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Analysis of Local Bus Markets

FINAL REPORT

VOLUME I – Methodology and Findings

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Submitted by

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16.Abstract

Despite having an extensive network of public transit, traffic congestion and transportation-related greenhouse gas (GHG) emissions are significant concerns in New Jersey. This research hypothesizes that traffic congestion and air quality concerns in the state would be much greater in the absence of public transit. With this hypothesis, the study examines the congestion and GHG impacts of transit by exclusively focusing on local buses in selected parts of the state.

While the primary objective of this research is to estimate the congestion and GHG impacts of local buses, its secondary objective is to examine the rider and travel characteristics of bus riders. To fulfill these objectives, a survey of bus riders was necessary. A list of 50 bus routes in four County Groups was prepared for the survey. Rider surveys were conducted on 23 of these routes as a part of this research. This research document pertains to the analysis of survey data from those 23 routes.

The survey revealed that a large proportion of riders would drive their own cars, carpool with others, or use app-based services or taxis to travel to their destinations in the absence of buses. Such diversions to the automobile would generate a significant amount of vehicle miles traveled, which in turn would generate a significant amount of GHG. The traffic simulation model also indicated that diversion of riders from buses to automobile would increase traffic delay by a discernible level. Based on these results, the study concludes that local buses can potentially help to reduce congestion and GHG emissions.

The analysis of rider and trip characteristics showed that the surveyed buses mostly serve riders from households without cars who have limited options to travel. Survey data analysis also showed that the buses serve a large number of low-income and minority populations, most of whom use buses to travel to work and school. Based on the results, a few recommendations have been made.

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As research team members, Dr. Xiang Liu of Rutgers Department of Civil and Environmental Engineering, senior research specialist Mark Walzer of the Bloustein Center for Survey Research, as well as senior research specialists Ryan Whytlaw and Andrea Lubin and research project coordinator Stephanie Kose of the Alan M. Voorhees Transportation Center significantly contributed to this study. Dr. Liu led the effort pertaining to traffic impacts of local buses. Mr. Whytlaw and Mr. Walzer assisted with survey scheduling and monitoring as well as with the supervision of the survey. Ms. Lubin assisted with hiring and training of surveyors and setting up the data-entry program. Ms. Kose assisted with surveyor hiring, monitoring of surveyor activities, timesheets, and other project administration activities, such as travel reimbursements.

The contribution of Rutgers students from various programs to this study was immense. Edward J. Bloustein School students Chihuangji Wang (Herbert) and Catrina Meyer assisted with scheduling and monitoring of the survey, GIS analysis, and other important logistical work. Catrina Meyer also helped preparing the literature review. Sarah Diyanidh assisted with survey monitoring and data analysis. Doctoral student Da Fei helped with survey data cleaning and weighting. Approximately 40 graduate and undergraduate students from various programs at Rutgers University undertook the difficult task of conducting onboard surveys. Without the contributions of all of the above, the study could not have been successfully completed.

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EXECUTIVE SUMMARY

Background

Despite having an extensive network of public transit, traffic congestion and transportation-related greenhouse gas (GHG) emissions are significant concerns in New Jersey. The traffic congestion and air quality concerns in the state could be much greater in the absence of public transit. With this hypothesis, the study examines the congestion and GHG impacts of transit by exclusively focusing on local buses in two selected regions of the state. Examining the impact of buses on traffic congestion and air quality is highly important in New Jersey because, on the one hand, it is one of the most congested states, and on the other hand, it is a state where a substantial proportion of trips are made by buses.

In order to assess the GHG and traffic congestion impacts of buses, it is important to analyze the current travel patterns of riders and to comprehend how they would have traveled in the absence of buses. Such analyses require a survey of bus riders. NJ TRANSIT periodically conducts surveys of bus riders to assess riders' personal and household characteristics, travel patterns, and satisfaction with transit. However, for 50 of the agency's more than 250 routes, such surveys have not been conducted in more than ten years. In order to conduct the required GHG and traffic analyses, those 50 routes were initially selected for the survey. NJ TRANSIT selected 23 of those routes for survey and analyses. This report presents results from the analyses of survey data from those 23 routes.

Research Objectives

The specific objectives of this research are the following:

(a) Assess the GHG and congestion impacts of local buses.
(b) Assess the characteristics of riders and their travel patterns.
(c) Generate a dataset of riders through a survey that can be used to answer the research questions of this study and also assist NJ TRANSIT with future service planning and modeling.

Research Tasks

The key tasks involved in this research are the following:

- **Literature review**: Conduct a review of literature related to transit's GHG and congestion impacts, traffic simulation models, and transit rider surveys.

- **Design and conduct a bus rider survey**: Design survey instrument; pre-test survey instrument; conduct an onboard survey of bus riders on 23 routes serving Hudson, Middlesex, and Monmouth Counties, to collect data from more than 6,600 riders; clean survey data; geocode trip origins and destinations; and weight survey data.

- **Analyze survey data**: Analyze survey data to examine route-specific riders' individual characteristics (including demographic and socioeconomic characteristics) and riders' travel characteristics (including trip origins and destinations, access and egress modes, trip frequency, ticket type, satisfaction with service, and the availability of travel alternatives).

- **Estimate congestion and air quality impacts of buses**: Calculate trip distances and use survey data along with network data such as traffic volumes, traffic controls, and roadway elements to estimate congestion impacts; estimate GHG emissions from trips that would be diverted to automobile in the absence of buses to determine the potential GHG impacts of buses.

Key Findings

The following are the key findings of this research:

- The rider survey for the 23 routes, conducted between 6 AM and 4 PM on weekdays over 13 weeks in two seasons, generated data from 6,757 riders.
- The analysis of the emissions impact of buses showed that the diversion of riders from buses to automobile would generate a large amount of GHG, composed mostly of carbon dioxide (CO_2). The analysis showed, based on one-way trip alone, more than 10,200 metric tons of CO_2 would be generated annually from automobiles if the riders diverted to that mode. It would take almost 2,200 automobiles to operate for a full year to generate that amount of emission.
- The traffic simulation model (VISSIM) for Rt. 80 indicated that the route helps to reduce traffic delay by 10.4 percent during the morning peak period. Similar delays can be expected for routes operating in similar conditions, but reduction in delay for routes may vary depending on network factors and traffic volume.
- The bus routes predominantly serve low-income populations. For all routes except five feeder routes, the share of low-income riders was significantly larger than the share of low-income persons in New Jersey.
- The routes predominantly serve racial and ethnic populations. The share of non-white persons for the routes varies between 46 percent and 99 percent.
- For 21 of the 23 routes, the share of riders without any household vehicle is greater than the share of such persons in New Jersey as a whole (11.7 percent). For 12 routes, the share of riders from households without vehicles is 50 percent or more.
- Thirty percent or more riders for all routes stated that they have no option to travel other the buses. For 15 routes, 50 percent or more riders stated that they had no other option to travel.
- A large proportion of the bus trips are made to go to work. The proportion of riders going to work by buses varied between 25 percent and 94 percent for the routes.
- Although a large proportion of riders walk to and from work, the buses also help a significant number of riders of specific routes to access NJ TRANSIT and PATH trains.

- Rider satisfaction scores indicated that far more riders are satisfied than dissatisfied with the bus service. However, on a 0 to 10 scale, median scores varied between 6 and 9, indicating that level of satisfaction varies between the routes.
- Although app-based services provided by transportation network companies did not even exist in New Jersey until November 2013, a large proportion of riders stated that they would take such services in the absence of buses. For 16 routes, the share of riders potentially taking app-based service is greater than potentially driving on their own.

Recommendations

On the basis of the experience with the survey and data analysis, the following recommendations are made:

- Promote local buses since they can potentially help to reduce GHG emissions and facilitate travel for a large number of riders who have no other option to travel.
- Consider conducting surveys between 6 AM and 9 PM in the future instead of only between 6 AM and 4 PM to collect data from more diverse riders.
- Conduct surveys on weekends to collect data from more diverse riders and examine weekend travel patterns.
- Examine through statistical methods whether surveys on selected bus trips instead of all bus trips would generate unbiased results to reduce the cost of surveys.
- Promote future research to understand how app-based services provided by transportation network companies can be integrated with transit services.

INTRODUCTION

Examining the impact of buses on traffic congestion and air quality is highly important in New Jersey because, on the one hand, it is one of the most congested states, and on the other hand, it is a state where a substantial proportion of trips are made by buses. Examining the impact of buses on congestion and air quality is particularly important in New Jersey because buses account for 60% of the trips made by all NJ TRANSIT riders.(1)

According to the United States Bureau of Transportation Statistics, the national mean duration of work trips is 25.7 minutes, whereas in New Jersey it is 30.7 minutes.(2) In New Jersey, 80.3% of these trips are made by car, either alone or in a carpool, and 10.6% are made by transit. Because of a high volume of trips by automobile, limited capacity on the state's road infrastructure, and bottlenecks due to bridges and tunnels, traffic congestion and air quality are two of the most commonly cited problems in the state.

The New York-Newark Urban Area, with 544,063,000 total hours of delay at a cost of $1,281 per commuter, was ranked among the worst in the country in 2011 in terms of traffic congestion.(3) The Philadelphia Urban Area, which includes parts of New Jersey, was also ranked among the worst because of 156,027,000 hours of annual delay at a cost of $1,018 per commuter. Due to the high volume of automobiles on roads and the resulting congestion, transportation contributes significantly to energy consumption and Greenhouse Gas (GHG) emissions in the state. According to the Bureau of Transportation Statistics, transportation accounts for 28.1% of the energy consumed nationally, but 37.2% of the energy consumed in New Jersey.(4) In 2009, according to the Federal Highway Administration, 1,816.9 million metric tons of carbon dioxide (CO_2), the primary component of GHG, were emitted by the transportation sector nationally.(5)

Due to the significant contribution of the transportation sector to overall CO_2 emissions, researchers have often looked at public transportation as a potential solution. Although New Jersey roads are highly congested, transit usage in the state is also one of the highest in the nation. In addition to seven major commuter rail lines and three light rail lines, NJ TRANSIT operates over 250 bus routes throughout the state of New Jersey, some connecting places in the state to places in New York State and Pennsylvania. According to the agency's Quarterly Ridership Trend Report for the 2nd quarter of FY-2017, the average weekday ridership for this bus system is 523,300.

NJ TRANSIT often conducts surveys to collect data from bus and rail riders that are used to aid various types of service planning, forecasting, and marketing activities. The data collected through the surveys pertain to riders' demographic and socioeconomic characteristics, trip origins and destinations, access and egress modes, trip frequency, alternative travel modes, ticket type, and satisfaction with service. These surveys are generally conducted onboard transit vehicles, meaning that surveyors travel by buses and trains and distribute surveys to traveling riders. Completed surveys are sometimes collected onboard by the surveyors, but riders are also allowed to mail the surveys back.

For past several years, NJ TRANSIT has not conducted surveys on 50 of its bus routes. These routes can be categorized into four County Groups: Hudson County, Middlesex/Monmouth County, Burlington County, and Morris County. NJ TRANSIT suggested that 23 of those 50 routes be selected to conduct the rider survey that would generate the necessary data for this research. Thus the primary objective of this research is to conduct an onboard survey of riders traveling by buses on the 23 routes and use the data to examine the traffic and air quality impacts of local buses. The secondary objective of this research is to use the survey data to conduct analysis on the characteristics of the riders and their travel patterns. The 23 bus routes surveyed through this research are shown in Table 1.

Table 1 – The Surveyed Bus Routes

Route #	Market	Location/Service Area	Median Weekday Ridership (Trips)
Hudson County Routes			
6	North Jersey Local	Hudson	1,707
22	Contract	Hudson	2,382
30	North Jersey Local	Essex/Bergen/Hudson	2,481
80	North Jersey Local	Hudson	7,414
81	North Jersey Local	Hudson	3,097
82	North Jersey Local	Hudson	345
83	North Jersey Local	Hudson/Bergen	3,880
84	North Jersey Local	Hudson	4,745
85	North Jersey Local	Hudson	1,758
86	North Jersey Local	Hudson	780
87	North Jersey Local	Hudson	11,627
89	North Jersey Local	Hudson	1,405
108	NY Interstate	Essex/Hudson/NYC	1,445
181	NY Interstate	GWB - Hudson/Bergen/NYC	533
329	North Jersey Local	Hudson	257
Middlesex/Monmouth County Group			
801	Contract	Metropark Loop Shuttle	220
802	Contract	Metropark Loop Shuttle	330
803	Contract	Metropark Loop Shuttle	268
804	Contract	Metropark Loop Shuttle	291
813	Contract	Middlesex	957
817	Contract	Middlesex	359
819	Contract	Middlesex/Union	596
822	Contract	Academy Express/Plainfield	75

Although for simplicity this study broadly defines the surveyed routes as Hudson County routes and Middlesex/Monmouth County routes, selected routes in the former also serve parts of Essex and Bergen Counties as well as New York City, whereas selected routes in the latter serve small parts of Union and Somerset Counties. However, the parts of Bergen, Essex, Union, Somerset Counties served by the surveyed routes are very small in area. Two Hudson County routes end in New York City, but they do not serve any stops in New York City other than the terminals.

The rider surveys onboard the 23 routes were conducted in two seasons, namely, in spring and fall of 2016. Following NJ TRANSIT convention, surveys were conducted only on Tuesday, Wednesdays, and Thursdays, excluding holidays. The survey period on each day was from 6 AM to 4 PM, meaning that riders on all buses leaving the origin stop between the two time periods were asked to complete the survey.

The spring survey continued for five weeks, whereas the fall survey continued for eight weeks. During the fall season, the survey was discontinued for several days because of a train crash at the Hoboken Terminal Station that affected bus operations in the surrounding area as well as other parts of the state.

In addition to describing the survey and providing survey results, this report includes discussions on literature related to impacts of buses on traffic and air quality and results of a microsimulation model (VISSIM) estimating traffic impacts of buses. Due to the high cost of conducting traffic simulation models that involve the collection of detailed information on traffic volumes and signals for an entire bus route, the simulation effort included only one surveyed bus route, namely, Rt. 80 that serves Jersey City.

This volume of the report is accompanied by two additional volumes (Volume II and Volume III) showing detailed survey results on rider characteristics and travel characteristics. The survey data file in SPSS format and various related material were separately provided to NJ TRANSIT and the New Jersey Department of Transportation’s Bureau of Research. This report only describes the methodologies, presents summary results, and discusses the implications of the findings.

LITERATURE REVIEW

Introduction

This literature review has been prepared with a three primary objectives. First, it is intended to provide a context to the overall study. Second, it is intended to provide a background for estimation of environmental and traffic impacts of buses. Third, it is intended to provide guidance for selecting appropriate methodologies for transit survey data collection.

Based on the overall research objectives, the remainder of this task report is divided into five sections. The first includes a review of studies on the impact of public transportation on congestion. The second includes a review of studies on transit's impact on air quality. The third includes a review of studies on simulation models that can be used to examine the effect of buses on roadway traffic condition. The fourth section includes a review of transit rider survey methods with the objective of identifying methods that may be applicable to the current study. The fifth and final section summarizes the key observations from the preceding sections.

Transit's Impact on Congestion Reduction

A common justification for investing in transit is that it benefits society by reducing traffic congestion. Although diverting people from automobile to transit can be logically expected to decrease congestion, some studies have found results that are consistent with this expectation, while others have found results that are contrary. For example, Stopher argued that only major transit investments could significantly decrease congestion in the long run.(6) Similarly, Duranton and Turner found no impact of transit on vehicle kilometers traveled (VKT).(7) The study claimed that the additional road capacity created by drivers diverting to transit is soon filled by new drivers due to induced demand. Litman acknowledged that possibility, but held that transit can have a prolonged impact on congestion because it can be continually made more attractive relative to driving.(8)

In a study involving 74 urbanized areas of the United States, Rubin and Mansour did not find a statistically significant relationship between increased annual per capita unlinked transit trips and reduced traffic congestion. (9) Nor did the study find evidence of a relationship between increased per capita annual transit passenger miles and reduced traffic congestion. However, Litman was highly critical of the study because of its methodology.(10)

Beaudoin, Farzin, and Lin used a model of transit investment that incorporates demand and cost interdependencies.(11) It found that a 10% increase in transit capacity is required to reduce congestion by 0.8%. However, Winston and Lager found expanding bus systems increases congestion, especially when an existing traffic lanes are dedicated to buses.(12) Winston and Maheshri concluded that rail transit has discernible congestion relief effects, but did not analyze the effects of buses.(13)

The literature review showed that studied have examined effects of transit on congestion in number of ways. One method is to examine how riders travel in the absence of transit. Strikes provide an opportunity to examine how the absence of transit or a transit supply shock impacts congestion.(14) Van Excel and Rietveld examined 13 transit strike studies and found that 10-20% of trips are canceled, while the captive riders are compelled to find alternative modes of transportation.(15) Anderson analyzed a transit strike in Los Angeles and found a 47% increase in congestion as a result of the strike.(16) Using the same methodology as Anderson, Adler and Van Ommeren studied the impacts of transit strikes in Rotterdam, Netherlands.(14) While the specificities of Dutch cities and American cities are different, they also concluded that car speeds decreased as a result of the strike. Bauernschuster et al. examined 71 transit strikes in Germany over a nine year period and found that on strike days there was a 12.3% increase in average morning trip duration.(17)

The studies using transit worker strikes consistently showed an increase in congestion during the strikes. However, Aftabuzzaman criticized such studies and maintained that the short-term effects of transit worker strikes may not continue in the long run.(18)

Instead of relying on transit worker strikes, the Wisconsin Department of Transportation took recourse to a stated preference survey, asking people how they would travel in the absence of transit.(19) It found that 27.4% respondents would switch to a car as a driver or passenger. Two studies with a similar hypothetical scenario by Deka in New Jersey also showed a significant diversion from transit to automobile, leading them to the conclusion that transit helps to reduce a substantial amount of VMT.(20,21)

Transit's Impact on Air Quality

Improving air quality is another common justification for investing in transit and increasing transit capacity. Reducing greenhouse gas (GHG) emissions is an expected outcome of transit investments. Bel and Holst undertook a before-and-after study to compare the impact of a bus rapid transit (BRT) system in Mexico City on air quality.(22) The study concluded that the BRT was a success from an environmental perspective because it found a reduction in emissions of a number of pollutants. A similar study was conducted by Nugroho, Fujiwara and Zhang in Jakarta, Indonesia, after the implementation of a BRT system. That study also found a reduction in emissions.(23)

Analyzing additional off-peak service along the Pascack Valley line in New Jersey, Deka and Marchwinski included in their survey a question about what the riders' alternative transportation would have been.(24) The study used a formula developed by the United States Environmental Protection Agency to estimate GHG emissions from transit riders potentially diverting to the automobile. A study by Martin and Shaheen on GHG emission impacts of car sharing employed a similar strategy to retroactively attain emissions before a service.(25) This study used a survey that asked participants to estimate VMT in the year before joining the car sharing service and to state the make, model, and year of the car. These details were used to attain the fuel economy of the vehicles from the EPA's database. Subsequently the fuel economies were used as inputs into the EPA's method for calculating GHG emissions.

American Public Transit Association's (APTA) guide to Quantifying GHG Emissions from Transit identified a number of factors to quantify the emissions from transit service.(26) Bailey et al. used a model that takes into account these factors to estimate transit's effect on air quality.(27) The study considered reduction in emissions due to reduced VMT, congestion, and changes in land use patterns around transit. In another study, Feigon also addressed land use around transit.(28) The study asserted that transit-supportive polices and land uses are needed to achieve a substantial reduction in GHG.

The impact of buses on air quality is more nuanced than transit in general. O'Toole noted in 2008 that buses are not always running at capacity and do not have good fuel economies.(29) He pointed out that buses on busy bus corridors are often replaced by rail, and when that happens, riders along the corridor divert from bus to rail. Yet, instead of drastically curtailing bus service, buses are re-oriented to serve as feeder to rail transit. The result, he concluded, is increased fuel consumption and GHG emissions per passenger mile from transit.

By providing people the opportunity to avoid making automobile trips, transit can reduce automobile trips, VMT, and emissions from automobiles. However, transit also contributes to air pollution due to emissions from buses and trains. In the context of rail transit, Deka and Marchswinski noted that different emissions models predict widely divergent emissions from transit.(24) The emissions from bus transit also vary based on the type of engine buses use, including the new electric and hybrid options. Tzeng et al. examined buses with traditional internal combustion engine, hybrid electric engine, and full electric engine by using multi-criteria optimization.(29) The study concluded that hybrid electric buses were the best choice for improving air quality. In another study, Hajbabaei et al. examined the impact on emissions of different compositions of compressed natural gas.(31)

Traffic Simulation Models

Bus operation has the potential to reduce traffic congestion by shifting riders from automobiles to public transit. It is important for this research is to understand how the shift from automobiles to other modes of transport (e.g., buses) can alleviate road congestion. Recognizing that traffic operation is a complex system involving signals, drivers and passengers, cars and the built environment, it is challenging to develop an exact formulation of the traffic capacity and congestion. In practice, traffic simulation is commonly used to approximate the likely traffic scenarios given various infrastructure and operational characteristics. One widely used simulation tool is Highway Capacity Software (HCS), developed by McTrans associated with the University of Florida.(32) This software implements the Highway Capacity Manual procedures for urban streets, signalized intersections, interchange ramp terminals, roundabouts, basic freeway segments, freeway weaving segments, freeway merge and diverge segments, freeway facilities, two-lane highways and multilane highways. The HCS is suited to analyze relatively moderate traffic congestion through a quick and easy procedure to evaluate whether an infrastructure element operates above or below capacity. In addition, there are a number of other traffic simulation tools, such as CORSIM, TRANSYT and SYNCHRO.(33)

Hidas et al. used a simulation tool called AIMSUN to evaluate the effect of buses on traffic.(34) Cortes et al. provided a systematic review on the existing simulation tools for modeling passengers and buses, discussed their relative advantages and limitations, and proposed possible extensions.(35) In order to assist transportation analysts in choosing and using proper traffic simulation software, the Federal Highway Administration (FHWA) published a report that describes a process for the recommended use of traffic microsimulation software in transportation analyses.(36) The seven-step process include: 1) scope project, 2) data collection, 3) base model development, 4) error checking, 5) compare model fit to field data (and adjust model parameters), 6) alternatives analysis, and 7) final report. Each step is described in detail and accompanied with practical examples.

Transit Surveys

It was important for this research to examine the literature related to transit survey methods. In A Design Manual for Customer On-Board Surveys, Baltes made recommendations about conducting transit surveys based on a review of over 100 reports from transit agencies in the US and Canada and a review of general survey literature.(37) The guide goes through the process of conducting a transit surveys from sampling respondents to reporting results. Of importance to this study is the section on crafting and administering surveys. The guide explains two different types of survey questions. It asserts that questions should be unbiased and easy to respond. Questions should be worded in the simplest form to avoid different interpretations by different respondents. According to the guide, responses to hypothetical questions should be interpreted with caution. It mentions that questions should be worded to minimize this negative reaction. Finally, the guide makes note of the survey delivery methods, noting that self-administered surveys distributed on board by surveyors related to the transit agency are the most common method. The guide notes that these surveys have a modest response rate but they save time.

With the advent of electronic data collection technologies, it has become important to examine the effectiveness and efficiency of different data collection methods. From a comparison of self-administered paper surveys, self-administered online surveys, and interviewer-administered surveys on tablets, Agrawal et al. recommended the use of traditional paper surveys for collecting data from transit riders.(38) The online option had the lowest return rate, while the paper survey was completed by most people. Therefore, the study recommended the use of a self-administered paper survey to collect data from transit riders.

Conclusions

This literature review showed that a fairly large number of studies have already been conducted on transit's air quality and congestions effects, but most of the studies were conducted in the general context of transit or in the context of rail transit. Only a few studies were specifically conducted for bus transit. Studies have generally shown mixed results, some showing a significant effect of transit, but others showing little or no effect.

The literature review showed empirical studies on the effect of transit on air quality and congestion can be before-and-after studies when the transit system is newly built. However, for existing systems, it is important to find out how many people would deviate to the automobile if the transit systems did not exist. While some studies on existing systems sometimes used data from periods of transit worker strikes, other studies used stated preference surveys asking riders how they would travel in the absence of transit. The literature shows that examining transit's impact by focusing on transit strikes has a limitation in that the effects of strikes are short term. Although stated preference studies are more advantageous in that regard, their results also need to be interpreted with care since people may not always do what they say they would do.

The brief discussion on traffic simulation studies provided a description of the methods used and the data needed. The review of transit survey methods showed the advantages and disadvantages of the methods. The review provided some principles for survey design and showed the circumstances when caution is necessary. It also showed that onboard paper surveys are more efficient than surveys conducted by other modes, such as the Internet.

CONDUCTING SURVEY AND ANALYZING SURVEY DATA

Introduction

The rider survey on the 23 routes was completed in two seasons: the spring and fall of 2016. The spring survey was conducted for five weeks (from 3-30-16 to 4-27-16) and the fall survey was conducted for eight weeks (from 9-20-16 to 11-15-16, with one cancelled week in between). Surveys were completed on six routes during spring and 17 routes during fall. A reason for the discrepancy of number of surveyed routes between the two seasons is that the number of trips and riders per route were far greater for the spring routes than the fall routes. The spring survey included routes from only the Hudson County Group, whereas the fall survey included routes from both Hudson and Middlesex/Monmouth County Groups. The research team's objective was to complete the surveys of the Hudson County routes before conducting survey in the other three County Groups. However, because of a train crash at the Hoboken Terminal on September 29, the survey in the Hudson Group was temporarily suspended. After a break for several days, the surveyors were sent to selected Middlesex/Monmouth County routes. Towards the end of the fall survey, as ridership on the Hudson County routes went back to normal, surveyors went back to survey the Hudson County routes.

Survey Preparation

The survey questionnaire was provided to the research team by NJ TRANSIT because of the need to be consistent with past surveys by the agency. Only minor tweaks were needed to ensure that the survey generated the required information for this research. The research team formatted the survey following instructions from NJ TRANSIT and added the consent language required by the Institutional Review Board (IRB) of Rutgers University. Approval for the survey was acquired from IRB prior to the survey.

For each season, approximately three weeks were needed to prepare for the survey. First, the surveyor jobs were advertised using various online outlets at Rutgers University's New Brunswick campus. For the Spring survey, a total of 31 students were hired to conduct onboard surveys and two additional students were hired to undertake survey scheduling and monitoring activities from the survey center set up at the Alan M. Voorhees Transportation Center. For the fall survey, 13 surveyors from the spring survey were retained and additional 18 new surveyors were hired for a total of 31 surveyors.

Prior to the survey, mandatory training sessions were organized for the surveyors in each season. The training included topics such as preparation, responsibility, role, safety, and courtesy. Staff from VTC and NJ TRANSIT provided instruction at each session. All surveyors were required to take additional training on human subject research administered online by the Rutgers University Institutional Review Board (IRB) and obtain the Collaborative Institutional Training Initiative (CITI) certificate. NJ TRANSIT notified the bus garage personnel and NJ Transit police about the survey and provided an authorization letter which included the names of all surveyors that was carried by the surveyors when conducting the onboard survey. Each surveyor was also provided an apron bearing the Rutgers University logo to be worn during the survey.

NJ TRANSIT determined the number of surveys to be printed (both Spanish and English). Each survey instrument (and the envelope) had a unique serial number. Before the commencement of the survey in each season, NJ TRANSIT provided the driver paddles for the pertinent routes to the research team. The bus driver paddles are the schedules for each bus showing the daily trips, including arrival and departure times. The paddles are used by drivers to maintain their schedule. The research team used the paddles to prepare assignment sheets for each bus trip surveyed. The assignment sheets had all bus stops for the route listed, in addition to the trip start time and end time and beginning stop and ending stop. They also had spaces for the surveyors to write down the number of boarding and alighting riders at each stop.

The schedulers at the survey center prepared a contact list of all surveyors, indicating which surveyors had personal automobiles to drive themselves and other surveyors to the survey site. They also prepared a document indicating each surveyor's availability on Tuesdays, Wednesdays, and Thursdays. Using this document and the driver list, VTC staff prepared the survey schedule for each week. The schedule was emailed to all surveyors a week prior to the actual survey for confirmation. Once confirmation was received, survey bags, containing survey instruments, pencils, assignment sheets, etc., were prepared for each day. Drivers for each shift were instructed to collect the bags the evening before the survey date.

At the survey center, VTC staff and students prepared a "Masterfile" containing information on each scheduled trip, including the names of the surveyors and the drivers carrying surveyors to the site as well as start and end time of shifts. The Masterfile was used to monitor the progress of the survey each day. When trips were missed for any reason (e.g., late arrival of bus, buses posting a run number different from assignment sheet, surveyor failing to find bus stop, etc.), the information was recorded in the Masterfile so that surveys for the missed trips could be scheduled on a future date.

Conducting the Onboard Survey

Designated drivers carried one or three other surveyors to the site, depending on the schedule for that day. The surveyors arrived at the beginning bus stop 15-20 minutes before the departure time of the bus. They introduced themselves to the bus operators and presented their Rutgers ID card and the NJ TRANSIT authorization letter issued. When bus runs included a large number of trips (e.g., eight or ten trips), the surveyors continued to stay on the same bus conducting survey for a maximum of eight hours per shift. When runs contained only two or three trips, the surveyors often transferred to another run on the same route or to another route operating in the same area.

Two surveyors boarded each bus to conduct survey and record the number of riders. One surveyor distributed and collected completed surveys, whereas the other surveyor filled out the assignment sheets, including the number of boarding and alighting riders at each stop. At the conclusion of each trip, the surveyors bundled the completed surveys together with the assignment sheet for the trip and prepared for the next trip. At the conclusion of the entire shift, they organized the completed and unused surveys into separate bundles and brought them back to the survey center, where completed surveys from each trip were filed separately in locked filing cabinets. Approximately 90% of the completed surveys were collected onboard by the surveyors onboard while the remaining surveys were mailed back by the respondents in postage-paid envelopes given to them.

Data Entry, Cleaning, Geocoding, and Weighting

For each season, two students were hired for entering data from the paper surveys into a computer. Prior to the task, English and Spanish data-entry templates were set up in Qualtrics and the data-entry personnel were familiarized with each bus route surveyed. Once the data were entered, the data were checked for anomalies such as duplicate entry and implausible serial number. Whenever possible, the erroneous data were corrected.

The trip origins and destinations of the riders were subsequently geocoded using ArcGIS. When the respondents provided detailed addresses, it was possible to geocode the origins and destinations to exact location. When respondents provided only partial addresses such as only the street name or the zip code, their origins and destinations were geocoded to an approximate location.

In the final step of the process, a weight variable was created following a methodology provided by NJ TRANSIT. The methodology uses average weekday ridership data for each route together with directional number of respondents for peak and off-peak periods. Application of the weight variable expands the survey responses to represent the full universe of weekday riders on each route.

Data Analysis

The survey data analysis for this report included only frequency tables and cross-tabulations. The analysis was divided into two broad sections: (a) rider characteristics, and (b) trip characteristics. The rider characteristics pertain to demographic and socioeconomic variables. The trip characteristics include trip origins and destinations, access and egress modes, trip frequency, return trip mode, ticket type, ticket type, the availability of alternative modes, et cetera.

NJ TRANSIT requested detailed route-specific results from all survey questions. Due to limitations imposed by NJDOT on report length, the detailed tables are provided in two separate volumes, each pursuant to the two sections mentioned above. In the following two broad sections, the analysis results are presented in summary tables for all routes. For ease of comparison, the results are presented only in percentage form together with the total number of weekday riders for each route. It is important to note that all analyses in this report were undertaken by using the weight variable so that the numbers represent weekday riders instead of survey respondents.

The survey margins of error (MOE) for each route are shown in Table 2. The results for the routes with a large MOE are less representative of the riders (e.g., Rt. 822 with 16.4% MOE) than the results for the routes with a lower MOE (e.g., Rt. 87 with 1.2% MOE).

Table 2 – Margin of error for surveyed routes at the 95% confidence level

Rt. #	Margin of Error (Percent)
6	3.5
22	2.5
30	2.8
80	1.6
81	2.6
82	7.7
83	2.3
84	1.9
85	2.7
86	4.7
87	1.2
89	3.4
108	3.2
181	4.7
329	9.0
801	9.8
802	8.0
803	8.6
804	8.6
813	4.1
817	7.5
819	5.8
822	16.4

RIDER CHARACTERISTICS

introduction

This broad section presents a description of the demographic and socioeconomic characteristics of the surveyed riders. The demographic characteristics include gender and age. The socioeconomic characteristics include race, ethnicity, occupation, income, household size, number or vehicles in household, et cetera. All figures shown here represent average weekday riders.

Gender

The male-female split of riders for the surveyed routes is presented in Table 3. One can apply the percentages to the number of riders in the last column (N) to calculate number of male and female riders for each route. In the table, N represents weighted survey respondents who responded to the question instead of all riders. When comparing the male-female percentage split of riders per route, one may note that the split for New Jersey's population as a whole, according to the 2015 American Community Survey, is 48.8 percent male and 51.2 percent female.

Table 3 – Male-female split of riders for the surveyed routes

	Percent			Riders
Rt.	Male	Female	Total	(N)
6	33.23	66.77	100.00	1,339
22	35.02	64.98	100.00	2,116
30	48.56	51.44	100.00	2,051
80	41.25	58.75	100.00	6,631
81	33.48	66.52	100.00	2,682
82	56.19	43.81	100.00	315
83	48.16	51.84	100.00	3,310
84	34.35	65.65	100.00	4,050
85	44.07	55.93	100.00	1,643
86	43.28	56.72	100.00	677
87	39.03	60.97	100.00	10,480
89	29.10	70.90	100.00	1,251
108	43.00	57.00	100.00	1,293
181	57.81	42.19	100.00	448
329	51.43	48.57	100.00	245
801	87.91	12.09	100.00	182
802	74.67	25.33	100.00	304
803	68.48	31.52	100.00	257
804	69.62	30.38	100.00	260
813	58.09	41.91	100.00	878
817	35.20	64.80	100.00	304
819	42.05	57.95	100.00	516
822	0.00	100.00	100.00	75

When compared to the state population, the share of female riders is higher than the state's population for 13 of the 23 routes, lower in eight routes, and more or less equal in the remaining two routes. Most routes with a lower share of female riders are in the Middlesex/Monmouth Country group. For the Hudson County routes, where ridership is significantly higher, the share of female riders is also higher.

One should note that the proportion of male riders in Table 3 is shown as 0.00 percent from weighted data because of a large margin of error for that route. The same analysis with unweighted data shows that 7.7 percent of the riders are male.

Age

The age distribution of the riders for each surveyed route is shown in Table 4. The column N represents the weighted riders who responded. For reference, one may note that 22.7 percent of New Jersey's population is under age 18 and 18.6 percent is age 65 or over. For most bus routes surveyed, the proportion of riders belonging to these two age groups is smaller than the state population proportions.

Table 4 – Age distribution of riders for the surveyed routes

	Percent									
Rt.	Under 18	18-24	25-34	35-44	45-54	55-61	62-64	65+	Total	N
6	5.94	12.78	24.30	15.71	19.90	10.27	2.65	8.45	100.00	1,432
22	1.49	14.03	23.70	17.43	16.22	8.69	5.11	13.34	100.00	2,152
30	3.04	18.33	21.79	18.19	17.04	13.77	3.92	3.92	100.00	2,171
80	17.48	19.54	19.00	14.29	13.18	8.70	2.17	5.64	100.00	6,864
81	14.27	10.75	20.14	19.57	17.20	9.93	2.40	5.73	100.00	2,790
82	26.17	1.56	30.84	16.82	7.79	12.15	4.67	0.00	100.00	321
83	2.68	29.40	21.81	13.03	14.99	10.64	2.16	5.29	100.00	3,476
84	5.52	14.38	19.08	14.99	15.91	13.63	5.15	11.33	100.00	4,255
85	1.36	15.16	27.49	19.41	12.33	12.15	4.72	7.37	100.00	1,695
86	22.68	8.22	23.08	17.64	8.36	8.49	2.39	9.15	100.00	754
87	8.83	15.66	21.72	17.30	17.21	10.26	3.24	5.77	100.00	10,893
89	0.60	10.28	22.06	20.11	16.80	16.13	4.88	9.15	100.00	1,333
108	3.86	31.62	17.31	13.59	13.52	10.73	1.79	7.58	100.00	1,398
181	0.00	7.14	13.69	19.25	23.21	10.52	6.35	19.84	100.00	504
329	0.00	3.67	42.04	26.53	15.51	10.61	1.63	0.00	100.00	245
801	0.00	0.00	29.95	37.56	13.20	15.23	2.03	2.03	100.00	197
802	0.00	3.95	33.74	46.81	6.38	7.90	0.00	1.22	100.00	329
803	0.00	6.46	37.26	47.91	4.56	0.00	0.00	3.80	100.00	263
804	0.00	8.15	18.15	27.78	34.44	6.67	1.48	3.33	100.00	270
813	1.20	43.65	13.89	8.97	16.52	9.85	2.63	3.28	100.00	914
817	2.17	13.35	23.29	15.84	16.46	14.60	4.66	9.63	100.00	322
819	8.15	15.00	28.33	13.89	18.52	10.37	3.15	2.59	100.00	540
822	30.67	0.00	49.33	6.67	0.00	6.67	0.00	6.67	100.00	75

Insofar as riders below age 18 are concerned, the highest proportion was found for Rt. 822 in Middlesex/Monmouth County Group. However, the share of such riders is among the lowest for several routes in that County Group (Routes 801, 802, 803, 804), which primarily serve as rail feeder. On the other hand, for several Hudson County routes (Routes 82, 86, 80, 81) the share of riders under age 18 is high (greater than 10 percent). A reason for the large proportion of under-18 riders on some routes, especially those in Hudson County, is that they are used heavily by high school students traveling to and from school. Another reason is that those students had a greater exposure than workers because of the survey period. As the survey period was between 6 AM and 4 PM, most students had exposure to the surveyors twice, whereas many regular office workers presumably had exposure only once because they return from work after 4 PM.

The survey data does not indicate that the share of riders under age 18 is higher or lower in any specific County Group. However, the proportion of riders age 62+ (age 62-64 plus 65+) is noticeably higher in the Hudson routes than the Middlesex/Monmouth routes. The eight routes that have greater than 10 percent riders in the age 62+ group are all in Hudson County. The route with the highest share is Interstate NYC Route 181 with more than 26 percent riders in that age. Among the 10 routes with the lowest share of riders age 62+, only three are from the Hudson County Group whereas the other seven are from the Middlesex/Monmouth County Group.

Race

The share of riders belonging to different races is shown in Table 5. For reference, one may note that the share of white, African American, and Asian persons in the state of New Jersey, according to the 2015 American Community survey, are 67.7 percent, 13.4 percent, and 9.5 percent, respectively.

In none of the 23 routes the share of white persons is close to the state population share of 67.7 percent. It indicates that the surveyed local buses provide access to a relatively large share of racial minorities. The highest share of white persons can be observed for Route 817, where the share is 53.4 percent.

The share of African Americans is greater than the state average of 13.4 percent in 12 of the 23 routes. These routes are found in both County Groups. For example, Rt. 819 in Middlesex/Monmouth Group has the highest share of African American riders (65 percent), followed by Rt. 6 in Hudson County with 60 percent African American riders.

Five of the routes with the highest proportion of non-white riders are in the Middlesex-Monmouth County Group (Routes 801, 802, 803, 804, and 819). However, that is primarily because of extremely large share of Asian riders. In four of those five routes, the share of Asian riders is more than 70 percent. For these routes, the share of African American riders is low despite the proportion of nonwhite riders being high.

The share of Asian riders is significantly higher for most surveyed routes compared to the share of Asians in New Jersey in general. For instance, for 16 of the 23 routes, the share of Asian riders is greater than the state average. For Rt. 802, an overwhelming 92.3 percent of the riders are Asian. In sum, all surveyed routes serve a far larger proportion of racial minorities compared to the state's racial minority population. For some routes, it is because they serve an overwhelmingly large Asian population, for other routes it is because they serve a very large proportion of African American population.

Table 5 – Racial composition of riders for the surveyed routes

	Percent							
Rt.#	White	Black or African American	Asian	American Indian or Alaska Native	Multi-racial	Other	Total	N
6	15.70	60.02	8.75	0.00	4.82	10.71	100.00	1,223
22	43.84	9.53	10.24	0.00	9.71	26.68	100.00	1,679
30	41.74	16.52	16.14	1.33	6.64	17.63	100.00	1,883
80	17.73	28.25	33.22	1.19	8.18	11.42	100.00	6,113
81	27.88	42.98	10.62	0.00	7.04	11.48	100.00	2,457
82	22.78	7.12	47.33	0.00	10.68	12.10	100.00	281
83	33.37	15.33	24.62	1.74	9.11	15.83	100.00	2,811
84	42.25	14.75	8.78	1.35	11.12	21.75	100.00	3,472
85	32.57	10.91	19.60	0.93	5.77	30.22	100.00	1,403
86	37.92	12.75	29.53	1.51	8.39	9.90	100.00	596
87	20.95	42.04	16.90	1.14	6.87	12.11	100.00	9,770
89	51.11	12.60	4.64	4.54	8.87	18.25	100.00	992
108	29.06	26.56	7.40	0.62	15.06	21.30	100.00	1,122
181	44.75	3.31	25.41	3.31	9.94	13.26	100.00	362
329	45.25	7.69	35.29	0.00	4.07	7.69	100.00	221
801	3.61	2.06	80.41	2.06	2.06	9.79	100.00	194
802	1.23	1.23	92.31	0.00	1.23	4.00	100.00	325
803	14.34	6.77	74.90	1.99	1.99	0.00	100.00	251
804	5.02	6.95	84.94	0.00	1.54	1.54	100.00	259
813	25.43	32.88	17.49	0.00	6.20	17.99	100.00	806
817	53.43	16.97	1.81	1.81	0.00	25.99	100.00	277
819	10.76	64.98	4.22	0.84	8.44	10.76	100.00	474
822	24.56	57.89	0.00	0.00	17.54	0.00	100.00	57

Ethnicity

Responses to a survey question inquiring about the ethnicity of the riders are summarized in Table 6. It shows the percent of riders for each route that were Hispanic, Latino, or Spanish. For reference, one may note that the proportion of Hispanic or Latino persons in entire New Jersey in 2015 was 19.7 percent. Only for five of the 23 surveyed routes (Routes 329, 801, 802, 803, 804) the proportion of Hispanic riders is lower than the state average. For all routes combined, the share of Hispanic or Latino riders is far greater than the share of Hispanic or Latino persons among New Jersey’s state population.

Table 6 – Ethnicity of riders for the surveyed routes

	Percent			
Rt. #	Hispanic, Latino, or Spanish	Not Hispanic, Latino, or Spanish	Total	N
6	36.29	63.71	100.00	1,185
22	72.08	27.92	100.00	1,977
30	53.57	46.43	100.00	1,988
80	26.29	73.71	100.00	6,085
81	29.80	70.20	100.00	2,406
82	38.31	61.69	100.00	295
83	56.02	43.98	100.00	3,163
84	72.61	27.39	100.00	3,929
85	55.23	44.77	100.00	1,577
86	54.55	45.45	100.00	704
87	32.67	67.33	100.00	9,418
89	74.06	25.94	100.00	1,226
108	62.26	37.74	100.00	1,256
181	70.82	29.18	100.00	473
329	17.04	82.96	100.00	223
801	2.06	97.94	100.00	194
802	1.33	98.67	100.00	300
803	8.56	91.44	100.00	257
804	1.62	98.38	100.00	247
813	36.75	63.25	100.00	879
817	47.93	52.07	100.00	290
819	27.85	72.15	100.00	474
822	78.46	21.54	100.00	65

Table 6 shows that the proportion of Hispanic or Latino riders varies widely for the surveyed routes, with the lowest for Rt. 802 in Middlesex/Monmouth County Group (only 1.3 percent) and the highest for Rt. 822 in the same County Group (78.5 percent). However, the routes in Middlesex/Monmouth County Group, on average, have a lower proportion of Hispanic or Latino riders than the routes in the Hudson County Group. For example, among the five routes with the lowest proportion of Hispanic or Latino riders, four are in the Middlesex/Monmouth County Group. The reason for the generally higher proportion of Hispanic or Latino riders in the Hudson County routes than the Middlesex/Monmouth County Group is that the proportion of Hispanic or Latino persons living in Hudson County is far greater the proportion living in Middlesex and Monmouth Counties.

Household Income

The distribution of annual household income of riders on the surveyed routes is shown in Table 7. For comparing the income of riders with the state's population, one may note that only 11.0 percent of the state's population has a household income below $15,000 and 15.5 percent has an income below $25,000. At the other end of the spectrum, 6 percent of the state's population has household income greater than $200,000 and 27.6 percent has an income exceeding $100,000.

Only for five of the 23 routes, the share of riders with income less than $15,000 (and also $25,000) is lower that the share of New Jersey population with that level of income. These routes are Rt. 329 in Hudson County Group and Routes 801, 802, 803, and 804 in Middlesex/Monmouth County Group. Rt. 329 serves Harmon Cove and Secaucus Junction and the 801, 802, 803, and 804 routes serve Metropark Station. For the other 18 routes, the share of riders with such low levels of income was greater than the share of persons with similar income in the state, indicating that most bus routes serve a large share of low-income riders. By comparing the income of riders with New Jersey population's income at the high end of the income spectrum, one would come to the same conclusion. For example, only for two of the 23 routes (Rt. 329 and Rt.804), the share of riders with $200,000+ income exceeds the share of New Jersey population with that level of income.

Table 7 – Annual household income of riders for the surveyed routes

Rt. #	Under $15K	$15K-$24K	$25K-$49K	$50K-$74K	$75K-$99K	$100K-$199K	$200K+	Total	N
6	33.96	22.33	26.65	11.54	2.72	2.46	0.34	100.00	1,178
22	36.05	19.58	20.66	9.56	5.11	6.56	2.48	100.00	1,936
30	37.03	24.32	23.74	6.36	3.62	4.04	0.89	100.00	1,904
80	23.07	17.13	24.97	15.61	9.02	8.00	2.19	100.00	5,574
81	23.88	14.90	27.17	12.12	9.25	10.12	2.55	100.00	2,194
82	13.67	1.95	23.05	26.95	19.14	15.23	0.00	100.00	256
83	37.28	19.60	25.02	6.79	5.33	5.16	0.82	100.00	2,929
84	34.49	19.21	27.22	10.78	4.90	3.19	0.21	100.00	3,758
85	28.36	21.64	20.25	17.13	8.76	3.87	0.00	100.00	1,576
86	25.74	10.70	26.66	17.05	6.20	10.86	2.79	100.00	645
87	33.33	14.67	26.79	12.01	5.66	6.06	1.48	100.00	9,508
89	24.77	17.33	30.94	13.52	3.36	8.62	1.45	100.00	1,102
108	28.33	14.53	26.49	15.89	6.02	8.19	0.56	100.00	1,246
181	26.43	7.93	29.30	6.17	7.93	22.25	0.00	100.00	454
329	0.00	10.96	20.61	7.46	13.16	30.70	17.11	100.00	228
801	2.34	4.09	12.87	17.54	23.98	35.09	4.09	100.00	171
802	1.46	4.74	6.20	15.69	31.39	39.05	1.46	100.00	274
803	0.00	12.45	9.44	16.74	15.45	45.92	0.00	100.00	233
804	7.50	3.75	9.17	7.50	20.42	38.75	12.92	100.00	240
813	29.86	14.50	31.85	18.22	2.48	3.10	0.00	100.00	807
817	46.43	20.71	22.50	4.29	4.29	1.79	0.00	100.00	280
819	35.48	18.57	32.62	4.52	8.81	0.00	0.00	100.00	420
822	69.70	0.00	0.00	15.15	15.15	0.00	0.00	100.00	33

Note: K refers to one thousand. For example, $15K is $15,000.

A comparison of household income across the surveyed routes shows that income of riders in the Middlesex/Monmouth County routes is generally higher than riders in the Hudson County routes. However, there are a few exceptions. For example, Middlesex/Monmouth County routes such as Rt. 817 and Rt. 822 also have a large share of low-income riders, whereas Rt. 329 in Hudson County has a very high share of high-income riders.

Vehicles in Household

The availability of household vehicles for riders of the 23 bus routes is shown in Table 8. It shows the share of riders with no vehicle, one vehicle, two vehicles, and three or more vehicles in household. Among these groups, those with no vehicles in household are of greater significance since public transit is expected to serve them more than persons from households with one or more vehicles. For reference, one may note that the proportion of households with no vehicles in household in the state of New Jersey is 11.7 percent.

Table 8 – Distribution of riders by number of vehicles in household

	Percent					
Rt. #	No car	One car	Two cars	Three or more cars	Total	Riders (N)
6	60.38	27.49	9.43	2.70	100.00	1,368
22	59.28	29.50	7.17	4.05	100.00	2,149
30	50.00	35.15	8.70	6.15	100.00	2,114
80	38.85	33.83	19.53	7.79	100.00	6,754
81	43.47	37.22	15.48	3.83	100.00	2,687
82	56.70	27.73	9.35	6.23	100.00	321
83	49.91	34.24	12.13	3.72	100.00	3,388
84	55.92	32.01	9.58	2.49	100.00	4,174
85	63.65	29.96	4.76	1.63	100.00	1,659
86	56.69	32.19	9.93	1.19	100.00	755
87	53.76	30.50	12.02	3.72	100.00	10,739
89	53.99	32.17	11.48	2.36	100.00	1,315
108	37.92	38.71	19.25	4.12	100.00	1,382
181	50.00	25.00	22.67	2.33	100.00	516
329	20.82	44.49	34.69	0.00	100.00	245
801	17.46	51.32	27.51	3.70	100.00	189
802	10.43	64.42	21.17	3.99	100.00	326
803	11.79	60.84	25.48	1.90	100.00	263
804	9.52	40.29	42.12	8.06	100.00	273
813	34.64	37.78	21.19	6.39	100.00	892
817	54.43	30.06	10.13	5.38	100.00	316
819	41.59	34.04	16.63	7.74	100.00	517
822	62.30	37.70	0.00	0.00	100.00	61

Table 8 shows that the share of riders with no vehicles in household is lower than the state as a whole only for Rt. 802 and Rt. 804. The share for Rt. 803 is almost similar to the share of the state population with no vehicles. For the other 20 routes, including Rt. 329, where riders on average have a high income, the share of riders with no vehicle in household is greater than the share for the state's overall population. The results thus substantiate the usual belief that public transit disproportionately serves persons from households with no vehicles.

A comparison across the surveyed routes shows that the riders of the Hudson County Routes are generally more likely to belong to households without vehicles than the riders of the Middlesex/Monmouth County routes. Of the 12 routes where 50 percent or more riders belong to households without vehicles, 10 are in Hudson County and only 2 are in the Middlesex/Monmouth County Group. The share of riders with no vehicles in household is extremely high for Rt. 822 (62.3 percent) and relatively high for Rt. 817 (54.4 percent). The share of low-income riders for these routes is also extremely high.

Occupation

Selected occupation of riders from the survey data analysis is shown in Table 9. In addition to the occupations shown in the table, a few other occupations, including “not currently employed,” “home maker,” “non-office worker” and “other” were included in the survey questionnaire as response categories. Those categories have been combined into the “Other” category in Table 8 because of space limitation.

Table 9 – Occupation of riders

	Percent								
Rt.#	Management/ Professional	Technical/ Skilled	Clerical/ Secretarial	Sales/ Retail	Retired	Student	Other	Total	Riders (N)
6	12.62	5.30	11.21	4.28	6.31	13.55	46.73	100.00	1,284
22	14.39	4.15	3.17	4.83	13.56	15.37	44.55	100.00	2,050
30	8.78	9.27	7.05	8.23	4.29	19.23	43.15	100.00	2,028
80	14.42	8.79	7.27	6.17	4.56	26.79	32.00	100.00	6,465
81	19.10	8.17	9.67	8.84	5.34	17.41	31.47	100.00	2,545
82	20.92	19.28	11.11	0.00	0.00	24.18	24.51	100.00	306
83	9.25	8.65	6.16	9.04	3.91	26.40	36.59	100.00	3,296
84	11.07	7.44	6.75	5.74	8.91	14.67	45.42	100.00	4,075
85	14.98	14.17	3.07	13.23	7.84	9.22	37.49	100.00	1,595
86	13.06	9.25	1.90	5.58	6.94	20.82	42.44	100.00	735
87	14.92	8.13	6.97	6.81	4.96	19.66	38.55	100.00	10,449
89	15.92	6.34	5.20	5.61	3.57	7.31	56.05	100.00	1,231
108	15.83	2.51	4.29	9.17	7.84	30.18	30.17	100.00	1,352
181	19.54	13.66	5.04	2.52	3.36	5.04	50.84	100.00	476
329	55.32	12.77	11.06	12.34	0.00	0.00	8.51	100.00	235
801	37.37	46.84	5.79	2.11	0.00	2.11	5.79	100.00	190
802	35.20	54.93	2.96	1.32	0.00	4.28	1.32	100.00	304
803	32.14	44.05	1.98	5.95	0.00	0.00	15.87	100.00	252
804	37.45	44.40	1.54	1.54	0.00	5.02	10.03	100.00	259
813	16.27	5.61	4.15	8.19	2.81	28.28	34.68	100.00	891
817	3.28	7.87	5.57	8.52	12.79	4.59	57.38	100.00	305
819	1.22	7.52	2.24	15.24	3.05	15.65	55.08	100.00	492
822	0.00	0.00	0.00	0.00	0.00	44.23	55.78	100.00	52

It is evident from the table that some of the Middlesex/Monmouth County routes (e.g., Routes 801, 802, 803, 804) have the highest share of riders with Management/Professional and Technical/Skilled occupations, whereas some other routes (e.g., Routes 817, 819, 822) from the same County Group have the lowest share of riders with these occupations. Riders on the routes with a low share of workers in these two occupational categories also have very low household income. One may note that the Middlesex County routes with a large share of Management/Professional and Technical/Skilled occupations are feeder routes serving the Metropark Station.

The share of students in a number of routes is exceptionally high. Rt. 822 in Middlesex/Monmouth County Group has the highest share of student riders (44.2 percent), but this result needs to be interpreted with care since the margin of error for that route is very high. Interstate NYC Rt. 108 has the highest share of students in the Hudson County Group (30.2 percent). Although selected routes from both County Groups have a very high share of student riders, few routes in Hudson County have a low share of student riders. For 11 of the 15 Hudson County routes, the share of student riders is greater than 10 percent.

Household Size

The distribution of riders by household size (i.e., number of persons in household), is shown in Table 10. Of particular interest are the proportions of riders in single-person and 5+ person households since existing literature generally shows that persons from single-person households typically use more transit and persons from large households typically use less transit.

Data from the 2015 American Community Survey show that 25.2 percent of persons in New Jersey as a whole lives in single-person households and 11.8 percent lives in households with five or more persons. For only two routes (Rt. 85 and Rt. 181 in Hudson County Group), the share of riders in single-person households is greater than the share of state population in single-person households. There are two inter-related reasons for this discrepancy. First, the proportion of persons living in single-person households generally is high because many elderly persons live in single-person households. Second, as shown in Table 4, the share of elderly riders is significantly lower than the share of elderly persons in the state for most surveyed routes.

Table 10 – Distribution of riders by household size

	Percent						
Rt. #	One person	Two person	Three person	Four person	Five or more person	Total	Riders (N)
6	16.85	23.90	20.75	18.58	19.93	100.00	1,335
22	22.46	22.83	24.48	21.28	8.95	100.00	2,124
30	19.89	21.39	17.87	22.19	18.67	100.00	2,132
80	12.17	17.04	19.90	24.44	26.45	100.00	6,707
81	14.57	25.83	25.05	19.57	14.98	100.00	2,683
82	8.17	19.28	19.28	35.29	17.97	100.00	306
83	11.75	20.01	21.65	25.25	21.35	100.00	3,363
84	17.01	22.14	22.21	20.85	17.80	100.00	4,120
85	25.63	28.45	23.83	10.44	11.64	100.00	1,666
86	9.63	25.40	19.65	23.80	21.52	100.00	748
87	14.97	24.12	23.54	20.01	17.36	100.00	10,644
89	19.45	29.02	25.50	13.25	12.79	100.00	1,306
108	15.06	20.76	17.18	24.42	22.59	100.00	1,368
181	28.82	17.99	20.31	11.03	21.86	100.00	517
329	12.86	46.89	17.43	17.84	4.98	100.00	241
801	2.07	21.24	34.72	34.72	7.26	100.00	193
802	2.80	14.60	33.23	43.79	5.60	100.00	322
803	5.73	23.66	40.46	26.34	3.82	100.00	262
804	0.00	13.41	18.77	49.04	18.78	100.00	261
813	14.65	20.26	13.11	20.59	31.39	100.00	908
817	11.94	13.23	38.39	11.61	24.84	100.00	310
819	10.10	29.11	19.41	12.87	28.52	100.00	505
822	8.06	51.61	16.13	8.06	16.12	100.00	62

While the proportion of riders from single-person households is smaller for most routes than the share of New Jersey population from single-person households, the share of riders from 5+ person households is greater than the share of New Jersey population in such households for 17 of the 23 routes. The routes that have the lowest share of riders from 5+ households are also those that have a high share of riders from high-income households and the routes that have a very large share of riders from 5+ person households have a large share of riders from low-income households.

On the whole, the theory that persons from single-person households use more transit and persons from large households use less transit does not seem to apply to the surveyed bus routes. A reason for the discrepancy may be the special socioeconomic characteristics of riders on the surveyed routes.

Disability

The proportion of riders with disability for the surveyed bus routes is shown in Table 11. For reference, the proportion of person with disabilities in the entire state of New Jersey is 10.3 percent. Table 11 shows that the proportion of riders with disability is significantly smaller than the state average for all routes. A potential reason for the low share of riders with disability for the surveyed routes is the small share of elderly riders, for the share of persons with disability is usually significantly higher among elderly persons than non-elderly persons. Another reason for the low share of bus riders with disability is that many persons with disability use NJ TRANSIT's ADA-complementary Access Link paratransit service because of its greater convenience and comfort.

Table 11 shows that all routes with a relatively high share of riders with disability are in the Hudson County. In contrast, all routes in the Middlesex/Monmouth County Group have a low share of riders with disability. It also appears that the routes with very low share of riders with disability have a low share of riders with low household income.

Table 11 – Proportion of riders with disability

	Percent			
Rt. #	Has Disability	Does not have	Total	Riders (N)
6	5.70	94.30	100.00	1,387
22	5.84	94.16	100.00	2,142
30	4.18	95.82	100.00	2,107
80	2.86	97.14	100.00	6,717
81	4.17	95.83	100.00	2,713
82	1.56	98.44	100.00	320
83	4.24	95.76	100.00	3,369
84	4.99	95.01	100.00	4,170
85	2.58	97.42	100.00	1,668
86	6.49	93.51	100.00	755
87	5.37	94.63	100.00	10,717
89	4.68	95.32	100.00	1,283
108	3.02	96.98	100.00	1,390
181	3.09	96.91	100.00	517
329	0.00	100.00	100.00	241
801	0.00	100.00	100.00	190
802	1.21	98.79	100.00	330
803	0.00	100.00	100.00	263
804	1.44	98.56	100.00	277
813	0.79	99.21	100.00	886
817	3.73	96.27	100.00	322
819	0.00	100.00	100.00	511
822	0.00	100.00	100.00	61

TRAVEL CHARACTERISTICS

This broad section describes how the riders use buses on the surveyed routes. It includes discussions on origin and destination places, access and egress modes, trip frequency, travel mode for return trips, and type of tickets purchased.

Origin and Destination Places

The origin and destination places for this analysis do not pertain to any specific geographic locations such as cities, city blocks, or neighborhoods. Instead they pertain to places such as home, work, and schools. As such, the analyses show trip purposes rather than actual locations where trips started or ended.

The origins of the bus trips (i.e., the trips where the riders were intercepted by the surveyors) are presented in Table 12. The destination places for the routes are shown in Table 13.

Table 12 – Origin places of riders for bus trips

	Percent										
Rt. #	Home	Work	Shop	Personal business	Medical /dental	Social/ recreation	School (K-12)	Tech., college or university	Other	Total	Riders (N)
6	69.91	11.10	1.89	4.44	1.96	0.85	2.81	3.20	3.85	100.00	1,532
22	60.58	17.76	1.43	1.34	7.52	1.88	0.00	1.79	7.70	100.00	2,235
30	65.13	21.52	1.64	3.10	1.16	0.00	1.12	2.63	3.70	100.00	2,323
80	62.61	14.17	1.42	1.63	1.39	0.42	11.88	2.84	3.64	100.00	7,136
81	64.44	14.08	2.25	2.69	2.92	0.84	9.48	0.84	2.45	100.00	2,975
82	67.07	16.31	3.02	0.00	3.02	0.00	9.06	0.00	1.51	100.00	331
83	62.79	17.52	2.97	2.53	1.16	0.83	4.02	5.78	2.42	100.00	3,636
84	58.81	16.90	2.15	6.04	4.24	0.71	3.75	3.13	4.26	100.00	4,503
85	70.61	17.98	4.78	0.00	1.50	1.44	1.33	0.75	1.61	100.00	1,735
86	56.24	9.59	4.60	3.55	2.37	0.00	21.68	0.00	1.97	100.00	761
87	66.58	12.81	1.54	3.75	2.78	0.61	6.38	2.79	2.76	100.00	11,359
89	64.42	23.37	1.11	1.92	2.37	0.00	1.78	0.59	4.44	100.00	1,352
108	68.80	12.75	0.56	5.77	0.00	0.00	3.10	7.25	1.76	100.00	1,420
181	97.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	533
329	95.58	1.61	0.00	0.00	0.00	2.81	0.00	0.00	0.00	100.00	249
801	93.24	6.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	207
802	90.80	7.98	0.00	0.00	0.00	0.00	0.00	0.00	1.23	100.00	326
803	90.87	9.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	263
804	89.51	7.69	0.00	1.40	0.00	0.00	0.00	1.40	0.00	100.00	286
813	60.17	20.13	1.40	2.48	0.00	0.00	2.80	12.27	0.75	100.00	929
817	54.39	19.83	11.05	1.98	1.42	1.98	1.98	1.98	5.38	100.00	353
819	58.02	24.50	0.00	6.31	1.26	1.26	1.80	1.26	5.59	100.00	555
822	62.67	18.67	0.00	0.00	0.00	0.00	18.67	0.00	0.00	100.00	75

Table 12 shows that more than 50 percent of trips for each route originated at the riders' homes. A reason for such a high proportion of trips originating at home for all routes is that the survey was conducted between 6 AM and 4 PM. If the survey continued beyond 4 PM, the proportion of trips from home would have been lower since the many more workers' return trips from work would have been accounted for. For Routes 181, 329, 801, 802, and 803, more than 90 percent of the trips originated at home. A reason for this could be that these routes are predominantly used by commuters traveling to work.

Although significantly lower than trips originating at home, the share of trips originating at work is not negligible for most routes. For some routes such as Rt. 86 and Rt. 822, the share of trips originating at K-12 schools is also high. The share of trips originating at college or university is the highest for Rt. 813 probably because the route begins/ends at the Middlesex County College.

Table 13 – Destination places of riders for bus trips

	Percent										
Rt. #	Home	Work	Shop	Personal business	Medical /dental	Social/ recreation	School (K-12)	Tech., college or university	Other	Total	Riders (N)
6	22.56	41.19	2.62	13.46	6.48	0.73	1.97	4.73	6.26	100.00	1,374
22	24.55	43.61	4.46	3.92	6.12	3.14	3.04	5.59	5.59	100.00	2,041
30	26.84	41.57	2.09	5.75	3.28	0.38	2.61	11.92	5.56	100.00	2,105
80	24.82	41.29	1.81	4.42	2.54	1.69	11.05	7.28	5.10	100.00	6,703
81	26.78	47.29	2.02	4.66	3.89	1.21	9.65	0.95	3.56	100.00	2,726
82	18.44	56.88	0.00	4.69	0.00	0.00	16.88	0.00	3.13	100.00	320
83	24.15	41.03	3.29	3.95	2.18	1.67	3.80	14.17	5.77	100.00	3,346
84	29.37	36.97	3.42	5.01	6.55	1.17	3.05	7.28	7.16	100.00	4,092
85	17.76	60.48	7.57	0.00	4.07	0.94	1.19	4.50	3.50	100.00	1,599
86	37.43	32.89	6.58	6.29	1.32	3.65	5.70	3.95	2.19	100.00	684
87	22.74	41.49	2.13	7.42	4.52	1.20	7.39	7.16	5.97	100.00	10,626
89	22.73	49.30	2.11	5.16	3.75	1.25	2.66	3.28	9.77	100.00	1,280
108	22.84	40.34	0.53	4.89	1.76	0.00	2.44	20.86	6.34	100.00	1,309
181	9.73	75.22	9.73	0.00	2.65	0.00	0.00	2.65	0.00	100.00	452
329	2.81	94.38	0.00	2.81	0.00	0.00	0.00	0.00	0.00	100.00	249
801	3.68	92.11	0.00	0.00	0.00	0.00	0.00	2.11	2.11	100.00	190
802	0.00	91.48	0.00	2.95	0.00	0.00	0.00	5.57	0.00	100.00	305
803	5.32	94.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	263
804	1.52	90.15	0.00	3.41	0.00	0.00	0.00	4.92	0.00	100.00	264
813	27.44	39.00	2.72	2.61	2.15	0.79	2.15	20.41	2.72	100.00	882
817	32.24	33.55	11.18	11.18	5.59	0.00	2.30	2.30	1.64	100.00	304
819	25.15	45.94	3.76	6.93	1.19	0.00	9.50	4.55	2.97	100.00	505
822	36.84	25.00	13.16	0.00	18.42	0.00	6.58	0.00	0.00	100.00	75

Table 13 shows that trips to work destinations constitute the largest share of trips for most routes. Routes that showed a very high proportion of trips beginning at home in Table 12 (e.g., Routes 181, 329, 801, 802, 803, 804) have the highest proportion of trips ending at work, further indicating that buses on these routes are predominantly used by commuters. Routes 80 and 82 have a significantly higher share of trips ending at K-12 schools because of a number of high schools in their service area. Interstate NYC Route 108 shows the greatest share of trips to college/university, followed by Rt. 813 serving Middlesex County College.

Access and Egress Mode

The travel modes used by the riders to access boarding bus stops for the 23 routes are shown in Table 14. Their egress modes from alighting stop are shown in Table 15.

Table 14 – Access mode to boarding bus stop

	Percent												
Rt. #	Walked only	Drove and parked	Carpool/ Drop-off	Another bus	Light Rail	NJT Train	PATH	Bike	Taxi	App-based service	Other	Total	Riders (N)
6	83.42	0.47	0.23	9.84	0.35	1.23	3.87	0.00	0.23	0.00	0.35	100.00	1,707
22	85.48	0.00	0.46	7.51	0.88	2.10	1.76	0.46	0.46	0.88	0.00	100.00	2,383
30	81.50	0.24	0.16	12.74	1.13	2.22	2.02	0.00	0.00	0.00	0.00	100.00	2,481
80	87.69	0.31	0.50	6.42	1.86	0.34	2.04	0.07	0.09	0.18	0.50	100.00	7,409
81	88.31	0.71	0.29	2.55	1.84	0.48	5.65	0.00	0.00	0.16	0.00	100.00	3,097
82	98.48	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.00	0.00	0.00	100.00	330
83	77.26	1.19	1.29	14.74	2.04	1.50	1.34	0.13	0.13	0.13	0.26	100.00	3,874
84	78.76	0.89	1.46	14.12	1.25	1.50	1.77	0.00	0.00	0.13	0.13	100.00	4,737
85	80.66	0.00	0.00	12.86	1.88	0.00	3.19	0.00	0.74	0.68	0.00	100.00	1,758
86	94.09	0.00	0.77	1.16	0.00	1.93	2.05	0.00	0.00	0.00	0.00	100.00	779
87	86.89	0.65	0.58	5.75	1.06	1.20	3.43	0.07	0.08	0.00	0.30	100.00	11,516
89	87.19	0.00	0.00	5.37	2.79	2.22	1.72	0.00	0.00	0.72	0.00	100.00	1,397
108	64.20	3.19	1.11	22.85	6.02	2.08	0.00	0.00	0.00	0.00	0.55	100.00	1,444
181	74.44	2.26	0.00	15.79	2.26	5.26	0.00	0.00	0.00	0.00	0.00	100.00	532
329	59.14	6.61	0.00	0.00	0.00	34.24	0.00	0.00	0.00	0.00	0.00	100.00	257
801	87.50	0.00	0.00	1.92	0.00	5.29	0.00	0.00	5.29	0.00	0.00	100.00	208
802	94.85	0.00	0.00	1.21	0.00	3.94	0.00	0.00	0.00	0.00	0.00	100.00	330
803	79.10	0.00	0.00	3.73	0.00	17.16	0.00	0.00	0.00	0.00	0.00	100.00	268
804	89.66	1.38	4.48	0.00	0.00	3.10	1.38	0.00	0.00	0.00	0.00	100.00	290
813	67.15	2.38	1.14	9.40	0.72	17.36	1.14	0.72	0.00	0.00	0.00	100.00	968
817	79.11	0.00	0.00	10.86	1.39	1.39	3.34	1.95	0.00	0.00	1.95	100.00	359
819	71.94	0.00	3.91	11.05	1.02	8.33	0.00	2.55	0.00	1.19	0.00	100.00	588
822	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	75

Table 14 shows that walking to boarding bus stops is the most common practice for bus riders. While for all routes more than half of the riders walk to the boarding stop, for 14 routes more than 80 percent riders do so. Although not nearly as common as walking, taking another bus to the boarding station is more common than taking any other mode. For eight of the routes more than 10 percent of the riders came to the boarding station by another bus. The two routes with the highest proportion of riders coming to the boarding stop by bus are Interstate NYC Routes 108 and 181. The share of riders coming to the boarding station by NJT Train is the highest for Rt. 329, followed respectively by Rt. 813 and Rt. 803. Rt. 329 connects to Secaucus Station, Rt. 813 connects to Metuchen Station, and Rt. 803 connects to Metropark Station. Driving, carpooling, biking, PATH, taxi, and app-based services (also known as transportation network companies that include companies like Uber and Lyft) to access stops are not very common. Despite their increasing popularity, app-based services were used by none of the riders on 17 of the 23 routes.

Table 15 – Egress mode from alighting bus stop

	Percent												
Rt. #	Walked only	Drove and parked	Carpool/ Drop-off	Another bus	Light Rail	NJT Train	PATH	Bike	Taxi	App-based service	Other	Total	Riders (N)
6	83.42	0.47	0.23	9.84	0.35	1.23	3.87	0.00	0.23	0.00	0.35	100.00	1,707
22	85.48	0.00	0.46	7.51	0.88	2.10	1.76	0.46	0.46	0.88	0.00	100.00	2,383
30	81.50	0.24	0.16	12.74	1.13	2.22	2.02	0.00	0.00	0.00	0.00	100.00	2,481
80	87.69	0.31	0.50	6.42	1.86	0.34	2.04	0.07	0.09	0.18	0.50	100.00	7,409
81	88.31	0.71	0.29	2.55	1.84	0.48	5.65	0.00	0.00	0.16	0.00	100.00	3,097
82	98.48	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.00	0.00	0.00	100.00	330
83	77.26	1.19	1.29	14.74	2.04	1.50	1.34	0.13	0.13	0.13	0.26	100.00	3,874
84	78.76	0.89	1.46	14.12	1.25	1.50	1.77	0.00	0.00	0.13	0.13	100.00	4,737
85	80.66	0.00	0.00	12.86	1.88	0.00	3.19	0.00	0.74	0.68	0.00	100.00	1,758
86	94.09	0.00	0.77	1.16	0.00	1.93	2.05	0.00	0.00	0.00	0.00	100.00	779
87	86.89	0.65	0.58	5.75	1.06	1.20	3.43	0.07	0.08	0.00	0.30	100.00	11,516
89	87.19	0.00	0.00	5.37	2.79	2.22	1.72	0.00	0.00	0.72	0.00	100.00	1,397
108	64.20	3.19	1.11	22.85	6.02	2.08	0.00	0.00	0.00	0.00	0.55	100.00	1,444
181	74.44	2.26	0.00	15.79	2.26	5.26	0.00	0.00	0.00	0.00	0.00	100.00	532
329	59.14	6.61	0.00	0.00	0.00	34.24	0.00	0.00	0.00	0.00	0.00	100.00	257
801	87.50	0.00	0.00	1.92	0.00	5.29	0.00	0.00	5.29	0.00	0.00	100.00	208
802	94.85	0.00	0.00	1.21	0.00	3.94	0.00	0.00	0.00	0.00	0.00	100.00	330
803	79.10	0.00	0.00	3.73	0.00	17.16	0.00	0.00	0.00	0.00	0.00	100.00	268
804	89.66	1.38	4.48	0.00	0.00	3.10	1.38	0.00	0.00	0.00	0.00	100.00	290
813	67.15	2.38	1.14	9.40	0.72	17.36	1.14	0.72	0.00	0.00	0.00	100.00	968
817	79.11	0.00	0.00	10.86	1.39	1.39	3.34	1.95	0.00	0.00	1.95	100.00	359
819	71.94	0.00	3.91	11.05	1.02	8.33	0.00	2.55	0.00	1.19	0.00	100.00	588
822	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	75

Similar to access modes, walking is the most common egress mode for most routes, followed by the use of another bus (See Table 15). However, the proportion of riders using NJ TRANSIT train is exceptionally high for Middlesex County routes 801, 802, 803, and 804, all of which connect to the Metropark Station. Rt. 329, which connects to the Secaucus Junction Station, also shows an exceptionally high proportion of riders using NJ TRANSIT train. These results indicate that buses on these routes serve as feeders to NJ TRANSIT trains.

PATH is also a fairly often used egress mode for the bus riders, especially for the Hudson Country routes that serve or are near PATH stations. Routes 6, 80, 81, and 87 show greater than 10 percent riders using PATH as an egress mode, meaning that these riders use buses to access PATH to travel to New York City or stations in New Jersey. For NYC Interstate Rt. 181, the share of riders mentioning the use of light rail is significantly higher than the other routes. The explanation for this could be that one end of this route is near the Bergenline Ave Station of the Hudson Bergen Light Rail line (HBLR). Second to Rt. 181 is Rt. 89 in terms of the use of light rail as an egress mode. This route connects the Hoboken Terminal Station, where the Hudson Bergen Light Rail is available.

Trip Frequency

Riders were asked how frequently they take the bus. The results for all 23 routes are shown in Table 16. Riders who made trips six or seven times a week may be considered dependent users since many of them are likely to use the bus for commuting to work as well as other activities such as shopping and errands. Some of them may also work more than five days a week. Riders who made trips five times a week can be considered commuters, who are highly likely to take the bus to work or school/college. Riders who made trips more than one time but less than five times a week can be considered regular but infrequent users. Riders who made 1-3 trips a month can be considered occasional users, while riders who made less than one trip a month can be considered sporadic users.

When one follows the above categorization of riders, most routes in Hudson County have a high proportion of dependent riders. The only exceptions are Rt. 82 and Rt. 329, which provide service only in peak periods. In all other Hudson County routes, the share of dependent riders is more than 20 percent. However, some routes in the Middlesex/Monmouth County Group, such as Routes 813, 817, 819, and 822, also have a high share of dependent riders.

The Metropark Shuttle routes in Middlesex County (Routes 801, 802, 803, and 804), which provide only peak period service, have the smallest share of dependent riders. However, probably because these routes operate only during peak periods and serve the Metropark train station, they have a very high share of commuters. Route 82 in Hudson County, which provides only peak period service between Summit Ave. at Hague Street and the Exchange Place PATH Station, also falls into this category. Rt. 329, which also provides only peak period service (between Harmon Cove and Secaucus Junction Station), is another route with a high proportion of commuters.

The share of infrequent riders is between 15 percent and 30 percent for 16 of the 23 routes. The share of infrequent users is the highest for Rt. 817. The route operates between Middletown (Garfield Ave. at Leonardville Rd.) and Perth Amboy (Rector St. at Washington St.). The peak-only routes in Hudson and Middlesex County that have a high share of commuters have the smallest share of infrequent users. The share of occasional and sporadic riders is very small for all surveyed routes to show any noticeable pattern.

Table 16 – Frequency of trips made by buses on the surveyed routes

	Percent										
Rt. #	7 days/ week	6 days/ week	5 days/ week	3-4 days/ week	1-2 days/ week	1-3 days/ month	<one day/ month	<one day/ year	First time user	Total	Riders (N)
6	25.19	8.89	37.26	13.55	5.72	5.08	3.39	0.28	0.64	100.00	1,417
22	20.95	10.17	31.35	12.26	15.11	4.75	4.51	0.00	0.90	100.00	2,105
30	20.52	12.32	36.11	18.72	6.78	2.80	2.09	0.00	0.66	100.00	2,110
80	21.30	10.16	42.17	14.58	6.55	3.28	1.08	0.18	0.70	100.00	6,761
81	18.10	8.74	39.65	16.12	6.02	4.96	3.74	0.81	1.87	100.00	2,724
82	7.79	3.12	75.39	10.59	3.12	0.00	0.00	0.00	0.00	100.00	321
83	15.89	11.39	35.90	19.46	10.14	3.31	1.80	0.49	1.63	100.00	3,443
84	24.51	11.85	29.82	13.99	7.82	5.19	4.41	1.11	1.30	100.00	4,145
85	21.05	9.12	46.76	10.34	6.00	2.75	2.39	0.00	1.59	100.00	1,634
86	18.12	11.20	44.12	6.50	10.79	3.46	4.70	0.00	1.11	100.00	723
87	24.99	10.41	39.67	13.58	4.51	3.53	1.78	0.44	1.08	100.00	10,544
89	19.20	11.30	38.93	15.87	4.64	4.49	2.86	1.24	1.47	100.00	1,292
108	12.14	8.71	41.18	21.89	5.36	4.10	2.98	0.74	2.90	100.00	1,343
181	17.46	6.03	54.09	5.17	17.24	0.00	0.00	0.00	0.00	100.00	464
329	3.59	3.59	74.10	10.36	3.59	4.78	0.00	0.00	0.00	100.00	251
801	2.06	0.00	74.74	23.20	0.00	0.00	0.00	0.00	0.00	100.00	194
802	1.30	1.30	79.22	13.96	1.30	2.92	0.00	0.00	0.00	100.00	308
803	1.90	0.00	86.31	11.79	0.00	0.00	0.00	0.00	0.00	100.00	263
804	1.54	1.54	83.40	11.97	0.00	1.54	0.00	0.00	0.00	100.00	259
813	5.32	8.26	50.45	24.32	10.07	0.79	0.79	0.00	0.00	100.00	884
817	4.01	17.06	24.41	23.08	24.08	7.36	0.00	0.00	0.00	100.00	299
819	9.57	10.35	42.58	25.39	3.13	5.86	1.56	0.78	0.78	100.00	512
822	25.00	6.58	30.26	13.16	18.42	6.58	0.00	0.00	0.00	100.00	75

Return Trip

The bus riders were asked in the survey how they would travel when making the return trip. Their responses are summarized in Table 17.

It is evident from Table 17 that half or more riders for every surveyed route would take the same bus for their return trip. The lowest shares can be observed for Rt. 802 and Rt. 822 in the Middlesex/Monmouth County Group. The highest shares can be observed for Rt. 803 in the Middlesex/Monmouth County Group, followed by Rt. 108, which serves NY City. The share of riders who stated that they would return by another bus is the highest for Rt. 82, followed by Rt. 86 and Rt. 22, respectively. This is not surprising since these routes operate in Hudson County where segments of multiple routes overlap on same roads.

The share of riders who stated that they would return by train is the highest for Rt. 802, followed by Rt. 801, and Rt. 804. All these routes are shuttle routes serving Metropark Station in Middlesex County. A reason for the high share of return train trips for these routes could be misinterpretation of the survey question by many riders, who most likely thought about the train trips they would make while returning because of their longer length and duration (instead of taking the shuttles where they completed the survey).

Table 17 – Stated mode for return trip by bus riders

Rt. #	Percent: Same bus route	Another bus	Train	Car	Other	Total	Riders (N)
6	64.37	19.46	4.90	5.34	5.93	100.00	1,367
22	58.02	26.91	2.74	3.37	8.96	100.00	2,077
30	60.10	24.89	4.30	3.95	6.77	100.00	2,025
80	65.02	16.05	5.81	6.88	6.23	100.00	6,536
81	68.49	8.82	11.03	4.25	7.40	100.00	2,539
82	58.44	35.31	1.56	1.56	3.13	100.00	320
83	73.29	16.47	1.67	4.98	3.59	100.00	3,291
84	60.62	25.50	2.88	3.26	7.74	100.00	3,992
85	73.96	11.59	3.48	2.32	8.66	100.00	1,640
86	55.42	27.34	5.79	5.20	6.24	100.00	673
87	71.88	12.64	5.96	2.62	6.90	100.00	10,368
89	60.99	22.31	4.32	7.49	4.89	100.00	1,228
108	74.40	16.11	3.69	1.81	3.99	100.00	1,328
181	55.32	25.77	6.62	5.67	6.62	100.00	423
329	56.10	21.54	15.45	1.63	5.28	100.00	246
801	58.06	2.15	31.72	5.91	2.15	100.00	186
802	50.00	6.82	32.14	4.22	6.82	100.00	308
803	74.52	8.37	10.65	6.46	0.00	100.00	263
804	60.00	3.40	24.91	8.30	3.40	100.00	265
813	60.65	11.77	7.62	14.69	5.27	100.00	892
817	59.67	22.30	3.93	6.23	7.87	100.00	305
819	53.71	19.14	0.78	16.02	10.35	100.00	512
822	50.00	6.58	0.00	18.42	25.00	100.00	76

The share of riders who mentioned that they would return by car is generally higher for the Middlesex/Monmouth County routes than the Hudson County routes. This may be partly explained by lower automobile ownership rate for riders of many Hudson County routes. Another explanation could be the lower availability of buses for return trips in the Middlesex/Monmouth County Group relative to Hudson County.

Ticket Type

The survey respondents were asked about the type of tickets they used for the rides where they were intercepted by surveyors. The results are summarized in Table 18. The figures in the table show that monthly passes and one-way tickets/cash are the most common types of tickets used by the riders. For 17 of the routes, monthly passes are more common whereas for the other six routes one-way tickets/cash are more common.

The Metropark shuttle routes (Routes 801, 802, 803, and 804) as well as Rt. 329 in Hudson County have the highest share of monthly pass users. These routes also appear to be highly commuter oriented.

Rt. 822 has the highest share of one-way ticket/cash users, followed by Rt. 819. Both these routes serve the Plainfield area of Union and Somerset Counties. The third highest share is found for Rt. 817, another route from Middlesex County that serves Perth Amboy. A likely reason for the high share of one-way ticket users for these routes could be that they are used by a large share of non-commuters or low income riders that cannot afford a monthly pass.

Table 18 – Type of tickets used by riders

	Percent											
Rt.#	One-way Ticket/ Cash	Monthly Pass	Senior/ Person with disability/ Children	Round Trip	10-Trip/ Multi-trip	Weekly Pass	Student Monthly Pass	Student One-way	Student 10-Trip	Other	Total	Riders (N)
6	41.61	44.52	5.33	2.06	0.00	0.00	0.57	1.28	0.00	4.62	100.00	1,362
22	32.55	50.55	7.27	3.47	0.39	0.00	2.74	0.48	0.00	2.55	100.00	2,126
30	48.32	38.17	3.75	3.37	0.00	1.28	1.00	0.95	0.00	3.18	100.00	2,073
80	36.08	41.92	4.09	1.24	0.31	0.30	2.60	9.77	0.37	3.32	100.00	6,518
81	36.41	42.98	4.89	3.55	0.67	0.37	0.63	6.05	0.63	3.81	100.00	2,640
82	19.94	67.60	0.00	0.00	0.00	0.00	1.56	9.35	1.56	0.00	100.00	316
83	33.73	47.57	5.39	3.58	1.14	0.47	3.90	1.00	1.26	1.96	100.00	3,396
84	32.32	47.98	9.14	2.38	0.00	1.26	3.11	1.24	0.00	2.55	100.00	4,006
85	26.47	59.08	7.32	1.30	0.00	0.81	2.48	0.00	0.00	2.54	100.00	1,614
86	30.94	46.48	8.06	2.20	0.00	0.00	0.00	9.82	1.32	1.17	100.00	698
87	41.84	40.99	5.82	2.53	0.63	0.34	2.00	3.29	0.19	2.37	100.00	10,390
89	35.96	46.92	8.75	2.52	1.26	1.26	1.26	0.00	0.00	2.05	100.00	1,269
108	25.41	50.82	7.20	3.52	3.37	0.00	9.67	0.00	0.00	0.00	100.00	1,286
181	17.49	43.63	19.87	6.05	7.78	0.00	0.00	0.00	0.00	5.18	100.00	434
329	4.80	85.20	1.60	4.80	0.00	3.60	0.00	0.00	0.00	0.00	100.00	250
801	3.61	90.21	2.06	0.00	0.00	0.00	2.06	0.00	0.00	2.06	100.00	190
802	5.59	88.82	0.00	1.32	0.00	1.32	2.96	0.00	0.00	0.00	100.00	296
803	4.69	87.50	3.91	0.00	0.00	3.91	0.00	0.00	0.00	0.00	100.00	250
804	3.36	83.96	4.85	1.49	0.00	1.49	3.36	0.00	0.00	1.49	100.00	269
813	45.11	33.97	6.64	2.02	1.35	1.46	4.05	3.37	0.00	2.02	100.00	858
817	61.06	12.54	18.48	2.31	0.00	0.00	0.00	2.31	0.00	3.30	100.00	299
819	64.40	22.80	3.60	6.20	0.00	0.00	0.00	0.00	0.00	3.00	100.00	494
822	86.67	6.67	0.00	0.00	0.00	0.00	6.67	0.00	0.00	0.00	100.00	75

The use of reduced fare tickets for senior citizens, persons with disabilities, and children is significantly more common for Rt. 181 and Rt. 817 riders than riders for all other routes. Rt. 181 is a NYC interstate service between Union City and the George Washington Bridge Terminal, whereas Rt. 817 operates between Perth Amboy in Middlesex County and Middletown in Monmouth County. Since Monmouth and Middlesex Counties account for a large share of senior citizens within New Jersey, the high share of reduced fare ticket holders for Rt. 817 is understandable. However, the reason for the high share of reduced fare ticket holders for Rt. 181 will need further investigation.

Satisfaction

A question was included in the survey that pertains to the riders' satisfaction of the bus service they were using. Riders were instructed to give a satisfaction score for the service. The score ranged from 0 to 10, 0 being unacceptable and 10 being excellent. Thus higher score reflected greater satisfaction and the lower score reflected lower satisfaction. Table 19 shows the share of riders giving specific score to each route. Although riders could select each specific integer score between 0 and 10, some scores have been combined in the table for space limitations. The two columns in the extreme right hand side of the table show the mean and median scores for each route.

Table 19 – Satisfaction scores for the routes

	Percent								Riders		
Rt. #	0	1-2	3-4	5	6-7	8-9	10	Total	(N)	Mean	Median
6	2.72	3.89	6.09	19.97	22.47	24.67	20.19	100.00	1,362	6.83	7
22	0.89	3.39	4.89	16.51	16.18	29.07	29.07	100.00	2,126	7.47	8
30	1.06	0.77	2.27	17.08	20.02	33.82	24.99	100.00	2,073	7.58	8
80	0.78	2.49	8.90	20.39	23.21	28.43	15.80	100.00	6,518	6.87	7
81	0.72	1.40	6.55	18.64	21.36	31.89	19.43	100.00	2,640	7.23	8
82	1.58	6.33	4.75	18.67	32.59	26.58	9.49	100.00	316	6.53	7
83	0.50	1.06	6.77	15.87	23.73	28.80	23.26	100.00	3,396	7.36	8
84	0.67	1.37	6.57	16.40	15.43	30.23	29.33	100.00	4,006	7.58	8
85	2.97	1.55	4.58	11.77	16.05	33.27	29.80	100.00	1,614	7.61	8
86	0.00	0.00	5.87	13.18	24.93	26.65	29.37	100.00	698	7.64	8
87	1.39	2.95	8.03	20.11	23.89	25.11	18.53	100.00	10,390	6.87	7
89	0.79	2.68	8.27	16.39	26.87	26.56	18.44	100.00	1,269	6.96	7
108	4.90	6.84	12.91	19.83	19.91	23.87	11.74	100.00	1,286	6.08	6
181	0.00	2.76	2.76	16.59	18.43	34.33	25.12	100.00	434	7.52	8
329	0.00	0.00	1.60	24.40	24.40	34.40	15.20	100.00	250	7.30	7
801	2.11	2.11	7.89	23.68	17.37	29.47	17.37	100.00	190	6.94	7
802	0.00	7.43	1.35	14.53	20.27	41.89	14.53	100.00	296	7.14	8
803	0.00	2.00	10.80	15.20	12.00	23.60	36.40	100.00	250	7.56	8
804	0.00	1.49	3.35	14.87	9.67	29.74	40.89	100.00	269	8.18	9
813	0.00	1.40	7.93	15.97	26.92	34.27	13.52	100.00	858	7.16	7
817	0.00	0.00	1.67	20.07	24.08	24.75	29.43	100.00	299	7.71	8
819	1.42	1.21	14.17	18.83	11.13	22.06	31.17	100.00	494	7.19	8
822	0.00	0.00	6.58	0.00	13.16	43.42	36.84	100.00	76	8.49	9

It is evident from Table 19 that the satisfaction scores for all routes are skewed, showing that more riders chose scores closer to excellent than unacceptable. This is also evident from the fact that the median score for all routes is greater than 5, the central point of the continuous series between 0 and 10. However, a comparison of the mean and median scores shows that some routes are more satisfactory to the riders than other routes. The two routes with the highest mean and median scores (Routes 822 and 804) serve Middlesex County, whereas the route with the lowest mean and median score (Route 108) is a Hudson County route that operates between Newark City and the Port Authority Bus Terminal in NY City. However, several routes in Hudson County also received high scores. For example, eight routes from the Hudson County

Group received a median score of 8. Although the four routes to receive the highest share of score 10 are all from the Middlesex/Monmouth County Group, for five Hudson County routes, more than 25 percent riders gave a score 10 for the bus routes they used.

Responses to another survey question provide additional insights about the satisfaction of riders with the bus routes they used. Through this question, the riders were asked whether they would recommend the service they used to a friend or relative. The responses to that question are summarized in Table 20.

Table 20 – Likelihood of recommending service to friend or relative

Rt. #	Very Likely	Somewhat Likely	Do Not Know	Somewhat Unlikely	Very Unlikely	Total	Riders (N)
6	41.47	36.13	7.11	8.18	7.11	100.00	1,406
22	45.79	30.43	8.71	5.10	9.97	100.00	2,136
30	54.67	29.26	4.58	4.04	7.45	100.00	2,054
80	39.27	38.43	10.10	7.09	5.10	100.00	6,700
81	43.17	33.03	11.07	5.50	7.23	100.00	2,710
82	38.32	46.11	4.67	6.23	4.67	100.00	321
83	51.19	30.10	7.69	5.33	5.68	100.00	3,432
84	55.20	28.52	4.64	3.97	7.67	100.00	4,134
85	58.08	28.00	3.54	5.25	5.13	100.00	1,639
86	48.30	35.27	8.36	4.67	3.40	100.00	706
87	43.64	33.33	9.34	6.39	7.31	100.00	10,553
89	47.26	35.60	7.75	3.68	5.71	100.00	1,278
108	40.29	36.08	8.33	9.83	5.48	100.00	1,333
181	40.63	37.95	2.68	15.18	3.57	100.00	448
329	36.14	38.55	11.65	12.05	1.61	100.00	249
801	53.89	29.02	2.07	3.63	11.40	100.00	193
802	61.17	23.62	1.29	9.71	4.21	100.00	309
803	56.43	21.99	2.07	9.96	9.54	100.00	241
804	56.41	27.47	1.47	0.00	14.65	100.00	273
813	37.73	33.03	16.06	5.50	7.68	100.00	872
817	50.99	34.21	2.30	3.95	8.55	100.00	304
819	51.07	26.80	12.43	1.94	7.77	100.00	515
822	49.33	44.00	6.67	0.00	0.00	100.00	75

Consistent with the responses to the question on satisfaction score that showed a far larger proportion of riders giving high scores than low scores, Table 20 shows that a far greater share of riders would recommend the service rather than not recommend. When those who are very likely and somewhat likely to recommend are combined, even for the least satisfactory route, 70 percent said they would recommend the service.

Among the top six routes most likely to be recommended, three are Metropark shuttles from Middlesex County, whereas three are from Hudson County. Although it is unclear from the “very likely” responses whether riders are more satisfied with the Hudson County routes or the Middlesex/Monmouth County routes, the “very unlikely” responses seem to suggest that rider dissatisfaction is greater with the Middlesex/Monmouth routes than the Hudson routes. Among the seven least likely to be recommended routes, six are from the Middlesex/Monmouth County group. However, these results need to be interpreted with caution since the socioeconomic characteristics of persons often influence their satisfaction and dissatisfaction with goods and services.

Reason for Using Bus

The survey respondents were asked about the reasons for using the bus where they were intercepted by surveyors. They were given three responses to choose form: (a) I have no other way to travel, so I use the bus; (b) I use the bus because it is the best choice for me, even though there are other ways I could travel; and (c) I usually use another type of transportation, but I occasionally take the bus. The responses are summarized in Table 21.

Table 21 – Reasons for using buses by riders

	Percent				
Rt. #	No other way	Best choice	Atypical rider	Total	Riders (N)
6	58.68	32.11	9.22	100.00	1,389
22	52.47	41.25	6.27	100.00	2,041
30	64.32	29.20	6.48	100.00	2,113
80	47.54	42.38	10.08	100.00	6,748
81	36.68	46.92	16.40	100.00	2,713
82	41.56	58.44	0.00	100.00	320
83	60.97	32.16	6.87	100.00	3,333
84	58.99	33.09	7.93	100.00	4,062
85	58.90	39.37	1.74	100.00	1,613
86	50.73	41.13	8.14	100.00	688
87	50.23	42.24	7.54	100.00	10,630
89	50.97	43.26	5.76	100.00	1,232
108	49.43	44.53	6.04	100.00	1,307
181	52.16	45.26	2.59	100.00	464
329	51.81	46.59	1.61	100.00	249
801	41.05	56.84	2.11	100.00	190
802	32.46	63.28	4.26	100.00	305
803	30.92	69.08	0.00	100.00	262
804	29.37	67.29	3.35	100.00	269
813	59.80	28.04	12.16	100.00	888
817	74.10	17.38	8.52	100.00	305
819	67.08	20.86	12.07	100.00	489
822	56.00	37.33	6.67	100.00	75

It is evident from Table 21 that a substantial proportion of riders on all routes have no option to travel other than buses. However, significant variations exist among the routes. For example, less than 30% of riders on Rt. 804 and almost 75% of the riders on Rt. 817 stated that they had no other way to travel. Perhaps the most fascinating finding is that the three routes with the lowest proportion of riders and the two routes with the highest proportion of riders not having any other option are all from the Middlesex/Monmouth County Group. While the three routes with the lowest proportion are short Metropark Shuttle routes that connect customers from apartments/condos to the Metropark Station, the two routes with the highest proportion are long routes connecting Perth Amboy, a relatively low-income community.

The three Metropark shuttle routes that had the smallest proportion of riders with no other option rank the highest in terms of proportion of riders who thought the bus was their best choice. Similarly, the two Perth Amboy routes (and also Rt. 819 serving Plainfield) with the highest proportion of riders having no other travel option rank the lowest in terms proportion of riders who stated that the bus was their best option.

Travel Alternatives

The bus riders were asked how they would have traveled if the bus service was not available. In addition to various travel modes they could use, they were also given an option to state that they would not make the trip. The responses to the question are summarized in Table 22.

Table 22 – How riders would have traveled if the bus was not available

	Percent										
Rt. #	Would not make this trip	Drive a car	Car-pool	Taxi	App-based service	Jitney	Walk	Bike	Other	Total	Riders (N)
6	9.82	9.30	4.26	11.72	16.44	2.10	25.74	2.10	18.53	100.00	1,527
22	7.85	8.24	2.00	11.45	22.39	12.97	14.75	3.77	16.57	100.00	2,305
30	15.61	11.67	1.63	19.14	14.07	1.04	21.95	4.62	10.27	100.00	2,210
80	8.79	16.43	3.57	8.96	18.28	3.52	18.91	3.68	17.86	100.00	7,643
81	8.53	11.08	2.54	8.36	12.71	1.81	14.21	1.04	39.71	100.00	2,871
82	1.32	7.89	6.58	8.95	19.47	2.63	15.53	3.95	33.68	100.00	380
83	19.67	13.83	5.70	10.24	24.19	4.60	8.92	1.94	10.91	100.00	3,564
84	12.50	8.60	3.48	9.72	19.68	11.56	15.89	2.32	16.24	100.00	4,568
85	18.37	5.26	1.85	13.77	27.21	4.26	6.72	1.96	20.60	100.00	1,786
86	6.48	5.97	3.18	6.48	17.92	5.97	21.47	4.83	27.70	100.00	787
87	10.14	9.19	3.48	8.70	21.91	4.72	22.11	2.73	17.02	100.00	12,145
89	6.99	9.67	2.40	10.30	25.62	6.21	21.10	3.32	14.40	100.00	1,417
108	16.54	12.96	4.89	6.75	24.81	3.03	4.34	1.17	25.50	100.00	1,451
181	12.50	23.98	5.74	3.28	20.49	5.74	10.86	0.00	17.42	100.00	488
329	11.44	29.41	2.94	16.67	16.99	1.31	12.75	0.00	8.50	100.00	306
801	4.55	35.54	4.55	13.64	12.40	0.00	27.69	0.00	1.65	100.00	242
802	6.21	49.41	7.69	10.06	15.09	0.00	8.88	0.00	2.66	100.00	338
803	1.82	44.00	0.00	12.36	30.18	0.00	8.00	0.00	3.64	100.00	275
804	6.27	50.87	0.00	13.94	15.33	0.00	4.53	0.00	9.06	100.00	287
813	16.90	10.84	0.00	29.02	30.54	0.00	7.93	0.00	4.78	100.00	858
817	33.64	4.24	0.00	33.33	6.67	0.00	7.27	0.00	14.85	100.00	330
819	23.93	6.12	0.00	17.07	29.31	0.00	12.62	0.00	10.95	100.00	539
822	0.00	7.14	0.00	40.00	7.14	0.00	45.71	0.00	0.00	100.00	70

The first column of Table 22 shows the share of riders in each route that would not make the trip if the bus service did not exist. It is evident from this column that riders of the long routes in Middlesex/Monmouth County Group where a very large share of riders also said they had no other option to travel (e.g., Routes 813, 817, and 819) are more likely to give up their trips in the absence of buses. As expected, very small proportions of riders on the Metropark shuttle routes are likely to forgo their trips. A very large share of riders on these routes stated that they would drive cars if the bus route did not exist. In fact, riders of the four Metropark shuttle routes are the most likely to drive in the absence of the buses, followed by commuter Route 329 in Hudson County. A large share of riders on several long routes in the Middlesex/Monmouth County Group stated that they would take a taxi. It is well documented in transportation literature that people from low-income households without cars are more likely to take taxis than others.

The share of riders who would walk in the absence of buses varies from a low 4.34 percent for RT. 817 to a high of 45.71 percent for Route 813. It does not appear that the share of riders who would walk is higher in any of the two county groups. The reason is that only those riders who made relatively short bus trips can make walking trips to their destinations.

One of the most fascinating results in Table 22 is the high proportion of riders who stated that they would app-based services like Uber and Lyft if buses were absent. For 16 of the 23 routes the share or riders who stated that they would take app-based services was greater than the share of riders who stated that they would drive a car. For 19 of the 23 routes, the share of riders who stated that they would take an app-based service in the absence of buses was greater than the share of rider who stated that they would take a taxi.

ENVIRONMENTAL AND TRAFFIC IMPACT

Introduction

Two of the most important objectives of this research are to estimate the environmental impacts and traffic impacts of buses. Pertaining to the environmental impact, analyses were conducted to estimate CO_2 emissions that would have been generated if the bus riders were to use alternative transportation modes such as cars, taxis, or app-based services. The CO_2 estimates were obtained for 23 bus routes surveyed. Due to extensive data requirement and the high cost of estimating traffic impact of buses through traffic simulation models, the traffic impact analysis was undertaken for Rt. 80 only, which serves Jersey City in Hudson County.

Environmental Impact

As the literature review showed, the air quality impact of transit is often estimated by examining how the transit riders would have traveled between their trip origins and destinations if the transit service did not exist. Adopting that approach, this study uses responses from a survey question. Through that question, respondents were asked what alternative travel mode they would have used in the absence of the bus service they were using. Although many riders selected other modes such as walk, bike, train, another bus, etc., the relevant trips for the analysis here are only those that would have been made by an automobile, whether that be by driving alone, carpool, taxi, or app-based service such as Uber and Lyft. The riders who said they would not make the trips they were making in the absence of buses were also excluded from analysis because they would not generate any VMT by giving up their trips.

The following sequential steps were involved in estimating the CO_2 emissions that would have been generated from the diversion of bus riders to the automobile.

(a) Geocode the trip origins and destinations of the survey respondents.
(b) Using GIS, estimate network distances (miles) between the origins and destinations of each trip in the survey data.
(c) Select the trips for which the rider stated that he or she would have traveled by an automobile mode in the absence of the bus.
(d) Apply appropriate vehicle occupancy rate for those who said they would carpool in the absence of buses.
(e) Estimate vehicle miles traveled (VMT) for each potential automobile user by applying respective vehicle occupancy rates.
(f) Make a realistic assumption about miles per gallon (MPG) for automobile and CO_2 emission per gallon of gasoline.
(g) Use MPG, emissions per gallon, and VMT to estimate CO_2 emissions that would have been generated if riders diverted to automobile as stated in the survey.

The distances between bus trip origins and destinations were estimated by the ArcGIS Network Analyst. Vehicle occupancy rate for those who said they would carpool was obtained from responses to a specific survey question. For those who said they would carpool but did not mention the number of people they would carpool with, the average occupancy rate for all carpool riders was used. This average was 2.93 persons per car for those who stated the number of carpool riders. For those who said they would drive alone, take a taxi, or take an app-based service, the vehicle occupancy rate was assumed to be one since potential taxi users and app-based service users were not sked about sharing vehicles with others.

Table 23 shows the estimated route-specific vehicle miles traveled (VMT) for the riders who stated that they would use an automobile mode in the absence of buses. The VMT estimates are based on one-way trip only. They would be twice as much if all riders returned by the same bus. The estimates are shown separately for those who would drive or carpool and those who would use app-based service or taxi, in addition to the total VMT obtained by aggregating the two. In addition to the estimates of VMT, the table shows the number of riders in each route that would use the specific modes.

Table 23 – Estimated vehicle miles to be traveled in the absence of buses

	Driver and Carpool		App-based and Taxi		Total	
Rt.#	Riders (N)	VMT	Riders (N)	VMT	Riders (N)	VMT
6	130	453	305	1,405	435	1,859
22	192	898	602	2,728	794	3,626
30	219	1,590	626	2,594	845	4,184
80	1,047	3,971	1,555	6,127	2,602	10,097
81	248	1,172	429	2,401	677	3,574
82	34	122	79	238	113	360
83	536	3,277	931	6,461	1,467	9,738
84	354	1,906	958	5,375	1,312	7,280
85	103	514	563	2,338	666	2,852
86	59	241	132	796	191	1,037
87	1,038	5,613	2,917	12,565	3,955	18,177
89	121	736	416	1,500	537	2,236
108	178	1,716	384	3,740	562	5,456
181	105	881	76	481	181	1,363
329	72	603	57	448	129	1,051
801	85	2,192	45	1,019	130	3,210
802	154	3,053	69	1,593	223	4,646
803	98	2,011	107	1,573	205	3,584
804	150	3,431	66	1,445	216	4,876
813	162	1,234	337	2,556	499	3,790
817	11	84	109	660	120	744
819	41	181	191	1,870	232	2,052
822	5	90	19	39	24	128
Total	5,145	35,969	10,971	59,950	16,116	95,919

Note: The figures are based on one-way trip. They would be double if riders returned by the same bus.

The United States Environmental Protection Agency (EPA) uses a formula to estimate CO_2 emissions from gasoline consumption by automobiles.[40] The formula can be stated as:

$$Total\ CO_2 emissions = \frac{CO_2 emissions\ per\ gallon}{MPG} X\ VMT$$

By assuming 8,887 grams of emissions per gallon of gasoline, 21.6 MPG, and 11,400 annual VMT, it estimated that the average annual emission per car is approximately 4.7 metric tons. The same assumptions have been made here to estimate CO_2 reduction for each bus route. Instead of annual VMT for a car, the VMT estimates from Table 23 were used for each route. The average weekday and annual estimates of CO_2 for the routes are shown in Table 24. The figures in the table show how much CO_2 would have been emitted if the bus riders who said they would travel by automobile in the absence of buses truly made their trips by automobile. Thus the figures indicate how much additional CO_2 would have been generated by additional automobile trips due to diversion from buses. While the weekday emissions were obtained by the EPA formula, to obtain the annual estimates, it was assumed that there are 260 working days in a year. Hence the annual estimates are 260 times larger than the weekday estimates.

Table 24 shows that emissions from driver and carpool are generally lower than emissions from app-based service and taxi. This is because a larger number of riders stated that they would use app-based service or taxi than driving or carpooling. The factors that affected the estimated emissions for each route were (a) distance between trip origins and destinations, and the (b) number of riders who stated that they would use an automobile mode. For short bus routes, one can expect to see a low estimate of emissions, whereas for long routes, emissions depend on whether the riders that stated that they would take an automobile mode made long or short trip.

Using the EPA's estimate of 4.7 metric tons of CO_2 per car per year, from the annual emissions figures in Table 24, one can estimate the number of cars that would have to be removed in order to achieve the estimated reduction in emissions. The estimated number of reduced cars from roads for each bus route is shown in Table 25.

Table 24 – Average weekday and annual CO_2 emissions from diversion to automobile

	Average weekday emissions (Metric tons)			Annual emissions (Metric tons)		
Rt.#	Driver and carpool	Taxi and app-based	Total	Driver and carpool	Taxi and app-based	Total
6	0.19	0.58	0.76	48.50	150.34	198.84
22	0.37	1.12	1.49	96.11	291.77	387.88
30	0.65	1.07	1.72	170.07	277.50	447.57
80	1.63	2.52	4.15	424.74	655.41	1,080.15
81	0.48	0.99	1.47	125.41	256.88	382.29
82	0.05	0.10	0.15	13.06	25.48	38.54
83	1.35	2.66	4.01	350.57	691.15	1,041.72
84	0.78	2.21	3.00	203.86	574.96	778.82
85	0.21	0.96	1.17	54.98	250.11	305.09
86	0.10	0.33	0.43	25.78	85.13	110.91
87	2.31	5.17	7.48	600.40	1,344.08	1,944.48
89	0.30	0.62	0.92	78.72	160.44	239.15
108	0.71	1.54	2.24	183.58	400.05	583.63
181	0.36	0.20	0.56	94.28	51.48	145.77
329	0.25	0.18	0.43	64.51	47.89	112.39
801	0.90	0.42	1.32	234.44	108.97	343.41
802	1.26	0.66	1.91	326.61	170.42	497.02
803	0.83	0.65	1.47	215.17	168.22	383.39
804	1.41	0.59	2.01	367.05	154.53	521.58
813	0.51	1.05	1.56	131.99	273.41	405.40
817	0.03	0.27	0.31	8.93	70.61	79.54
819	0.07	0.77	0.84	19.40	200.07	219.47
822	0.04	0.02	0.05	9.61	4.14	13.74
Total	14.80	24.67	39.46	3,847.76	6,413.03	10,260.79

Note: The figures are based on one-way trip. They would be double if riders returned by the same bus.

One should note that the number of cars reduced in Table 25 Is not for one weekday but for the whole year. The figures in the table indicate, based on one-way trips alone, the total emissions reduced by the 23 routes by allowing people to take buses instead of automobiles is equivalent to taking away 2,183 cars from roads for one full year.

One may note that buses also contribute to CO_2 emissions. To accurately estimate emissions from buses, information is needed about type of fuel used by buses. Additionally, assumptions have to be made about vehicle speed, traffic conditions, et cetera. Due to the unavailability of related information, efforts were not made to estimate emissions from the buses. Thus the CO_2 emissions shown here should not be interpreted as net savings.

Table 25 – Number of cars that would be removed from roads to achieve the estimated reduction in CO_2

Rt.#	Driver and carpool	Taxi and app-based	Total
6	10	32	42
22	20	62	83
30	36	59	95
80	90	139	230
81	27	55	81
82	3	5	8
83	75	147	222
84	43	122	166
85	12	53	65
86	5	18	24
87	128	286	414
89	17	34	51
108	39	85	124
181	20	11	31
329	14	10	24
801	50	23	73
802	69	36	106
803	46	36	82
804	78	33	111
813	28	58	86
817	2	15	17
819	4	43	47
822	2	1	3
Total	819	1,364	2,183

Note: The figures are based on one-way trip. They would be double if riders returned by the same bus.

Traffic Impact

The estimation of traffic impact of buses was undertaken for Rt. 80, which runs within Jersey City between Exchange Place and Old Bergen Road at Gates Ave (i.e., the Greenville Bus Garage). The route travels through highly congested roads that contain more than 50 signalized intersections.

The approach to the estimation of traffic impact was the same as the approach for estimating CO_2 emissions in that traffic impact was also estimated by examining how many people would make automobile trips if the bus service did not exist. Responses from the same survey question were used for estimating traffic impact.

In order to estimate how traffic along the route would be affected if the bus riders used automobile instead of buses, additional data about the street network were required. The data included roadway configuration, traffic volume, and signal timing configurations at various intersections. The required data were collected through field visits by several researchers.

The actual estimation of traffic impact was undertaken VISSIM, a widely used microsimulation model for traffic analysis. It allows a wide variety of traffic analysis applications, integrating public and private transportation. The core algorithms of VISSIM are well documented and many model parameters are accessible for calibration. Intensive research involving a large user community worldwide has recognized VISSIM to be the leading traffic and transit microsimulation software. VISSIM has been used for many transit related studies involving bus rapid transit, light rail transit, and multimodal transit terminals. It uses information on infrastructure characteristics, traffic controls, and traffic volume as inputs. Its outputs include traffic delay, travel time, and traffic density.

Following common practice, the traffic simulation analysis was conducted using morning peak hour traffic volumes. The analysis of survey data revealed that there would be additional 19 cars on the road in the absence of a Rt. 80 bus. Using this information together with the information on the bus network (traffic volume, signals, and roadway characteristics), the simulation results were obtained. Following convention, analysis results were obtained for a one-hour interval (3600 seconds). The results of the analysis are summarized in Table 26.

Table 26 - Summary of simulation results assuming replacement ratio of 19 cars

	Simulation Period (sec)	Average Delay per Vehicle (sec)
Before bus replacement	3600	524
After bus replacement	3600	579

The results in Table 25 show that the traffic delay would increase by 10.4% if 10 buses were replaced by 190 cars [(579-524)/524=0.104 or 10.4%]. Before the replacement of the buses, for each vehicle on the bus route, the average delay is 524 seconds in a one-hour interval. In lieu of buses, additional cars would be needed to accommodate the bus riders who shifted modes. This consequently increases the total number of vehicles in the system, thereby causing extra delay for each vehicle. This analysis indicates a positive impact of bus operation on mitigating traffic congestion. The overall conclusion from the analysis is that buses help to reduce traffic congestion and delay along Rt. 80 by more than 10% in the morning peak period.

One may note that the overall reduction of traffic delay due to buses on any specific bus route depends on a number of factors, including the mode they would shift to, the length of the route, traffic volume, traffic controls, and roadways configuration. Since these variables widely fluctuate among the 23 routes, one cannot directly apply the results from Rt. 80 to other routes. The routes that operate in more congested road conditions than Rt. 80 could potentially decrease delay more, while the opposite would be true for routes that operate in less congested conditions.

CONCLUSIONS AND RECOMMENDATIONS

Summary of Findings

This research was based on a survey of riders on 23 NJ TRANSIT bus routes operating in the Hudson County and Middlesex/Monmouth County Groups. The analysis included analyses of (a) riders' characteristics, (b) riders' travel characteristics, (c) CO_2 emissions from buses, and (d) traffic impact of buses. The analysis was preceded by a literature review on pertinent subject matters.

The analysis on riders' demographic characteristics showed that a large number young adults use buses. However, the proportion of persons age 65+ is not high. A large proportion of riders on most routes are from low-income households. Many are also from households without vehicles. The survey results showed that a large proportion of riders do not have other means of travel to make their trips. The only exceptions were the Metropark Shuttle routes and Rt. 329 in Hudson County which primarily operate as feeder service to rail stations.

Analysis of the socioeconomic data also showed that a large proportion of riders in both County Groups are racial or ethnic minorities. While for some routes the proportion of African American riders is very high, for some other routes the proportion of Asian riders is very high. For almost all routes, the proportion of Hispanic riders is very high. For all surveyed routes, the proportion of racial and ethnic minorities is far higher than the proportion of racial and ethnic minorities in New Jersey.

A number of key observations can be made from the analysis of riders' travel patterns. First, because of the duration of the survey (6 AM to 4 PM), a large proportion of the trips were made from home for all routes. The largest proportion of riders for most routes stated that they were going to work. A large proportion of riders on several routes also stated that they were going to school. The high proportion of work and school trips by the buses shows their importance in facilitating important non-discretionary trips.

Second, the analysis of access and egress modes showed that most riders walk to and from the bus stops. However, the survey results also showed that a substantial proportion of riders on selected routes use the buses to access PATH trains, NJ TRANSIT trains, and buses on other routes. Third, the analysis of trip frequency showed that the proportion of riders using buses for more than five days a week is significant for most routes with the exception of the feeder routes. The high proportion of riders using buses for more than the five days a week indicates the importance of buses in facilitating weekend travel.

Fourth, the analysis of ticket types showed that monthly passes and cash/daily tickets are the most common for all routes. Fifth, satisfaction scores for all routes are negatively skewed, meaning that more people are satisfied than dissatisfied for all routes. Despite that, however, the scores vary noticeably across the routes. Sixth, A large proportion of riders on all routes except the feeder routes stated that they use the bus because they have no other way to travel. This indicates the importance of the bus routes for riders with unmet travel needs. Finally, a large share of riders indicated that in the absence of buses they would use an automobile mode, whether that be driving on their own, carpooling, taking a taxi, or using an app-based service. Although app-based serviced did not even exist in New Jersey until November 2013, a surprisingly large number of riders stated that they would use this service in the absence of buses.

The analysis of the emissions impact of buses showed that the diversion of riders from buses to automobile would generate a large amount of CO_2. The analysis showed, based on one-way trips alone, more than 10,200 metric tons of CO_2 would be generated annually from automobiles if the riders decided to use that mode. It would take almost 2,200 automobiles to operate for a full year to generate that much emission.

In addition to the emissions impact, buses are also likely to have traffic impacts measured in terms of congestion and traffic delay. The analysis undertaken for Rt. 80 showed that the buses on this route in the morning peak hour helps to reduce delay by more than 10%.

Recommendations

The purpose of this research was primarily to examine the emissions and traffic impacts of local buses. Based on the results showing significant positive impacts in both regards, the promotion of the local bus services can be highly recommended. The promotion of local buses can also be recommended for several other reasons. First, they serve a large proportion of riders who have no other means of travel. Second, local buses serve a large proportion of low-income and minority populations. In that sense, it is beneficial for achieving transportation equity. Third, the surveyed local buses are predominantly used for trips to work and school – trips that are important and non-discretionary. Fourth, buses on some of the surveyed routes also serve as useful feeder service to NJ TRANSIT trains and PATH trains, thereby helping to increase overall transit ridership.

Since the most significant task of this research was to conduct a large survey of bus riders, a few recommendations can be made for future surveys. First, extending the survey period from 6 AM–4 PM to 6 AM–9 PM could generate data from a more diverse set of riders. Second, since services are provided on many of the surveyed routes during weekends, conducting the survey on Saturdays and Sundays would generate additional useful information that can be used for service planning. Third, because of the high cost of conducting surveys onboard every bus trip, NJ TRANSIT can consider conducting surveys on selected trips instead of all trips. However, in order to get appropriate representation of riders, further research would be needed to determine the number of trips to be surveyed for each bus route.

Considering that a very high proportion of riders on almost all routes stated that they would use an app-based service in the absence of buses, attention is needed in future research about the possibility of current transit riders choosing to take app-based services instead of transit. Coordination between app-based service providers and transit service providers to integrate the two types of services could ensure that they continue to be complementary to each other instead of being substitute.

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