their hours more (Börjesson, Fosgerau, Algers 2013). This could result in wealthier individuals being less likely to switch modes even if there is a cost savings in taking the bus.
Attracting New Riders

Figure 3 developed by Krizek and El-Geneidy shows a categorization of current and potential users of transit, which is useful in visualizing the various populations to which a transit agency can market itself. Yet, there is a common perception that developing new ridership for buses often faces an uphill battle against an image problem (Popuri et al 2011). Buses, by virtue of being a form of public transportation, are often compared (unfavorably) to rail options. This expressed itself during the debate over the busway in 2011 with several opponents of the busway calling instead for light rail (Stacom 2012).

However, much of the literature suggests that if BRT systems attain high levels of service, branding can help overcome much of this negative perception (Henke 2007, Hess & Bittermen 2008, Ben-Akiva & Morikawa 2002, Cain & Flynn 2013). Several technical manuals suggest that each route should have at least four buses per hour during off-peak times, and at least 6 per hour during peak times to be considered at a BRT level of frequency (APTA & ITDP). This is seen as critical to the BRT systems branding as a higher level than buses. Henke also notes that while service and reliability are some of the most important factors to all populations, the perception of safety was the top concern of non-transit users. Safety, or rather the perception of, has been found to be strongly correlated with where the line passes through and its primary population (Cain & Flynn 2013). Which is to say that lines that run through lower income neighborhoods are more likely to be viewed as dangerous.

Park and Ride

Park-and-Ride facilities (P&R) are a commonly implemented method of encouraging multimodalism and reducing downtown traffic (Kuzmyak 2003). Studies show a mixed level of effectiveness in reducing congestion. While they are generally effective in reducing traffic in downtown areas, this may be a simple redistribution of traffic to the sites around the area (Parkhurst 2000), but also lead to lower consumer VMT (Duncan and Cook 2014). The ability of park-and-ride to create greater transit ridership is generally confirmed, but because of its multimodal approach it is subject to concerns over transfer times. A recent study conducted in
Melbourne investigated the travel preferences of P&R users. They concluded that travelers will opt to choose P&R over transit-only when transit travel and transfer times are high, and that similarly lower public transit times will drive a mode shift away from cars (Islam, Liu et al. 2015). Interestingly, and highly relevant to the Hartford region, is that they also find that low parking prices shift users towards choosing cars, which is further corroborated by studies in Japan (Kono, Uchida et al. 2013) and the United States (Duncan 2010). Given that finding and paying for parking is a large cost of operating a vehicle, this is unsurprising. On the development side P&R facilities as a less sustainable strategy as compared with transit-oriented development, though they may be more effective at increasing ridership in systems with longer distances between stops (Duncan 2010). Land values will almost always be higher in TOD areas (Currie 2006) and as a result are more likely to spur gentrification (Kahn 2007). Also important in a consumer’s P&R decision calculus is their direction and the location of the P&R facility. Catchment areas for P&Rs have been shown to be elliptical, which indicates that drivers are more inclined to drive towards their destination than away from it to utilize a park-and-ride facility (Farhan and Murray 2005).

All of this is rather important in the context of the Greater Hartford region because of the large quantity of surface level parking. New Britain has 20 percent of its downtown area consumed by surface level parking, while Hartford has lost 22 percent of its area to parking (McCahill and Garrick 2010; City of New Britain 2013).

**BRT Design**

In the APTA and ITDP guides to BRT, what is clear is that BRT cannot be viewed as a singular, monolithic system, but rather a suite of design elements. While this is useful in making BRT effective in a wide variety of contexts, it creates difficulties in making comparisons. The design elements of stations and bus can vary greatly based upon cost and political considerations, all of which have effects on mobility and services. Elements that are particularly important for the average speed of the service are separated right-of-ways, signal priority, level boarding and off-board ticketing (Weinstock 2011, APTA 2010, FTA 2010). These critical features are all present in CTfastrak’s design.
METHODOLOGY

Quantitative Surveys

Design & Administration
A consumer satisfaction survey conducted by ConnDOT in June of 2015 asked similar questions regarding usage. However, their questions regarding usage were generally broader and did not count physical trips, or account for how the riders accessed their stations. Additionally, their survey did not contain any questions regarding demographic data, limiting their understanding of how different populations have used the system (ConnDOT 2015). This study’s survey instrument was designed to collect data similar to the ridership use and access patterns of the ConnDOT survey, but also include as demographic and mode of access data.

Surveys were collected using random sampling at CTfastrak stations and on the buses. Surveys were collected primarily along the busway, but also at several other CTfastrak locations, including Westfarms Mall and the Downtown Hartford stops. Respondents were chosen for intercept using a randomized procedure. When the survey site was a physical station, every third entrant was asked to participate for a period of 30 minutes during rush hours. Outside of rush hour every other station entrant was asked due to a lower volume of riders. If the survey was administered on a bus, the only one respondent per bus was asked to participate. The stations were selected by volume. If a station did not have a new entrant within 15 minutes, a bus was taken to the next station.

Surveys were administered verbally in English to participants. If the participant did not have sufficient English skills to answer the questions, they were omitted from the study. This method was chosen so as to ensure greater uniformity of interpretation from response to response, as only one field researcher administered surveys. For the questions concerning the respondents’ reported rides this was critical for the data collection. Respondents often replied with answers like “every day” or “all the time” at which point a clarifying question (“Could you please estimate the number?”) and/or an example (“If I took a round trip that would be 2 times”) was required.

Surveys were conducted in the early days of January between 7:00 in the morning to 7:00 at night on weekdays only. During the survey period, the temperature rarely rose above freezing, with several days registering temperatures in the low teens during the morning rush hour. This may have had an effect on the types of riders that used the system, given that inclement weather conditions may have constituted an avoidable cost for higher income riders.

Data Cleaning & Variable Recoding
Following the collection of surveys, the resultant dataset was cleaned and recoded to produced usable and measurable variables. For all questions, if a respondent declined to answer a question then it was marked “N/A” though their responses were still included in the dataset. For all derived binary variables, a “1” was used for an affirmative, and “0” used for a negative.

The median and average ages were calculated for the total dataset. From there, two derived binary variables denoting whether the respondent was below or above the median (“BelMedAge” and “AboMedAge”) were created. An identical process was used for income, where respondents were marked either above or below the sample median income (“BelMedY” and “AboMedY”).
question regarding race and ethnicity was recoded categorically with binary variables, as was the question regarding gender.¹

For the section of the survey regarding automobile, two derived variables were created. The first was the ratio of available cars to the number of persons with a driver’s license in the household (“CarRatio”). A second binary variable was created denoting whether the respondent’s ratio was above or below one (“CarRatioPlus”).

For the questions regarding frequency of usage, several derived variables were created. First a change in the number of public transit rides taken before and after CTfastrak’s implementation was recorded (“Delta_PT”). This was used to create a binary variable of increased rides (“IncreasedRides”) and also to calculate a percent change (“Pct_Delta_PT”). Another derived variable measured the percentage of rides taken by the respondent in the previous month on CTfastrak (“Pct_CTF”, range 0.0 to 1.0). Two binary variables were created to categorize respondents as new or previous riders.

For questions concerning destinations and access modes, binary variables were created for each option, and variables for the number of destination types and number of access modes were created.

Variables denoting whether the respondent was surveyed during AM rush, daytime or PM rush the time of the survey was recorded. Riders using the system until 10:00AM were recorded as AM rush riders, and those using the system from 3:50PM onwards were recorded as PM rush riders. All other riders were recorded as day time riders.

Hypotheses

As a starting point this study began with five hypotheses that were tested using Pearson’s Chi-Square Test of Independence and two forms of t-Tests.

1. Previous transit riders have switched from CTtransit to CTfastrak, therefore accounting for the drop in CTtransit ridership
2. That if new transit riders existed, they would be more likely to be higher income, white riders than previous transit riders.
3. That new transit riders would be more likely than previous riders to utilize park and ride access modes.
4. That previous riders will use the service more frequently.
5. Previous riders would use the system to reach a greater variety of destinations than new riders.

Chi-Square

Pearson’s Chi-Square provides a test of independence between categorical variables, meaning that it tests whether or not there is a correlation between two categorical variables or if they occur independently of one another. It accomplishes this by through a comparison of expected and observed values against a known distribution for given degrees of freedom. Within the context of this study, a chi-square test allows us to examine whether or not certain subsets of the sample are more likely to exhibit certain behaviors or characteristics at a given level of confidence (or alpha-

¹ While a non-binary “Other” option was included in the survey, all respondents answered either “Male” or “Female.”
value, \( \alpha \)). This study uses a 90% Confidence Level to determine significance, meaning that all p-values of the test statistic must be less than the \( \alpha \) of 0.1. Additionally, this study makes note of relationships that are significant at higher levels of confidence. If \( p \) is greater than \( \alpha \), then we cannot reject the null hypothesis that the two variables are independent of one another.

However, the chi-square test of independence does have its limitations. If an individual cell’s expected value is less than five, then the \( n \) may not be large enough to make a statistically significant determination. Furthermore, as the number of categories increases so does the number of degrees of freedom will increase, thus weakening the results. To counter this, I collapse the responses of some variables into groups. For instance, when looking race and ethnicity, the groups are collapsed into White and Non-White subsets. For questions that had checkboxes (such as mode of access or destination type) the recoding binary variables utilized.

**T-Tests**

In addition to Pearson’s Chi-Square, several hypotheses were tested using different \( t \)-statistic measures. The results of the tests can be checked against the known \( t \)-distribution and determined whether or not the results are significant at the given level. Several different forms of \( t \)-tests exist depending on different measures.

**Paired \( t \)-Test**

A paired \( t \)-Test is used to measure the difference in two variables of a singular sample group. Often, a paired \( t \)-test is used in clinical studies to evaluate effects before and after a treatment. This function was used to determine whether or not there was a statistically significant increase in the number of rides reported by respondents before and after implementation of CTfastrak.

**Independent Means \( t \)-Tests**

An independent means \( t \)-Test is utilized for reasons similar to chi-square, but rather than only testing categorical variables, a \( t \)-Test allows for testing of numerical variables. In this study the test is used to ascertain whether there is a statistically significant difference between the reported rides in the past month of difference populations, as well as the number of reported CTfastrak rides. While the test can utilize a pooled variance of the two samples, for the purposes of this study, unequal variances were assumed.
SURVEY RESULTS

Demographics

A total of 91 surveys were collected in between January 5th and 13th. The sample is 59.34% male and 40.66 percent female. A detailed racial and ethnic background breakdown is given in Figure 4, but White, Hispanic and Black riders made up the vast majority of respondents.

![Gender of Respondents](image1)

*Figure 4: Gender of Respondents*

![Racial/Ethnic Composition of Respondents](image2)

*Figure 5: Race/Ethnicity of Respondents*

The annual household income median was $37,000 and the mean $49,617, with a standard deviation of $40,324, which demonstrates a large range of incomes. There is a clear
demonstration of racial and ethnic difference among income. 68.8% of the white population surveyed reported an income above the sample median. This contrasts with 35 percent and 28 percent of black and Hispanic respondents respectively. When split into new and previous riders, considerably more new riders were above the sample median income.

The mean age of the sample was 35.8 and the median 34. The male average age was 35.4 and median 33. The female average was 36.5 and the median 35. The white population skewed older, with 55.9% percent of the population over the median age, while the black and Hispanic populations were younger with 45.5 percent and 34.6 percent respectively being over the median age of the sample.
**Usage Trends**

Out of 91 respondents, 34.8 percent were new riders who reported 30.5 percent of the CTfastrak rides. Previous transit riders account for 65.2 percent of the sample, and 69.5 percent of the reported CTfastrak rides. Figure 8 shows the histograms of transit usage. Overall the ridership patterns demonstrate relatively similar distributions in the Pre-CTF and past month reported rides, but the addition of new ridership has created far more regular riders within the corridor. After the implementation of CTfastrak, the sample mean of public transit use was 44.6 rides per month with a standard deviation of 28.8.

![Histograms of Usage](image)

*Figure 8*

Table 2 shows the proportion of reported rides and respondents by income, race, and previous vs. new riders. Riders below the sample median income accounted for a larger proportion of the reported rides than their percentage of the sample, regardless of whether they were new or previous riders.

The data show a general increase in public transit usage among the sample population in the time period since implementation, which matches with the trend reported in ConnDOT’s ridership reports.
Table 2: Proportion of CTfastrak Rides by Income & Race

<table>
<thead>
<tr>
<th>Category</th>
<th>n</th>
<th>Pct of CTF Rides</th>
<th>Pct of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PrevRider</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BelMedY</td>
<td>32</td>
<td>46.55%</td>
<td>38.55%</td>
</tr>
<tr>
<td>Black/African American</td>
<td>10</td>
<td>14.09%</td>
<td>12.05%</td>
</tr>
<tr>
<td>Caucasian</td>
<td>7</td>
<td>11.91%</td>
<td>8.43%</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>14</td>
<td>19.36%</td>
<td>16.87%</td>
</tr>
<tr>
<td>Two or More Races</td>
<td>1</td>
<td>1.19%</td>
<td>1.20%</td>
</tr>
<tr>
<td><strong>AboMedY</strong></td>
<td>21</td>
<td>22.96%</td>
<td>25.30%</td>
</tr>
<tr>
<td>Asian</td>
<td>3</td>
<td>3.57%</td>
<td>3.61%</td>
</tr>
<tr>
<td>Black/African American</td>
<td>4</td>
<td>2.74%</td>
<td>4.82%</td>
</tr>
<tr>
<td>Caucasian</td>
<td>10</td>
<td>11.61%</td>
<td>12.05%</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>4</td>
<td>5.03%</td>
<td>4.82%</td>
</tr>
<tr>
<td><strong>NewRider</strong></td>
<td>30</td>
<td>30.49%</td>
<td>36.14%</td>
</tr>
<tr>
<td>BelMedY</td>
<td>9</td>
<td>12.36%</td>
<td>10.84%</td>
</tr>
<tr>
<td>Black/African American</td>
<td>2</td>
<td>2.08%</td>
<td>2.41%</td>
</tr>
<tr>
<td>Caucasian</td>
<td>3</td>
<td>6.40%</td>
<td>3.61%</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>4</td>
<td>3.87%</td>
<td>4.82%</td>
</tr>
<tr>
<td>AboMedY</td>
<td>21</td>
<td>18.14%</td>
<td>25.30%</td>
</tr>
<tr>
<td>Asian</td>
<td>2</td>
<td>1.25%</td>
<td>2.41%</td>
</tr>
<tr>
<td>Black/African American</td>
<td>3</td>
<td>3.10%</td>
<td>3.61%</td>
</tr>
<tr>
<td>Caucasian</td>
<td>12</td>
<td>11.32%</td>
<td>14.46%</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>3</td>
<td>2.44%</td>
<td>3.61%</td>
</tr>
<tr>
<td>Two or More Races</td>
<td>1</td>
<td>0.03%</td>
<td>1.20%</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td>83</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Among new users of transit, respondents who reported income below the sample median composed 30 percent of the new ridership, and 40.5 percent of the new ridership’s reported CTfastrak usage. This suggests that the new ridership is more financially well off and thus uses transit less. Furthermore, new riders have a higher proportion of their public transit rides taken on CTfastrak than previous riders, across racial and income categories.
Destinations

Figure 9 shows the frequency of destination types among respondents. Work was by far the most common destination type, with a full 85 percent of the sample reporting that they used CTfastrak to access employment.

![Figure 9: Frequency of Reported Destinations](image)

Figure 10 shows the differences in number of destination types between new and previous riders. Previous ridership has a much broader distribution, suggesting they are much more likely to use transit to access a larger number of destination types.

![Figure 10: Number of Reported Destination Types](image)
Access

Figure 11 shows the frequency of reported access modes from the past month. Walking was by far the most report with 59 respondents, and transit, parking and drop-off registered 30, 26 and 23 respondents respectively.

![Access Modes](image)

*Figure 11: Respondents’ Reported Access Modes in the Past Month*

Figure 12 shows the frequency of respondents that fell into the car to driver ratio categories. 41 respondents had a ratio above 1, 36 below 1, and 14 without any cars in their household.

![Respondent Car:Driver Ratios](image)

*Figure 12: Respondents’ Reported Household Car:Driver Ratios*

Figure 13 shows the difference in access modes between new riders and previous riders. There are broadly different patterns here among the two sub-groups, particularly in the use of parking facilities and transit as access modes.
Table 3 shows the percent change in the number of rides taken by previous riders, and what proportion of the totals rides taken they accounted for on CTfastrak, categorized by the use of parking facilities and race. Every group reported increases in their use of public transit except African American women, though the decrease can be primarily attributed to one respondent who dropped from 160 times in an average month to 120 in December. On the whole those riders who did not use parking facilities increased their usage by 12.58%, with Caucasian identified respondents accounting for the largest increase.

Table 3: Percent Change in Number of Rides, and CTfastrak Percentage of Total Public Transit Use, by Use of Parking Facilities and Race

<table>
<thead>
<tr>
<th></th>
<th>Pct Change Rides</th>
<th>CTfastrak Pct of Total Rides</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous Rider</td>
<td>11.00%</td>
<td>72.27%</td>
<td>58</td>
</tr>
<tr>
<td>No_Park</td>
<td>12.58%</td>
<td>61.82%</td>
<td>49</td>
</tr>
<tr>
<td>Black/African American</td>
<td>-5.58%</td>
<td>16.82%</td>
<td>14</td>
</tr>
<tr>
<td>Caucasian</td>
<td>32.90%</td>
<td>21.00%</td>
<td>14</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>13.49%</td>
<td>22.73%</td>
<td>19</td>
</tr>
<tr>
<td>N/A</td>
<td>0.00%</td>
<td>0.25%</td>
<td>1</td>
</tr>
<tr>
<td>Two or More Races</td>
<td>0.00%</td>
<td>1.02%</td>
<td>1</td>
</tr>
<tr>
<td>Park</td>
<td>2.50%</td>
<td>10.45%</td>
<td>9</td>
</tr>
<tr>
<td>Asian</td>
<td>8.33%</td>
<td>3.31%</td>
<td>3</td>
</tr>
<tr>
<td>Black/African American</td>
<td>0.00%</td>
<td>1.02%</td>
<td>1</td>
</tr>
<tr>
<td>Caucasian</td>
<td>0.00%</td>
<td>6.12%</td>
<td>5</td>
</tr>
</tbody>
</table>
ANALYSIS & INTERPRETATION

Chi-Square Results

For the purposes of this study I use an 90% Confidence Level and an alpha value of 0.1. At this level of significance, there are several statistically significant relationships between demographic factors and ridership behaviors, as shown in Table 4.

Table 4: Statistically Significant Relationships Based Upon Chi-Square

<table>
<thead>
<tr>
<th>Var 1</th>
<th>Var 2</th>
<th>Chi-Square</th>
<th>Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>New or Previous Rider</td>
<td>0.31830908</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Walk</td>
<td>0.36874819</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Park</td>
<td>0.22445233</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Day or Rush</td>
<td>0.43768666</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Work or Not_Work</td>
<td>0.85558265</td>
<td></td>
</tr>
<tr>
<td>Above or Below Median Income</td>
<td>New or Previous Rider</td>
<td>0.00707517</td>
<td>***</td>
</tr>
<tr>
<td>Above or Below Median Income</td>
<td>Walk</td>
<td>0.01184953</td>
<td>**</td>
</tr>
<tr>
<td>Above or Below Median Income</td>
<td>Park</td>
<td>2.07687E-07</td>
<td>***</td>
</tr>
<tr>
<td>Above or Below Median Income</td>
<td>Transit</td>
<td>0.00458995</td>
<td>***</td>
</tr>
<tr>
<td>Above or Below Median Income</td>
<td>Day or Rush</td>
<td>0.17785270</td>
<td></td>
</tr>
<tr>
<td>Above or Below Median Income</td>
<td>Work or Not_Work</td>
<td>0.13145904</td>
<td></td>
</tr>
<tr>
<td>Car Ratio Above or Below 1</td>
<td>New or Previous Rider</td>
<td>0.00270791</td>
<td>***</td>
</tr>
<tr>
<td>Car Ratio Above or Below 1</td>
<td>Walk</td>
<td>0.01376882</td>
<td>**</td>
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<tr>
<td>Car Ratio Above or Below 1</td>
<td>Park</td>
<td>1.48653E-05</td>
<td>***</td>
</tr>
<tr>
<td>Car Ratio Above or Below 1</td>
<td>Transit</td>
<td>0.00023054</td>
<td>***</td>
</tr>
<tr>
<td>Car Ratio Above or Below 1</td>
<td>Day or Rush</td>
<td>0.13848105</td>
<td></td>
</tr>
<tr>
<td>White or Non-White</td>
<td>New or Previous Rider</td>
<td>0.14825436</td>
<td></td>
</tr>
<tr>
<td>White or Non-White</td>
<td>Walk</td>
<td>0.06647153</td>
<td>*</td>
</tr>
<tr>
<td>White or Non-White</td>
<td>Park</td>
<td>7.05563E-05</td>
<td>***</td>
</tr>
<tr>
<td>White or Non-White</td>
<td>Day or Rush</td>
<td>0.35492619</td>
<td></td>
</tr>
<tr>
<td>White or Non-White</td>
<td>Above or Below Med. Income</td>
<td>0.00763868</td>
<td>***</td>
</tr>
<tr>
<td>White or Non-White</td>
<td>Work or Not_Work</td>
<td>0.88976864</td>
<td></td>
</tr>
<tr>
<td>Park</td>
<td>New or Previous Rider</td>
<td>0.00010186</td>
<td>***</td>
</tr>
<tr>
<td>Park</td>
<td>1 Destination or 2+</td>
<td>0.00362017</td>
<td>***</td>
</tr>
<tr>
<td>Park</td>
<td>1 Destination or 2+</td>
<td>0.05415998</td>
<td>*</td>
</tr>
</tbody>
</table>

Gender, race, and income were tested against being a new or previous rider, if the respondent walked to the station or parked, if they were a daytime or rush hour rider, and if they used CTfastrak to get to work. No significant relationship was found between gender and these variables.

Race, for the purpose of this study, respondents were grouped into as white and non-white populations. Statistically significant relationships were found between white populations and access modes. Specifically, non-white respondents are more likely to walk to CTfastrak stations, and white respondents are more likely to use parking facilities at stations. This fits with the study's
hypothesis that new riders would be more likely to use parking facilities than previous transit riders.

While there is no significant relation between being White and being a new rider, there is a relationship between white and being higher income, and a relationship between being higher income and being a new rider. So, though there is no significant relationship between being white and being a new rider, there is perhaps a suggestive relationship. In order to explore this further, I used crosstabs to test the relationship white riders with above median incomes and the “NewRider” variable. The results shown below in Figure #### demonstrate that this particular sub-group is disproportionately represented among new riders at a 95% confidence level, allowing us to reject the null hypothesis.

Table 5: Chi-Square Calculation: Income & White vs. New Rider Status

<table>
<thead>
<tr>
<th></th>
<th>Prev</th>
<th>New</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NonWht_Bel</td>
<td>25</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>NonWht_Abo</td>
<td>11</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Wht_Bel</td>
<td>7</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Wht_Abo</td>
<td>10</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>53</td>
<td>30</td>
<td>83</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 19.79518 \]
\[ 11.20482 \]
\[ 12.77108 \]
\[ 7.228916 \]
\[ 6.385542 \]
\[ 3.614458 \]
\[ 14.04819 \]
\[ 7.951807 \]

chisq = 0.049066

For income, respondents were classified as either above or below median income. There were statistically significant relationships between new or previous rider status as previously noted, and the three most utilized access modes. This supports the claim in the literature that income is an important predictor of transportation mode choice. Riders with incomes above the median were more likely to park at the station, while those below the median were more likely to walk and use transit.

Other statistically significant relationships exist with the number of destination types. New riders are more likely to use the system to reach only a singular destination type. The same relationship exists for riders who use the parking facilities at the stations. This would suggest that the new discretionary park-and-rider population is using CTfastrak in a limited extent, primarily to commute to and from work.
<table>
<thead>
<tr>
<th></th>
<th>Dest1</th>
<th>Dest2+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prev</td>
<td>18</td>
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</tr>
<tr>
<td>New</td>
<td>19</td>
<td>11</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>51</td>
<td>88</td>
</tr>
</tbody>
</table>

\[ \begin{align*}
\text{Dest1} & : & 24.38636364 & \quad \text{Dest2+} : & 33.61364000 \\
\text{Total} & : & 12.61363636 & \quad \text{Total} & : & 17.38636364 \\
\end{align*} \]

\[ \text{chisq} \quad 0.003620173 \]

**t-Testing**

There are two primary questions in analyzing usage trends: 1) how has usage changed for the previously CT Transit riding population? And 2) how has the composition of the ridership changed after the introduction of CTfastrak? To answer these questions this analysis tests two different dependent variables: the number of riders, and the number of reported rides, both pre- and post- implementation of CTfastrak.

**New Ridership Behavior**

Using chi-square new riders were determined to be statistically more likely to be white, above median income, to have a car to driver ratio above 1, and to more likely to park their cars at the stations. However, the results of a Two Sample t-Test of Unequal Variances reveals that new riders use public transportation less than the previous riders (see Table 7).

<table>
<thead>
<tr>
<th></th>
<th>Previous Rider</th>
<th>New Rider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>48.89655172</td>
<td>35.09677</td>
</tr>
<tr>
<td>Variance</td>
<td>869.7434967</td>
<td>618.757</td>
</tr>
<tr>
<td>Observations</td>
<td>58</td>
<td>31</td>
</tr>
<tr>
<td>Hypothesized Mean</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>2.334073068</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.011213231</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.293589269</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.022426461</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>1.666599658</td>
<td></td>
</tr>
</tbody>
</table>

This suggests that new ridership is wealthier and using CTfastrak as a discretionary mode of transportation which has several implications for the future of the system’s operation. First, new riders are statistically more likely to have a car to driver ratio above one, giving them more mobility options at their disposal. Previous ridership is more likely to be a captive population with a more inelastic demand for transit trips. As new riders are wealthier they can be expected to have
a more elastic demand based upon the availability of substitutes (car trips) and will therefore be more difficult to retain as riders.

Secondly, their ability to park at the station is a strong incentive to use the system. Again, while not accounted for formally, many riders noted a preference for more parking spaces, which CTfastrak is addressing this year. This would suggest that the park-and-ride population responds primarily to the differential in parking and congestion costs between locations. The relatively high cost of parking in Hartford compared to the free or $3.00 parking in New Britain, riders could be saving themselves upwards of $260.00 per month (based upon $16.00 per day at Hartford garages). If enhanced with a transit benefits those savings could be even larger, as some respondents noted.

**Previous Ridership Behavior**

Another key finding is that there has been an 11 percent increase in the number of reported transit rides by previous riders. This increase was found to be statistically significant using a Two-Tailed t-Test of Dependent Means. The difference between their reported number of pre-CTfastrak rides and their post CTfastrak rides was tested, and returned a $t$-statistic of -2.11 which is significant at a 95% confidence level, above this study’s 90% confidence threshold. This result shows that the benefits of the expansion and improvement over the pre-existing transit system has not only accrued to new riders but has also ostensibly increased the utility of previous riders. 27.6 percent of previous riders that increased their ridership after the implementation of CTfastrak suggesting that there have been small, but broadly distributed gains in the number of trips taken.

**Table 8: t-Test: Paired Two Sample for Means: Previous Riders Reported Rides**

<table>
<thead>
<tr>
<th></th>
<th>Pre-CTF</th>
<th>Post-CTF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
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<td>48.89655172</td>
</tr>
<tr>
<td>Variance</td>
<td>1182.47</td>
<td>869.7434967</td>
</tr>
<tr>
<td>Observations</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>0.86047</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>$t$ Stat</td>
<td>-2.10591</td>
<td></td>
</tr>
<tr>
<td>$P(T&lt;=t)$ one-tail</td>
<td>0.01981</td>
<td></td>
</tr>
<tr>
<td>$t$ Critical one-tail</td>
<td>1.29658</td>
<td></td>
</tr>
<tr>
<td>$P(T&lt;=t)$ two-tail</td>
<td>0.03963</td>
<td></td>
</tr>
<tr>
<td>$t$ Critical two-tail</td>
<td>1.67203</td>
<td></td>
</tr>
</tbody>
</table>

**Anecdotally**

In the course of collecting my surveys, I found ample opportunity to discuss the impact of the new system more broadly and less formally with riders, staffers, and local officials. While not scientifically collected, I believe that these anecdotes added to my understanding of what implementation of the system has meant at a human scale for its riders.

One survey respondent I spoke with was middle aged and homeless with numerous comorbid health conditions, including mental illness. Before CTfastrak, they frequently received warnings from the local shelter because they would miss curfew times coming home from doctors’
appointments. However, now that the frequency of buses has increased they are able to make it to both their medical appointments and get home back to the shelter before their curfew. Additionally, the bus system now provides better service to where their nephew lives, who helps administer care to the respondent.

Several interesting common threads ran through the comments of the commuting park-and-ride population. The most repeated comment was the need for more parking or improved parking facilities at the stations, particular at East St and Cedar St. These stations provide the largest number of free parking spaces along the line. Over the course of my research, if I arrived later than 7:30AM these parking lots were either full or nearly so. At East St, riders parked their cars along the side of the long driveway of the station.

However, the largest parking lot, Szczesny Garage in New Britain, was often comparatively empty. Several factors may be potentially contributing to this underutilization. First, unlike the parking at the stations along the busway, Szczesny Garage charges CTfastrak riders three dollars per day for parking, though this reduced rate is not advertised broadly. Several park-and-ride respondents noted that one of the attractive features of the system was the free parking. When informed that the garage charges three dollars, some riders were not convinced that they would use the facilities. This would seem to indicate a high elasticity with respect to the price of parking. Whether this is effect of an additional purchase point, or a matter of higher total cost may be an area of further study. This would seem to indicate that the discretionary riders are not using the system to necessarily avoid the time cost of congestion, but rather the monetary cost of parking in Hartford. This has implications for growing the new ridership in that new riders will possibly be more responsive to their wallet than their watch.

Secondly, rather than being directly attached to the busway station, the station is a five-minute walk away. Given the prevailing sub-freezing temperatures, this may have affected some park-and-riders’ willingness to use the facility during the week. While little can be done to mitigate harsh New England winters, service plans could likely forecast smaller populations of discretionary riders.

Additionally, some P&R users try to park their vehicles at the closest free parking lot and if full they might try their luck at the next station. This likely happens just outside the New Britain terminus, since the East Street Station is in close proximity to the larger amounts of parking at the Cedar St Station.

**Interviews**

In addition to the surveys, this study also incorporates three interviews with planning officials in the in service area.

*Lyle Wray, Executive Director CRCOG*

The first is an informal interview with Lyle Wray, the Executive Director of the Capitol Region Council of Governments. One of the weak points that Mr. Wray pointed out about the transit system on the whole was the surrounding normal CTtransit routes. Mr. Wray argued for a Houston-like reworking of the system that took into account the changes in the region’s demographics and employment centers. He argued that this would help create cost savings in the system and create new sources of ridership. This linked to the so-called “last mile” problem in transit, where potential consumers may be close to transit but require another mode of
transportation to get there. Mr. Wray argued for a multitude of options that included integration of greater pedestrian access, and the use of cab-hailing services like Uber and Lyft.

Mr. Wray also noted the role of the new Connecticut Transit Corridor Development Authority in shaping development in the CTfastrak service area. He cited the need for a unified vision for the corridor and innovative financing techniques, such as TIF districts and value-capture. This view echoes recent statements made by Garrett Eucalitto, the Undersecretary for Transportation Policy, at the 2016 New Partners for Smart Growth Conference. Eucalitto made the point that in the absence of county level government there is little coordination among municipalities on development or transportation issues.

*Todd Dumais, Town Planner West Hartford*

Another interview was conducted with Todd Dumais, the town planner of West Hartford. Mr. Dumais noted that there was opposition to the busway construction project during the implementation process, but since opening, the opposition has died down. He noted that this was in part because there was very little proactive outreach from the state to the towns during the process.

The town enabled TOD style projects along the CTfastrak corridor with a small yet critical change to their zoning code. Previously the area was zoning primarily for industrial uses. This change has allowed developers and the West Hartford Housing Authority to move forward with projects that would have previously been out of compliance with the zoning code. The town has moved forward with a complete street study that will incorporate the possibility of street improvements and a focus on transit accessibility in the catchment area.

*Craig Minor, Town Planner Newington*

The final interviewee of this study was Craig Minor the town planner of Newington. Most saliently, he notes that “Opposition to CTfastrak became expected of any candidate for political office. However, in the year since it opened, hostility seems to have cooled off.” This would seem to reinforce news reports that the town was comparatively. The town has just recently adopted TOD regulations that create a zoning overlay within walking distances of the CTfastrak. Minor went on to say that technical expertise and funding is available from regional planning entities, but the town’s attitude towards CTfastrak has prevented it from fully embracing that assistance.
CONCLUSIONS

Summary of Findings

The results of survey show that there is a considerable base of new ridership using transit since the opening of CTfastrak. This population is more likely to be white and have a higher income. They are more likely to use the parking facilities, but as a result use the system for a singular purpose, specifically commuting to work. Therefore, increasing the new ridership would likely increase the number of riders during AM and PM rush, but the challenge lies in either increasing parking or getting them to the station some other way. CTfastrak is already increasing the amount of parking available at the stations, which should raise capacity for this specific type of rider.

Previous transit riders have increased their usage of the transit system as a whole, and are more likely to use CTfastrak to travel to destinations other than work. Previous riders are more likely to be low income, and thus have fewer transportation options. As such, they are the heaviest users of the system, and rely on it to meet their basic daily needs and form the base of the ridership. Additionally, they are more likely to either walk or use transit to access CTfastrak, meaning that planning decisions surrounding the facilities and CTtransit networks will have a greater effect on them.

There is evidence that CTfastrak’s growth has come at the expense of pre-existing routes. On the whole, previous riders reported that 89.5 percent of their trips use CTfastrak. This explains some of the decrease in the number of CTtransit rides reported by ConnDOT. Yet, the number of overall rides in the region has increased, presumably due to the influx of new riders.

Keys to Further Success

Developing policy recommendations for CTfastrak at this early juncture may seem premature. To a certain extent this is true, in that long-term ridership patterns have not yet been fully established. However, after being in operation for a brief number of months, the evidence of new transit users merits attention and planning from ConnDOT and CTfastrak. This study identifies policy areas which will be critical going forward, rather than developing specific policy proposals.

Embracing Intermodalism for a Diverse Ridership

Perhaps the biggest key to CTfastrak’s continued success is planning for a diverse ridership that uses a variety of modes to access the system. CTfastrak officials can continue to exceed ridership targets by recognizing the differences in access mode behaviors of different rider profiles.

CTfastrak’s success in attracting discretionary riders has been in part driven by the state’s ability to encourage intermodalism among car owners. The price imbalance between the free and low cost parking of the CTfastrak facilities and the relatively high cost of parking in downtown Hartford creates a strong draw for discretionary riders. Expanding the parking around the stations and allowing free use of the municipal garage in New Britain should attract more of these riders. As ridership patterns mature, further surveys should evaluate the price elasticities for parking of riders at the stations. Dependent upon those results, CTfastrak could increase the price of parking at the stations allowing ConnDOT to recoup some of the costs of the system from riders with more disposable income, while holding everyday riding prices steady for low income riders. This could be accomplished simply through implementation of pay stations at the parking lots, or
a parking permit included with the sale of a monthly pass. An even more advanced step would be the regional coordination of parking facilities to establish pricing levels.

Discretionary riders may also be served by redesigned local CTtransit routes. Redeploying resources to new or redesigned routes that take into account the presence of CTfastrak could expand the number of potential riders within the service area, and decrease travel times for captive riders. Mr. Wray suggested a complete overhaul of the local CTtransit routes similar to Houston’s recent route redesign. While a full-fledged redesign of CTtransit routes may be needed, it can also take a considerable amount of time to design and implement. Other interim options may be available, including working with employers to increase the number of corporate shuttles, or partnering with taxi companies to local jitney service. These options should not necessarily require large state expenditures, and provided that the level of service is reliable and frequent during rush hours, new feeder routes may draw in more of discretionary riders, and create better service for previous CTtransit users.

Another key market demographic to engage are the government workers in Hartford. State labor agreements complicate the matter by guaranteeing a free parking space for every state employee. This stipulation subsidizes driving as a mode choice and thereby disincentivizes state employees from carpooling or using transit. This has the added benefit of potentially lowering long term state costs as the government may be able to consolidate its parking in Hartford and sell off the excess.

Integration of Development

Over the long run, CTfastrak will see greater success if the state and municipalities can encourage businesses and developers to locate their projects within the corridor. The Connecticut Transit Corridor Development Authority is a good first step, yet the financial constraints imposed by the state’s difficult fiscal position have prevented it from accomplishing its mission. There is a clear need for the state to better coordinate regional growth, and there is a strong case for centering its development strategy around CTfastrak in the Capitol Region. Priority should be given to sites within the catchment area for redevelopment and tax credits. BRT can act as a force multiplier for larger state efforts to create a dense core of employers and ideally attract a larger tax base.

Steps have already been taken to support those efforts, though they have been subject to broader budgetary difficulties. A bill was passed during the 2015 legislative session establishing the Connecticut Transit Corridor Development Authority, though the office was not established and funded. A reworked version of the same bill is currently working its way through the legislative process in this year’s session, though it faces an uphill climb through the appropriations process.

On the residential front, some areas surrounding CTfastrak stations may be suitable for Transit Oriented Development projects. As discussed in the literature review, bus rapid transit systems with higher levels of service can both support, and be supported by TOD. As noted in the interview section, West Hartford has already changed their zoning code to remove nearly all restrictions on land use surrounding their stations. This change was led a developer with a specific site and project in mind. The fifty-four-unit project has recently been approved by the town, and it has received ten million dollars in federal housing tax credits.

On a regional economic scale, Hartford, in conjunction with the state government, is undergoing several initiatives that aim to revitalize the downtown area. The University of Connecticut is relocating a satellite campus from West Hartford to the downtown core. A large coalition of public and private actors is working to create a new urban design plan for the downtown called iQuilt.
These will help create more demand downtown for trips, and help create a more pedestrian friendly area. The UConn campus in particular will generate both student commuters and employees to help service the student population.

Opportunities for TOD exist along the line, but providing access to park & riders will likely still account for more riders. However, if the system becomes more popular, property values around it will begin to increase creating competition for land use. Given the slow pace of regional economic growth this is unlikely to happen overnight, but must be accounted for. Balancing the needs of those who use the parking facilities and the growth of TOD will be critical going forward for the municipalities.

**Working with Employers**

Connecticut has wrestled with state budgetary shortfalls for several years running. Within this context it is important that the state partner with the private sector around areas of mutual interest. A state program called CTRides provides employers with information. The state should work to promote commuter benefits among major private employers in the service area. For public employees, the state should look into renegotiating the free parking requirement in the union contract to make the benefit a bit more flexible. Providing a transit pass over a parking space could gradually help cull parking spaces from the downtown corridor.

**Further Research**

This study has opened up several paths for further research in the Connecticut Capitol Region. Primarily, a qualitative study of the discretionary new riders could prove useful. Such research should address several topics of interest.

First, the effect of employer policies on the travel behaviors of commuters in the region should be investigated further. This would include a survey of employees of companies that offer transit benefits or incentives for reducing car travel. Aetna, as a prime example, has charged its employees for parking unless they were using a van- or car-pool. Additionally, Aetna provides its employees with a pre-tax commuter benefit which can be put towards transit passes and tickets. This policy shapes the commute cost calculus for its workers, as demonstrated by several respondents who mentioned they worked at Aetna. Government workers are another critical sector to understand. For state workers, their union agreement dictates that all employees be granted free parking at their office. Again, such a policy will affect the employees’ commuter behavior.

Secondly, the differences in ticket purchasing patterns between low income riders and wealthier riders should be investigated. Lower income riders are at greater risk for income instability and thus may not be able to afford the cash flow shortages a monthly pass may entail, even if the overall cost is less. At $54.00 per month, CTtransit passes are not as expensive as some other transit agencies, yet this effect may still have a negative effect upon the service’s most frequent riders and should be investigated.

Third, an analysis of the change in property values surrounding the stations should be undertaken to better understand the potential gentrifying dynamics of transit-oriented development in the region. A shift in development practices may increase pressures against vulnerable populations who require easy access to transit. As 29.7 percent of the sample population did not have a car, rising property values near stations could have a deleterious effect upon the system’s base of riders.
Fourth, a survey of CTtransit users within the service area, but outside the busway corridor about CTfastrak usage could prove to be an interesting population of study. Investigating how CTfastrak has changed their behavior could show some of the more regional effects, and whether or not that has changed destination patterns for riders.

A Final Word

Perhaps the most telling aspect of my field research was that I never spoke with an unhappy customer. I might have gotten some looks asking about income or age, but most folks I spoke with were more than happy to speak about CTfastrak in a positive light. CTfastrak appears to refute the criticisms of its earlier detractors who called it “the bus to nowhere.” It has succeeded in creating brand new transit riders, and provided significant time savings to previous riders. In doing so, the system has dramatically changed their clientele, and paved the way for new (hopefully more sustainable) development patterns and partners. This is not to say that it is not without a hefty price tag. At $17.5 million in annual operating costs, and only a quarter of that covered by fares, CTfastrak is a lot to invest in a system in a state with annual budget crises and a stubbornly stagnated economy. But as a transfer to lower and middle income households, CTfastrak is putting money back in the pockets of the folks who will reinvest those savings into their community.
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Mass Transit.


Survey Questions

Demographics

1. What is your age?
2. What is the gender you identify with?
   - Male
   - Female
   - Other
3. What is your race or ethnicity?
   - Caucasian
   - Black/African American
   - Asian
   - Hispanic or Latino
   - Native American or Pacific Islander
   - Two or more races
   - Other: ______
4. What is your annual household income?
5. What is your home zip code?
6. How many cars do you have in your household?
7. How many people are there with a driver's license in your household?

Public Transportation Usage

1. Before CTfastrak, how many times did you use public transportation in an average month? Please count a round trip as two times.
   - Follow up: “Could you estimate the number? For example, if I took a round trip to and from work that would be two times.”
2. How many times did you use public transportation in the past month? Please count a round trip as two times.
3. How many times did you use CTfastrak in the past month in particular? Please count a round trip as two times.
4. What destinations do you use CTfastrak to get to? Please check all that apply
   - Work
   - Daily Shopping (i.e. grocery store, pharmacy)
   - Destination Shopping (i.e. mall, specialty stores)
   - School
   - Recreation (visiting friends or family, going out)
   - Doctor’s or other appointment
   - Other: ________
5. In the past month how have you accessed CTfastrak? Please check all that apply
   - Walk
   - Bike
   - Car - parked at the station
   - Car - dropped off by someone else
   - Other CTtransit
   - Other: _________
6. What is your most frequent destination’s zip code? If you do not know the zip code, please state the area of town.

7. What is your most frequently used CTfastrak Route?

**Reported Rides**

Change in Number of Rides by Income & Race

<table>
<thead>
<tr>
<th></th>
<th>Pre-CTF Avg Monthly Rides</th>
<th>Past Month Rides</th>
<th>Past Month CTF Rides</th>
</tr>
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<tr>
<td><strong>PrevRider</strong></td>
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<td>2334</td>
</tr>
<tr>
<td>Below Med Inc.</td>
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<td>1703</td>
<td>1563</td>
</tr>
<tr>
<td>Black/African American</td>
<td>551</td>
<td>516</td>
<td>473</td>
</tr>
<tr>
<td>Caucasian</td>
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<td>484</td>
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<tr>
<td>Hispanic/Latino</td>
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<td>Caucasian</td>
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<tr>
<td>Hispanic/Latino</td>
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<td>Above Med. Inc</td>
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<td>Hispanic/Latino</td>
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<td>Two or More Races</td>
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<td>1</td>
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<td><strong>Grand Total</strong></td>
<td>2391</td>
<td>3664</td>
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Reported Rides by Race, Use of Parking, and Previous Rider Status

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<tr>
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<th>Pre-CTF Avg Monthly Rides</th>
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</tr>
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<tr>
<td>Black/African American</td>
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<td>692</td>
</tr>
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<td>892</td>
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</tr>
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### Pearson’s Chi-Square Results

#### Gender

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\[
\chi^2 = 12.19101124 \quad 22.80898876 \\
18.80898876 \quad 35.19101124 \\
\]

\[
\text{chi sq} = 0.31830908
\]

#### Walk

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\[
\chi^2 = 23.98901099 \quad 13.01098901 \\
35.01098901 \quad 18.98901099 \\
\]

\[
\text{chi sq} = 0.368748191
\]

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\[
\chi^2 = 10.57142857 \quad 26.42857143 \\
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\[ \text{chi sq} = 0.224452331 \]

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\[ \text{chi sq} = 0.437686661 \]

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\[ \text{chi sq} = 0.855582654 \]

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\[ \text{chi sq} = 0.066472 \]

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