North Dakota State University Transit Study Report 2018-2019

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The Small Urban and Rural Transit Center (SURTC) changed its name to the Small Urban and Rural Center on Mobility (SURCOM) in January 2020 to reflect the center's expanded focus on all types of personal mobility.

Disclaimer

The contents presented in this report are the sole responsibility of the Upper Great Plains Transportation Institute and the authors.

ABSTRACT

This document contains a report based on two online surveys conducted by the Small Urban and Rural Transit Center (SURTC), Upper Great Plains Transportation Institute, NDSU, during the 2019 spring semester. The first survey captured the NDSU student experience with Metro Area Transit (MATBUS) and students' travel behavior. The survey was administered to NDSU students, and it received 1,180 responses, capturing a significant amount of information regarding student travel behavior, transit use, and opinions about current MATBUS service. The survey obtained information on student transportation modes used to travel to campus, student access to vehicles, factors influencing mode choice, use of transit services, opinions on MATBUS service, thoughts on how to improve service, and willingness to pay for transit services. The second survey was administered to some universities; and feedback on the hourly operational costs of their transit systems, their payment methods, transit system asset ownership, and other characteristics of their campus transit environment was collected.

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EXECUTIVE SUMMARY

NDSU's Facilities Management Department contracted with SURTC to complete an assessment of MATBUS services on the NDSU campus, and to recommend changes that would improve operations and increase rider satisfaction. This assessment was done with data from NDSU (Residence Life and Parking and Transportation) and MATBUS, along with feedback from two surveys (NDSU MATBUS Transit Survey and University Transit System Survey).

The objectives of the study were to:

- Collect and analyze current and previous NDSU MATBUS transit ridership data
- Study the spatial interaction of trips to determine if existing transit routes should be modified
- Study the impact of changes to student residence (location and size) on ridership
- Describe existing levels of transit service on campus
- Identify gaps in existing service and base levels of required transit service
- Develop recommendations for meeting identified mobility needs
- Compare the costs and type of service offered by different transit agencies/groups to determine the best transit service provider for NDSU for fiscal year 2019

Data Collection and Analysis

For this study, the ridership data for NDSU's exclusive MATBUS routes (excluding Route 13U) are collected and analyzed. The ridership data are then combined with some seasonal and non-seasonal attributes from other data sources and then transformed and assembled in one database. Two subsets of the ridership data are created from the database, for daily and weekly ridership, and the data range is set between 2014 and 2018 (four years). The daily ridership subset has 1,461 observations, and the weekly ridership subset has 209 observations. Before the analysis, the authors highlighted the decline of NDSU student enrollment and semester occupancy of NDSU on-campus residents.

The ridership data for routes 31, 32, 33, 34 (34W and 34E), and 35 (+TapRide) are studied using time series analysis. A typical trend pattern (a prominent valley shape or U-shape) is observed in bus route 32–34 trends during the period 2015–2016. However, route 31 and 35 show a different pattern with a continuous ridership decline over the study period. The impact of changes to the seasonal and non-seasonal factors considered in the study is examined using statistical methods. Of 42 predictor factors, 10 are picked for their statistical significance. Multiple linear regression models are built for the analysis of all routes, and the results of the models show that three factors (weekends, holidays, and Burgum Hall resident occupancy) consistently reduce MATBUS ridership. It was also observed that any increase to NDSU University Village Apartment residency or occupancy increases ridership on routes 32 and 34 only. Lastly, on routes 31, 32, 34, and 35, the increase in average daily temperature reduces ridership, while an increase in wind speed increases ridership.

To predict the daily ridership on all routes, the authors built both statistical and machine learning models. The results from the prediction model show that the machine learning models (artificial neural networks) are better in prediction accuracy than the statistical models (regression models). The difference in accuracy is due to the nature of transit demand modeling (which is both an art and a science), which involves the estimation of real-time unknown variables of demand with a certain degree

of rationality. Hence, regression methods can be too simplistic for transit demand or ridership prediction despite their complexities and strengths.

Survey Development and Results

Two surveys were developed to gather relevant information. The first was conducted to gather information from NDSU students. The second survey gathered information from other U.S. campuses that have campus transit service. Both surveys were conducted online in the 2019 spring semester. Using the results from both surveys, the SURTC assessed MATBUS's on-campus service perception, identified some service gaps, and made recommendations for improving MATBUS services on campus.

NDSU MATBUS Transit Survey Result

From the results of the first survey, the authors observed that a majority of survey respondents were 18 to 24 years old, with most identifying as females (~64%) and as undergraduates (~82%). About 44% of the respondents live on campus, and more than half (~58%) live about a mile or less from campus. When asked about access to vehicles, about 84% of respondents owned or had access to a vehicle. Most of the students with vehicle access or ownership lived off campus and stayed five miles or more from the campus. The highest mode share (30.4%) chosen by respondents was transit (MATBUS), followed by walking (30.1%), and then automobile (22.2%). The scooter had the lowest mode share (1% for male and 0% for female). Among respondents who chose the transit mode, the majority identified MATBUS Route 32E and Route 33 as their most used routes, and Route 31 as the least used route.

Regarding the willingness of respondents to walk in temperatures above freezing, it increases continuously until one mile; however, it decreases for temperatures below freezing, and this willingness to walk decreases steadily with an increase in distance. The least willing to walk are respondents who chose the scooter as a transportation mode. In general, female respondents show more willingness to walk for certain distance ranges under certain conditions. For temperatures above freezing, females show more willingness to walk distances less than a mile, and for temperatures below freezing, they show more willingness to walk distances less than 0.75 miles; beyond these ranges, males show more willingness to walk. The willingness to walk was significantly higher for respondents with vehicle access or ownership. As shown in Figure S-1, most work trips are made by part-time workers and by off-campus students. Regarding shopping trips, most of these are made by part-time workers and on-campus students.

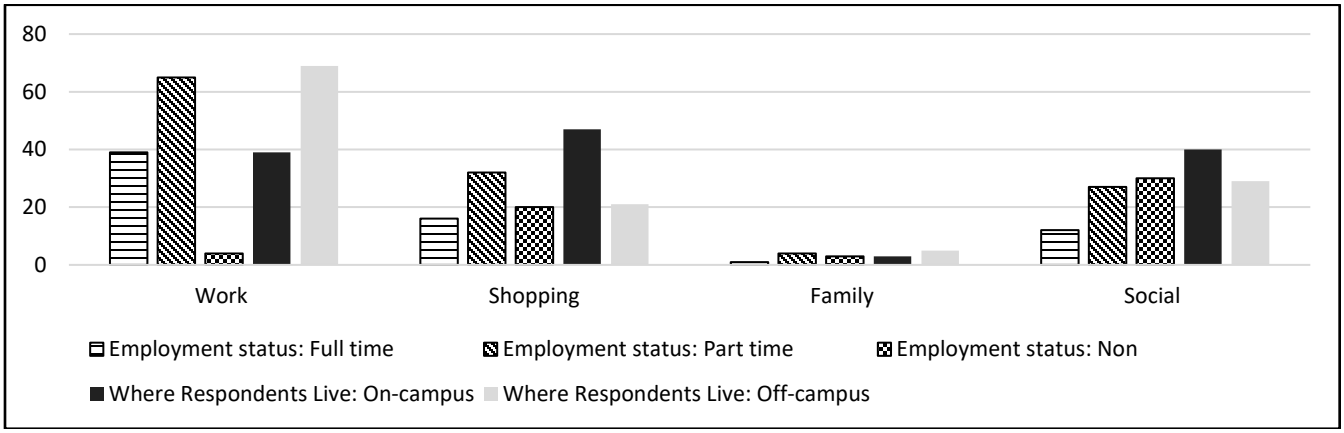

Figure S-1 Employment Status, Residency, and Trip Purpose

For the relationship between mode share and employment, the survey response suggests that respondents identified as part-time workers have the most significant percentage of all modes used. The employment group, with the second largest share of all modes used, is the unemployed group. For the relationship between mode share and a student's resident location, the response from the survey suggests that respondents who live off campus have a higher mode share on automobile, MATBUS, scooter, and walking, compared with on-campus residents (Figure S-2). On the other hand, respondents who lived on campus had a higher mode share for carpooling and bicycle share, compared with off-campus students. The most common trip frequency chosen by the respondents is the 2-one-way trip (33.39%), which is seen more with part-time workers and off-campus students (especially those who reside one to five miles from campus). Most of the respondents who make 2-one-way trips either walk or use the transit mode share the most. The least trip frequency chosen by the respondents is the +5-one-way trip. As shown in Figure S-2, most respondents who use the MATBUS mode are part-time workers and off-campus residents. Most of the respondents who carpool are on-campus residents.

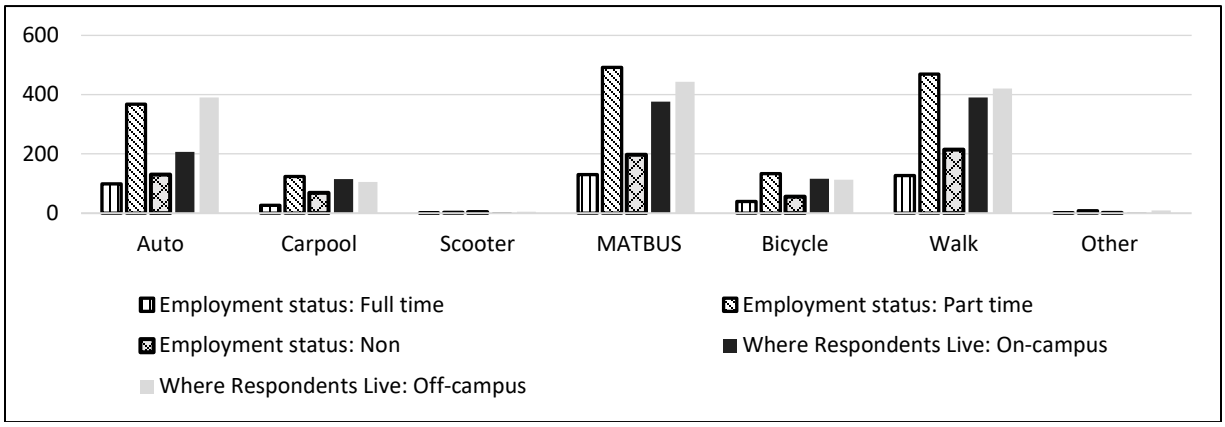

Figure S-2 Relationship of Employment Status and Residence on Mode Share

About 25% of respondents were extremely satisfied with the MATBUS service; and within this group of respondents, more than half (53.33%) reside off campus, with 25% of them living 1 to 5 miles from campus. At least 69.26% of the respondents are satisfied (extremely satisfied or somewhat satisfied) with the MATBUS service. Additionally, 19.03% are indifferent (neither satisfied nor dissatisfied), and 11.71% are dissatisfied with the service. About 1.74% of the respondents are extremely dissatisfied, and

within this group, all (100%) have a driver's license, and 94.74% have access to a vehicle (5.26% have no access to a car). Among these groups, the MATBUS route used most frequently is Route 32W, followed by Route 32E. More than half (57.89%) indicated there are additional stops/locations they want the transportation system to cover. Also, 73.68% think the service span of the MATBUS is inadequate. A majority of these respondents want more services during the early and late hours of the day (Table S-1). A majority of these respondents pointed out the following MATBUS service attributes that should be improved: on-time performance, frequency of service, and reliability of service.

Table S-1 MATBUS Service Satisfaction

		NDSU MATBUS Service Satisfaction				
		Extremely satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Extremely dissatisfied
Residence:	On-campus	126	223	83	41	3
	Off-campus	144	264	125	68	16
Valid driver's license:	Yes	250	449	198	100	19
	No	19	38	10	9	0
Access to a vehicle:	Yes	225	406	188	88	18
	No	44	81	20	21	1
Frequent MATBUS Routes:	Route 13	98	158	29	39	4
	Route 13U	58	120	18	21	2
	Route 31	44	83	12	10	3
	Route 32E	133	214	34	56	5
	Route 32W	69	149	22	41	7
	Route 33	142	234	33	41	2
	Route 34	67	126	16	22	1
	TapRide	17	46	5	11	0
	None	9	31	123	13	7
	Other:	4	13	4	5	0
Desire additional stops:	Yes	47	145	39	52	11
	No	220	340	162	57	8
Desire a better service span:	Yes	154	202	62	27	1
	Maybe	75	176	100	32	4
	No	36	107	39	50	14
Desired periods for increased services:	Weekdays	28	94	37	33	9
	Weekends	52	111	44	35	3
	Early Morning	21	76	41	27	11
	Late Nights	83	195	76	55	11
Transit service attributes that should be improved:	Reliability of service	30	133	51	62	13
	On-time Performance	86	275	85	75	14
	Frequency of Service	86	237	75	65	13
	Seat Availability	48	80	32	15	4
	Technology	59	90	43	25	6

The survey had a few questions regarding the new NDSU TapRide service, which is a relatively new on-demand service offered on the NDSU campus, Monday through Friday, from 7:30 p.m. to 11:00 p.m. It was introduced to replace MATBUS Route 35 and provide rides to more remote corners of campus where fewer students go. More than half (59.03%) of respondents have heard of the service, and within this group, 91.14% of them indicated they want more TapRide services (Table S-2).

). Among the respondents who want more services, 77.78% stay on campus, 72.22% of them have a valid driver's license, 50% have access to vehicles, a majority of them walk and use the transit around campus, and 69.44% indicate there are locations on campus too far to walk to (Table S-3).

About 80.4% of respondents stated they were unwilling to pay an activity fee for transit around campus. Among the respondents who indicated a willingness to pay:

- More than half (55.56%) worked part time
- 41.12% were somewhat satisfied with the transit service
- 81.82% have heard of the TapRide
- 42.45% stated the MATBUS service is adequate
- A significant number want the service span to extend to late nights

Among respondents willing to pay a per-semester fee, about 29% of were willing to pay less than $10; the majority of respondents (43.46%) specified they were willing to pay between $11 and $20; and 16.36% of them stated they were willing to pay between $21 and $30 (Figure S-3 and Table S-3).

Table S-2 Willingness to Pay Per Semester and Service Satisfaction

		Willingness to pay	
		Yes	No
Level of study:	Undergraduate	176	716
	Graduate	40	159
Employment status:	*Full time*	*43*	*135*
	Part-time	*120*	*520*
	Not Working	*53*	*229*
Frequent MATBUS Routes:	Route 13	87	241
	Route 13U	61	157
	Route 31	34	118
	Route 32E	96	348
	Route 32W	62	228
	Route 33	98	353
	Route 34	42	190
	TapRide	22	57
	None	18	172
Satisfaction with NDSU MATBUS Services:	*Extremely satisfied*	*81*	*188*
	Somewhat satisfied	*88*	*399*
	Neither satisfied nor dissatisfied	*20*	*187*
	Somewhat dissatisfied	*22*	*87*
	Extremely dissatisfied	*3*	*16*
How much respondents are willing to pay per semester:	Less than $10	61	0
	$11 to $20	93	0
	$21 to $30	35	0
	$31 to $40	11	0
	$41 to $50	7	0
	More than $50	7	0
Would you want more TapRide services on campus?	*Yes*	*18*	*54*
	No	*4*	*3*
Do you think that the service span of the MATBUS service is adequate?	Yes	90	355
	Maybe	64	328
	No	58	189
What periods would you want increased services?	*Weekdays*	*36*	*167*
	Weekends	*45*	*202*
	Early Morning	*34*	*144*
	Late Nights	*93*	*329*

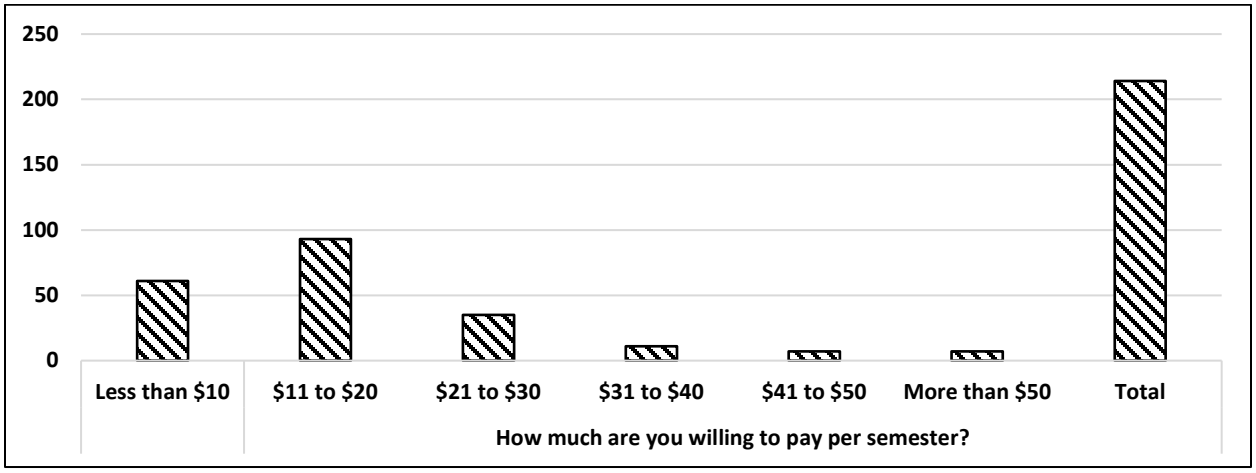

Figure S-3 What Respondents are Willing to Pay Per Semester

Route Recommendations

The survey respondents were asked to list any additional bus stops they want on campus and locations that are too far to walk. The top 10 locations respondents mentioned are shown below (Table S-3). SURTC recommends that MATBUS modify some of its services, within budget, by modifying some of its route frequencies (increasing them). MATBUS could modify its existing fixed-route service windows and frequencies or by expanding its TapRide service to cover the gaps in the fixed-route service.

Table S-3 Locations or Stops Recommended for Service Addition or Improvement

Stops (Locations)	**Sum**	**Stop Location**							**Sum**
		Address	13	13U	31	32E	32W	33	34	
Richard H. Barry Hall	74	811 2nd Ave N	1	1	0	0	0	1	0	3
Fargodome	58	1800 N University Dr	1	1	1	1	1	1	1	7
Library	35	1201 Albrecht Blvd #2080	0	0	1	1	1	0	0	3
Minard Hall	22	1210 Albrecht Blvd	0	0	1	1	1	0	0	3
Wellness Center	21	1707 Centennial Blvd	0	0	1	0	0	0	0	1
Niskanen	16	1805 N University Dr	1	1	0	0	0	1	1	4
West Dining	12	1500 15th Ave N	0	0	1	1	1	0	0	3
Animal Nutrition and Physiology Center	7	1801 15th Ave N	0	0	1	0	0	0	0	1
Renaissance Hall	7	650 Northern Pacific Ave	1	1	0	0	0	0	0	2
Klai Hall	5	711 2nd Ave N	1	1	0	0	0	1	0	3

U.S. University Transit System Survey Results

A seven-question survey was developed in Qualtrics, and a survey link was emailed to 53 university campus transit contacts across the United States on March 11, 2019. Responses were received from 32 universities for a 60% response rate, which is quite good. The university size ranged between 12,500 and 44,000 students. Among respondents, 63% (20) reported their school has multiple campuses (clusters of buildings in separate areas), and 94% (17) reported the multiple campuses are served by transit service. Each respondent was asked to check all of the services that apply to their campus. (Table S-4).

Table S-4 Kinds of Transportation Options Available to Campus Community

Kinds of Transportation Options Available to Campus Community, N=92		
Type of service	Count	Percent
On-campus circulator/shuttle	25	27
Shuttles from remote parking lots to campus	18	20
Regular fixed-route service	25	27
Accessible service for students with disabilities	24	26

The respondents were asked who operates the campus transit system. There were some campuses with multiple operators, e.g., some are only university-operated agencies; others are university and private contractor operated; a few campuses reported transit agency, university, and private contractor operations. The schools that reported multiple operators also have multiple services, including on-campus circulator/shuttle, shuttle from remote parking lots to campus, regular fixed-routes, and accessible service for students with disabilities.

Table S-5 shows the survey results of who operates the campus transit system. Among respondents, 45% (21) reported the university/college operates the transit agencies.

Table S-5 Campus Transit System Operator

Who operates the campus transit system (select all that apply)		
Operator	Count	Percent
University/college	21	45
Private contractor	14	30
Transit agency	11	23
Other (contracted drivers & maintenance)	1	2
Total	47	100

The survey respondents from the 32 campus transit systems reported operating expenses from $36 an hour with the university owning the buses to a high of $166 an hour with the transit agency operating the system. Due to the wide range of variance in the survey numbers, it was clear the dollar amounts did not have consistent methods for calculating expenses. Therefore, the National Transit Database was utilized to determine numbers that could be factually comparative.

Table S-6 illustrates the minimum, mean, standard deviation, median, and maximum operating expense per vehicle revenue hour for 89 urban transit agencies located within the Federal Transit Administration's Region 5 (Illinois, Ohio, Minnesota, Wisconsin, Indiana, and Michigan), Region 7 (Missouri, Iowa, Nebraska, and Kansas), and Region 8 (Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming). Fargo's MATBUS calculation is also listed to show the comparison. MATBUS's fully

loaded hourly operating expense is $72.05, as reported in the National Transit Database for 2017. This number is much lower than the mean dollar value of $109.28 and lower than the median value of $83.74.

Table S-6 Operating Expense

Operating Expense Per Vehicle Revenue Hour					
	Vehicle Operations	**Vehicle Maintenance**	**Non-Vehicle Maintenance**	**General Administration**	**Total**
MATBUS Fargo	$34.05	$13.24	$2.54	$22.02	$72.05
Mean	$66.10	$18.11	$4.92	$20.16	$109.28
Standard Deviation	$145.22	$39.84	$16.39	$47.32	$247.85
Minimum	$26.00	$2.69	$0.06	$2.88	$37.18
Q2	$42.04	$11.18	$1.33	$10.80	$71.38
Median	$50.84	$13.61	$2.43	$14.41	$83.74
Q3	$59.33	$17.01	$3.96	$19.46	$95.36
Max	$1,416.32	$386.90	$154.01	$456.67	$2,413.90

Created from: United States Department of Transportation. Federal Transit Administration, National Transit Database, 2017, Washington, DC.

Other University Student Fees

U-PASS programs vary substantially across the United States. TCRP 2018 reports that funding sources for U-Pass programs often include a combination of student fees, parking permit revenue, parking fine revenue, university general funds, and federal, state, and local operating assistance funds (p. 10). From the TCRP survey, some of the details regarding student fees reported by institutions are presented in Table S-7.

At UC Davis, students pay $34.30 per each of three quarters, so they pay $102.90 per year for transit. The rates increased in 2019 by $13.33, so the cost was $47.63 per quarter, and then increased to $58 per quarter; by 2023, the price will increase to $67.83 per quarter. The price increase was voted on and passed with 92% approval. The cost increase was needed due to the increased minimum wage.

Table S-7 U-Pass Student Fee

U-Pass Program Student Fees Reported			
City	**Name**	**Price ($)**	**Unit**
Milwaukee, WI	University of Wisconsin-Milwaukee	45.10	Per Student Per semester
Madison, WI	University of Wisconsin – Madison	55.52	Per student per semester
Bloomington, IN	Indiana University	64.61	Per student per semester
Hartford, CT	Capital Community College	12.00	Per student per semester

Adapted from TCRP Synthesis 131 *College Student Transit Pass Programs.* Transit Cooperative Research Program, National Academies of Science, Transportation Research Board, Washington, DC, 2018

Recommendations

It is recommended that NDSU not cut MATBUS service, but rather expand it to meet the student demand, if fiscally possible. The students identified the desire/need for more frequency and access to the Wellness Center, Fargodome, Barry Hall, the library, downtown, Niskanen Apartments, and Minard Hall. MATBUS's hourly operating expenses are less than the median hourly operating costs for 89 transit agencies within the region, so it is unlikely to reduce the hourly cost MATBUS charges NDSU for service. If additional funds are needed to provide more service, NDSU should consider adding a small student fee to help cover the expenses. Although 80% of students who responded to the survey were not in favor of paying a student fee, about 28.5% were in favor of paying $10 per semester, and 43.46% were willing to pay between $11 and $20. Many universities charge a student fee for public transportation services.

INTRODUCTION

The survey of NDSU students focused primarily on travel behavior and student experience with Metro Area Transit (MATBUS) service. The research updates previous studies conducted with NDSU students by SURTC (Mattson, Ripplinger, & Peterson 2010; Hegland & Hough 2003; Peterson & Hough 2003; Peterson, Hough, Hegland, Miller, & Ulmer 2005; Ripplinger & Ulmer, 2005; Ulmer 2005; Ripplinger, Hough, & Easterday 2008; Ripplinger, Hough, & Brandt-Sargent 2009).

The objectives of the study were to:

- Collect and analyze current and previous NDSU MATBUS transit ridership data
- Study the spatial interaction of trips to determine if existing transit routes should be modified
- Study the impact of changes to student residence (location and size) on ridership
- Describe existing levels of transit service on campus
- Identify gaps in existing service and base levels of required transit service
- Develop recommendations for meeting identified mobility needs
- Compare the costs and type of service offered by different transit agencies/groups to determine the best transit service provider for NDSU for fiscal year 2019

The study would take into account the MATBUS/City of Fargo bus service cost, along with that of other public transit services. NDSU and other service providers can use the survey findings to identify programmatic and finance needs related to campus mobility. Finally, all data collected as a part of this study can be used by NDSU and local transit agencies to plan for future services.

CAMPUS TRANSIT RIDERSHIP DATA

NDSU participates in the U-Pass program, which offers unlimited free rides to students on any MATBUS. Some MATBUS routes exclusively serve the NDSU campus: 13U, 31, 32E, 32W, 33, 34, and Tap Ride. See Table 1 for the exclusive NDSU MATBUS routes, their frequencies, and the stops they serve. For this study, ridership data for most of the exclusive routes (all except route 13U) are collected and analyzed. For the analysis, the authors collected data from MATBUS for the NDSU routes and prepared the data for analysis. The ridership data were then combined with some seasonal and non-seasonal attributes from other data sources on one data frame. The data used were set to both daily and weekly ridership frequencies, and the observational range used was between 2014 and 2018 (four years). The ridership of the bus routes studied (Route 31, Route 32E, Route 32W, Route 33, Route 34, and Route 35/TapRide), had 1,461 observations for the daily ridership dataset and 209 observations for the weekly ridership dataset.

Table 1 NDSU MATBUS Route Details

Route	Frequency	Stops
13U	30 mins	NDSU Transit Hub, Family Fare, Renaissance Hall, GTC, Klai Hall, R.H. Barry Hall, Niskanen, University & Centennial
31	15 mins	Minard Pullout (west), Thorson Hall, Stevens Hall, Wallman Wellness Ctr., Candlewood Suites, Research & Tech Park, Fargodome, High Rises, Loftsgard Hall, Shepperd Arena
32E	30 mins	Minard Pullout (east), Residence Dining Center, Fargodome, University Village, High Rises, Minard Pullout (west), Dakota Drive & 16th St., Prairie Hall
32W	30 mins	Minard Pullout (west), West Port on Dakota Dr, Bison Crossing & Prairie Hall, Minard Pullout (east), Residence Dining Center, Fargodome, University Village, High Rises
33	12 mins 7 mins	NDSU Transit Hub, Family Fare, R.H. Barry Hall, Klai Hall, University Village, SHAC, Centennial Shelter
34	20 mins	NDSU Transit Hub, Reed/Johnson Halls, Fargodome, NDSCS - Fargo, Stop-N-Go Center (SGC), Niskanen Expansion, Centennial Shelter
TapRide (35)	*N/A	*Main NDSU Campus, *SGC Apartments, *University Village, *Dakota Drive (This is an on-demand service offered on NDSU campus during the academic year on weekdays, from 7:30 pm to 11:00 pm. It provides pick-up and drop-off, "curb-to-curb" service with the use of a mobile phone.)

Given the assumption that NDSU college enrollment guarantees some level of transit trips (Chakraborty & Mishra 2013) and profoundly impacts the use of NDSU MATBUS ridership, the authors considered NDSU's annual student enrollment between 2014 and 2018 (Figure 1).

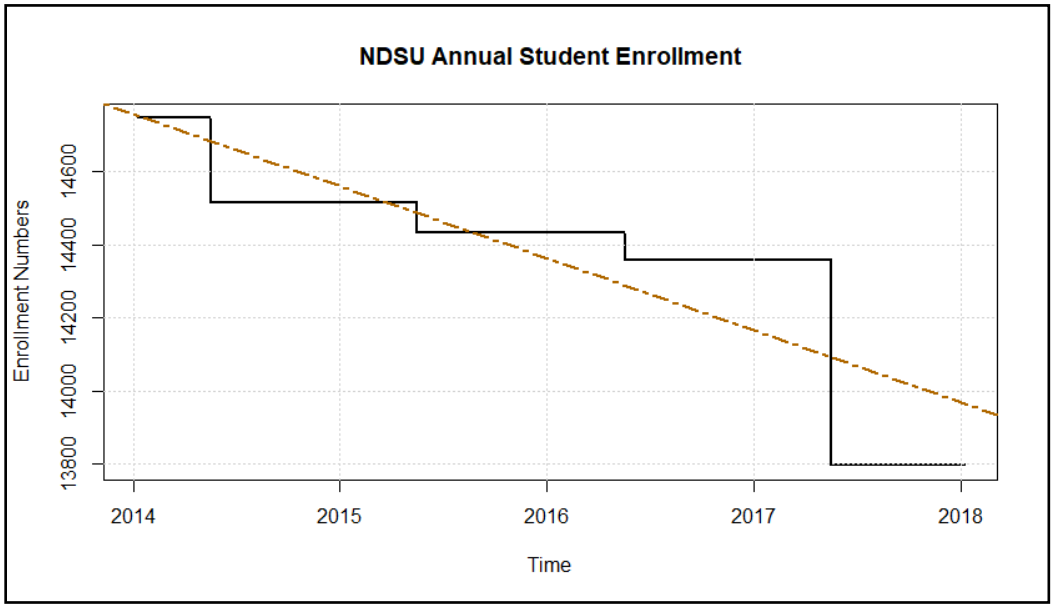

Figure 1 Annual NDSU Student Enrollment

Given that prior research has made known the interdependency of public transit and high-density land use developments, and the impact of housing and residential patterns on transit (Chakraborty & Mishra 2013), the authors considered NDSU student residency (on-campus) in the analysis. The student residence hall and student apartment occupancy trend between 2014 and 2018 is explored (Figure 2). The on-campus residency has declined significantly during these four years, correlating with reduced student enrollment and suggesting a possibility of reduced transit use. In the next section, the trends and seasonality of NDSU MATBUS ridership are discussed for all NDSU exclusive routes.

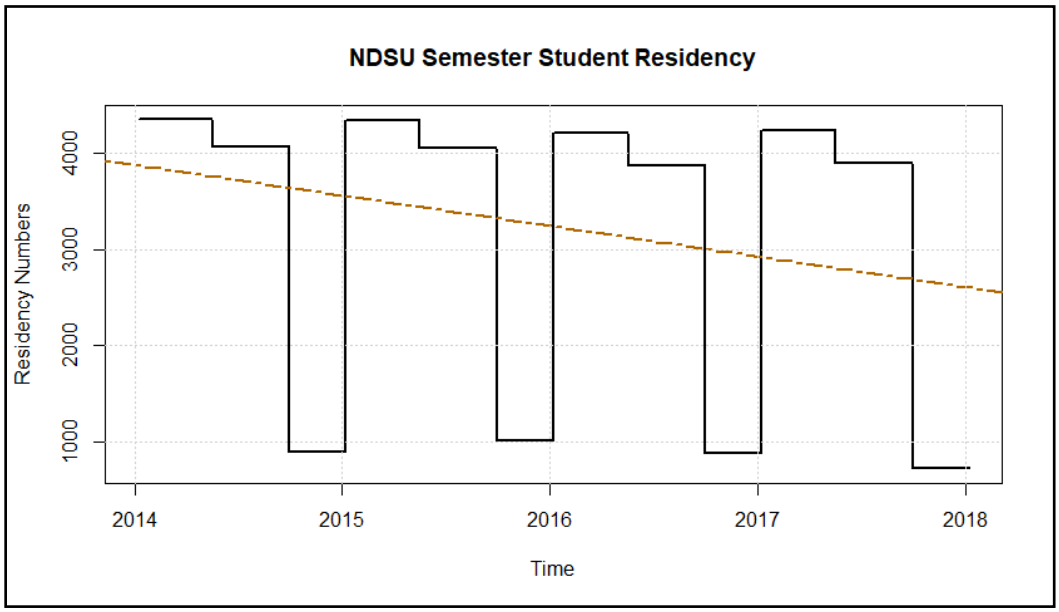

Figure 2 NDSU On-Campus Resident Occupancy (2014 – 2018)

NDSU MATBUS RIDERSHIP AND ANALYSIS

As observed in other daily or weekly transportation indicators, public transit ridership is highly seasonal. Seasonality usually shows long-term variabilities with a repetitive pattern (Bureau of Transportation Statistics 2019); and when the seasonal and irregular components of a ridership time series are separated from the trend (time series decomposition), it is easier to observe the long-term trend of transit ridership. Hence, to better analyze the ridership of all NDSU MATBUS routes, time series analysis and other analytical methods (statistical and machine learning) are used to study the routes and build ridership prediction models. The time series plot of the cumulative ridership of all NDSU exclusive routes in the study shows an overall declining linear trend (Figure 3). The decomposed time series plot (Figure 4) has a trend with a narrow valley between fall and spring semester and a wider one during the summer semester (some NDSU MATBUS routes are only available for spring and fall semester).

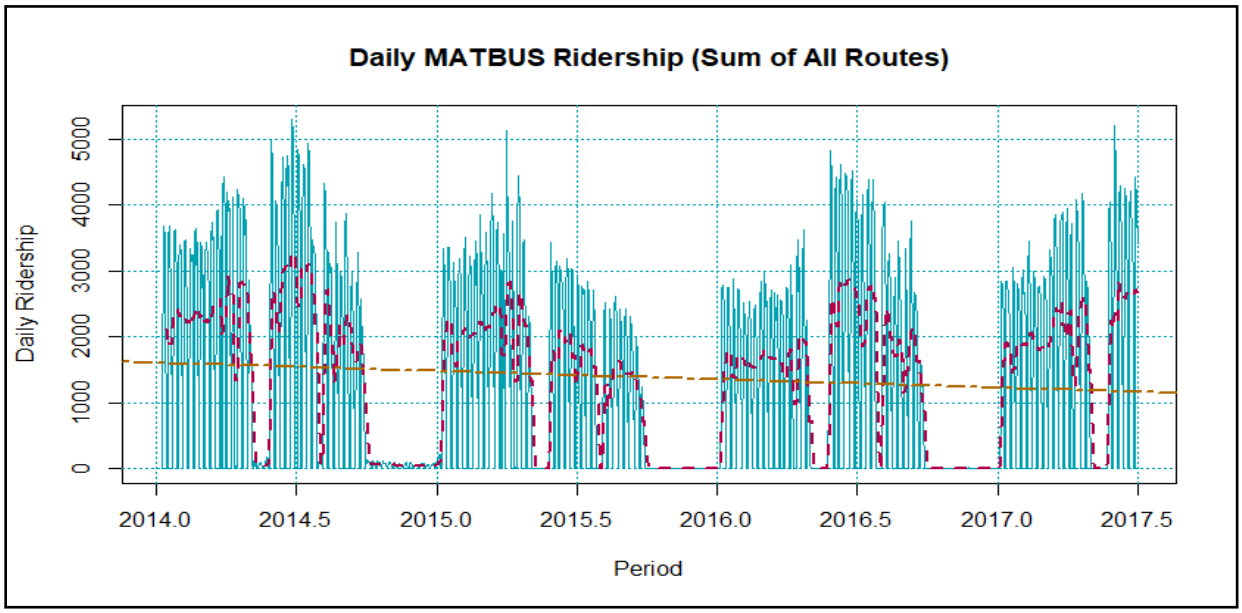

Figure 3 Cumulative NDSU MATBUS Ridership (Routes 31-35/Tap)

The decomposed time series shows that, while the trend is initially continuously downward, it changes to an upward trend at the end of 2015, and continues upward until 2017. However, when the trend is considered linearly (from the start point to the end point), the ridership appears to be on a steady overall decrease (Figure 4).

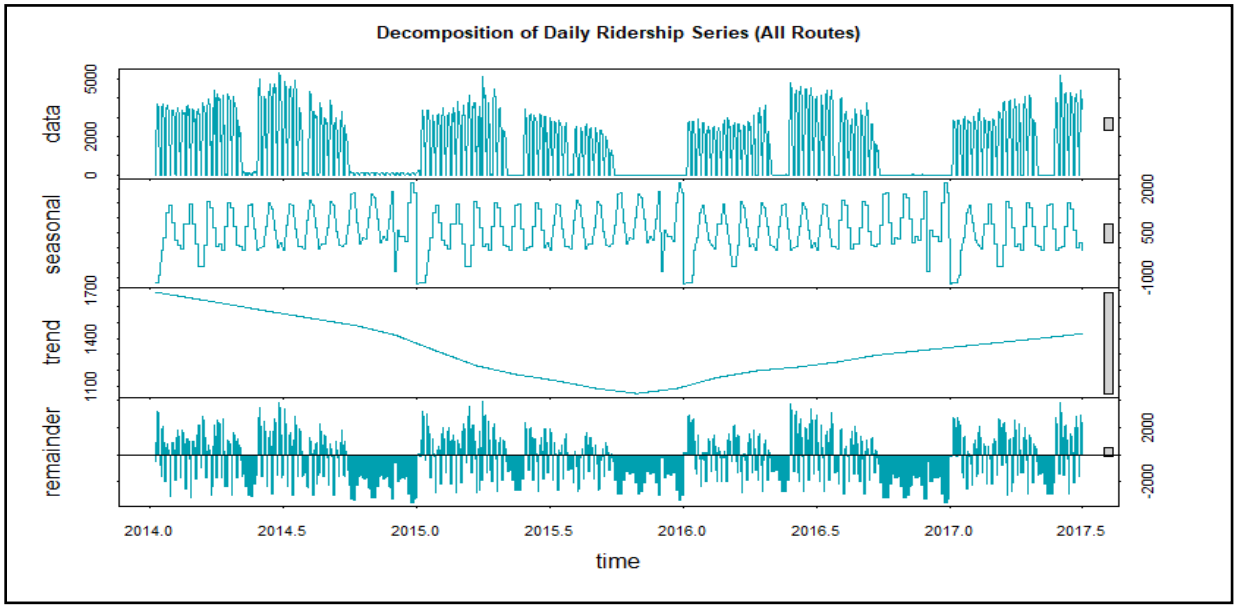

Figure 4 Decomposition of the Cumulative Daily Ridership (Routes 31-35/Tap)

The trend changes within a 600-ridership interval (± 300 daily rides), and the skew on the random effects (reminder) on the daily ridership suggests an overall advantageous tilt in the positive direction. The seasonality shows a recurring seasonal pattern with changes that range between +2,000 rides and -1,000 rides (a 3,000 ridership range). The observed seasonality could inform the decisions of MATBUS or other transit service providers regarding route planning and operations. The hourly ridership of all the routes considered in the cumulative daily ridership is shown in Figure 5 through Figure 9. Route 31 showed increased ridership between 8 a.m. and 11 a.m. (Figure 5) while running at 15-minute intervals, primarily because of students utilizing the park and ride lots near the Fargodome on the north side of the main campus and the T-lot to the south of campus.

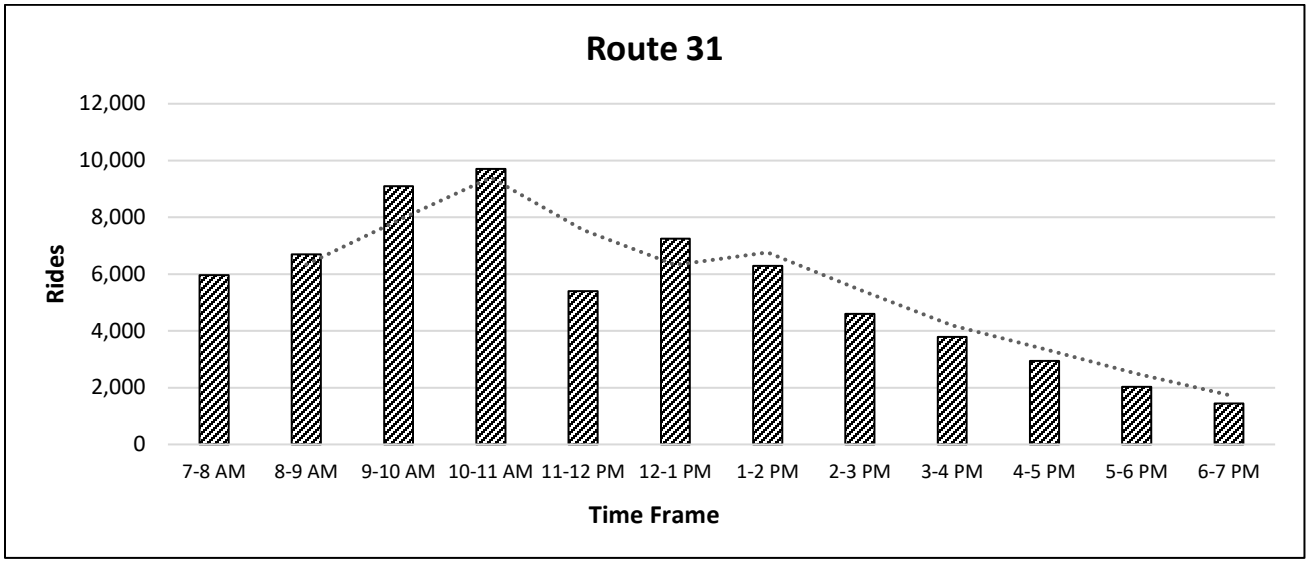

Figure 5 Route 31: Hourly Ridership

Route 32E, which operates at 30-minute intervals, exhibited relatively steady ridership throughout the day (Figure 6) while serving the University Village area, along with the many apartment complexes south of the main NDSU campus. Route 32W ridership is concentrated in the morning hours between 7:30 a.m. and 10 a.m. (Figure 7) while serving the apartment complexes to the southwest of campus along with the University Village area. Route 32W has discontinued afternoon and evening service. Route 33 was the most-used route at NDSU, accounting for more than 40% of ridership during the study time frame. Ridership was heaviest from 9 a.m. to 1 p.m. (Figure 8) but remained consistent from 8 a.m. to 4 p.m. This route serves the downtown campus via the east side of the main NDSU campus along University Avenue with service to University Village. The route runs at 7- to 12-minute intervals from 7 a.m. to 7 p.m. Finally, Route 34 runs at 20-minute intervals between 7:45 a.m. and 4:45 p.m. and saw its most substantial ridership from 8 a.m. to 10 a.m. and noon to 2 p.m. (Figure 9). The route serves the main campus and Fargodome area.

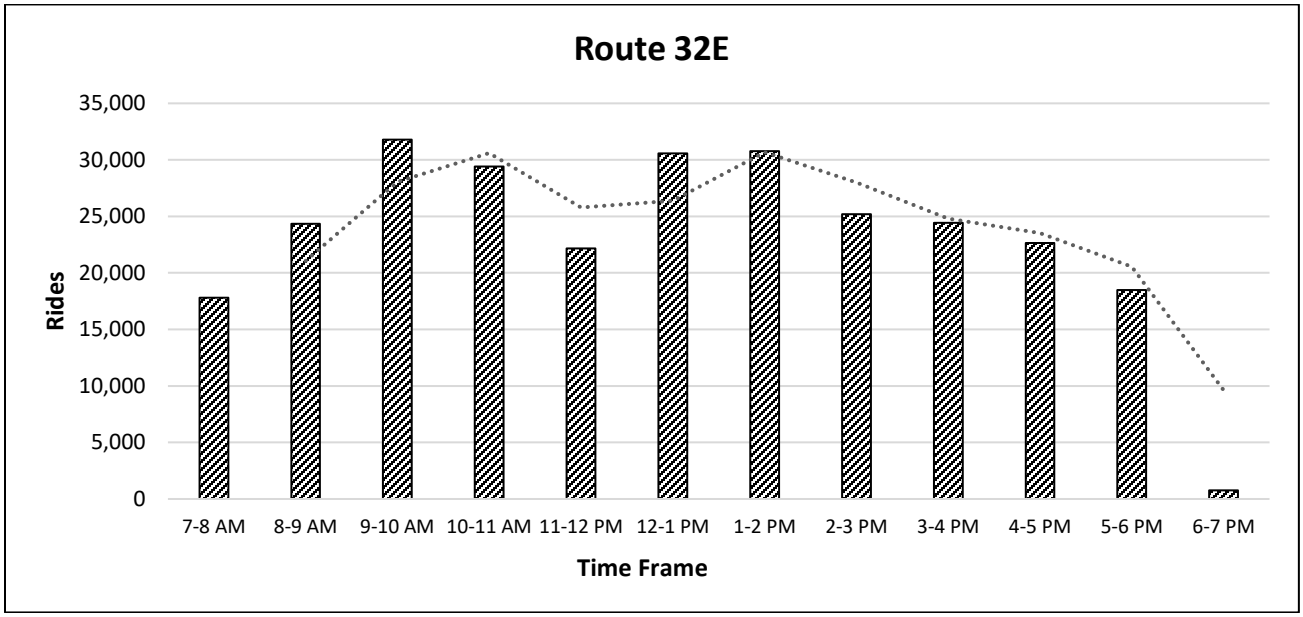

Figure 6 Route 32-East: Hourly Ridership

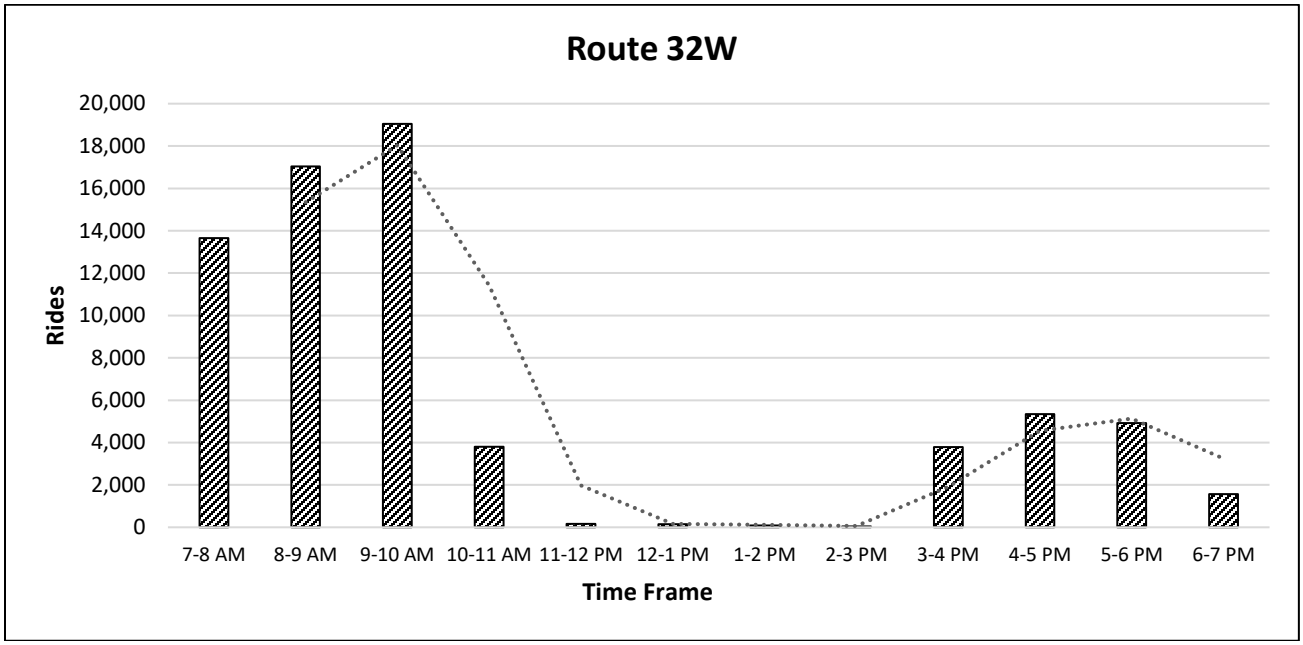

Figure 7 Route 32-West: Hourly Ridership

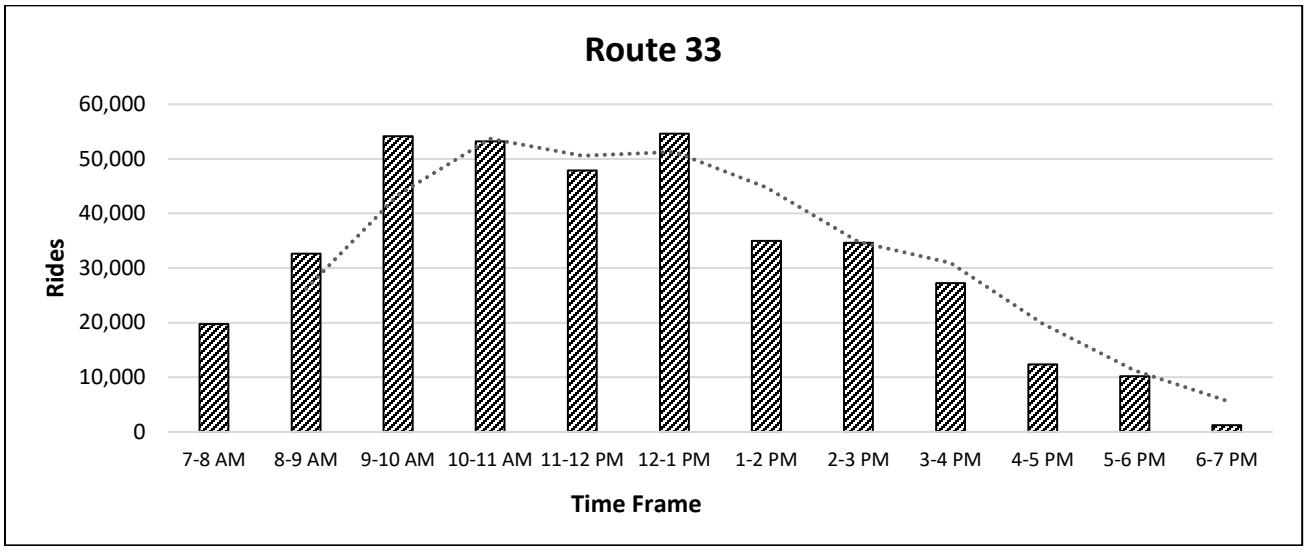

Figure 8 Route 33: Hourly Ridership

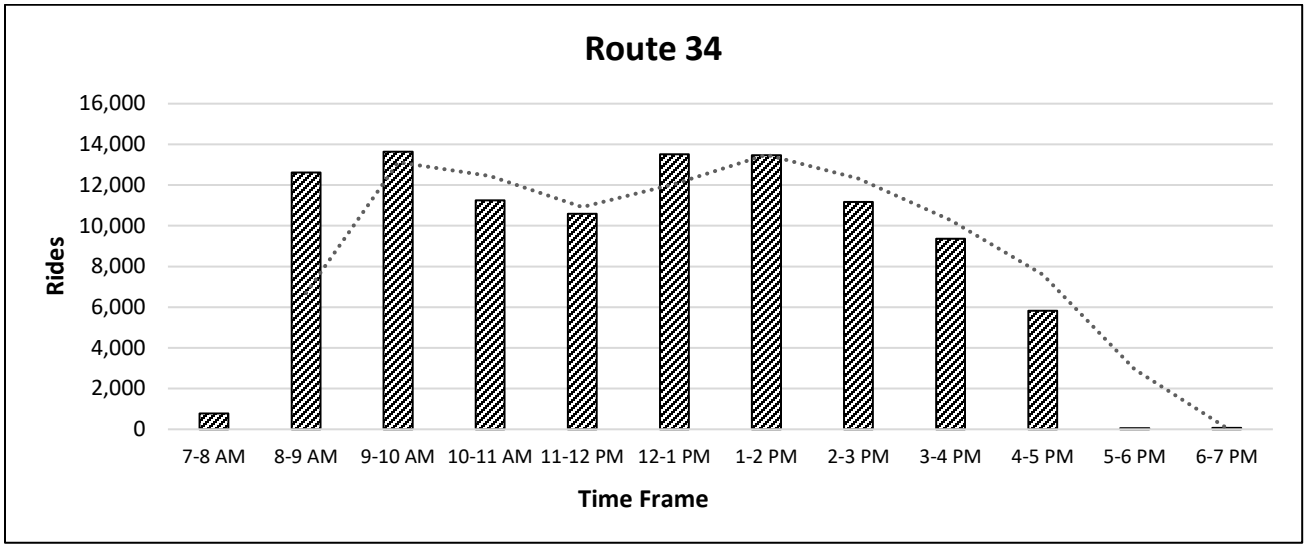

Figure 9 Route 34: Hourly Ridership

MATBUS - Route 31

Figure 10 and Figure 11 show the composite and decomposed time series data for Route 31 daily ridership. As can be seen from the composite time series plot, the trend is linear and goes downward, and the ridership varies depending on the time of year. A closer look at the trend without seasonality and randomness shows that the ridership continually dropped until the middle of 2017. This trend changes within an 80 ridership range or interval (± 40 daily rides from the mean). Figure 11 shows that the random effects (reminder) on the daily ridership numbers skew toward an increase in ridership. Seasonality shows a recurring seasonal pattern with maximum changes that range between +100 rides and -100 rides.

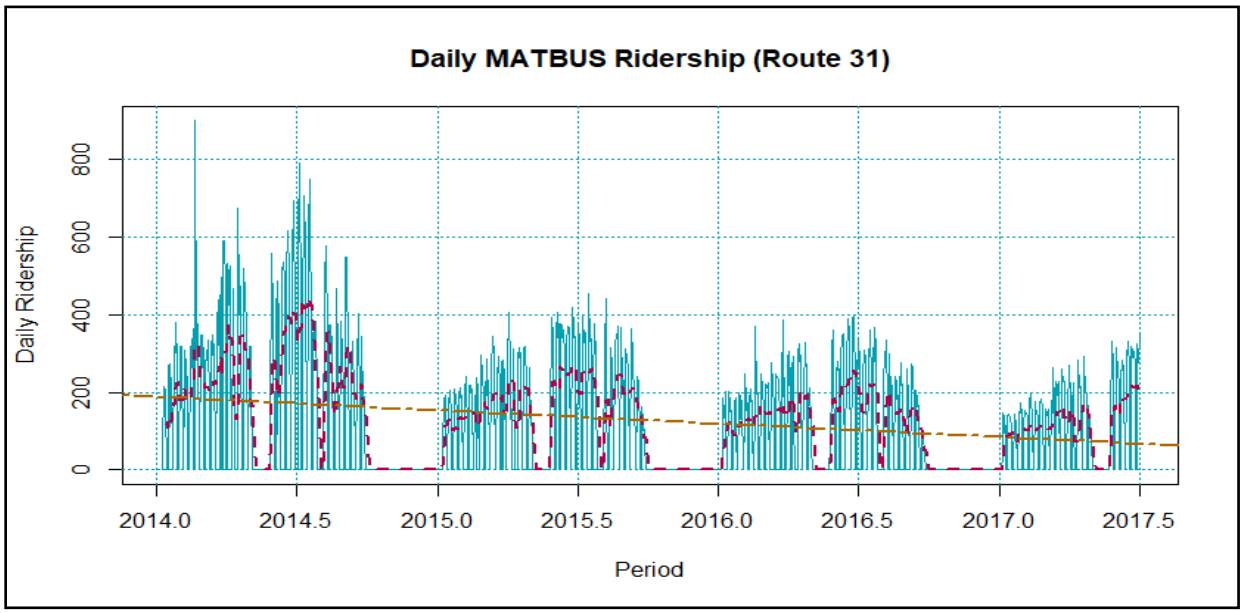

Figure 10 Daily Ridership of Route 31

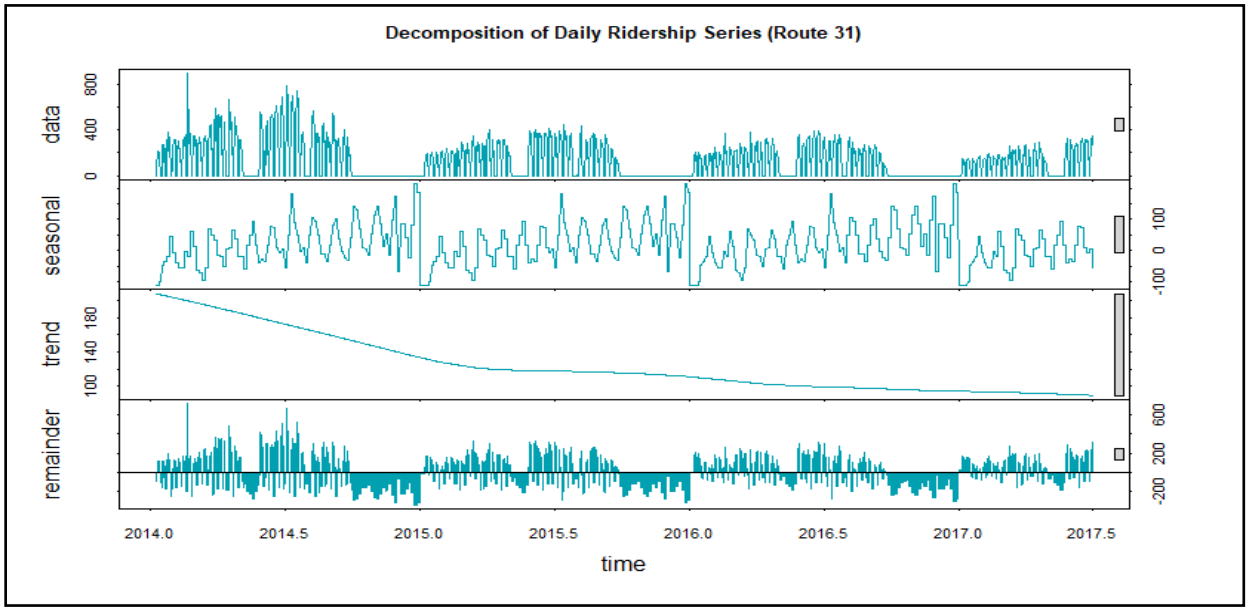

Figure 11 Decomposition of the Daily Ridership of Route 31

MATBUS - Route 32

Figure 12 and Figure 13 show the composite and decomposed time series data of Route 32 daily ridership. As can be seen from the composite time series plot, the trend is slightly upward, and the ridership also varies depending on the time of year. However, the decomposed time series shows a broad valley interrupting the positive trend in 2015. The trend changes within a 200-ride interval (± 100 daily rides).

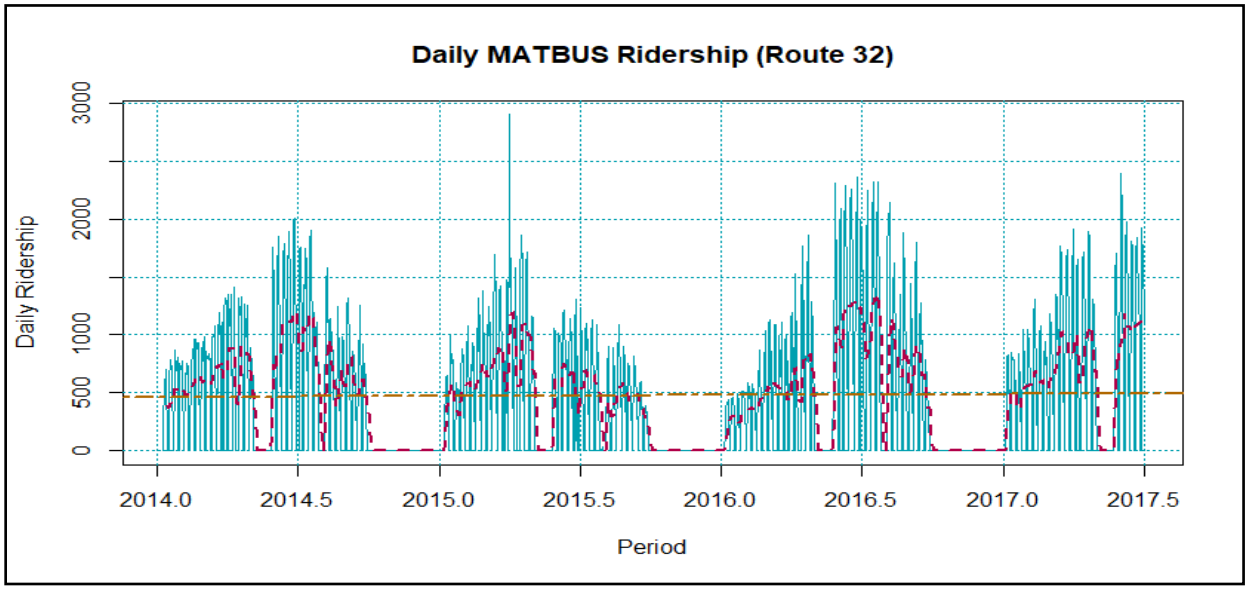

Figure 12 Daily Ridership of Route 32

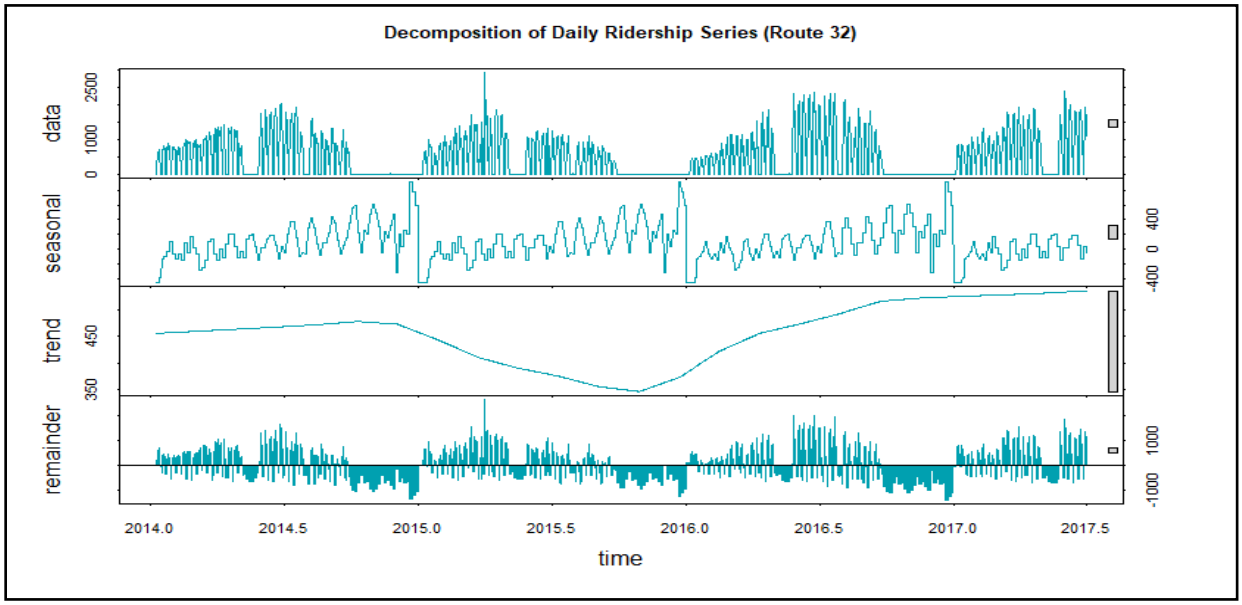

Figure 13 Decomposition of the Daily Ridership of Route 32

Figure 13 also shows that the random effects (reminder) on the daily ridership numbers skew toward an increase in ridership. The seasonality shows a recurring seasonal pattern with maximum changes that range between +400 rides and -400 rides.

MATBUS - Route 33

Figure 14 and Figure 15 show the composite and decomposed time series data of Route 33 daily ridership data. As can be seen from the composite time series plot, the linear trend is declining.

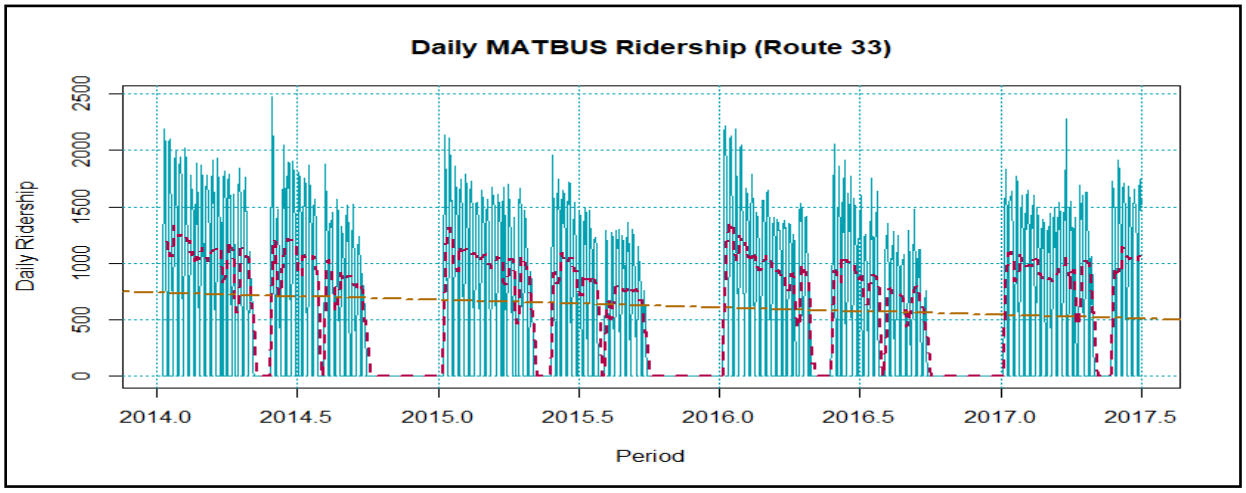

Figure 124 Daily Ridership of Route 33

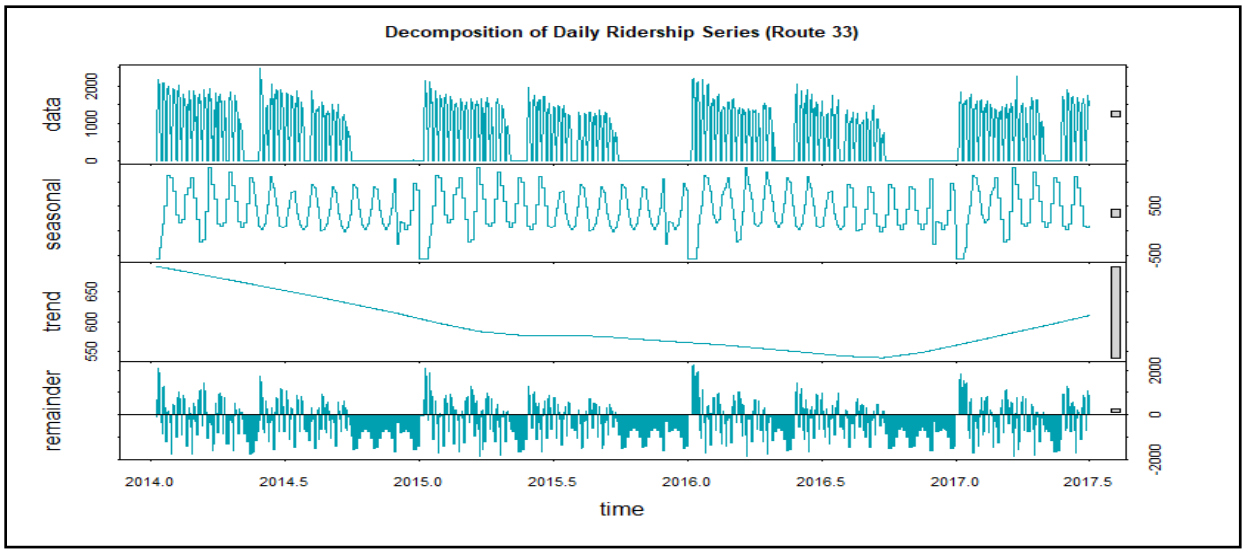

Figure 135 Decomposition of the Daily Ridership of Route 33

However, the decomposed time series shows the trend has a valley- or u-shaped trend. This trend changes within a 100-ride range or interval (± 50 daily rides from the mean). As shown in Figre 15, the random effects (reminder) on the daily ridership numbers skew toward an increase in ridership. The seasonality shows a recurring seasonal pattern with maximum changes that range between +2,000 rides and -2,000 rides.

MATBUS - Route 34

Figure 16 and Figure 17 show the composite and decomposed time series data of Route 34 daily ridership data (average weekly ridership shown with thick dashed lines).

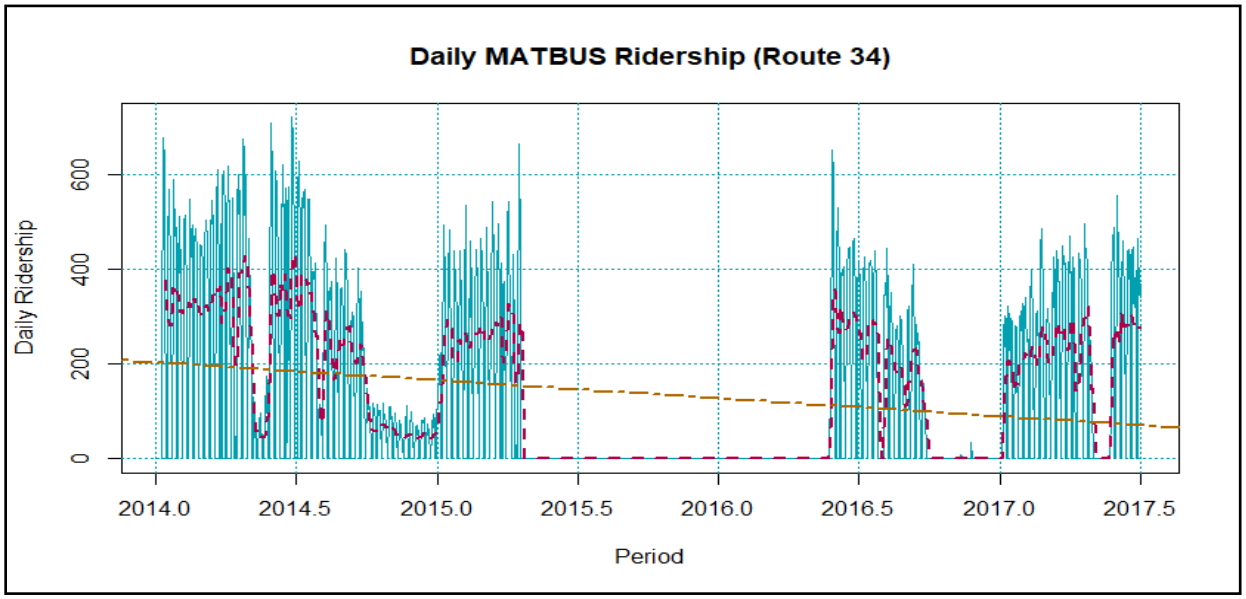

Figure 16 Daily Ridership of Route 34

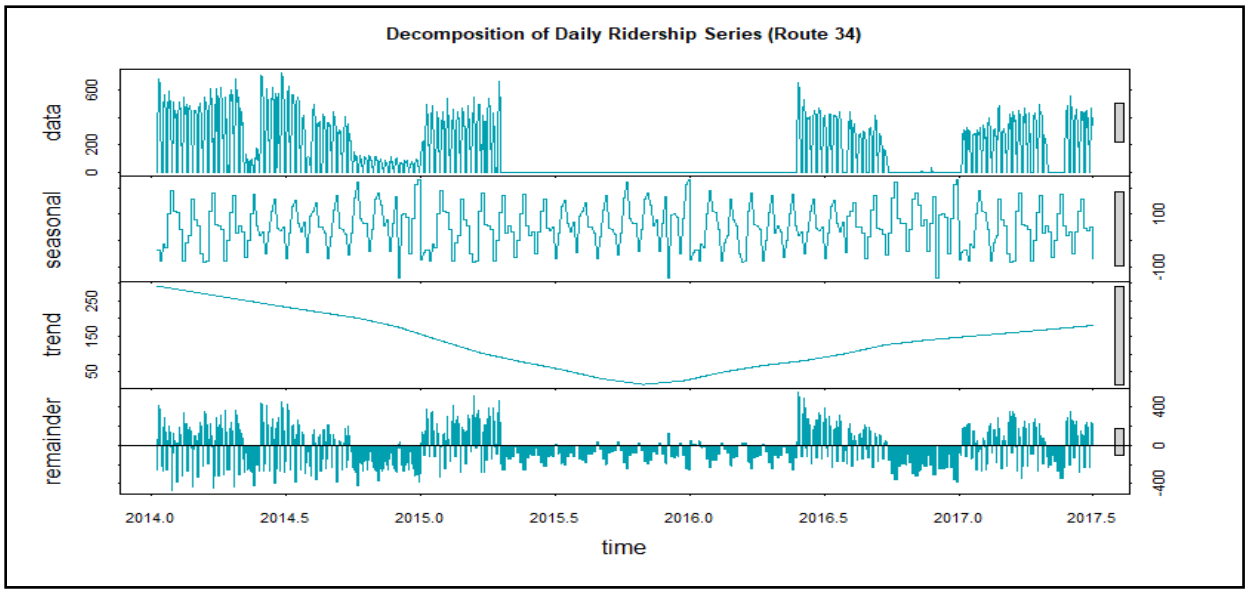

Figure 17 Decomposition of the Daily Ridership of Route 34

As can be seen from the composite time series plot, the linear trend is declining. However, the decomposed time series shows the trend has a valley- or u-shape trend. This trend changes within a 200-ride range or interval (± 100 daily rides from the mean). Figure 17 also shows that the random effects (reminder) on the daily ridership numbers skew advantageously toward an increase in ridership. The seasonality shows a recurring seasonal pattern with maximum changes that range between +400 rides and -400 rides.

MATBUS - Route 35

Figure 18 and Figure 19 show the composite and decomposed time series data of Route 35 daily ridership.

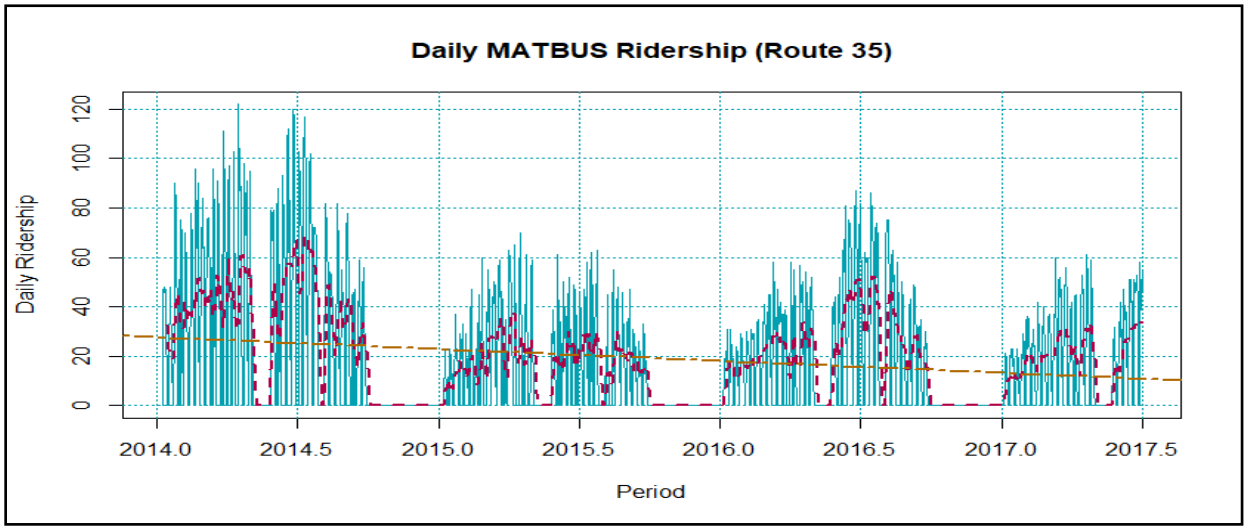

Figure 18 Daily Ridership of Route 35

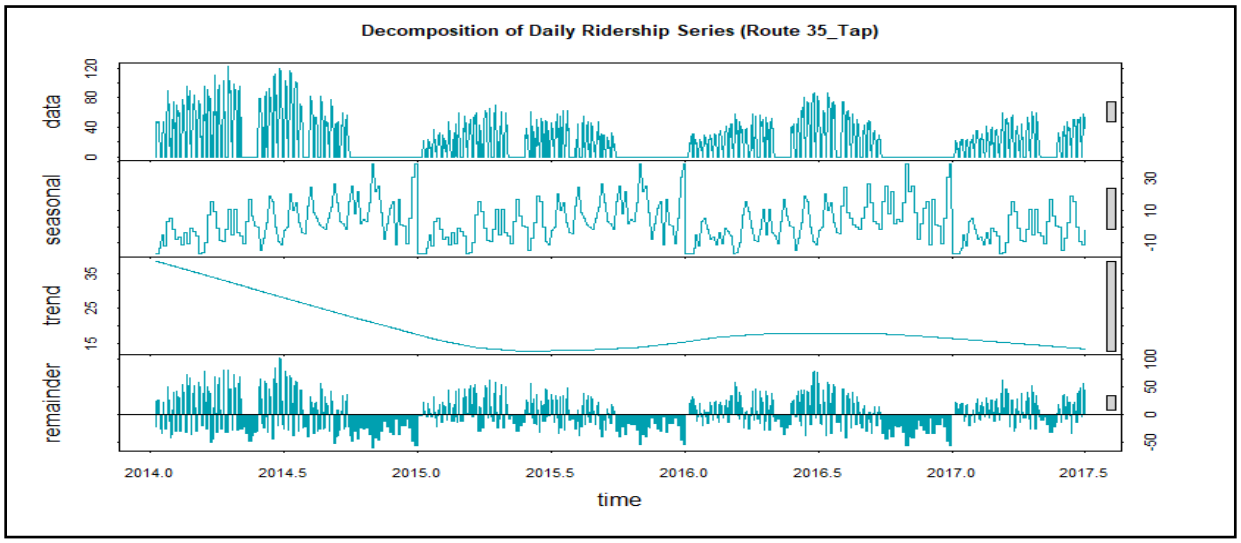

Figure 19 Decomposition of the Daily Ridership of Route 35

As can be seen from the composite time series plot, the linear trend is declining. However, the decomposed time series shows the trend had a steady decline in a valley- or U-shape trend. This trend changes within a 20-ride range or interval (± 10 daily rides from the mean). Figure 19 also shows that the random effects (reminder) on the daily ridership numbers skew advantageously toward an increase in ridership. The seasonality shows a recurring seasonal pattern with maximum changes that range between +30 rides and -10 rides.

RIDERSHIP ANALYSIS AND PREDICTION

Before the analysis for the impact of seasonal and non-seasonal factors on ridership, the ridership data are transformed, and out of 42 predictor variables from the dataset, 15 variables are selected based on their variable inflation factors (VIF) test scores and correlation with other variables (Appendix: Figure A-5 and Figure A-6). Because of the authors' interest in the impact of the changes (demolition and new construction) to University Village Apartment occupancy on ridership, it is added to the selected variables for analysis (Table 2).

Table 2 Selected Factors for Statistical Analysis

Selected Factors	**Data Tag (Attribute Name)**
The Observation Date Type	"Day_TypeW_End"
Holiday	"HolidayYes"
The Semester	"SemesterSpring + SemesterSummer"
NDSU Student Enrollment	"Enrollment"
Maximum Daily Temperature	"T_Max"
Maximum Wind Speed	"WS_Max"
Bison Court West	"B_Court_W"
Burgum Hall	"Burgum"
Churchill Hall	"Churchill"
Dinan Hall	"Dinan"
University Village Apartments	"UV_Apts"

Regression Analysis

For the regression analysis, six models are fitted to the observed ridership using the selected variables. One model is fit for the cumulative ridership of all routes in the study, and five other models are fit for each route. The mathematical equation for the fitted models are shown in Appendix B, Equation A-1 and the model outputs are shown in Appendix B, Figure A-7 through Figure A-18. While the six models show significant relationships between predictor variables and ridership, they do not explain all the variability in ridership and are unable to predict the ridership in all routes to a satisfactory level of confidence (95% CI): (Appendix B: Figure A-21, Figure A-22, Figure A-23, Figure A-24, Figure A-25, and Figure A-26). In Table 3, the impact of the factors on ridership slope is shown for each factor considered for the models; and as the table shows, weekends, holidays, and Burgum Hall residence occupancy have consistently negative impacts on the ridership of all routes considered. Also, any increase in University Village occupancy shows an overall negative impact on the ridership of most routes (Route 31, Route 33, and Route 35). Except for Route 33, the ridership of all routes decreases when there is an increase in temperature and increases when there is an increase in wind speed.

Table 3 Selected Predictor Factor Impacts

Predictor Variables and Intercept	M00 All Routes	M01 Route 31	M02 Route 32	M03 Route 33	M04 Route 34	M05 Route 35	Consistent Impact across all Models?
(Model Intercept)	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	FALSE
Day Type (Weekend)	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**TRUE**
Holiday (Yes)	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**TRUE**
Semester Spring	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	FALSE
Semester Summer	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	FALSE
Enrollment	[-] ve	[+] ve	[-] ve	[+] ve	[+] ve	[+] ve	FALSE
Maximum Temp.	*[-] ve*	*[-] ve*	*[-] ve*	***[+] ve***	*[-] ve*	*[-] ve*	*FALSE*
Maximum Wind Spd.	*[+] ve*	*[+] ve*	*[+] ve*	***[-] ve***	*[+] ve*	*[+] ve*	*FALSE*
Bison Court (West)	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	FALSE
Burgum Hall	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**TRUE**
Churchill Hall	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	FALSE
Dinan Hall	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	FALSE
University Village Apt.	*[+] ve*	*[-] ve*	*[+] ve*	*[-] ve*	*[+] ve*	*[-] ve*	*FALSE*

To better predict NDSU MATBUS ridership, the authors switch methods from statistics to machine learning because transit demand/ridership prediction is both an art and a science. Predicting ridership involves estimating real-time unknown variables of demand with a certain degree of rationality, that statistical methods (regression and time series) can be too simplistic for this study despite their complexities and strengths (Profillidis & Botzoris 2019). The limitations of statistical methods exist due to flaws they possess:

- Transit demand methods exhibit non-linear characteristics (regression).
- In time series methods, there can be only one independent variable (time).
- Both methods are based on assumptions that limit the flexibility of transit-demand problems.
- Both methods use limited datasets.
- Both methods use static models that lack the dynamic reflection of human behavior.

To mitigate the flaws of the statistical models, the authors use a machine learning model called a neural network. Two neural networks are built with the same inputs as the regression models and are used to predict the daily ridership of all NDSU MATBUS routes. The neural network (NN) models are used to predict both the overall ridership and the ridership of all five routes. The equation for the NN model used for the predictions are in Appendix B: Equation 2. An NN model with two hidden layers and a linear output is fit using resilient backpropagation ("rprop+ algorithm"). The weights of the NN models are in Appendix C, Table A-3 and Table A-4. The models predict MATBUS transit ridership better than the regression models. See Appendix B: Figure A-33 and Figure A-34 for network configuration; and Figure A-21 through Figure A-26 for daily ridership predictions.

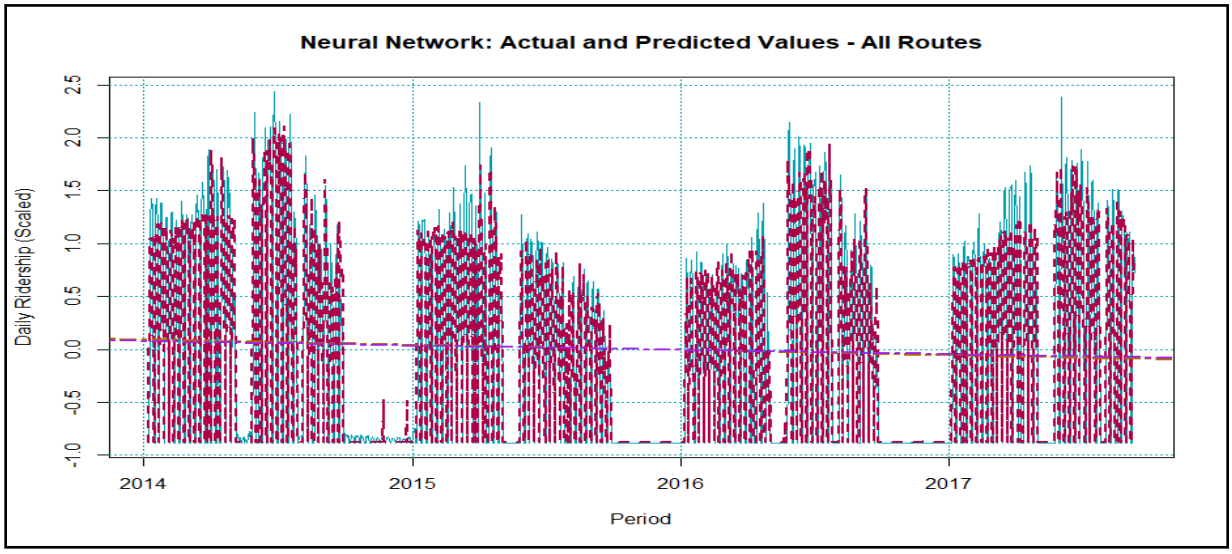

Figure 20 Cumulative Ridership (All Routes) Prediction

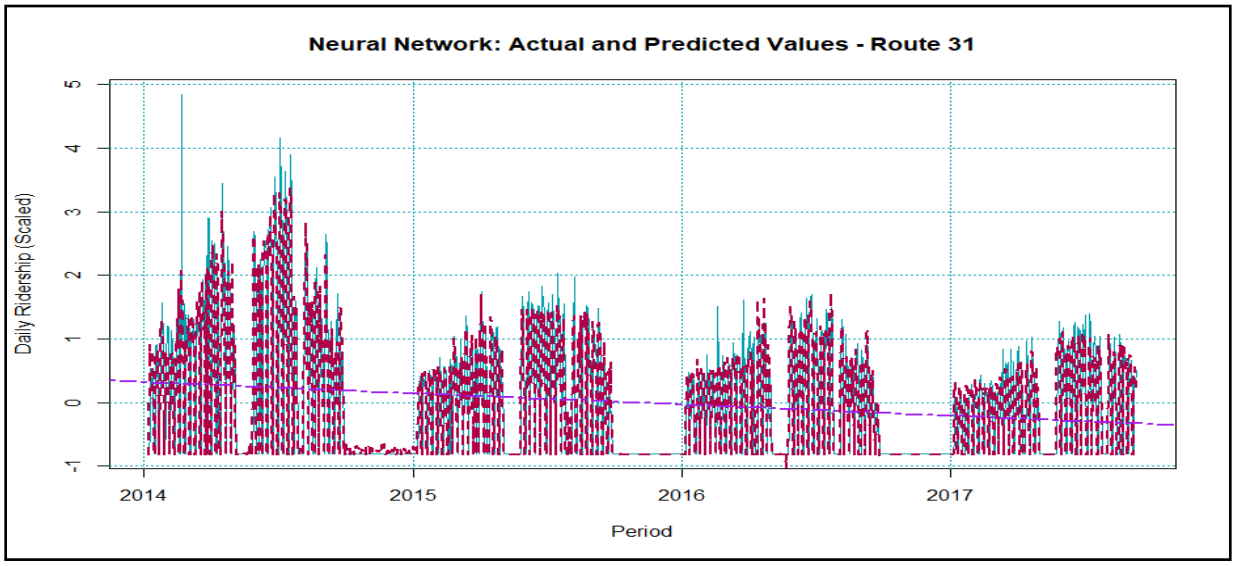

Figure 21 Route 31 Prediction

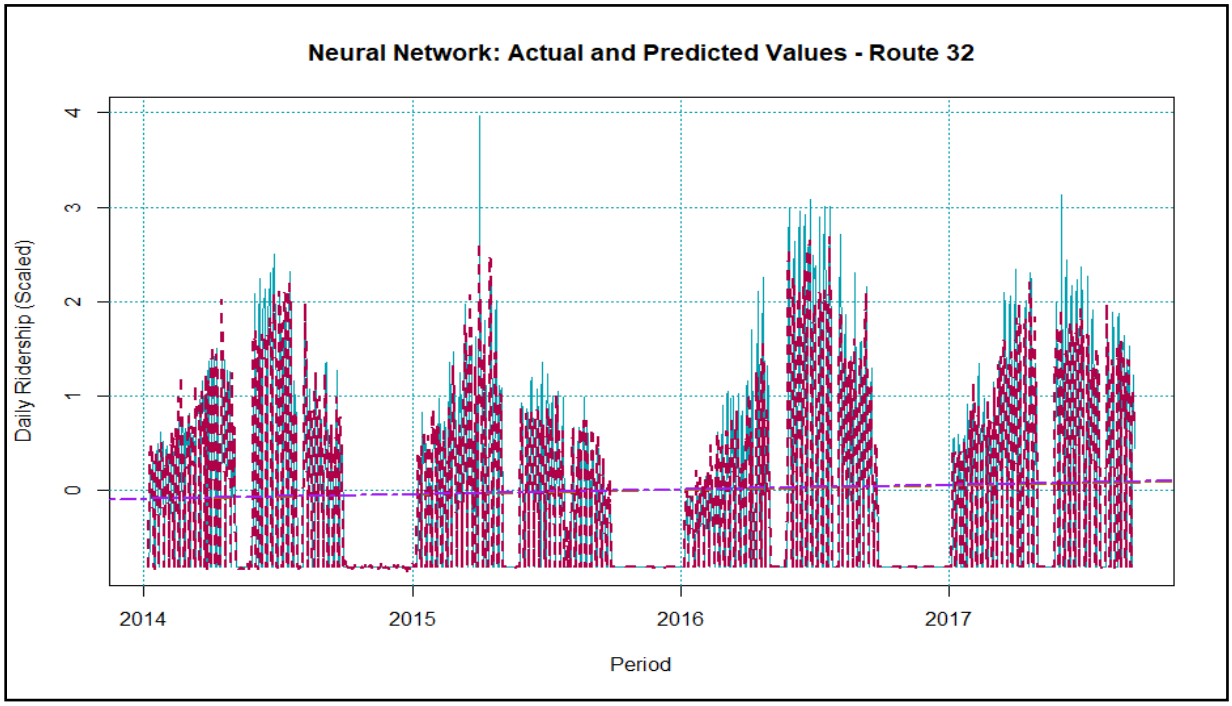

Figure 22 Route 32 Prediction

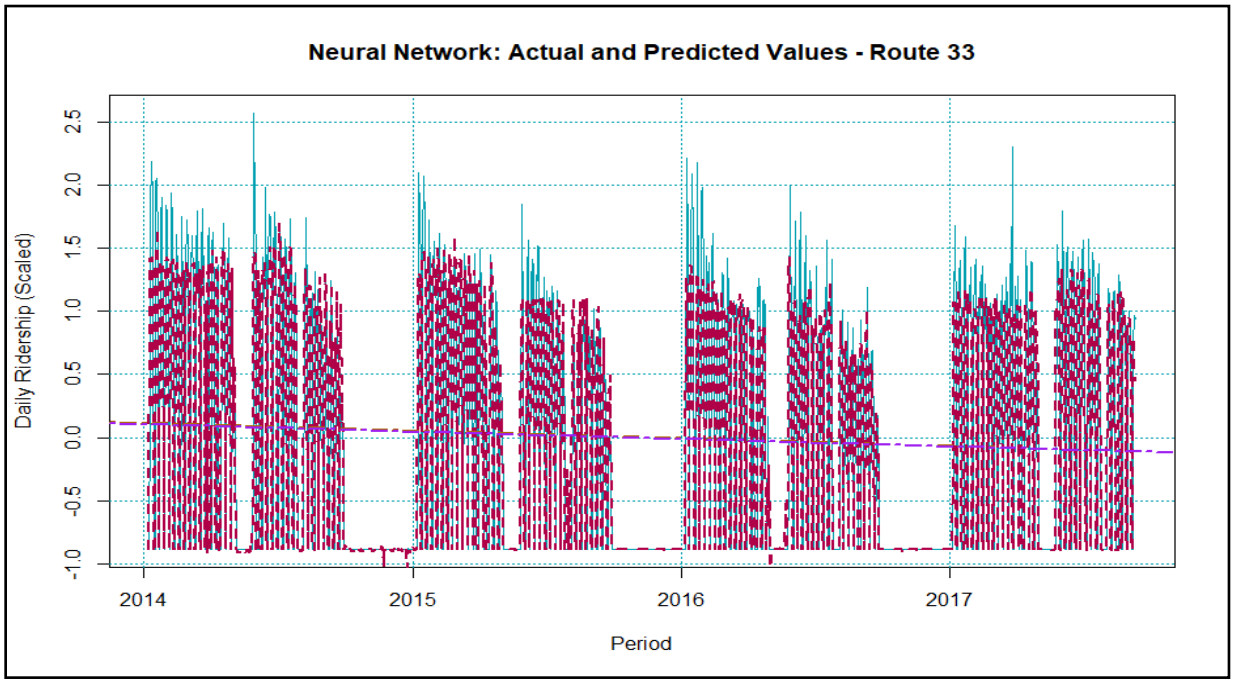

Figure 23 Route 33 Prediction

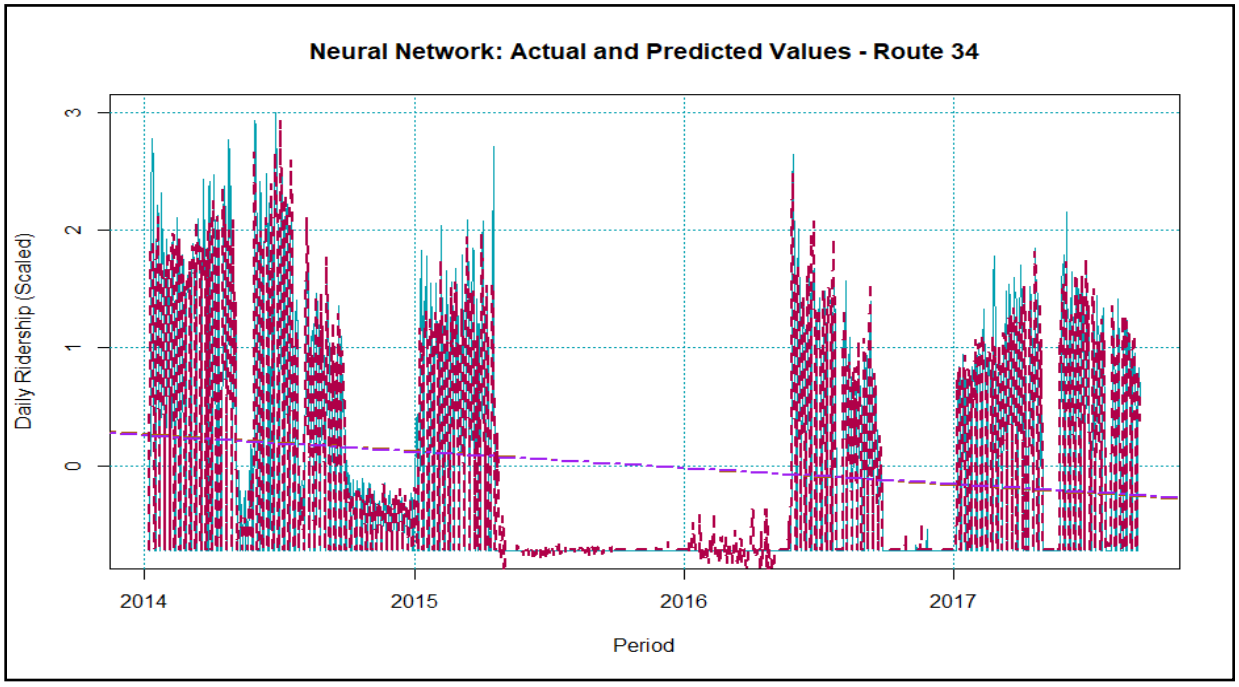

Figure 24 Route 34 Prediction

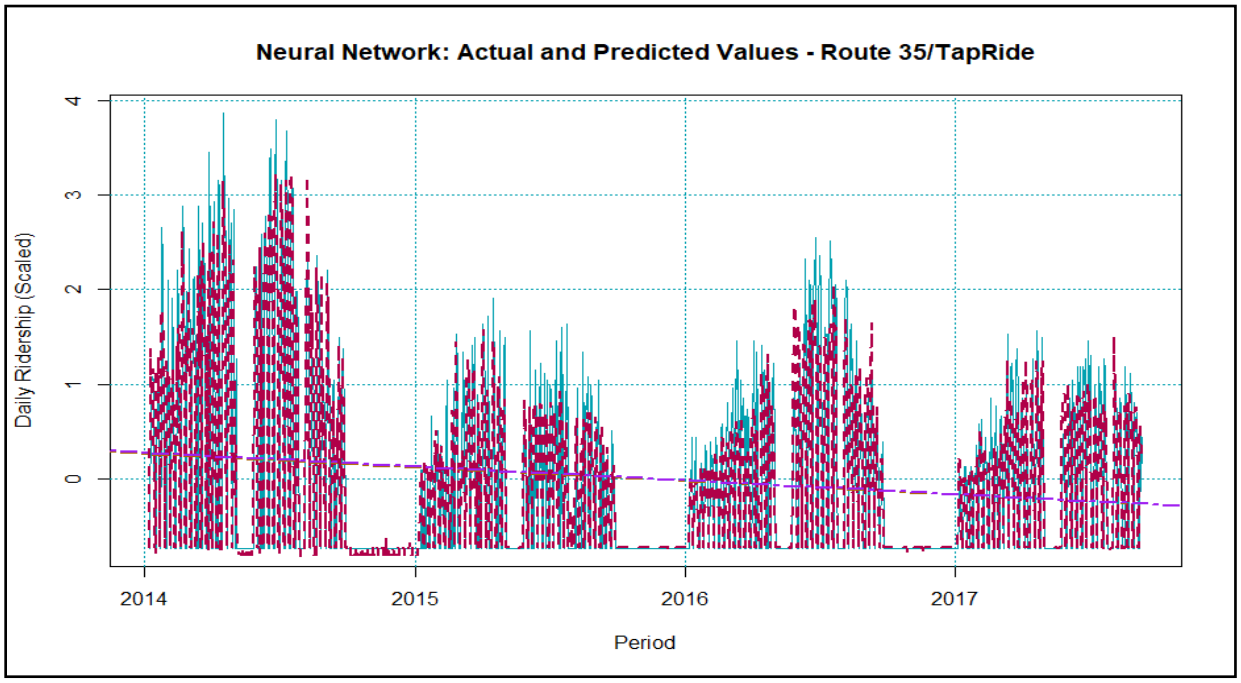

Figure 25 Route 35 (TapRide) Prediction

SURVEY SUMMARY

Profile of Respondents

A significant percentage (82.7%) of respondents was age 18 to 24. None of them were younger than 17, and only 1.1% were 45 or older. Most respondents (64%) were female, and a large proportion of the respondents (81.3%) were undergraduate students (Table 4 and Figure 26). The age profile from a 2014 Transit Center survey is similar to this one. Results from an earlier survey (TransitCenter 2019), suggest that millennials have pro-transit attitudes. However, they face the same factors that tend to pull people away from transit:

- Starting families
- Seeking larger homes
- Moving to less-dense neighborhoods

The decline in college campus transit ridership with age is similar to that observed in cities, where the older people get, the greater the likelihood they live farther from the nearest bus stop and the nearest commercial center. However, the age of riders in this survey is most likely a result of the age distribution of enrolled college students, which is mostly young (18 to 24 years).

Table 4 Demographic Characteristics of Respondents

		% of Respondents	#of Respondents
Age	Under 17 years old	0.0%	-
	18 - 24 years	82.7%	976
	25 - 34 years	14.3%	169
	35 - 44 years	1.9%	22
	45 - 54 years	0.9%	11
	55 - 64 years	0.1%	1
	65 and above	0.1%	1
	Total	*100.0%*	*1,180*
Gender	Male	41.7%	492
	Female	57.3%	676
	Non-binary	0.3%	3
	Prefer not to answer	0.6%	7
	Other (Please Specify)	0.2%	2
	Total	*100.0%*	*1,180*
Level of Study	Undergraduate	81.3%	959
	Graduate	17.9%	211
	Other:	0.9%	10
	Total	*100.0%*	*1,180*

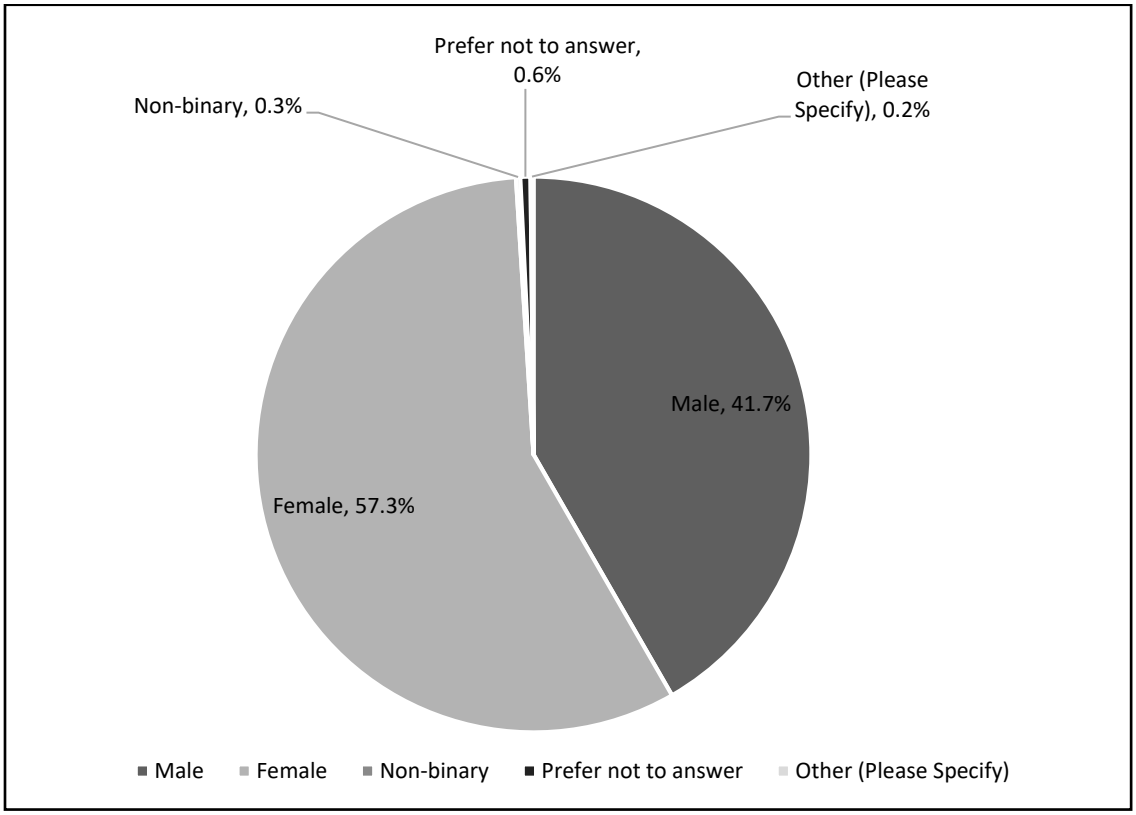

Figure 26 Gender or Respondents

Where Students Live

In the survey, respondents were asked if they live on or off campus and the distance of their residence from campus. About 44% (44.6%) of the students surveyed lived on campus (Figure 27 and Table 5) while the rest (~56%) lived off campus.

Table 5 Distance from Campus (Off-Campus Students)

Distance from Campus	%	Count
0.25 miles or Less - (0.4 km or Less)	19.34%	128
0.25 to 0.50 miles - (0.4 to 0.8 km)	18.43%	122
0.50 to 1.00 miles - (0.8 to 1.6 km)	20.09%	133
1.00 to 5.00 miles - (1.6 to 8.0 km)	22.51%	149
5.00 to 10.00 miles - (8.0 to 16.0 km)	15.11%	100
10 miles or More - (16 km or More)	4.53%	30
Total:	100%	662

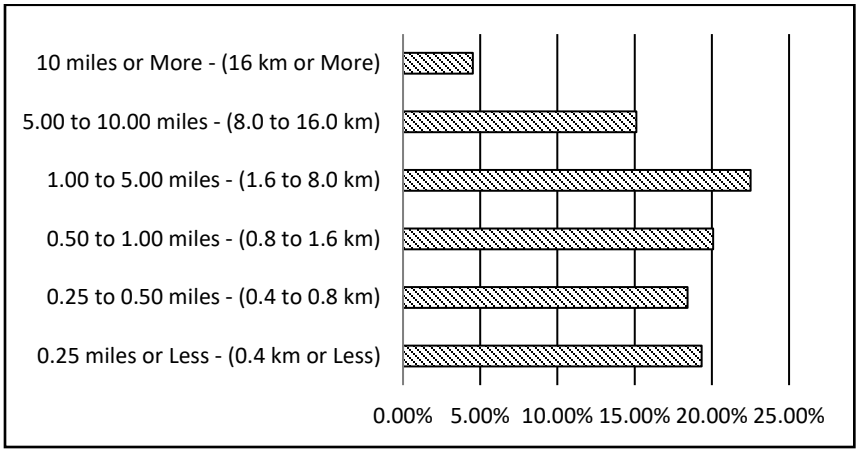

Figure 27 Distance from Campus (Off-Campus Students)

Travel Behavior

The survey contained questions regarding respondents' access to a vehicle, how they often travel around campus, what types of trips they generally make, the factors considered in deciding their mode choice, their willingness to walk in different weather conditions, locations too far to walk, and the number of daily trips they usually take to campus. They were also asked if they use MATBUS transit service, the routes taken by the students who use the MATBUS service, and the obstacles faced by the students not using the service.

Access to a Vehicle

About 84% (84.3%) of respondents own or have access to a vehicle. Off-campus students and students living farther from campus are more likely (by 15%) to have regular access to an automobile (Table 6).

Table 6 Vehicle Ownership or Access to Vehicles

		Access to a vehicle		
		Yes	Percentage	Total
Where respondents live:	On-campus	388	76%	512
	Off-campus	602	91%	662
	Total:	990	84%	1,174
How far respondents live from campus:	0.25 miles or Less	119	93%	128
	0.25 to 0.50 miles	106	87%	122
	0.50 to 1.00 miles	120	90%	133
	1.00 to 5.00 miles	134	90%	149
	5.00 to 10.00 miles	95	95%	100
	10 miles or More	28	93%	30

Mode of Transportation Used

Survey responses show that the students use a variety of modes for traveling around campus. Respondents were allowed to indicate all modes of transportation used, and transit (MATBUS) received the most significant share at more than 30% (30.38%). The least used way to get around campus was scooter at 0.3% (Table 7).

Table 7 NDSU Student Mode Share

Mode Share		
Mode	%	Count
Auto	22.18%	598
Carpool	8.16%	220
Scooter	0.30%	8
Transit - (e.g., MATBUS)	30.38%	819
Bicycle	8.49%	229
Walk	30.08%	811
Other (Please Specify)	0.41%	11
Total:	100%	2,696

The mode shares varied based on categories, such as gender, where students reside, as well as the bus routes that students use most frequently. Female respondents had the highest auto/vehicle mode share and the highest carpool mode share, but they shared the same walking mode share with respondents who identified as male. Male respondents had the highest mode share for scooters and bicycles. On-campus students were more likely to walk, cycle, and carpool, but were less likely to use auto. The closer students lived to campus, the more likely they were to walk (Table 8 and Figure 28).

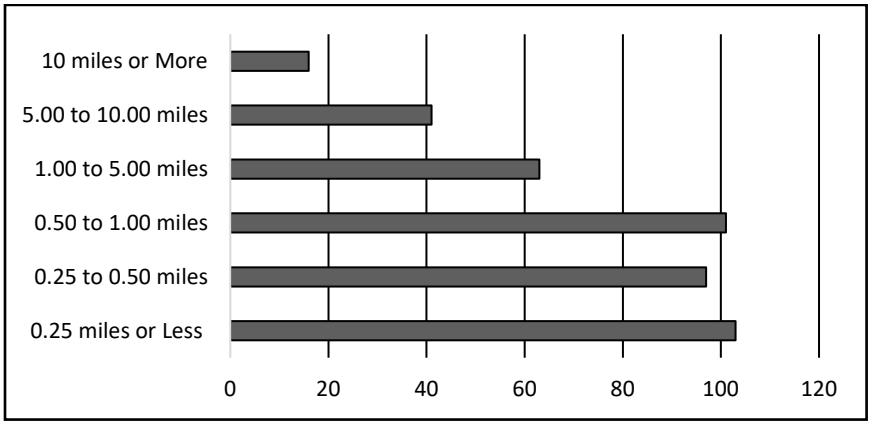

Figure 28 Effect of Residence Distance from Campus to Students' Preference to Walk

Table 8 Mode Differences for Different Categories

		How Respondents Often Travel to or around Campus						
		Auto	**Carpool**	**Scooter**	**MATBUS**	**Bicycle**	**Walk**	**Other**
Gender:	**Male**	231	74	6	341	115	337	7
		21%	*7%*	*1%*	*31%*	*10%*	*30%*	*1%*
	Female	361	145	2	471	112	466	4
		23%	*9%*	*0%*	*30%*	*7%*	*30%*	*0%*
	Non-binary	2	0	0	2	0	1	0
	Prefer not to answer	3	1	0	5	2	6	0
	Other	1	0	0	0	0	1	0
	Total	**598**	**220**	**8**	**819**	**229**	**811**	**11**
Student Residence:	**On-campus**	207	115	3	376	116	390	2
		17%	*10%*	*0%*	*31%*	*10%*	*32%*	*0%*
	Off-campus	391	105	5	443	113	421	9
		26%	*7%*	*0%*	*30%*	*8%*	*28%*	*1%*
	Total	**598**	**220**	**8**	**819**	**229**	**811**	**11**
Residence Distance from Campus:	**0.25 miles or Less**	57	21	3	68	17	103	0
	0.25 to 0.50 miles	61	22	1	87	36	97	3
	0.50 to 1.00 miles	75	28	1	106	36	101	0
	1.00 to 5.00 miles	94	17	0	105	20	63	2
	5.00 to 10.00 miles	81	15	0	59	4	41	2
	10 miles or More	23	2	0	18	0	16	2
	Total	**391**	**105**	**5**	**443**	**113**	**421**	**9**
MATBUS Routes Frequently used:	**Route 13**	145	65	4	280	63	224	5
	Route 13U	100	51	1	195	49	161	5
	Route 31	89	27	2	138	29	110	1
	Route 32E	213	85	3	415	112	334	4
	Route 32W	138	47	1	266	76	205	2
	Route 33	211	86	2	396	97	316	4
	Route 34	120	51	2	212	61	166	1
	Tap Ride	25	15	0	67	24	55	2
	None	125	34	1	12	21	148	2
	Other	12	9	0	19	10	20	1

Willingness to Walk

The response from students about their desire to walk under different weather conditions shows that when the temperature is below freezing (Figure 30) their desire to walk is the highest at less than 0.25 miles, and decreases steadily with increased distance. However, when the temperature is above freezing (Figure 29), the willingness to walk is the highest at 1 mile.

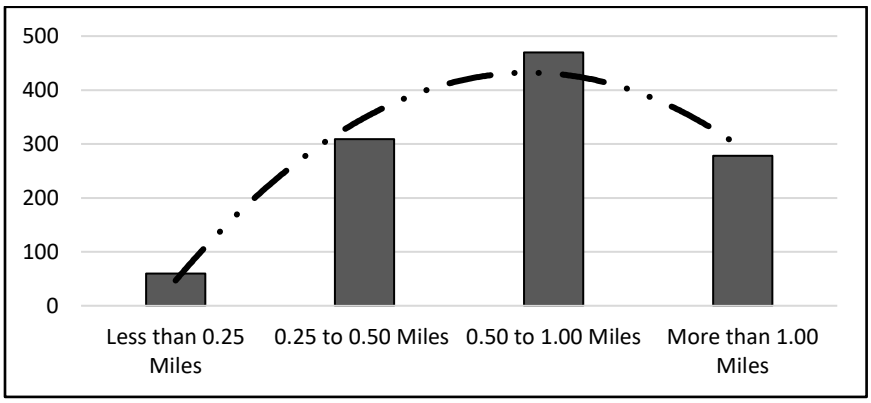

Figure 29 Willingness to Walk (>32F)

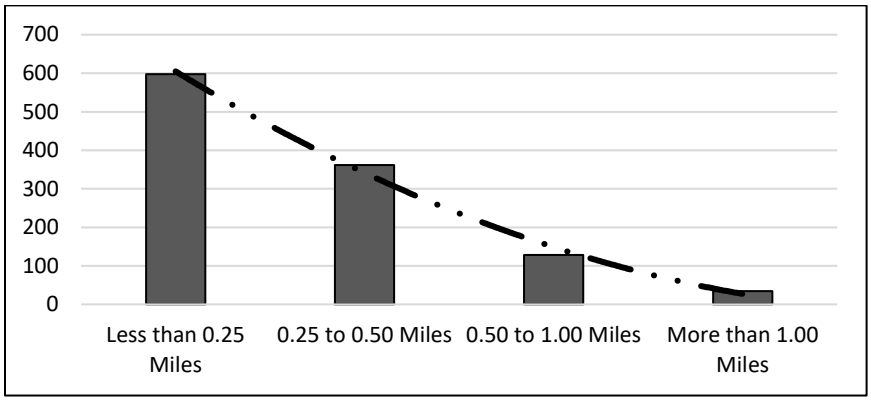

Figure 30 Willingness to Walk (<32F)

Results also show that both males and females follow the same willingness pattern of all respondents for all weather conditions considered. However, for temperatures above freezing, females outnumbered males in their willingness to walk up to a 1-mile distance; but for distances beyond 1 mile, male respondents were more likely to walk. A similar pattern is observed with the female respondents for temperatures below freezing, where males outnumber females beginning at about 0.75 miles. In both cases, up until the turning points, female respondents indicated a higher likelihood to walk than males (Figure 31, Figure 32, and Table 9).

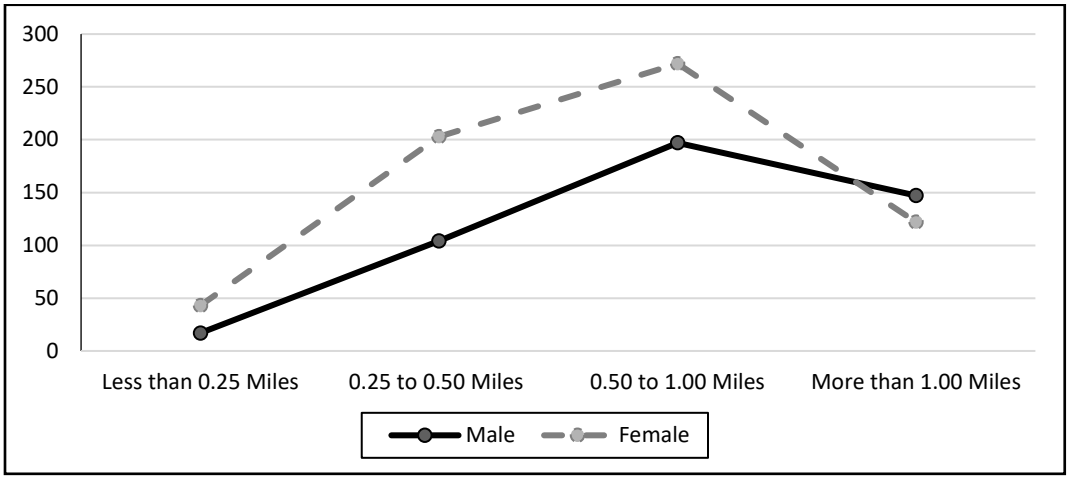

Figure 31 Willingness to Walk When Above Freezing

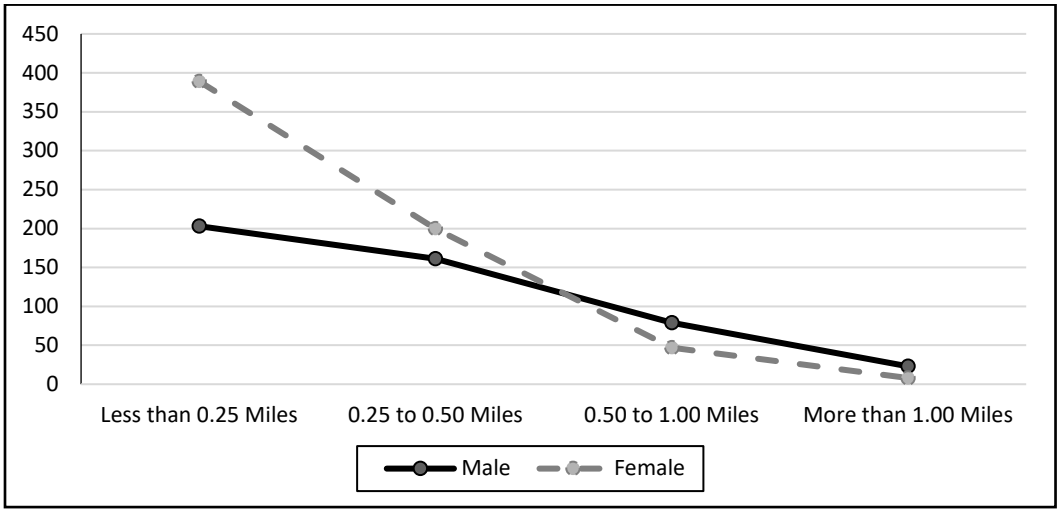

Figure 32 Willingness to Walk When Below Freezing

The results also show that the willingness to walk was significantly higher for respondents with a valid driver's license and, also for respondents with access to a vehicle. The least willing to walk are respondents who use a scooter on and around campus. This survey response shows a difference in responses between males and females, and is consistent with findings from an earlier study (Granié 2009) on the relationships between gender stereotypes and risk-taking. The study found that greater risk-taking occurred among masculine individuals and attributed it to weaker internalization of rules and safety. The study found that sex-stereotype conformity influences the tendency to take risks among pedestrians.

Table 9 Willingness to Walk (Under Different Conditions and Categories)

		Reasonable walking distance when the temperature is above freezing (>32 F)					**Reasonable walking distance when the temperature is below freezing (<32 F)**				
		Less than 0.25 Miles	0.25 to 0.50 Miles	0.50 to 1.00 Miles	More than 1.00 Miles	Total	Less than 0.25 Miles	0.25 to 0.50 Miles	0.50 to 1.00 Miles	More than 1.00 Miles	Total
Age:	18 - 24 years	33	261	399	234	927	480	317	109	21	927
	25 - 34 years	24	40	56	38	158	101	36	17	7	161
	35 - 44 years	3	5	9	3	20	13	3	1	4	21
	45 - 54 years	0	3	6	1	10	3	6	1	1	11
	55 - 64 years	0	0	0	1	1	1	0	0	0	1
	65 and above	0	0	0	1	1	0	0	0	1	1
Gender:	Male	17	104	197	147	465	203	161	79	23	466
	Female	43	203	272	122	640	389	200	47	8	644
	Non-binary	0	0	0	3	3	1	1	0	1	3
	No Answer	0	2	0	5	7	4	0	2	1	7
	Other	0	0	1	1	2	1	0	0	1	2
Class:	Undergraduate	36	256	387	231	910	469	308	107	26	910
	Graduate	23	51	80	45	199	123	51	21	7	202
	Other:	1	2	3	2	8	6	3	0	1	10
Residence:	On-campus	22	124	196	145	487	241	165	63	18	487
	Off-campus	38	185	274	133	630	357	197	65	16	635
Residence distance from campus:	0.25 miles or Less	8	46	43	23	120	60	44	15	1	120
	0.25 to 0.50 miles	6	33	54	22	115	69	33	10	5	117
	0.50 to 1.00 miles	4	23	69	33	129	60	48	20	1	129
	1.00 to 5.00 miles	12	47	56	26	141	95	34	9	5	143
	5.00 to 10.00 miles	6	28	41	21	96	55	31	8	3	97
	10 miles or More	2	8	11	8	29	18	7	3	1	29
Valid driver's license:	Yes	47	293	445	255	1040	555	344	115	29	1043
	No	13	16	25	22	76	43	17	13	5	78
Access to a vehicle:	Yes	44	272	412	220	948	516	312	98	25	951
	No	16	37	58	57	168	82	49	30	9	170

RESIDENCY, WORK, AND TRAVEL BEHAVIOR

Most survey respondents (56.36%) stay off campus. For these respondents, more than 80% (80.36%) live less than 5 miles from campus, while the rest (19.64%) live more than 5 miles away from the school. The mode with the highest share was MATBUS (Transit), with about 30% (30.75%) of the mode share. A glance at the relationship between mode share and employment (Figure 32 and Table 10) shows that respondents identified as part-time workers have the most significant percentage of the transit mode. Respondents identified as unemployed had the second largest share for all modes, except the scooter. The relationship between mode share and residence shows that respondents who live off campus have a higher mode share on auto, MATBUS, scooter, and walking. Respondents who live on campus had a higher mode share for carpooling and bicycle share (Figure 33 and Figure 34).

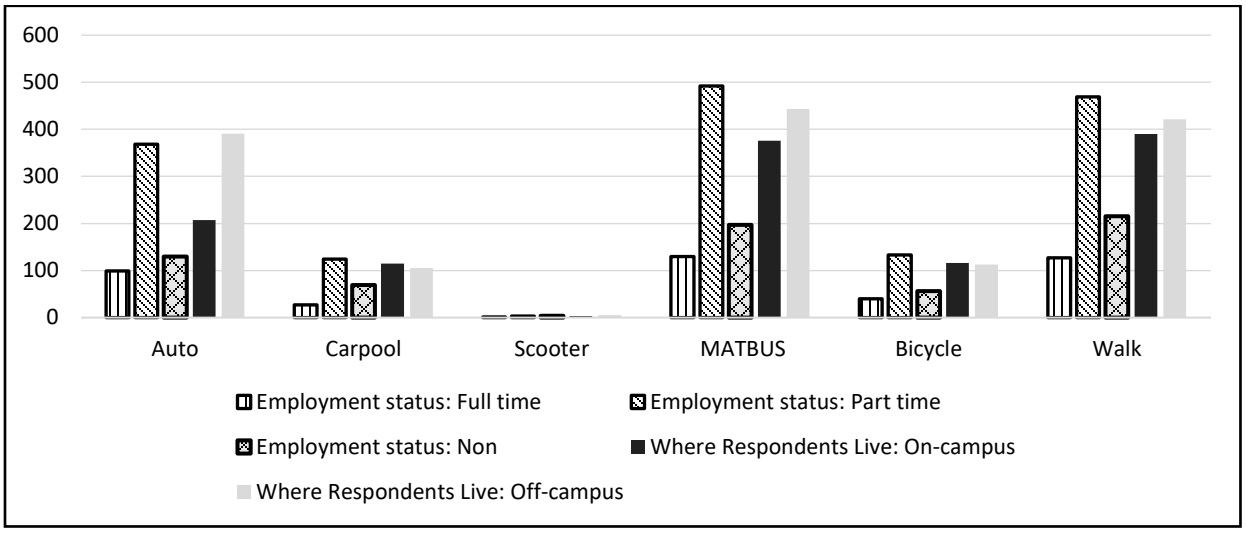

Figure 33 Relationship of Employment Status and Residence on Mode Share

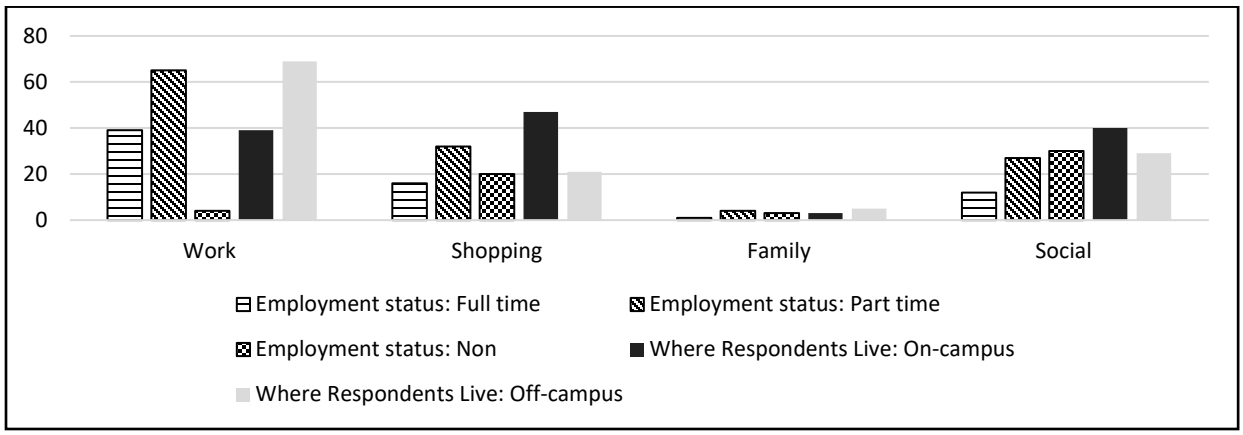

Figure 34 Trip Types by Employment Status and Residence

Table 10 Employment Status and Respondents Residence

		Employment status:			Where Respondents Live:	
		Full time	Part time	Non	On-campus	Off-campus
Age:	Under 17 years old	0	0	0	0	0
	18 - 24 years	101	595	280	449	527
	25 - 34 years	78	72	18	62	107
	35 - 44 years	9	9	4	2	20
	45 - 54 years	5	6	0	1	10
	55 - 64 years	0	0	1	0	1
	65 and above	0	0	1	1	0
Distance of residence from campus:	0.25 miles or Less	21	74	33	0	128
	0.25 to 0.50 miles	23	79	20	0	122
	0.50 to 1.00 miles	17	83	33	0	133
	1.00 to 5.00 miles	37	89	23	0	149
	5.00 to 10.00 miles	20	64	16	0	100
	10 miles or More	7	18	5	0	30
Mode of travel around campus:	Auto	99	368	130	207	391
	Carpool	27	124	69	115	105
	Scooter	1	3	4	3	5
	MATBUS	130	492	197	376	443
	Bicycle	40	133	56	116	113
	Walk	127	469	215	390	421
	Other	2	8	1	2	9
	Total:	186	651	285	487	636
Types of trips generally made with the MATBUS off campus:	Work	39	65	4	39	69
	Shopping	16	32	20	47	21
	Family	1	4	3	3	5
	Social	12	27	30	40	29
	Other	14	41	36	41	50
	No MATBUS	104	480	193	317	461
The number of one-way trips generally made to and from campus:	0	36	183	87	171	135
	1	22	74	36	54	78
	2	66	216	91	133	241
	3	16	47	17	36	44
	4	31	83	37	55	96
	5+	14	44	17	38	37

The Frequency of Trips Around Campus

The most reported trip frequency by survey respondents is the 2-one-way trips (33.39%), which is more prevalent with part-time workers who live off campus (especially students who reside 1 to 5 miles from campus) (Figure 35).

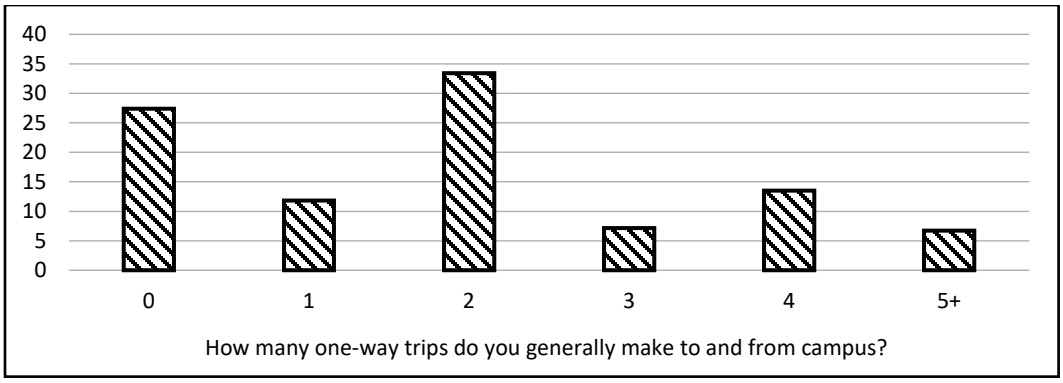

Figure 35 Trip Frequency

Most of the respondents that make 2-one-way trips either walk or use the transit mode share most often. The least common trip frequency chosen by the respondents is the +5-one-way trip (Table 11).

Table 11 Trip Frequency

		Number of one-way trips generally made from and to campus						
		0	1	2	3	4	5+	Total
Employment status:	Full time	36	22	66	16	31	14	185
	Part time	183	74	216	47	83	44	647
	Not Working	87	36	91	17	37	17	285
	Total	306	132	373	80	151	75	1117
Residence (on/off campus)	On-campus	171	54	133	36	55	38	487
	Off-campus	135	78	241	44	96	37	631
	Total	306	132	374	80	151	75	1118
Residence distance from campus:	0.25 miles or Less	22	15	43	9	21	8	118
	0.25 to 0.50 miles	16	11	47	13	21	9	117
	0.50 to 1.00 miles	25	23	49	7	19	6	129
	1.00 to 5.00 miles	35	15	50	9	21	10	140
	5.00 to 10.00 miles	24	13	41	5	13	2	98
	10 miles or More	13	1	11	1	1	2	29
	Total	135	78	241	44	96	37	631
How do students often travel to or around campus?	Auto	159	70	207	40	75	43	594
	Carpool	61	31	66	13	30	18	219
	Scooter	3	2	0	0	2	1	8
	MATBUS	208	104	271	58	114	61	816
	Bicycle	56	28	67	13	45	20	229
	Walk	223	98	259	55	114	58	807
	Other	4	1	3	0	1	2	11
	Total	306	132	374	79	151	75	1117

MATBUS USE AND SERVICE PERCEPTION

Nearly one-fourth of respondents (24.70%) are extremely satisfied with MATBUS service. Within this group, more than half (53.33%) reside off campus, with 25% of them living between 1 and 5 miles from campus. At least 69.26% of the respondents are satisfied (extremely satisfied or somewhat satisfied) with MATBUS service, 19.03% are indifferent (neither satisfied nor dissatisfied), and 11.71% are dissatisfied with the service (Table 12 and Figure 36).

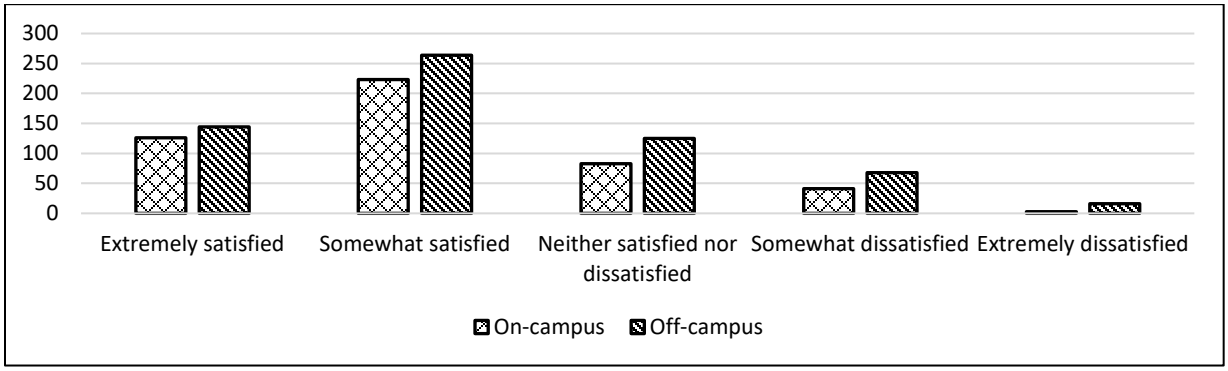

Figure 36 A Measure of Satisfaction within Student Residents (On and Off Campus)

About 1.74% of the respondents are extremely dissatisfied. Within this group, all (100%) have driver's licenses, and 94.74% have access to a vehicle (5.26% have no access to a car). Among this group, the MATBUS route they use most frequently is Route 32W, followed by Route 32E. More than half (57.89%) indicated there are additional stops/locations they want the transportation system to cover. Among respondents, 73.68% think the service span of the MATBUS is inadequate. Most of these respondents want more services during the early and late hours of the day (Table 12). The majority of these respondents identified on-time performance, frequency of service, and reliability of service as the attributes MATBUS should improve.

Table 12 Transit Satisfaction

		Student Satisfaction with the NDSU MATBUS Services				
		Extremely satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Extremely dissatisfied
Residence:	On-campus	126	223	83	41	3
	Off-campus	144	264	125	68	16
Valid driver's license:	Yes	250	449	198	100	19
	No	19	38	10	9	0
Access to a vehicle:	Yes	225	406	188	88	18
	No	44	81	20	21	1
Frequent MATBUS routes:	Route 13	98	158	29	39	4
	Route 13U	58	120	18	21	2
	Route 31	44	83	12	10	3
	Route 32E	133	214	34	56	5
	Route 32W	69	149	22	41	7
	Route 33	142	234	33	41	2
	Route 34	67	126	16	22	1
	TapRide	17	46	5	11	0
	None	9	31	123	13	7
	Other:	4	13	4	5	0
Desire additional stops:	Yes	47	145	39	52	11
	No	220	340	162	57	8
Desire a better service span:	Yes	154	202	62	27	1
	Maybe	75	176	100	32	4
	No	36	107	39	50	14
Desired periods for increased services:	Weekdays	28	94	37	33	9
	Weekends	52	111	44	35	3
	Early Morning	21	76	41	27	11
	Late Nights	83	195	76	55	11
Transit service attributes that should be improved:	Reliability of service	30	133	51	62	13
	On-time Performance	86	275	85	75	14
	Frequency of Service	86	237	75	65	13
	Seat Availability	48	80	32	15	4
	Technology	59	90	43	25	6

Of those responders, 9.97% are somewhat dissatisfied. Within this group, almost all (91.74%) have driver's licenses, and 80.73% have access to a vehicle (19.27% have no access to a car). Among this group, the most frequently used MATBUS route is Route 32W, followed by Route 32E and Route 33. More than half (47.71%) indicated there are additional stops/locations they want the transportation system to cover. Among respondents, 45.87% think the service span of MATBUS is inadequate. A majority of these respondents want more services during the late evening hours and weekends (Table 12). A majority identified on-time performance, frequency of service, and reliability of service as attributes MATBUS should improve.

TapRide Service

The survey had a few questions on the new NDSU TapRide service, which is a new on-demand service offered on the NDSU campus from Monday through Friday, from 7:30 p.m. to 11 p.m. The service was introduced recently to replace Route 35 and to provide rides, without increasing costs, to more remote locations of campus where fewer students go. More than half (59.03%) of the respondents have at least heard of the service. About 91.14% of respondents indicated they want more TapRide services (Table 13). Among the respondents who want more services:

- 77.78% stay on-campus
- 72.22% have a valid driver's license
- 50% have access to vehicles
- Most walk and use the transit around campus
- 69.44% indicate there are locations on campus that are too far to walk

Table 13 Tap Ride Service

		Awareness of TapRide service?		Want more TapRide services	
		Yes	No	Yes	No
Student residence:	On-campus	204	211	56	3
	Off-campus	209	384	16	4
Valid driver's license:	Yes	385	568	52	5
	No	27	27	20	2
Access to a vehicle:	Yes	356	521	36	6
	No	56	74	36	1
Locations too far to walk:	Yes	209	281	50	5
	No	204	314	22	2
How satisfied are you with the NDSU MATBUS Services?	Extremely satisfied	111	136	15	2
	Somewhat satisfied	200	236	43	3
	Neither satisfied nor dissatisfied	44	155	4	1
	Somewhat dissatisfied	47	50	10	1
	Extremely dissatisfied	10	9	0	0
Additional stops/locations for campus circulator to cover?	Yes	121	135	32	1
	No	288	453	40	6
Do you think that the service span (hours and days of service) of the MATBUS service is adequate?	Yes	176	254	11	4
	Maybe	143	226	19	2
	No	94	110	42	1
What periods would you want increased services? (Please select all that apply)	Weekdays	75	103	21	2
	Weekends	87	111	48	1
	Early Morning	65	93	17	2
	Late Nights	172	198	49	2
Which of the following transit service attributes should MATBUS improve (select all that apply):	Reliability of Service	118	148	22	1
	On-time Performance	216	274	39	4
	Frequency of Service	193	232	48	4
	Seat Availability (Capacity)	65	104	8	0
	Technology	86	112	23	2

WILLINGNESS TO SUPPORT TRANSIT SERVICE

Among respondents, 80.38% stated they were unwilling to pay an activity fee for transit around campus. For the respondents indicating they were willing to pay:

- More than half (55.56%) worked part-time
- 41.12% were somewhat satisfied with the transit service
- 81.82% have heard of the TapRide
- 42.45% stated that the MATBUS service is adequate
- A significant amount want the service span to extend to late nights

Of the respondents who were willing to pay, 28.50% were willing to pay less than $10, while (43.46%) of respondents stated they were willing to pay between $11 and $20, and 16.36% stated they were willing to pay between $21 and $30 (Figure 37 and Table 14).

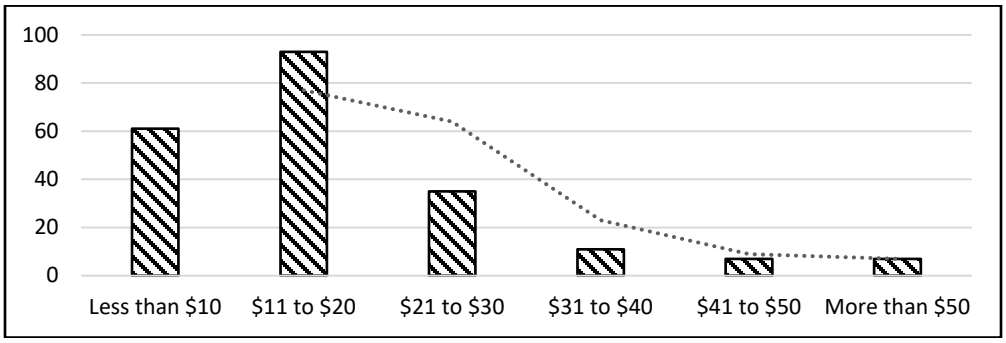

Figure 37 How much are Respondents Willing to Pay per Semester

Table 14 Willingness to pay an Activity Fee for Transit

		Willingness to pay	
		Yes	No
Level of study:	Undergraduate	176	716
	Graduate	40	159
Employment status:	*Full time*	*43*	*135*
	Part-time	*120*	*520*
	Not Working	*53*	*229*
Frequent MATBUS Routes:	Route 13	87	241
	Route 13U	61	157
	Route 31	34	118
	Route 32E	96	348
	Route 32W	62	228
	Route 33	98	353
	Route 34	42	190
	TapRide	22	57
Satisfaction with NDSU MATBUS Services:	*Extremely satisfied*	*81*	*188*
	Somewhat satisfied	*88*	*399*
	Neither satisfied nor dissatisfied	*20*	*187*
	Somewhat dissatisfied	*22*	*87*
	Extremely dissatisfied	*3*	*16*
How much are respondents are willing to pay per semester:	Less than $10	61	0
	$11 to $20	93	0
	$21 to $30	35	0
	$31 to $40	11	0
	$41 to $50	7	0
	More than $50	7	0
Want more TapRide services on campus?	*Yes*	*18*	*54*
	No	*4*	*3*
Do you think that the service span of the MATBUS service is adequate?	Yes	90	355
	Maybe	64	328
	No	58	189
What periods would you want increased services?	*Weekdays*	*36*	*167*
	Weekends	*45*	*202*
	Early Morning	*34*	*144*
	Late Nights	*93*	*329*

ROUTE RECOMMENDATION

Respondents were asked to list (a) additional stops they want the campus circulators to cover and (b) locations that are too far to walk. The top 10 locations listed by the respondents are shown in Table 15. (Details of the analysis for the 63 stops mentioned by the respondents are in the Stop Details section of Appendix B.) Most locations identified are within walking distance to stops served by two to seven MATBUS routes. However, two of the locations mentioned by respondents (Wellness Center and Animal Nutrition and Physiological Center) are served by only one MATBUS route, as shown in Table 15.

Table 15 Locations Too Far to Walk or Locations in Need of Stops

Stops (Locations)	**Sum**	**Stop Location**								**Sum**
		Address	13	13U	31	32E	32W	33	34	
Richard H. Barry Hall	74	811 2nd Ave N	1	1	0	0	0	1	0	3
Fargodome	58	1800 N University Dr	1	1	1	1	1	1	1	7
Library	35	1201 Albrecht Blvd #2080	0	0	1	1	1	0	0	3
Minard Hall	22	1210 Albrecht Blvd	0	0	1	1	1	0	0	3
Wellness Center	21	1707 Centennial Blvd	0	0	1	0	0	0	0	1
Niskanen	16	1805 N University Dr	1	1	0	0	0	1	1	4
West Dining	12	1500 15th Ave N	0	0	1	1	1	0	0	3
Animal Nutrition and Physiology Center	7	1801 15th Ave N	0	0	1	0	0	0	0	1
Renaissance Hall	7	650 Northern Pacific Ave	1	1	0	0	0	0	0	2
Klai Hall	5	711 2nd Ave N	1	1	0	0	0	1	0	3

The locations served by two to seven routes could have been listed for other reasons, such as service frequency, distance from the stop to the riders, bus capacity, and service span (time/day). To further understand this issue, the service span and ridership (daily/hourly) of the routes accessible from each of these locations are studied. Where available, the service hours of the destination or origin served by the bus stops are also checked (Figure 38-a). The origin-destination matrix of all the bus stops under consideration is computed (Figure 39).

As shown in Figure 37-b, the peak period of Route 31 ridership is offset from the peak period of service periods of the Wellness Center facility. This offset suggests that most wellness center visitors use other modes to commute to and from the facility during its peak hours. Figure 37-c shows the walking distance of 0.1 miles to shelter 248, which most riders are willing to walk. Table 16 shows the desire for respondents to walk compared with other attributes.

Table 16 Locations Too Far to Walk and Recommended Stops

		Locations too far to walk			Recommended stops		
		Yes	**No**	**Total**	**Yes**	**No**	**Total**
Reasonable walking distance when the temp. > 32F	Less than 0.25 Miles	39	21	60	22	36	58
	0.25 to 0.50 Miles	187	122	309	97	199	296
	0.50 to 1.00 Miles	228	242	470	121	334	455
	More than 1.00 Miles	111	167	278	53	220	273
Reasonable walking distance when the temp. < 32F	Less than 0.25 Miles	354	244	598	183	397	580
	0.25 to 0.50 Miles	162	200	362	82	270	352
	0.50 to 1.00 Miles	41	87	128	27	95	122
	More than 1.00 Miles	11	23	34	2	31	33
Frequent MATBUS Routes used	Route 13	187	142	329	95	230	325
	Route 13U	127	92	219	59	158	217
	Route 31	90	63	153	44	107	151
	Route 32E	214	232	446	130	310	440
	Route 32W	134	156	290	104	184	288
	Route 33	242	211	453	126	322	448
	Route 34	125	107	232	71	159	230
	TapRide	55	24	79	33	46	79
	None	80	113	193	33	151	184
Riders who have you heard about the MATBUS TapRide	Yes	209	204	413	121	288	409
	No	281	314	595	135	453	588
Riders that want more TapRide	Yes	50	22	72	32	40	72
	No	5	2	7	1	6	7
Riders who think that the service span of the MATBUS service is adequate	Yes	204	244	448	91	354	445
	Maybe	190	202	392	93	297	390
	No	154	93	247	107	137	244
Periods riders want increased services	Weekdays	107	96	203	78	125	203
	Weekends	137	110	247	86	160	246
	Early Morning	105	73	178	61	115	176
	Late Nights	239	183	422	150	269	419
Access to a vehicle	Yes	480	473	953	243	679	922
	No	88	82	170	52	113	165
		Yes	**No**	**Total**	**Yes**	**No**	**Total**
		Locations too far to walk			**Recommended Stops**		

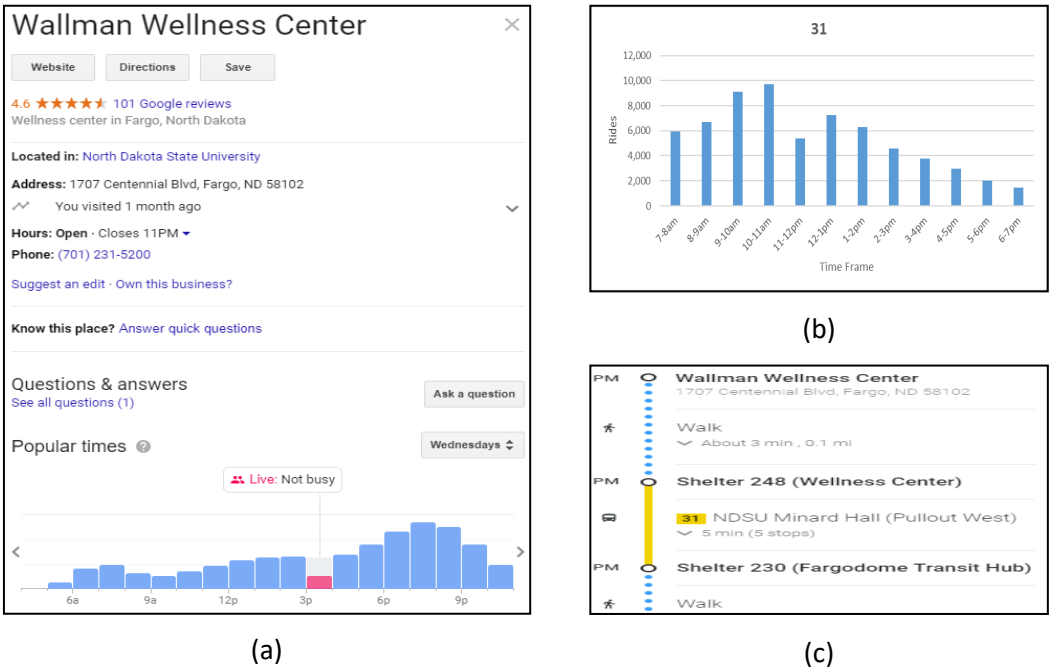

Figure 38 Peak Ridership Hours Compared with Peak Facility Service Hours (Source: Google Maps and MATBUS)

Recommendation for Route 31 (Wellness Center and ANPC Facility)

As shown in Figure 38-a and Figure 38-b, some adjustment to the span of Route 31 to provide transit service during the Wellness Center's peak service period could increase Route 31's ridership. It is important to note that survey results suggest that only a fifth of riders who are dissatisfied with NDSU's MATBUS service are transit dependent. The survey also reveals that 38.77% of respondents who indicate there are locations too far to walk use Route 32E most frequently, and 9.96% of them use the TapRide service. Of the respondents who indicated there are locations too far to walk, 42.65% have heard of the TapRide service (Table 16). For the other stops frequently mentioned by the students, an adjustment of NDSU MATBUS service capacity and service frequency could improve these stops (already served by two to seven routes). The most frequent stop mentioned by respondents is Barry Hall, which is served by Routes 13, 13U, 17, and 33 (four routes).

For the stops or locations listed or recommended for route adjustment, a data frame containing all NDSU MATBUS stops (containing existing stops and suggested stops) is created. For each stop, the longitude, the latitude, total number of routes, and route features (frequency, start time, close time) are also added as a record for the stop. These records are now assigned a score (equivalent to the frequency of mention in the survey) for service improvement.

Origin-Destination (O-D) Matrix of all NDSU Stops:

The OD matrix of all stops (63), both existing stops and suggested stops, is shown in Figure 39. The OD matrix shows some inconvenience (indicated in white) in the use of transit for some locations: Beef Cattle Barn, Dairy Barn, Sheep Barn, and Swine Barn. These locations involve some unusual degree of walking in places students do not have a willingness to walk (Location ID Key is in Figure 40).

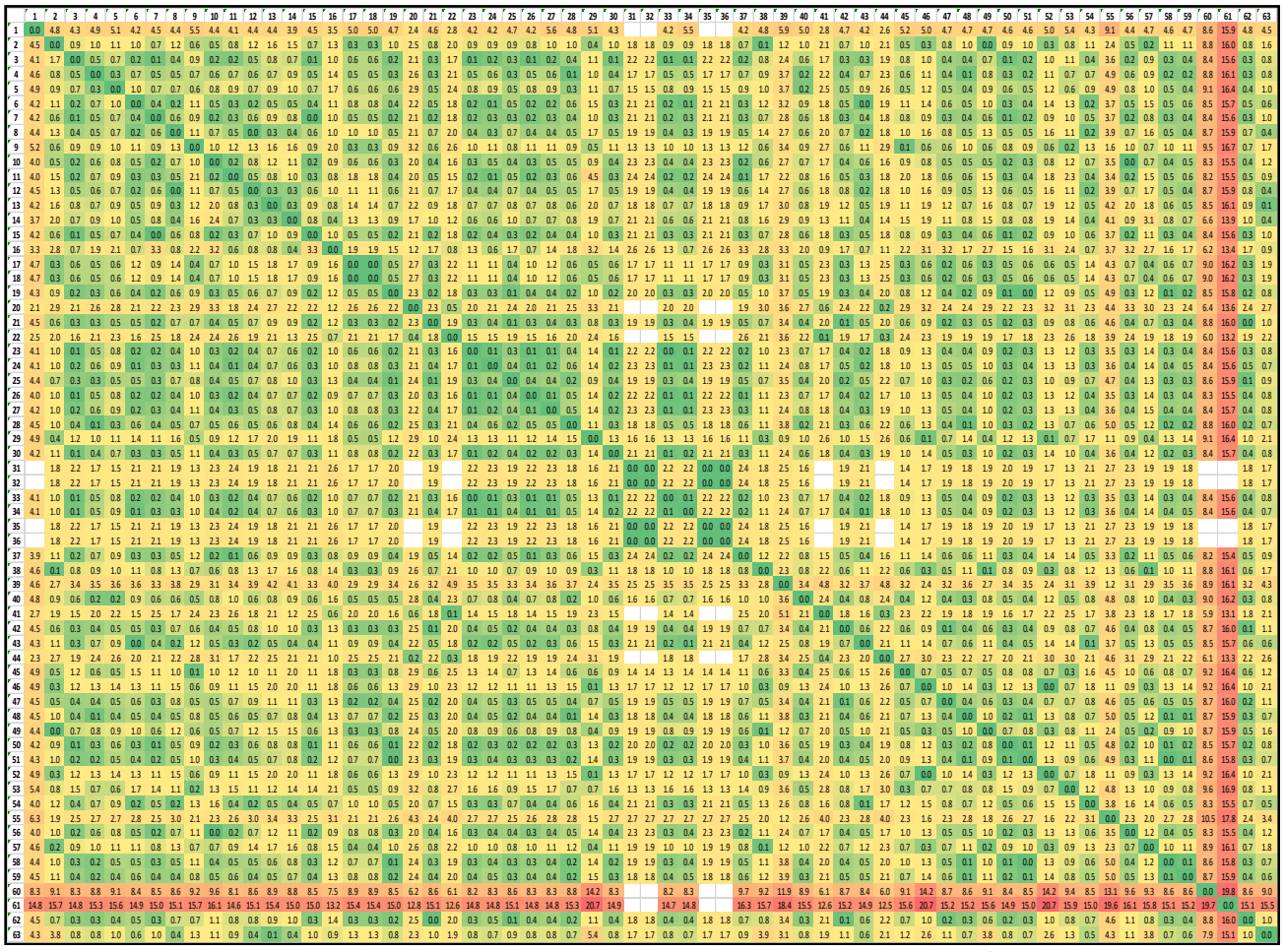

Figure 39 O-D Distance Matrix for all Stops in Miles (White: More Walking Involved/No Direct Link)

These locations are not convenient for NDSU MATBUS riders, especially when connecting from those locations to the following locations (or vice-versa):

- Walmart
- Barry Hall
- Klai Hall
- Renaissance Hall

ID	stopName	stopAddress	Latitude	Longitude	rSum	Freq
1	14th St. N. & 8th Ave.	V6MV+84 Moorhead, Moorhead Township, MN	46.8833360	-96.7576549	1	0
2	1701 apartments	1701 N University Dr, Fargo, ND 58102	46.9015022	-96.7977306	5	4
3	A. Glenn Hill Center (STEM)	1306 Centennial Blvd, Fargo, ND 58105	46.8931395	-96.8018022	4	4
4	AES Greenhouse	58102, 1440 18th St N, Fargo, ND 58105	46.8962279	-96.8075216	1	2
5	Animal Nutrition and Physiology Center	1801 15th Ave N, Fargo, ND 58102	46.8983716	-96.8116683	1	7
6	Askanase Hall	1497 12th Ave N, Fargo, ND 58105	46.8907557	-96.8033292	3	3
7	Bentson/Bunker Fieldhouse	1301 Centennial Blvd, Fargo, ND 58102	46.8947516	-96.8009890	4	1
8	Bison Crossing & CJ/PP	V5RV+45 Fargo, North Dakota	46.8903145	-96.8074043	2	0
9	Candlewood Suites	W53V+C8 Fargo, North Dakota	46.9033171	-96.8065484	1	0
10	Centennial Shelter	V6V2+PP Fargo, North Dakota	46.8942229	-96.7983367	4	0
11	Ceres Hall (NDSU Admissions)	1340 Administration Ave, Fargo, ND 58105	46.8920445	-96.7992261	4	1
12	Prairie (Criminal Justice & Public Policy)	V5RV+45 Fargo, North Dakota	46.8900998	-96.8074255	2	1
13	Dakota Creek Lofts	V5QQ+C9 Fargo, North Dakota	46.8881716	-96.8116121	2	0
14	Dakota Drive & 16th St.	V5PV+CJ Fargo, North Dakota	46.8859916	-96.8059606	2	0
15	Engineering - (CM&E Building)	1410 14th Ave N, Fargo, ND 58102	46.8945523	-96.8011606	7	2
16	Family Fare	V6M2+8J Fargo, North Dakota	46.8838588	-96.7989082	3	0
17	Fargodome	W52W+9X Fargo, North Dakota	46.9007801	-96.8027369	4	58
18	Fargodome Shelter	W52W+9X Fargo, North Dakota	46.9007801	-96.8027369	4	58
19	Gate City Auditorium	1330 Bolley Dr, Fargo, ND 58102	46.8942802	-96.8046535	1	0
20	GTC	502 Northern Pacific Ave, Fargo, ND 58102	46.8751186	-96.7858783	2	3
21	High Rises	V5WW+HQ Fargo, North Dakota	46.8964574	-96.8030504	3	0
22	Klai Hall	Klai Hall, 711 2nd Ave N Room 310, Fargo, ND 58102	46.8783506	-96.7915647	3	5
23	Ladd Hall	V5RX+R3 Fargo, North Dakota	46.8923933	-96.8025114	4	1
24	Library	1201 Albrecht Blvd #2080, Fargo, ND 58105	46.8909290	-96.8013320	3	35
25	Loftgard Hall	V5WW+6Q Fargo, North Dakota	46.8954689	-96.8036473	3	2
26	Memorial Union	1401 Administration Ave, Fargo, ND 58105	46.8923988	-96.8013116	4	2
27	Minard Hall	1210 Albrecht Blvd, Fargo, ND 58102	46.8914534	-96.8032971	4	22
28	MLC - Matthew Living Center	1435 18th St N, Fargo, ND 58102	46.8955035	-96.8078121	1	3
29	NDSCS - Fargo	1305 19th Ave N, Fargo, ND 58102	46.9060119	-96.7995010	2	0
30	NDSU Animal Science	V5VW+5J Fargo, North Dakota	46.8929792	-96.8040191	3	1
31	NDSU Beef Cattle Barn	3501-, 3559 19th Ave N, Fargo, ND 58102	46.9047468	-96.8324953	0	1
32	NDSU Dairy Barn	3136 19th Ave N, Fargo, ND 58102	46.9047468	-96.8324953	0	1
33	NDSU Minard Hall (Pullout East)	V5RX+R3 Fargo, North Dakota	46.8921560	-96.8024536	5	22
34	NDSU Minard Hall (Pullout West)	V5RX+M2 Fargo, North Dakota	46.8915524	-96.8024546	3	22
35	NDSU Sheep Barn	3400 19th Ave N, Fargo, ND 58102	46.9047468	-96.8324953	0	1
36	NDSU Swine Barn	3211 19th Ave N, Fargo, ND 58102	46.9047468	-96.8324953	0	1
37	NDSU Transit Hub	1337 Administration Ave, Fargo, ND 58105	46.8925479	-96.7991820	4	0
38	Niskanen Expansion	W632+5R Fargo, North Dakota	46.9023605	-96.7977686	2	16
39	Northport Hornbacher's	2510 N Broadway Avenue, Fargo, ND 58102	46.9105641	-96.7875450	1	0
40	Parking and Transportation Services	V5XR+46 Fargo, North Dakota	46.8981918	-96.8090653	1	2
41	R.H. Barry Hall	811 2nd Ave N, Fargo, ND 58102	46.8785110	-96.7933370	3	74
42	Reed/Johnson Halls	V5WX+W6 Fargo, North Dakota	46.8972945	-96.8020760	1	0
43	Reineke (Fine Arts Center)	V5RW+5C Fargo, North Dakota	46.8905025	-96.8039483	2	0
44	Renaissance Hall	V6G5+8R Fargo, North Dakota	46.8756979	-96.7905543	2	7
45	Research and Tech Park	W53V+48 Fargo, North Dakota	46.9020997	-96.8068614	1	0
46	Residence Dining Center	1919 N University Dr, Fargo, ND 58102	46.9054728	-96.7975942	4	0
47	R-Lot (parking)	V5XW+4R Fargo, North Dakota	46.8984603	-96.8023466	4	3
48	Robinson Hall	Robinson Hall, Fargo, ND 58105	46.8949798	-96.8073538	1	1
49	SHAC (Sheels Center)	W622+8P Fargo, North Dakota	46.9007982	-96.7981790	4	2
50	Shepperd Arena	V5VW+MR Fargo, North Dakota	46.8942866	-96.8033569	3	0
51	Stevens Hall	V5VV+PW Fargo, North Dakota	46.8943101	-96.8054637	1	0
52	Stop-N-Go Center (SGC)	1919 N University Dr, Fargo, ND 58102	46.9054728	-96.7975942	1	4
53	Technology Park	W53Q+MP Fargo, North Dakota	46.9042264	-96.8106652	1	1
54	T-Lot (Parking)	V5QV+HX Fargo, North Dakota	46.8897174	-96.8051102	3	1
55	U32 Apartments	1151 32nd Ave N, Fargo, ND 58102	46.9204231	-96.7966306	1	0
56	University & Centennial	V6V2+PP Fargo, North Dakota	46.8941769	-96.7983162	4	0
57	University Village	W623+WR Fargo, North Dakota	46.9018792	-96.7961366	6	3
58	Van Es	V5VV+PW Fargo, North Dakota	46.8941774	-96.8062241	1	1
59	Wallman Wellness Center.	V5VR+MX Fargo, North Dakota	46.8942931	-96.8082031	1	21
60	Walmart	4731 13th Ave S, Fargo, ND 58103	46.8646733	-96.8677045	0	1
61	Walmart	3757 55th Avenue South, Fargo, ND 58104	46.8014698	-96.8442488	0	1
62	West Dining	V5WW+RF Fargo, North Dakota	46.8969883	-96.8038575	4	12
63	West Port on Dakota Drive	V5QP+PV Fargo, North Dakota	46.8890783	-96.8130190	2	0

Figure 40 Location ID

Route and Location Analysis

Cluster Analysis

Before route recommendations, the authors explored the characteristics of the stops and routes in the study using cluster analysis. The analysis is used to split the 63 stops (Figure 39) into groups to check for any differences that may exist between the groups with high complaint scores and the ones with low complaint scores (location mention frequency). A centroid model with a vector quantization method (k-means algorithm) is used to split the stops into three groups or clusters (Appendix B, Figure A-1). Results from the analysis show that the attributes of stops with the higher scores (clusters 2 and 3) have some similarities (Appendix B, Figure A-2). They have few to no weekend routes, low bus frequency, and are dependent on Route 31 (mostly or entirely).

Regression Analysis

Using multiple regression analysis, the relationship between the complaint scores (dependent variables) and the bus stop locations and their service characteristics (independent variables) are estimated using statistical techniques for modeling and analyzing all the variables. From the analysis, similar results to the cluster analysis results are observed. Some factors that show a negative correlation with complaint score are the number of routes serving a stop, access to stops, weekend service, service span, and Route 31 (Appendix B, Figure A-3). A three-dimensional plot of all 63 locations with their longitude, latitude, and scores (complaints) is shown in Appendix B: Figure A-4-a.

Random Forest Analysis

Using a random forest algorithm, the importance or weight of the stop location and features (predictor variables) are explored. The results of the model weight summary (Appendix B, Figure A-4-b) shows the importance of the predictor variables. The top seven most essential variables of the model are listed by their significance in descending order below:

- Number of routes on stop/location
- Presence of Route 34
- Minimum service frequency on stop/location (service frequency)*
- Maximum service close time on location (service window)*
- Access to route 13U*
- Access to route 32W
- Weekend service*

The variables observed as significant in the regression analysis are marked with an asterisk (*).

Route Recommendation:

SURTC recommends that MATBUS modify some of its service routes by extending evening services and increasing weekend services within budget. This type of modification can be implemented with some consideration given to route frequencies, which should be increased. MATBUS could achieve this by modifying existing fixed routes (e.g., shifting Route 31's service window and increasing its frequency) or by expanding the TapRide service to cover the gaps in the fixed-route service.

SURVEY RESULTS FROM SELECT U.S. CAMPUS TRANSIT SERVICES

A survey of seven questions was developed in Qualtrics, and a survey link was emailed to 53 university campus transit contacts across the United States on March 11, 2019. Responses were received from 32 universities, yielding a reasonable response rate of 60%. Size of the universities surveyed ranged between 12,500 and 44,000 students. Among respondents, 63% (20) reported their school has multiple campuses (clusters of buildings in separate areas), and 94% (17) reported that multiple campuses are served by transit service. Each respondent was asked to check all of the services that apply to their campus. (Table 17).

Table 17 Kinds of Transportation Options Available to Campus Community

Kinds of Transportation Options Available to Campus Community, N=92		
Type of service	Count	Percent
On-campus circulator/shuttle	25	27
A shuttle from remote parking lots to campus	18	20
Regular fixed-route service	25	27
Accessible service for students with disabilities	24	26

The respondents were asked who operates the campus transit system. Some campuses had only university-operated agencies, while others had both transit services operated by both university agencies and private contractors. A few universities reported transit agency, university, and private contractor operations all serving their campuses. The schools that reported multiple operators also have multiple services, including on-campus circulator/shuttle, shuttle from remote parking lots to campus, regular fixed-route, and accessible service for students with disabilities.

Table 18 shows the results of who operates the campus transit system. Among respondents, 45% (21) reported that the university/college operates the transit agencies.

Table 18 Campus Transit System Operator

Who operates the campus transit system (select all that apply)		
Operator	Count	Percent
University/college	21	45
Private contractor	14	30
Transit agency	11	23
Other (contracted drivers & maintenance)	1	2
Total	47	100

The survey respondents from the 32 campus transit systems reported operating expenses from a low of $36 per hour with the university owning the buses to a high of $166 per hour with the transit agency operating the system. Because of the wide variance in the survey numbers, it was clear that respondents did not have consistent methods for calculating expenses. Therefore, the National Transit Database was utilized to determine numbers that could be compared.

Table 19 illustrates the minimum, mean, standard deviation, median, and maximum operating expense per vehicle revenue hour for 89 urban transit agencies located within Federal Transit Administration's Region 5 (Illinois, Ohio, Minnesota, Wisconsin, Indiana, and Michigan), Region 7 (Missouri, Iowa, Nebraska, and Kansas), and Region 8 (Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming). Fargo's MATBUS calculation is also listed to show the comparison. MATBUS's fully loaded hourly operating expense is $72.05, as reported in the National Transit Database for 2017. This number is much lower than the mean dollar value of $109.28 and lower than the median value of $83.74.

Table 19 Operating Expense per Vehicle Revenue Hour

	Vehicle Operations	Vehicle Maintenance	Non-Vehicle Maintenance	General Administration	Total
MATBUS Fargo	$34.05	$13.24	$2.54	$22.02	$72.05
Mean	$66.10	$18.11	$4.92	$20.16	$109.28
Standard Deviation	$145.22	$39.84	$16.39	$47.32	$247.85
Minimum	$26.00	$2.69	$0.06	$2.88	$37.18
Q2	$42.04	$11.18	$1.33	$10.80	$71.38
Median	$50.84	$13.61	$2.43	$14.41	$83.74
Q3	$59.33	$17.01	$3.96	$19.46	$95.36
Max	$1,416.32	$386.90	$154.01	$456.67	$2,413.90

Created from: United States Department of Transportation. Federal Transit Administration, National Transit Data Base, 2017, Washington, DC.

Other University Student Fees

U-PASS programs vary substantially across the United States. For example, University of California Davis students pay $34.30 per quarter and have three quarters, so they pay $102.90 per year for transit. The rates are increasing in 2019 by $13.33, so the cost will be $47.63 per quarter and then increase to $58 per quarter. By 2023, the price will increase to $67.83 per quarter. The price increase was voted on and passed with 92% approval. The increase was needed because of the increased minimum wage (Palmere 2019).

TCRP 2018 reports that funding sources for U-Pass programs often include a combination of student fees, parking permit revenue, parking fine revenue, university general funds, and federal, state, and local operating assistance funds (p. 10). TCRP surveyed campuses, and some of the details regarding student fees reported by institutions are presented in Table 20.

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Table 20 U-Pass Student Fee

U-Pass Program Student Fees Reported			
City	Name	Price ($)	Unit
Milwaukee, WI	University of Wisconsin-Milwaukee	45.10	Per student per semester
Madison, WI	University of Wisconsin – Madison	55.52	Per student per semester
Bloomington, IN	Indiana University	64.61	Per student per semester
Hartford, CT	Capital Community College	12.00	Per student per semester

Adapted from TCRP Synthesis 131 *College Student Transit Pass Programs.* Transit Cooperative Research Program, National Academies of Science, Transportation Research Board, Washington, DC, 2018.

Recommendation about Current Service (MATBUS)

It is recommended that NDSU not cut MATBUS service but, if fiscally possible, expand it to meet student demand. The students identified the desire/need for more frequency and access to the Wellness Center, Fargodome, Barry Hall, the Library, downtown, Niskanen Apartments, and Minard Hall. MATBUS's hourly operating expenses are less than the median hourly operating costs for 89 transit agencies within the region, so it is unlikely that MATBUS will reduce the hourly cost it charges NDSU for service. If additional funds are needed to provide more service, NDSU should consider adding a small student fee to help cover the expenses. Although most students who responded to the survey were not in favor of paying a student fee, about 20% were in favor of paying. Of the respondents (about 20%) that were in favor of paying, 28.5% were willing to pay less than $10 per semester, and 43.46% were willing to pay between $11 and $20. The survey results from select U.S. campus transit services show that many universities already charge a student fee for public transportation services.

SUMMARY AND CONCLUSIONS

The survey captured NDSU students' experience with Metro Area Transit (MATBUS). It was conducted online and received 1,180 responses, capturing a significant amount of information regarding student travel behavior, transit use, and opinions about current MATBUS service. A considerable proportion of the respondents (84.3%) own or have access to a vehicle, and off-campus students and students living farther from campus were more likely (by 15%) to have regular access to an automobile.

The survey results show that the willingness to walk is significantly higher for respondents with a valid driver's license, and as well for respondents with access to a vehicle. The least willing to walk are respondents who use a scooter on and around campus. The transit mode (MATBUS) had the highest significant share (30.38%). The least-used way to get around campus was scooter (0.3%).

Of the respondents, 1.74% expressed extreme dissatisfaction. Within this group, all (100%) have driver's licenses, and 94.74% have access to a vehicle. In this group, those who use MATBUS frequently use Route 32W the most, followed by Route 32E. More than half (57.89%) indicated there are additional stops/locations they want the transportation system to cover. Of these respondents (dissatisfied), 73.68% think the service span of MATBUS is inadequate. A majority of these respondents want more services during the early and late hours of the day. The majority of these respondents identified on-time performance, frequency of service, and reliability of service as the attributes MATBUS should improve.

Of the students who responded to the survey, 80.38% are unwilling to pay an activity fee for transit on campus. For the respondents who indicated they were willing to pay, more than half (55.56%) worked part time, 41.12% were somewhat satisfied with the transit service, 81.82% had heard of the TapRide, 42.45% stated that the MATBUS service is adequate, and a significant number wanted the service span extended to late nights. Of the respondents who were willing to pay an activity fee for transit, 28.5% are willing to pay less than $10, 43.46% of them are willing to pay between $11 and $20, and 16.36% are willing to pay between $21 and $30.

More than half (59.03%) of the respondents have at least heard of the TapRide service, and about 91.14% of these respondents (that have heard about the TapRide service) indicated they want more TapRide services. Among the respondents who want more TapRide services, 77.78% stay on campus, 72.22% have a valid driver's license, and 50% have access to vehicles. Most walk and use the transit around campus, and 69.44% indicated there are locations on campus that are too far to walk.

After studying the locations that were too far to walk or needed more transit services, the authors recommended that MATBUS modify some of its service routes by extending evening services and increasing weekend services within budget. The modification can be implemented with some consideration given to route frequencies, which could be modified to better serve the students. To accomplish this, MATBUS could modify existing fixed routes or expand the TapRide service to cover the gaps in the fixed-route service.

It is recommended that NDSU sustain the MATBUS services and consider expanding them to meet student demands, if fiscally possible. Since MATBUS's hourly operating expenses are less than the median hourly operating costs for 89 transit agencies within the region, it is unlikely that MATBUS will reduce the hourly cost it charges NDSU for service. However, if MATBUS needs additional funds to

provide more services, then NDSU should consider adding a small student fee to help cover the expenses. The survey showed that 80% of students did not favor paying a student fee; of the 20% in favor of paying, 28.5% were willing to pay less than $10 per semester, and 43.46% were willing to pay between $11 and $20. If additional funds are needed to provide more services, NDSU should consider adding a small student fee to help cover the expenses.

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APPENDIX – A: SURVEY QUESTIONS

NDSU - MATBUS TRANSIT SURVEY - 01 10 2019

Start of Block: KEY DEMOGRAPHICS - Who is Using MATBUS?

Q1.1 What is your age?

- Under 17 years old (1)
- 18 - 24 years (2)
- 25 - 34 years (3)
- 35 - 44 years (4)
- 45 - 54 years (5)
- 55 - 64 years (6)
- 65 and above (7)

Q1.2 Gender:

- Male (1)
- Female (2)
- Nonbinary (3)
- Prefer not to answer (4)
- Other (Please Specify) (5) _____

Q1.3 Please select your level of study:

- Undergraduate (1)
- Graduate (2)
- Other: (3) _____

Q1.4 What is your employment status:

- Full time (1)
- Part-time (2)
- Not Working (3)

Q1.5 Do you reside on/off campus?

- On-campus (1)
- Off-campus (2)

Display This Question:

If Do you reside on/off campus? = Off-campus

Q1.6 How far do you live from campus?

- 0.25 miles or Less - (0.4 km or Less) (1)
- 0.25 to 0.50 miles - (0.4 to 0.8 km) (2)
- 0.50 to 1.00 miles - (0.8 to 1.6 km) (3)
- 1.00 to 5.00 miles - (1.6 to 8.0 km) (4)
- 5.00 to 10.00 miles - (8.0 to 16.0 km) (5)
- 10 miles or More - (16 km or More) (6)

Q1.7 Do you have a valid driver's license?

- Yes (1)
- No (2)

Q1.8 Do you own or have access to a vehicle?

- Yes (1)
- No (2)

End of Block: KEY DEMOGRAPHICS - Who is Using MATBUS?

Start of Block: KEY TRAVEL CHARACTERISTICS - How and Why MATBUS?

Q2.1 How do you often travel to or around campus?(Please select more all modes that apply if you use more than one)

- Auto (1)
- Carpool (2)
- Scooter (3)
- Transit - (e.g. MATBUS) (4)
- Bicycle (5)
- Walk (6)
- Other (Please Specify) (7) _____

Q2.2 What types of trips do you generally make with the MATBUS off campus?

- Work (To/From Work) (1)
- Shopping (2)
- Family (Personal/Medical) (3)
- Social (Social/Recreational) (4)
- Other (Please Specify) (5) _____
- Don't use MATBUS off campus (6)

Q2.3 What are the most important factors when deciding a mode of transportation?

- Convenience (1)
- Weather (2)
- Cost of Parking/Lot Assignment (3)
- Parking Availability (4)
- Travel Time (5)

Q2.4 If you had to walk daily, what would you consider a reasonable walking distance when the temperature is: above freezing (>32 F)

- Less than 0.25 Miles - (0.4 km or Less) (1)
- 0.25 to 0.50 Miles - (0.4 to 0.8 km) (2)
- 0.50 to 1.00 Miles - (0.8 to 1.6 km) (3)
- More than 1.00 Miles - (1.6 km or More) (4)

Q2.5 If you had to walk daily, what would you consider a reasonable walking distance when the temperature is: below freezing (<32 F)

- Less than 0.25 Miles - (0.4 km or Less) (1)
- 0.25 to 0.50 Miles - (0.4 to 0.8 km) (2)
- 0.50 to 1.00 Miles - (0.8 to 1.6 km) (3)
- More than 1.00 Miles - (1.6 km or More) (4)

Q2.6 How many one-way trips do you generally make to and from campus?
(Please Note: A trip to and from campus would be a two-way trip)

- 0 (1)
- 1 (2)
- 2 (3)
- 3 (4)
- 4 (5)
- 5+ (6)

Q2.7 Are there any locations on campus that are too far to walk?

- Yes (1)
- No (2)

Display This Question:
If Are there any locations on campus that are too far to walk? = Yes
Q2.8 Please, could you identify the location(s)?
_____

End of Block: KEY TRAVEL CHARACTERISTICS - How and Why MATBUS?

Start of Block: SERVICE GAPS AND WILLINGNESS TO PAY

Q3.1 Which MATBUS Routes do you use frequently? (please select all that apply)

- Route 13 (1)
- Route 13U (2)
- Route 31 (3)
- Route 32E (4)
- Route 32W (5)
- Route 33 (6)
- Route 34 (7)
- TapRide (8)
- None (9)
- Other (Please Specify) (10) _____

Display This Question:
If Which MATBUS Routes do you use frequently? (please select all that apply) = None
And Which MATBUS Routes do you use frequently? (please select all that apply) q://QID31/SelectedChoicesCount Is Equal to 0

Q3.2 If you are not using the MATBUS, what factors are keeping you from using the service?
(Check all that apply)

- Lack of Information (1)
- Lack of Service (2)
- Bus not on schedule (3)
- Ride is too long (4)
- Bus stops too frequently (5)
- Long waits at transfer station (6)
- Inconvenient Service (7)
- Other (Please Specify) (8) _____

Q3.3 How satisfied are you with the NDSU MATBUS Services?

- Extremely satisfied (1)
- Somewhat satisfied (2)
- Neither satisfied nor dissatisfied (3)
- Somewhat dissatisfied (4)
- Extremely dissatisfied (5)

Q3.4 Are you willing to pay an activity fee for public transit around campus and the Fargo-Moorhead area?

- Yes (1)
- No (2)

Display This Question:
If Are you willing to pay an activity fee for public transit around campus and the Fargo-Moorhead area? = Yes
Q3.5 How much are you willing to pay per semester?

- Less than $10 (1)
- $11 to $20 (2)
- $21 to $30 (3)
- $31 to $40 (4)
- $41 to $50 (5)
- More than $50 (6)

Q3.6 Are there additional stops/locations that you would like the campus circulator to cover?

- Yes (1)
- No (2)

Display This Question:
If Are there additional stops/locations that you would like the campus circulator to cover? = Yes
Q3.7 Please list/suggest additional locations/stops:
_____

Display This Question:
If Which MATBUS Routes do you use frequently? (please select all that apply) != TapRide
Q3.8 Have you heard about the MATBUS TapRide service?
o Yes (1)
o No (2)

Display This Question:
If Which MATBUS Routes do you use frequently? (please select all that apply) = TapRide

Q3.9 Would you want more TapRide services on campus?
o Yes (4)
o No (5)

Q3.10 Do you think that the service span (hours and days of service) of the MATBUS service is adequate?
o Yes (1)
o Maybe (2)
o No (3)

Display This Question:
If Do you think that the service span (hours and days of service) of the MATBUS service is adequate? != Yes

Q3.11 What periods would you want increased services? (Please Select all that apply)
▢ Weekdays (1)
▢ Weekends (2)
▢ Early Morning (3)
▢ Late Nights (4)

Q3.12 Which of the following transit service attributes should MATBUS improve (select all that apply):
▢ Reliability of service (1)
▢ On-time Performance (2)
▢ Frequency of Service (3)
▢ Seat Availability (Capacity) (4)
▢ Technology (5)

End of Block: SERVICE GAPS AND WILLINGNESS TO PAY

APPENDIX – B: ANALYTICAL DETAILS

K-Means – Cluster Analysis:

In this section, the K-means algorithm is used to split the stops into three clusters (Figure A-1). On the average, the first cluster: cluster 1 has the lowest scores (complaints from respondents), followed by cluster 3, and then cluster 2 (highest score).

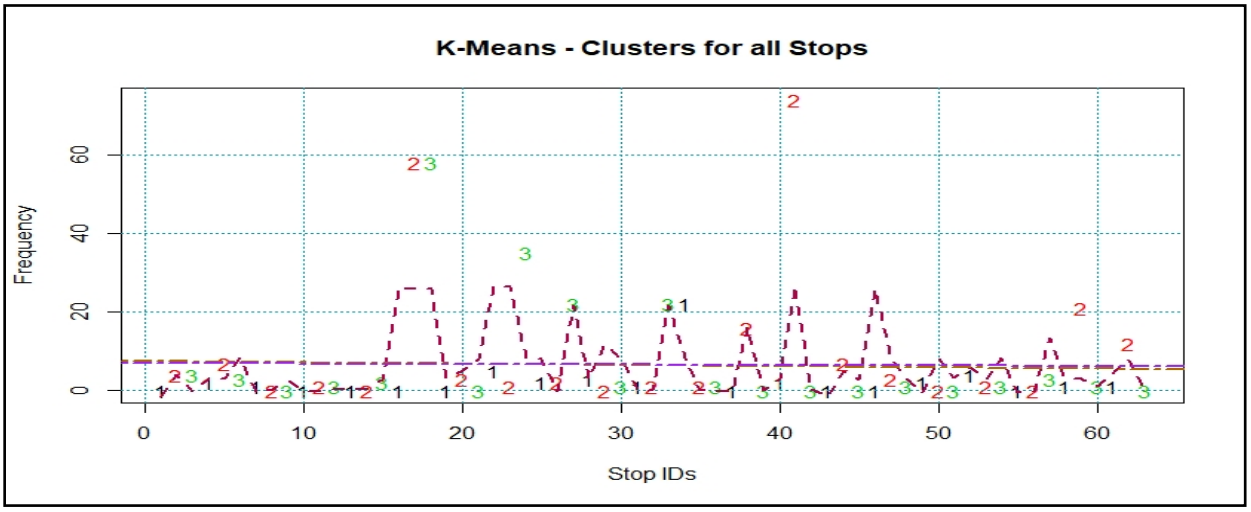


Figure A-1 Location Scores with Clusters Indicated (Three Clusters: 1, 2, and 3)

Results from the cluster analysis show that the attributes of stops with the higher scores (clusters 2 and 3) have some similarities (Figure A-2). They have little to no weekend routes, low minimum bus frequency, and are dependent on Route 31.

```
> clust.result
K-means clustering with 3 clusters of sizes 10, 36, 17

Cluster means:
     Latitude    Longitude        rSum R13          R13U          R31          R32E          R32W          R33           R34
1 46.89845364 -96.79677646 2.500000000   1 0.20000000000 0.0000000000 0.4000000000 0.4000000000 0.0000000000 0.50000000000
2 46.89205657 -96.81016554 1.555555556   0 0.02777777778 0.6111111111 0.4166666667 0.4166666667 0.0000000000 0.08333333333
3 46.89296112 -96.79910813 4.235294118   1 0.82352941176 0.2352941176 0.3529411765 0.3529411765 0.8235294118 0.64705882353
        W.Day1        W.End       Max.F        Min.F       Max.Op       Min.Op       Max.Cl       Min.Cl        Max.R
1 1.0000000000 1.0000000000 60.00000000 25.000000000 0.4897916667 0.2604166667 0.9659722222 0.7929166667 0.4761805556
2 0.8333333333 0.0000000000 19.72222222 15.277777778 0.4700617284 0.2608217593 0.7016975309 0.6235146605 0.2316358025
3 1.0000000000 0.9411764706 60.00000000  8.411764706 0.4880310458 0.2604166667 0.9659722222 0.7198937908 0.4779411765

Clustering vector:
 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
 2  3  3  2  2  2  3  2  2  3  3  2  2  2  3  3  1  1  2  1  2  3  1  2  2  3  2  2  1  2  2  2  3  2  2  2  3  2  1  2  3
42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63
 1  2  1  2  1  3  2  3  2  2  2  2  2  1  3  3  2  2  2  2  3  2

within cluster sum of squares by cluster:
[1]  276.9049168 7233.7296160  197.7016418
 (between_SS / total_SS =  77.7 %)

Available components:

[1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss" "betweenss"    "size"         "iter"
[9] "ifault"
```

Figure A-2 Cluster Details for all Stops

Multiple Regression – Analysis:

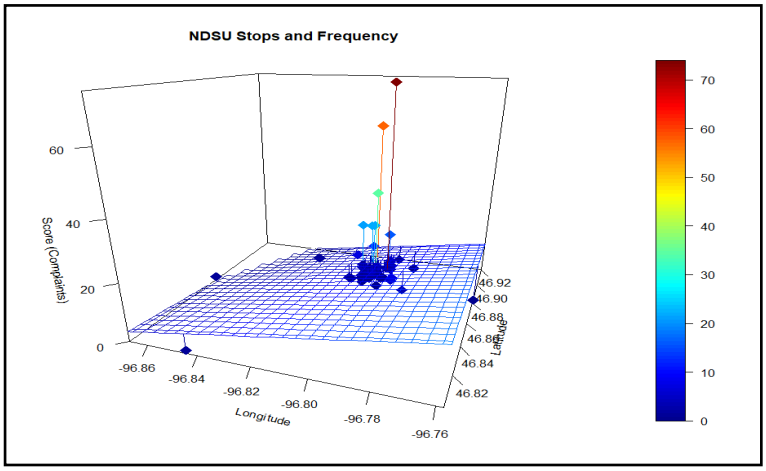
Using multiple regression to study the relationship between the attributes of the dataset, results similar to those of the cluster analysis are observed. As shown in the model summary in Figure A-3, the factors that show a negative correlation with score are listed below. The factors that are also observed in the cluster analysis are marked with an asterisk (*).

- Number of routes serving each stop
- Access to route (13 and 13U)
- Presence of Route 31
- Weekend service*
- Frequency of service*
- Service window*

```
> summary(routeModel)

Call:
lm(formula = dataBUS$Freq ~ ., data = var.var)

Residuals:
       Min         1Q     Median         3Q        Max
-26.332022  -3.047775  -0.216419   1.005261  47.347319

Coefficients: (2 not defined because of singularities)
                Estimate    Std. Error  t value  Pr(>|t|)
(Intercept)  3629.9613044 40997.5604931  0.08854 0.9298396
Latitude      -42.2088691   154.8318766 -0.27261 0.7863994
Longitude      17.0401480   387.6095054  0.04396 0.9651291
rSum           -6.3906528     9.1144528 -0.70116 0.4868159
R13           -11.2868492    33.7850863 -0.33408 0.7398728
R13U          -28.4461390    21.8554828 -1.30156 0.1996923
R31            -4.4461277    16.3713965 -0.27158 0.7871878
R32E            0.8788284    16.7097510  0.05259 0.9582884
R32W          715.5982671   262.1245537  2.72999 0.0090085 **
R33            12.3780019    33.9514041  0.36458 0.7171327
R34                    NA            NA       NA        NA
W.Day1       1192.3396047   475.0479374  2.50994 0.0157404 *
W.End          -4.0763954    20.5843582 -0.19803 0.8439107
Max.F          -1.4882204     1.5865894 -0.93800 0.3532520
Min.F          -1.2459587     1.0753702 -1.15863 0.2527180
Max.Op      -1416.9569062   525.6639111 -2.69556 0.0098474 **
Min.Op      -1358.9554368   861.1238113 -1.57812 0.1215431
Max.Cl         11.8292022   101.4625929  0.11659 0.9077062
Min.Cl       -344.7529111   168.2015278 -2.04964 0.0462545 *
Max.R                  NA            NA       NA        NA
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure A-3 Multiple Linear Regression Model Summary

A three-dimensional plot of all 63 locations using their longitude, latitude, and scores (complaints) is shown in Figure A-4-a. The plot shows the average weighting of all complaints sloping negatively toward higher latitudes and lower latitudes and longitudes. Only a few points at the central service locations (NDSU campus area) show a spike in complaint score: Barry Hall, Fargodome, Library, Minard Hall, Wellness Center, Niskanen Expansion.



(a) Locations Against Score

```
> importance(mRF)
                %IncMSE   IncNodePurity
Latitude    2.9129022965 2042.4607764128
Longitude  10.6786433588 3104.7559650573
rSum        7.7869200301  699.4565734640
R13         1.2592980575   97.7258377938
R13U        2.8478189824  198.9912844973
R31         1.1549895190  170.7005338317
R32E        1.3105351626  219.8617085436
R32W        2.5975614439  166.9968699951
R33         1.7030703820  300.8476242205
R34         4.5276777311  316.1685585269
W.Day1      2.3239740758    0.9366819958
W.End       2.5534887737  137.4282146324
Max.F       2.0421211829  113.5330228870
Min.F       3.4584561708  668.7005633725
Max.Op      1.3513478857  384.2108894904
Min.Op     -0.1696431625   85.0569288433
Max.Cl      3.0856222412   85.0872592466
Min.Cl      2.1683498667  400.4143979325
Max.R       0.5850313957  370.2572717316
```

(b) Attribute Weights on Model

Figure A-4 Attribute Impacts on Score

Additional Analysis: Random Forest Model

In this section, a random forest model is built to check the importance or weight of the predictor variables. The results of the model weight summary (Figure A-4-b) show that the importance of the predictor variables differs significantly, with stop locations. The stop latitudes have a higher significance (~5 times more) than the stop longitude. The top seven of the other attributes of the model are sorted by their weight or significance in descending order, and are listed below:

- *Number of routes on stop/location*
- *Presence of Route 34*
- *Minimum service frequency on stop/location (service frequency)**
- *Maximum service close time on location (service window)**
- *Access to route 13U**
- *Access to route 32W*
- *Weekend service**

The variables that are observed to be significant in the previous analysis are marked with an asterisk (*).

Impact of Changes in Seasonal and Non-Seasonal Factors on Ridership

Before the impact analysis, the predictor variables (seasonal and non-seasonal factors) were scaled so they produce zero mean. Using the standardized data for regression analysis, the intercept is not interpreted as the expected value of ridership when the predictor values are zero. It is unrealistic or unlikely such situations could exist (e.g., wind speed or enrollment equal to zero). Another reason for scaling the dataset is that the massive scale of ridership or enrollment and the small scale of temperature or humidity would be less efficient for model building. For the regression analysis, a data range of 1,342 observations, between August 24, 2014, and August 23, 2018, is used (a four-year range), with 42 predictor variables. However, a correlation chart and a variable inflation factors (VIF) test were used to reduce these variables by eliminating the ones with high correlation. The r command for the multicollinearity test is shown in Figure A-5. Because of the interest of the authors on the impact of the

changes (demolition and new construction) to University Village Apartments on ridership, it is added to the selected variables for analysis (Table A-1 and Figure A-6).

```
##############
# Regression #
##############
## Correlation (Routes)
#Subset Variables for All Routes Only
Variables_X_D = dataset_D[,c(8:9,16:55)]
#Check Correlation (Whole Dataset)
chart.Correlation(Variables_X_D,histogram=TRUE, pch=19)
## VIF TEST
Chosen = VIF::vif(Ridership_31_D,Variables_X_D)
Chosen$`select`
Chosen$modelmatrix
labels(Chosen$modelmatrix)
```

Figure A-5 Code for VIF and Correlation Test

```
[[2]]
 [1] "Day_TypeW_End"   "HolidayYes"      "SemesterSpring" "Enrollement"    "T_Max"          "WS_Max"
 [7] "B_Court_W"       "Burgum"          "Churchhill"     "Dinan"
```

Figure A-6 The list of Suggested Variables from VIF Function

Table A-1 Selected Factors for Statistical Analysis

Selected Factors	Data Tag (Attribute Name)
The Observation Date Type	“Day_TypeW_End”
Holiday	“HolidayYes”
The Semester	“SemesterSpring + SemesterSummer”
NDSU Student Enrollment	“Enrollment”
Maximum Daily Temperature	“T_Max”
Maximum Wind Speed	“WS_Max”
Bison Court West	“B_Court_W”
Burgum Hall	“Burgum”
Churchill Hall	“Churchill”
Dinan Hall	“Dinan”
University Village Apartments	“UV_Apts”

Analysis Using Multiple Linear Regression

A linear equation is fitted to the observed ridership data to better understand the relationship between the predictor variables (seasonal and non-seasonal factors) and the response variable (ridership). One model is fit for all the routes, and five models are fit for each route. In total, six multiple linear regression models are built with all the values of the independent variables associated with a value of the ridership (scaled). The general equation for the models used in Equation 1.

Equation 1. Multiple Linear Regression Model for Daily Ridership

$$\boldsymbol{y} = \boldsymbol{X\beta} + \boldsymbol{\epsilon}$$

Or

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \vdots \\ y_{1342} \end{bmatrix} = \begin{bmatrix} 1 & x_{1,1} & \dots & x_{1,15} \\ 1 & x_{2,1} & \dots & x_{2,15} \\ 1 & x_{3,1} & \dots & x_{3,15} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{1342,1} & \dots & x_{1342,15} \end{bmatrix} * \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \vdots \\ \beta_{15} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \vdots \\ \varepsilon_{1342} \end{bmatrix}$$

Where:

- $y = daily\ ridership\ for\ weeks\ \{1,2,\dots 1342\}$
- $x = factors\ considered\ \{1,2,\dots 15\}$
- $\beta = slopes\ \{0,1,\dots 15\}$
- $\varepsilon = standard\ errors\ \{1,2,\dots 15\}$

Model 00 – Ridership Sum of all Routes

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-7. The model's adjusted R-squared indicates that only 87.55% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-8).

```
> summary(m00)

Call:
lm(formula = dataset_D$Ridership_Sum ~ Day_TypeW_End + HolidayYes +
    SemesterSpring + SemesterSummer + Enrollement + T_Max + WS_Max +
    B_Court_W + Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)

Residuals:
     Min       1Q   Median       3Q      Max
-2.06316 -0.13760  0.01816  0.14891  1.30983

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)    3.220e-15  9.633e-03   0.000 1.000000
Day_TypeW_End -8.376e-01  1.072e-02 -78.162  < 2e-16 ***
HolidayYes    -7.936e-01  1.332e-02 -59.597  < 2e-16 ***
SemesterSpring -9.403e-01  1.437e-01  -6.545 8.47e-11 ***
SemesterSummer -1.046e+01  1.771e+00  -5.906 4.45e-09 ***
Enrollement   -4.307e-02  2.527e-02  -1.704 0.088551 .
T_Max         -1.186e-01  1.287e-02  -9.215  < 2e-16 ***
WS_Max         3.580e-02  9.720e-03   3.683 0.000239 ***
B_Court_W     -9.323e-02  2.278e-02  -4.093 4.52e-05 ***
Burgum        -3.625e+00  2.965e-01 -12.225  < 2e-16 ***
Churchhill     2.475e-01  5.138e-02   4.816 1.63e-06 ***
Dinan         -6.750e+00  1.621e+00  -4.164 3.33e-05 ***
UV_Apts        1.940e-01  4.947e-02   3.922 9.23e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3529 on 1329 degrees of freedom
Multiple R-squared:  0.8766,    Adjusted R-squared:  0.8755
F-statistic: 786.7 on 12 and 1329 DF,  p-value: < 2.2e-16
```

Figure A-7 Model 00 Summary

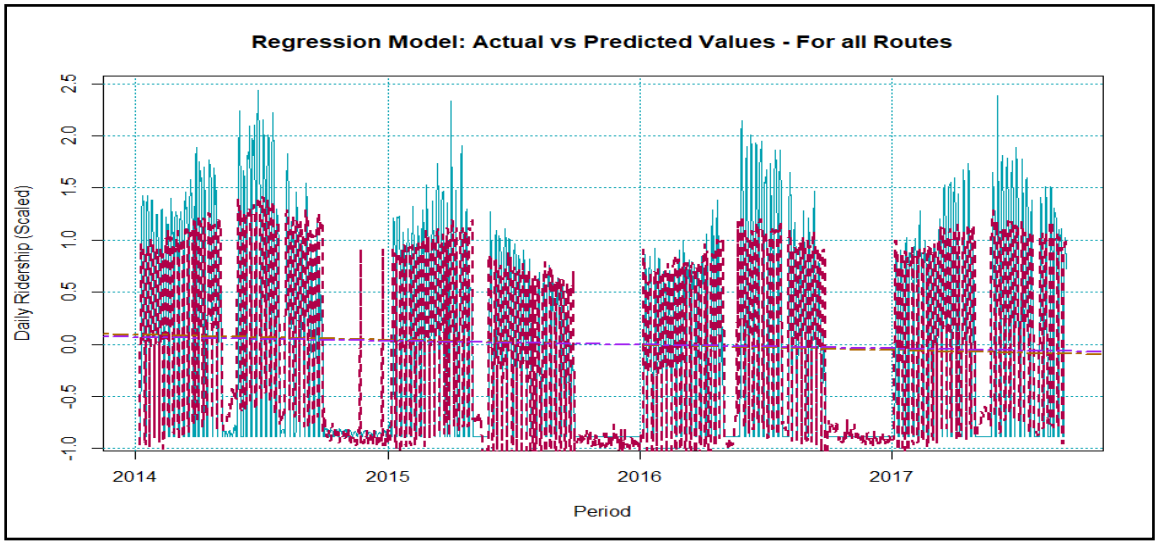


Figure A-8 Model 00 - Ridership Prediction

Model 01 – Ridership of Route 31

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-9. The model's adjusted R-squared indicates that only 80.81% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-10)

```
> summary(m01)

Call:
lm(formula = dataset_D$R_R31 ~ Day_TypeW_End + HolidayYes + SemesterSpring +
    SemesterSummer + Enrollement + T_Max + WS_Max + B_Court_W +
    Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)

Residuals:
    Min      1Q  Median      3Q     Max
-1.9412 -0.1647  0.0066  0.1835  3.7659

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)    -5.479e-15  1.196e-02   0.000 1.000000
Day_TypeW_End  -7.710e-01  1.330e-02 -57.960  < 2e-16 ***
HolidayYes     -7.484e-01  1.653e-02 -45.275  < 2e-16 ***
SemesterSpring  4.785e-01  1.783e-01   2.683 0.007387 **
SemesterSummer  5.101e+00  2.198e+00   2.321 0.020464 *
Enrollement     2.215e-01  3.137e-02   7.059 2.69e-12 ***
T_Max          -2.194e-01  1.597e-02 -13.735  < 2e-16 ***
WS_Max          5.805e-02  1.207e-02   4.811 1.67e-06 ***
B_Court_W       4.733e-02  2.828e-02   1.674 0.094402 .
Burgum         -2.343e+00  3.681e-01  -6.366 2.67e-10 ***
Churchhill     -1.075e-02  6.378e-02  -0.169 0.866177
Dinan           7.148e+00  2.012e+00   3.552 0.000395 ***
UV_Apts        -9.806e-02  6.140e-02  -1.597 0.110515
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.438 on 1329 degrees of freedom
Multiple R-squared:  0.8099,    Adjusted R-squared:  0.8081
F-statistic: 471.7 on 12 and 1329 DF,  p-value: < 2.2e-16
```

Figure A-9 Model 01 Summary

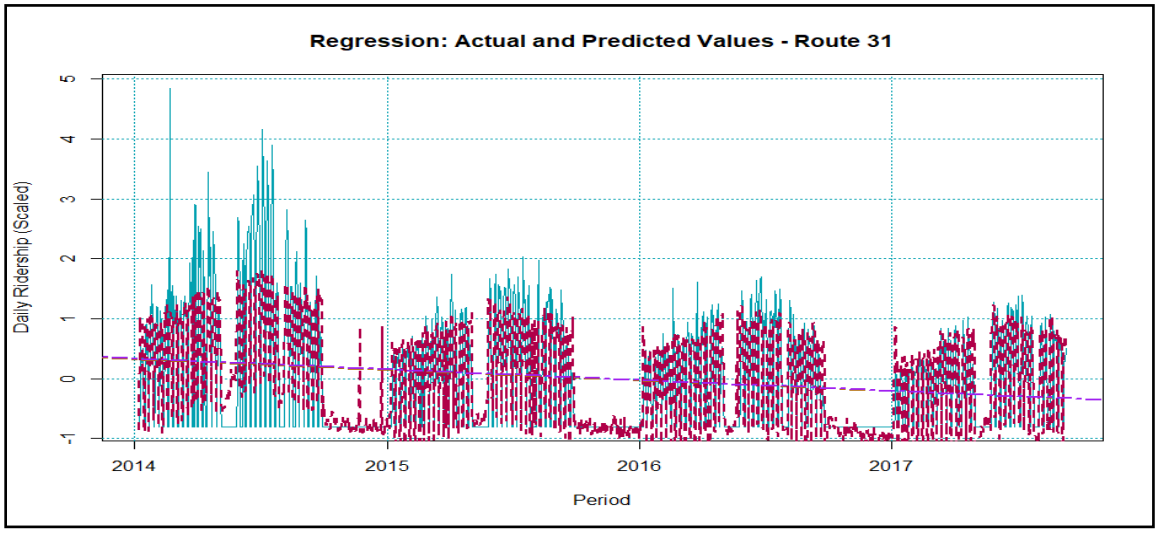


Figure A-10 Model 01 - Ridership Prediction

Model 02 – Ridership of Route 32

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-11. The model's adjusted R-squared indicates that only 78.64% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-12).

```
> summary(m02)

Call:
lm(formula = dataset_D$R_R32 ~ Day_TypeW_End + HolidayYes + SemesterSpring +
    SemesterSummer + Enrollement + T_Max + WS_Max + B_Court_W +
    Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)

Residuals:
     Min       1Q   Median       3Q      Max
-2.33881 -0.25435 -0.00786  0.18962  3.04572

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     1.076e-14  1.262e-02   0.000        1
Day_TypeW_End  -7.720e-01  1.403e-02 -55.005  < 2e-16 ***
HolidayYes     -7.542e-01  1.744e-02 -43.243  < 2e-16 ***
SemesterSpring -1.686e+00  1.882e-01  -8.960  < 2e-16 ***
SemesterSummer -2.014e+01  2.319e+00  -8.682  < 2e-16 ***
Enrollement    -1.906e-01  3.310e-02  -5.758 1.06e-08 ***
T_Max          -2.277e-01  1.685e-02 -13.514  < 2e-16 ***
WS_Max          7.386e-02  1.273e-02   5.802 8.20e-09 ***
B_Court_W      -1.746e-01  2.983e-02  -5.852 6.11e-09 ***
Burgum         -3.717e+00  3.884e-01  -9.572  < 2e-16 ***
Churchhill      3.932e-01  6.729e-02   5.844 6.42e-09 ***
Dinan          -1.628e+01  2.123e+00  -7.669 3.33e-14 ***
UV_Apts         4.271e-01  6.478e-02   6.593 6.22e-11 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4621 on 1329 degrees of freedom
Multiple R-squared:  0.7883,    Adjusted R-squared:  0.7864
F-statistic: 412.5 on 12 and 1329 DF,  p-value: < 2.2e-16
```

Figure A-11 Model 02 Summary

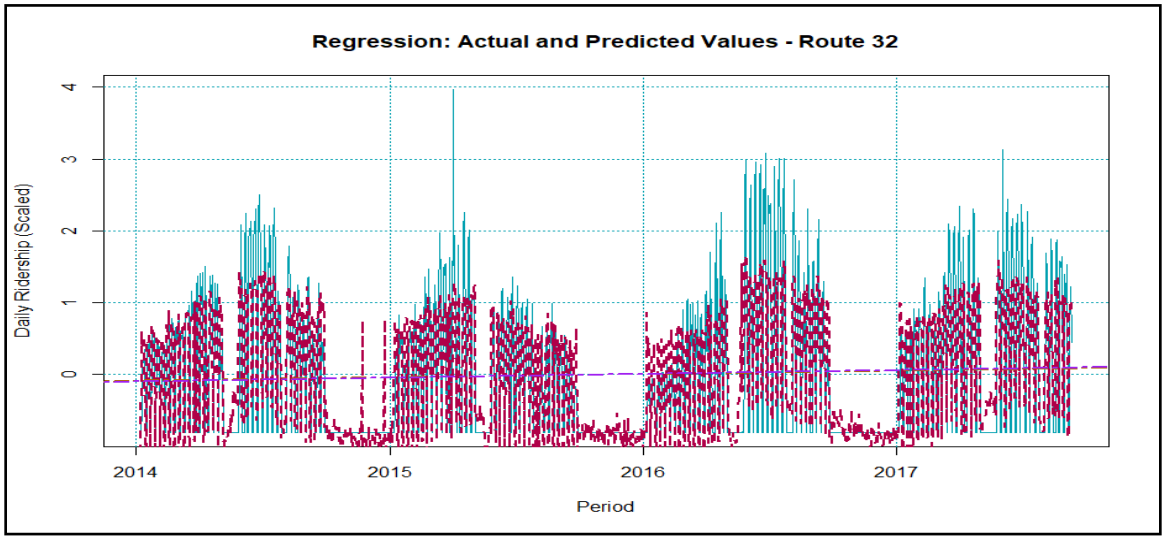


Figure A-12 Model 02 - Ridership Prediction

Model 03 – Ridership of Route 33

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-13. The model's adjusted R-squared indicates that only 86.73% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-14).

```
> summary(m03)

Call:
lm(formula = dataset_D$R_R33 ~ Day_TypeW_End + HolidayYes + SemesterSpring +
    SemesterSummer + Enrollement + T_Max + WS_Max + B_Court_W +
    Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)

Residuals:
     Min       1Q   Median       3Q      Max
-1.89720 -0.08954  0.00625  0.15137  1.56962

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)    -2.537e-15  9.945e-03   0.000   1.0000
Day_TypeW_End  -8.328e-01  1.106e-02 -75.265  < 2e-16 ***
HolidayYes     -7.765e-01  1.375e-02 -56.479  < 2e-16 ***
SemesterSpring  3.944e-02  1.483e-01   0.266   0.7904
SemesterSummer  2.009e+00  1.829e+00   1.099   0.2721
Enrollement     1.987e-03  2.609e-02   0.076   0.9393
T_Max           1.440e-02  1.329e-02   1.084   0.2786
WS_Max         -7.504e-03  1.004e-02  -0.748   0.4548
B_Court_W       1.001e-02  2.352e-02   0.426   0.6704
Burgum         -1.349e+00  3.062e-01  -4.405 1.14e-05 ***
Churchhill     -6.248e-03  5.305e-02  -0.118   0.9063
Dinan           3.379e+00  1.674e+00   2.019   0.0437 *
UV_Apts        -3.470e-02  5.107e-02  -0.680   0.4969
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3643 on 1329 degrees of freedom
Multiple R-squared:  0.8684,    Adjusted R-squared:  0.8673
F-statistic: 731.1 on 12 and 1329 DF,  p-value: < 2.2e-16
```

Figure A-13 Model 03 Summary

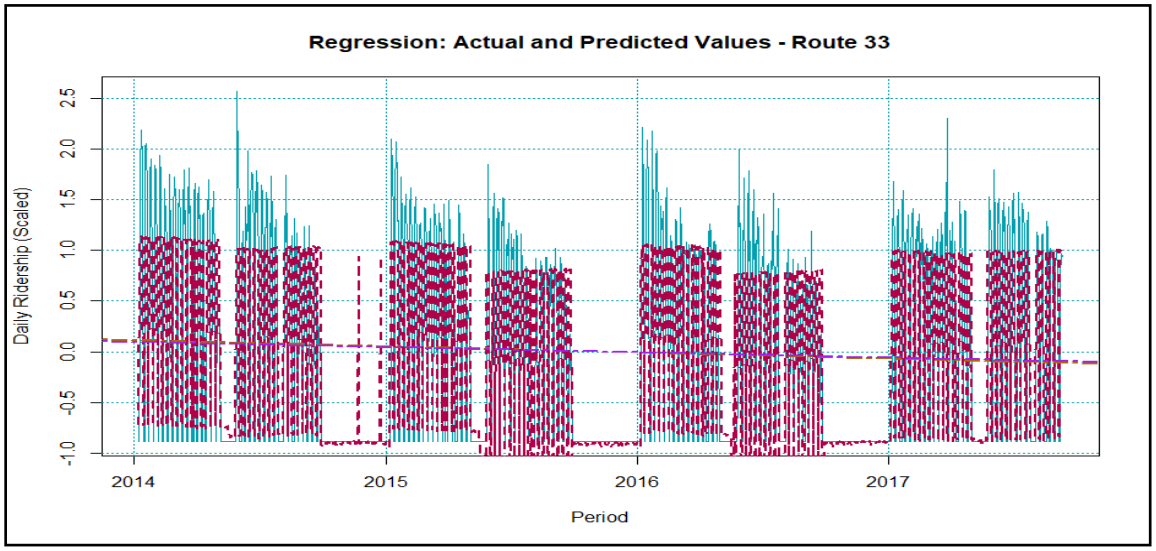


Figure A-14 Model 03 - Ridership Prediction

Model 04 – Ridership of Route 34

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-15. The model's adjusted R-squared indicates that only 70.31% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-16).

```
> summary(m04)

Call:
lm(formula = dataset_D$R_R34 ~ Day_TypeW_End + HolidayYes + SemesterSpring +
    SemesterSummer + Enrollement + T_Max + WS_Max + B_Court_W +
    Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)

Residuals:
     Min       1Q   Median       3Q      Max
-2.08602 -0.31599 -0.04224  0.34607  1.87238

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)    1.324e-14  1.487e-02   0.000   1.0000
Day_TypeW_End -6.621e-01  1.655e-02 -40.011  < 2e-16 ***
HolidayYes    -5.851e-01  2.056e-02 -28.454  < 2e-16 ***
SemesterSpring -3.011e+00  2.219e-01 -13.571  < 2e-16 ***
SemesterSummer -3.488e+01  2.735e+00 -12.754  < 2e-16 ***
Enrollement    1.255e-02  3.903e-02   0.322   0.7478
T_Max         -1.049e-01  1.987e-02  -5.278 1.53e-07 ***
WS_Max         3.274e-02  1.501e-02   2.181   0.0293 *
B_Court_W     -3.076e-01  3.518e-02  -8.745  < 2e-16 ***
Burgum        -1.066e+01  4.579e-01 -23.271  < 2e-16 ***
Churchhill     8.564e-01  7.935e-02  10.793  < 2e-16 ***
Dinan         -2.380e+01  2.503e+00  -9.506  < 2e-16 ***
UV_Apts        4.991e-01  7.639e-02   6.533 9.13e-11 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5449 on 1329 degrees of freedom
Multiple R-squared:  0.7057,    Adjusted R-squared:  0.7031
F-statistic: 265.6 on 12 and 1329 DF,  p-value: < 2.2e-16
```

Figure A-15 Model 04 Summary

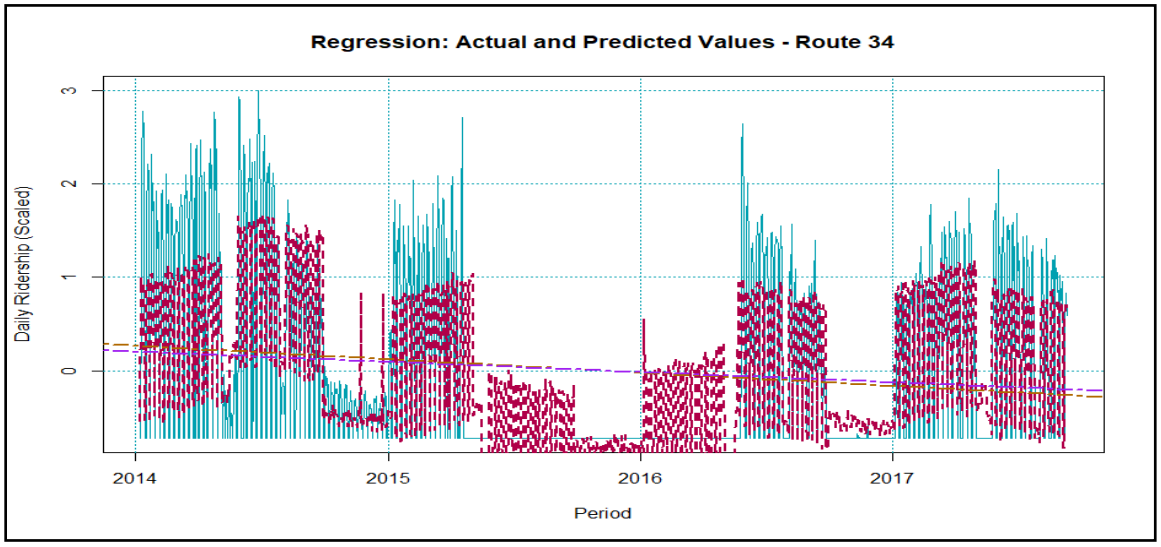


Figure A-16 Model 04 - Ridership Prediction

Model 05 – Ridership of Route 35 (+TapRide)

The model (multiple linear regression) summaries for the cumulative ridership is shown in Figure A-17. The model's adjusted R-squared indicates that only 69.25% of the variability of the ridership is explained, which is observed in its predicted ridership (Figure A-18).

```
> summary(m05)

Call:
lm(formula = dataset_D$R_R35_Tap ~ Day_TypeW_End + HolidayYes +
    SemesterSpring + SemesterSummer + Enrollement + T_Max + WS_Max +
    B_Court_W + Burgum + Churchhill + Dinan + UV_Apts, data = Variables_X_D)

Residuals:
     Min       1Q   Median       3Q      Max
-2.21364 -0.26305  0.02452  0.24074  2.31174

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  -7.822e-15  1.514e-02   0.000  1.00000
Day_TypeW_End -7.043e-01  1.684e-02 -41.818  < 2e-16 ***
HolidayYes    -6.855e-01  2.093e-02 -32.755  < 2e-16 ***
SemesterSpring  1.802e-01  2.258e-01   0.798  0.42502
SemesterSummer  2.812e+00  2.783e+00   1.010  0.31251
Enrollement    3.010e-01  3.972e-02   7.579 6.49e-14 ***
T_Max         -2.144e-01  2.022e-02 -10.601  < 2e-16 ***
WS_Max         7.470e-02  1.528e-02   4.890 1.13e-06 ***
B_Court_W      9.038e-02  3.580e-02   2.525  0.01170 *
Burgum        -4.337e+00  4.660e-01  -9.306  < 2e-16 ***
Churchhill    -1.641e-01  8.075e-02  -2.033  0.04229 *
Dinan          7.122e+00  2.548e+00   2.796  0.00525 **
UV_Apts       -2.464e-01  7.774e-02  -3.170  0.00156 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5546 on 1329 degrees of freedom
Multiple R-squared:  0.6952,    Adjusted R-squared:  0.6925
F-statistic: 252.6 on 12 and 1329 DF,  p-value: < 2.2e-16
```

Figure A-17 Model 05 Summary

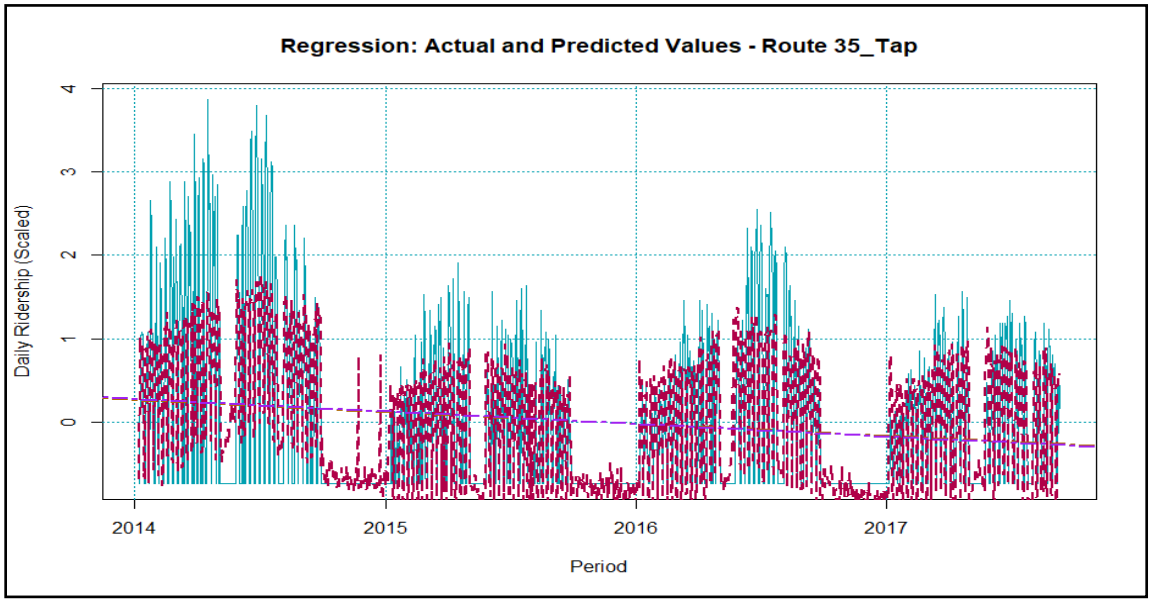


Figure A-18 Model 05 - Ridership Prediction

Inferences from Regression Analysis

While the six models show significant relationships between predictor variables and ridership, they do not explain all the variability in ridership and are unable to predict the ridership in all routes to a satisfactory level of confidence (95% CI). See Figures 22, 24, 28, 30, and 32 for regression model ridership projections. In Table 3, the slope of the impact of the factors on ridership is shown for each factor considered for the models. As can be seen from Table A-2, weekends, holidays, and Burgum Hall residence occupancy have consistent negative impacts on the ridership of all routes considered. Also, the impact of positive changes to University Village Apartment residency or occupancy across all routes is shown as positive for routes 32 and 34, but negative for the rest of the routes. Except for Route 33, all routes are affected negatively with an increase in temperature and positively with an increase in wind speed.

To better predict the ridership of all routes, the authors switch methods from statistics to machine learning. This is done because transit demand modeling is both an art and a science. Modeling ridership involves the estimation of real-time unknown variables of demand with a certain degree of rationality, and both regression and time series methods can be too simplistic despite their complexities and strengths (Profillidis & Botzoris 2019). This is because of certain flaws possessed by these statistical methods.

These flaws include:

- Transit demand methods exhibit non-linear characteristics (regression)
- In time series methods, there can be only one independent variable (time)
- Both methods are based on some assumptions that limit the flexibility that occurs in real transit-demand problems
- Both methods use limited datasets
- Both methods use static models that lack the dynamic reflection of human behavior

To mitigate the flaws of the statistical models, the authors use a machine learning model called a neural network. This neural network is built with the same inputs as the regression models and is used to predict the daily ridership of all NDSU MATBUS routes. In the following sections, two neural network models are used to predict both the overall ridership and the ridership of all five routes.

Table A-2 Selected Predictor Factor Impacts

Predictor Variables and Intercept	M00 All Routes	M01 Route 31	M02 Route 32	M03 Route 33	M04 Route 34	M05 Route 35	Consistent Impact across all Models?
(Model Intercept)	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	FALSE
Day Type (Weekend)	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**TRUE**
Holiday (Yes)	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**TRUE**
SemesterSpring	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	FALSE
SemesterSummer	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	FALSE
Enrollment	[-] ve	[+] ve	[-] ve	[+] ve	[+] ve	[+] ve	FALSE
Maximum Temp.	*[-] ve*	*[-] ve*	*[-] ve*	***[+] ve***	*[-] ve*	*[-] ve*	*FALSE*
Maximum Wind Spd.	*[+] ve*	*[+] ve*	*[+] ve*	***[-] ve***	*[+] ve*	*[+] ve*	*FALSE*
Bison Court (West)	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	FALSE
Burgum Hall	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**[-] ve**	**TRUE**
Churchill Hall	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	FALSE
Dinan Hall	[-] ve	[+] ve	[-] ve	[+] ve	[-] ve	[+] ve	FALSE
University Village Apt.	*[+] ve*	*[-] ve*	*[+] ve*	*[-] ve*	*[+] ve*	*[-] ve*	*FALSE*

Neural Network Models

In general, neural networks (NN) refer to simplified models that work like the human brain. NNs work by mimicking a large number of interconnected processing units that resemble abstract versions of biological neurons. NNs learn through the examination of individual records and the generation of predictions for each record. NNs also make adjustments to the weights whenever they make an incorrect prediction. This NN process repeats many times, and the network continues to improve its predictions until one or more of its stopping criteria is met.

The NN model in Equation 2 predicts the ridership values (scaled and centered) using the selected predicted variables and some new variables added for more control. The equation for the model developed for the routes is shown below:

Equation 2. Neural Network Model

$$Sum\ Daily\ Ridership\ \rightarrow \boldsymbol{y} = \boldsymbol{f}(\boldsymbol{z}) = \boldsymbol{b} + \sum_{\boldsymbol{i=1}}^{\boldsymbol{d^{(l-1)}}} \left(\boldsymbol{x_i^{(l-1)} w_i^l}\right) \rightarrow \cdots$$

Where:
b = bias, x = input to neuron, w = weights, Layers: $\{l \ \rightarrow \ 1 \leq l \ \leq L\}$, Inputs: $\{ i \ \rightarrow \ 0 \leq i \ \leq d^{(l-1)}\}$, Outputs: $\{ j \ \rightarrow \ 1 \leq j \ \leq d^{(l)} \}$

Neural Network Model 01 – All Routes (Sum)

An NN model with two layers and a linear output is fit. A “rprop+.” algorithm with two repetitions is used for model training. The weights of the NN model are in Table A-3. This model predicts the cumulative MATBUS transit ridership of the NDSU routes better than the regression model. See Figure A-19 for Network Configuration and Figure A-20 for Ridership Prediction.

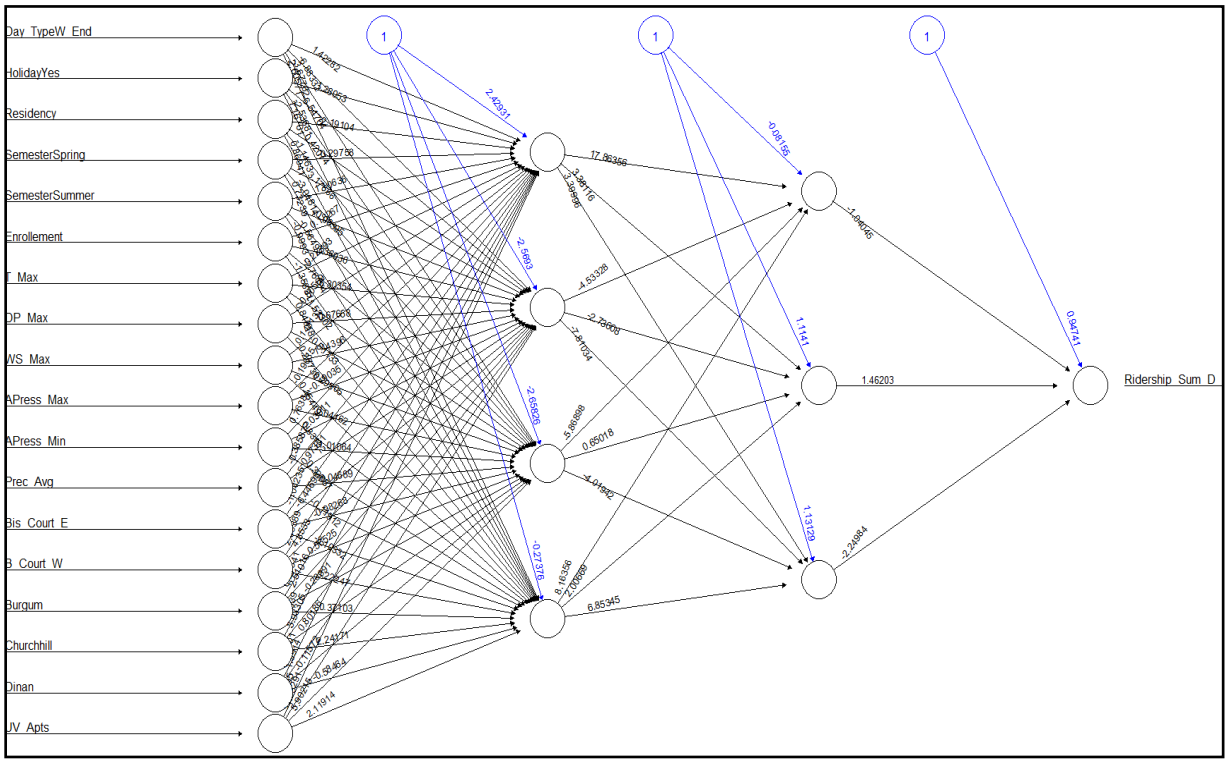


Figure A-19 Neural Network Model for All Routes (Sum)

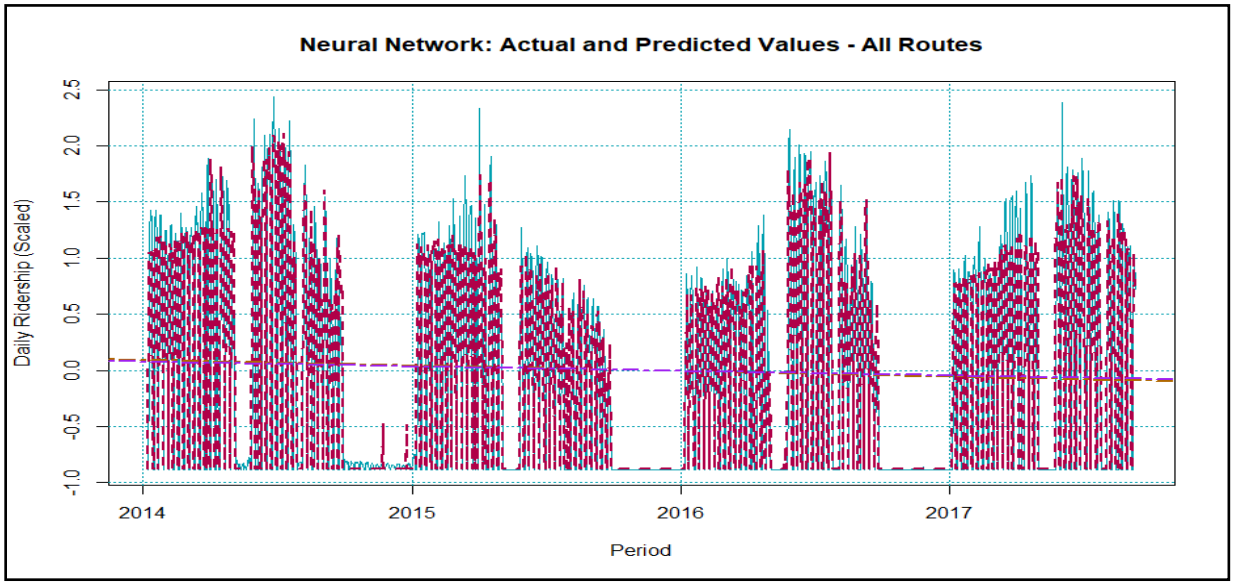


Figure A-20 Cumulative Ridership (All Routes) Prediction

Neural Network Model 02 – for Routes 31 through 35/TapRide

An NN model with two layers and a linear output is fit. A "rprop+." algorithm with two repetitions is used for model training. The weights of the NN model are in Appendix C, Table 22. This model predicts the MATBUS transit ridership of all the NDSU routes separately. See Figure A-21 for Network Configuration and Figure A-22 through Figure A-26 for Ridership Prediction of routes 31 - 35.

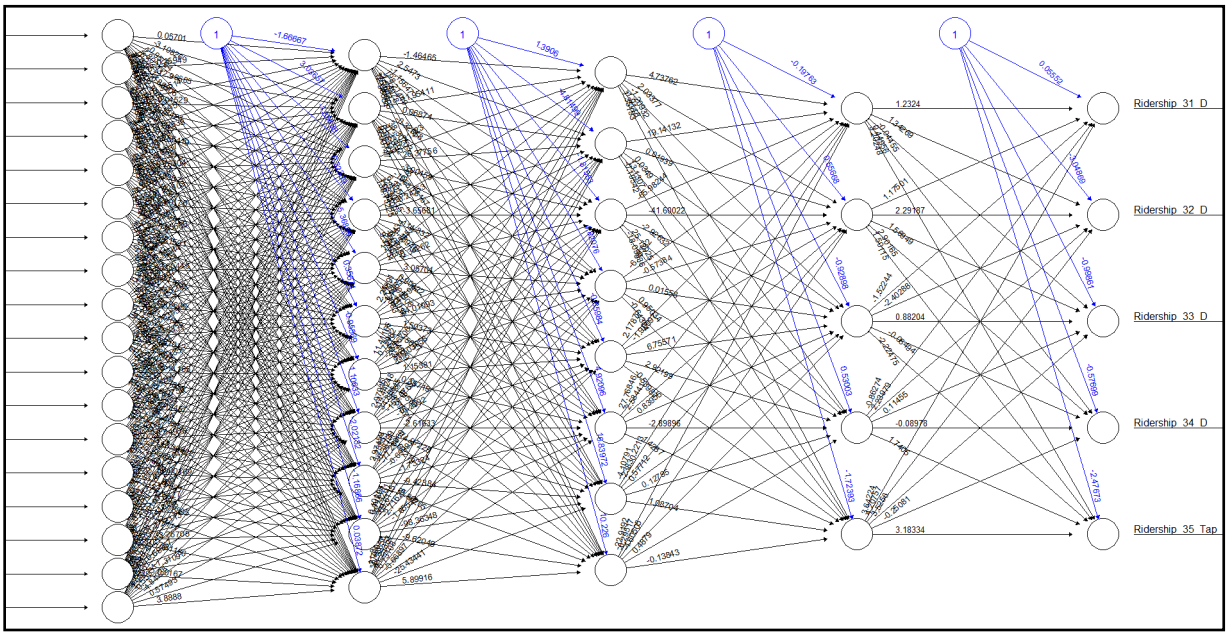


Figure A-21 Neural Network Model for Routes 31 to 35/TapRide

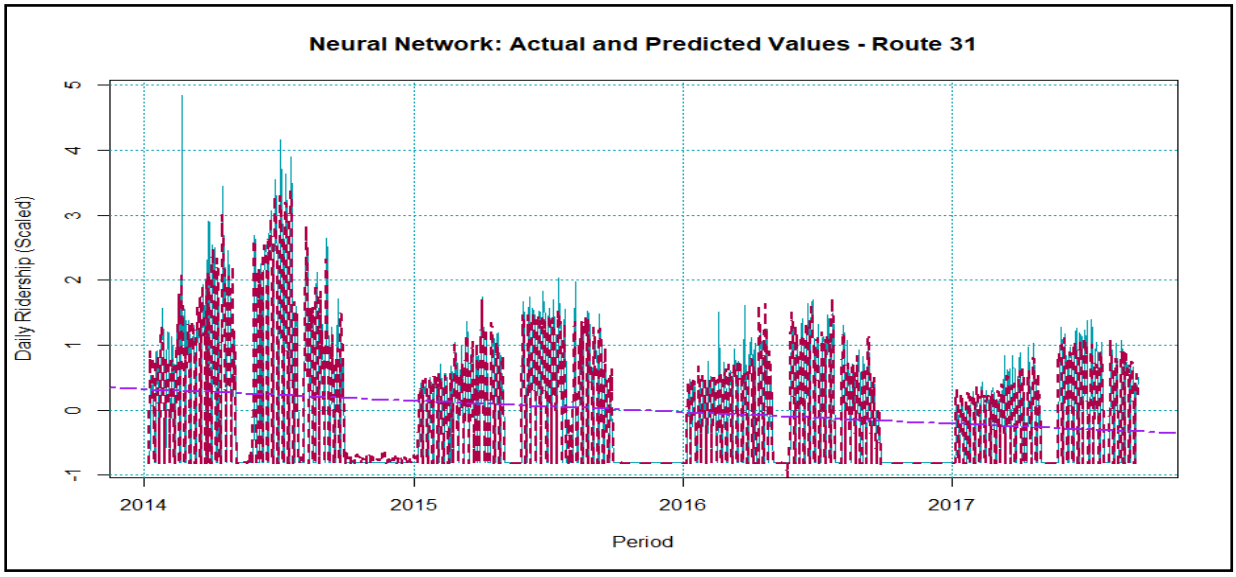


Figure A-22 Route 31 Prediction

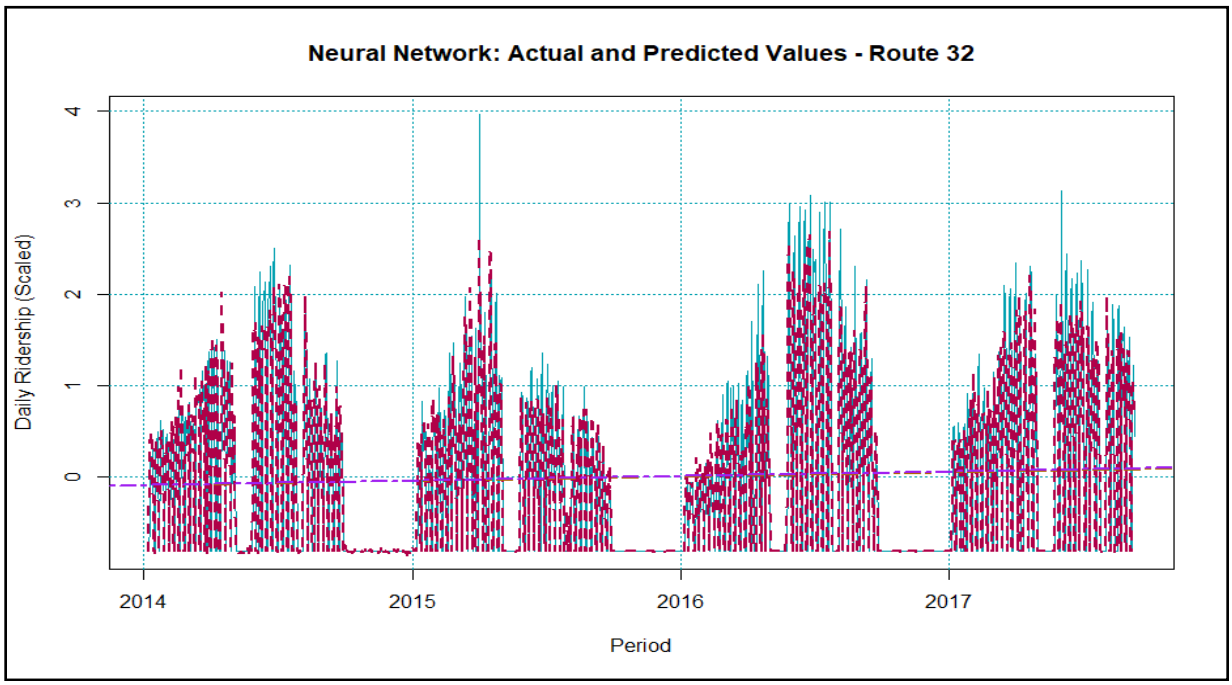


Figure A-23 Route 33 Prediction

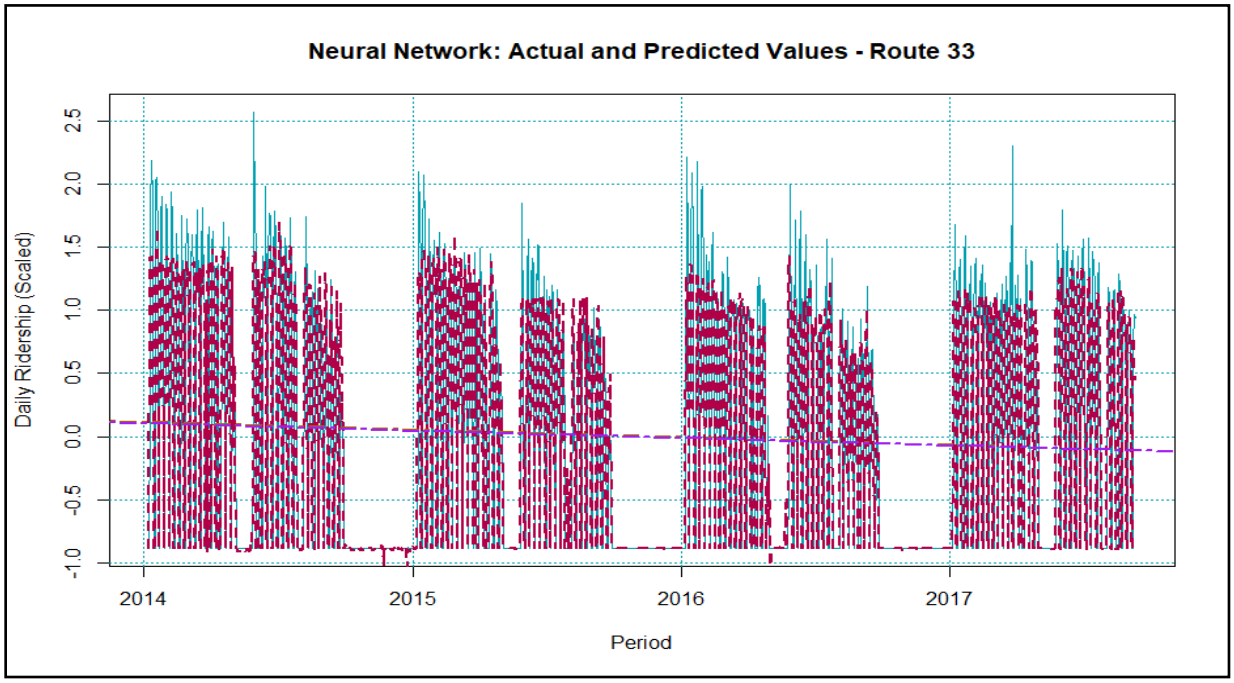


Figure A-24 Route 33 Prediction

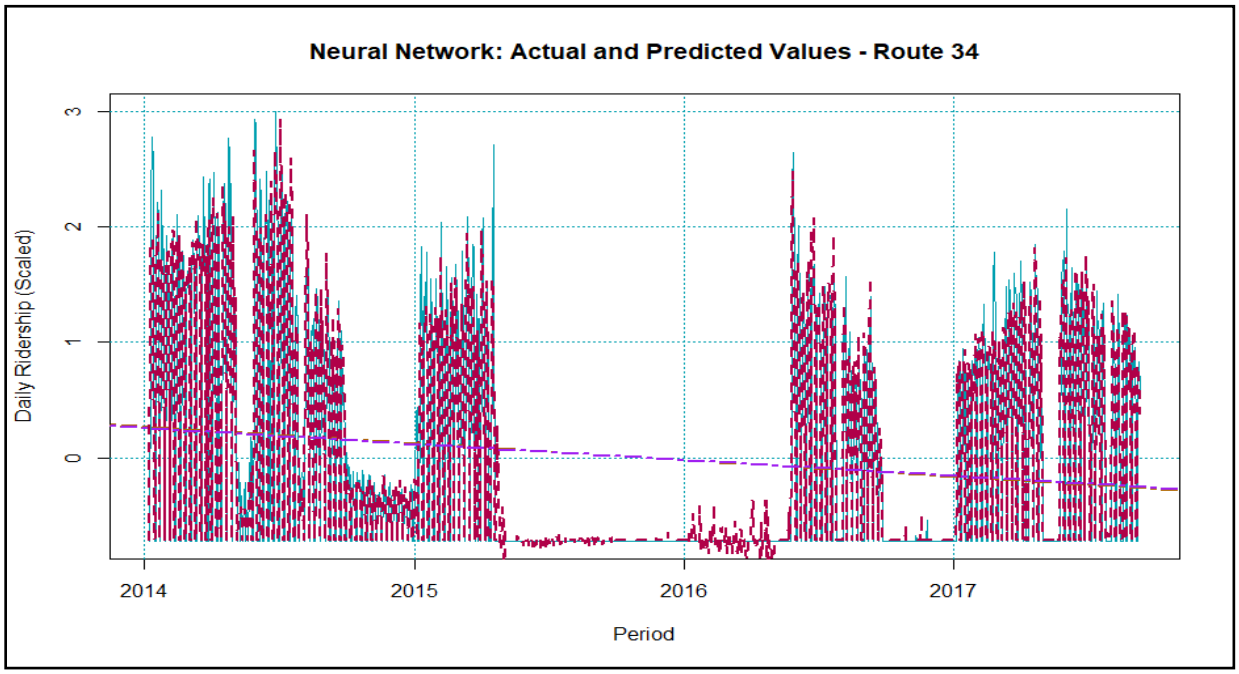


Figure A-25 Route 34 Prediction

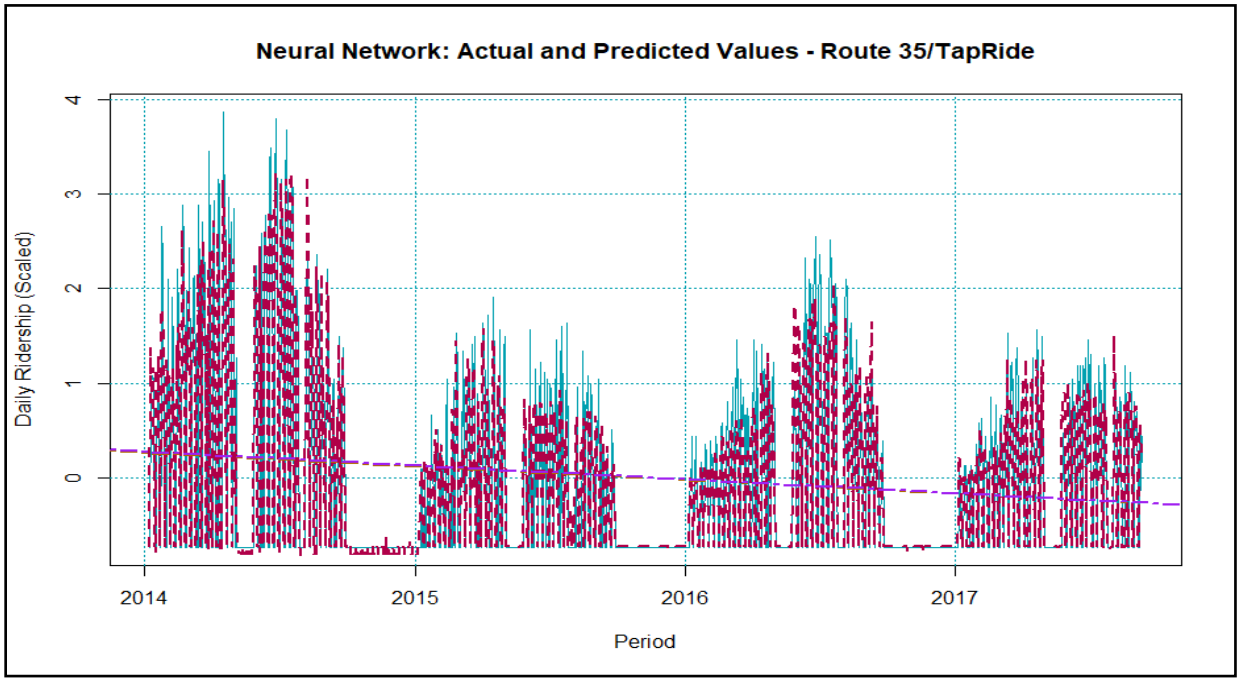


Figure A-26 Route 35 (TapRide) Prediction

APPENDIX – C: NEURAL NETWORK MODEL DETAILS

Table A-3 NN Model 01 – All Routes (Sum)

	1	2
error	39.18634819508	38.27279090719
reached.threshold	0.09993523378	0.09265399093
steps	5343.00000000000	4071.00000000000
Intercept.to.1layhid1	-1.56700899039	2.42931312862
Day_TypeW_End.to.1layhid1	-4.91593630633	1.42281597414
HolidayYes.to.1layhid1	-1.19913423944	1.28053214657
Residency.to.1layhid1	6.65215210760	-2.19103644482
SemesterSpring.to.1layhid1	-4.53247755355	-0.29758284243
SemesterSummer.to.1layhid1	-0.39116947849	1.10636282517
Enrollement.to.1layhid1	0.37754526499	0.18266690294
T_Max.to.1layhid1	-1.12323311749	0.22393476156
DP_Max.to.1layhid1	-0.19416113268	0.80569271580
WS_Max.to.1layhid1	0.07715903668	0.14812524694
APress_Max.to.1layhid1	0.15817270557	-0.19634815210
APress_Min.to.1layhid1	-0.26185512734	0.76384260934
Prec_Avg.to.1layhid1	-0.07519398335	-0.38586731128
Bis_Court_E.to.1layhid1	-1.18630550534	-1.04234500243
B_Court_W.to.1layhid1	-3.42770411567	2.09389454104
Burgum.to.1layhid1	0.56840358698	0.27341191515
Churchhill.to.1layhid1	-0.38206346888	1.63838926151
Dinan.to.1layhid1	0.27173958415	0.14801480377
UV_Apts.to.1layhid1	0.34547156278	0.69294970643
Intercept.to.1layhid2	0.36158780759	-2.56929945855
Day_TypeW_End.to.1layhid2	3.88737495541	-6.88332155767
HolidayYes.to.1layhid2	3.73027974607	-6.54703576581
Residency.to.1layhid2	0.16692997125	0.42073851456
SemesterSpring.to.1layhid2	-0.30824747741	3.17666136205
SemesterSummer.to.1layhid2	0.32050764976	-0.06395262572
Enrollement.to.1layhid2	-1.41819804023	1.36935950977
T_Max.to.1layhid2	-0.39663215050	5.30354363066
DP_Max.to.1layhid2	-0.76243444013	0.67657825139
WS_Max.to.1layhid2	-0.38975409238	1.44395874184
APress_Max.to.1layhid2	-0.15061338011	-0.19034575436
APress_Min.to.1layhid2	0.19569797991	2.03011112131
Prec_Avg.to.1layhid2	-0.21114826985	-0.97350553520
Bis_Court_E.to.1layhid2	0.07117632393	-6.44692691441
B_Court_W.to.1layhid2	-0.42854360362	4.85329870335
Burgum.to.1layhid2	-1.06309523569	2.51016072635
Churchhill.to.1layhid2	0.01217795026	3.93304903138
Dinan.to.1layhid2	0.34750116679	1.99139520193
UV_Apts.to.1layhid2	2.34080951822	-1.85291308762
Intercept.to.1layhid3	0.32879750797	-2.65825592625
Day_TypeW_End.to.1layhid3	-3.58417139200	-3.67782360155
HolidayYes.to.1layhid3	-3.28398725577	-2.53680519130
Residency.to.1layhid3	-0.83753475812	-1.14630430244
SemesterSpring.to.1layhid3	0.46135951473	-3.04813524300
SemesterSummer.to.1layhid3	1.50467259241	-0.56491734061
Enrollement.to.1layhid3	0.86871152341	-2.76193562924
T_Max.to.1layhid3	-1.92168489706	-1.52301540835
DP_Max.to.1layhid3	-2.25930557662	-0.51132755698
WS_Max.to.1layhid3	-3.96056641661	0.29504658819
APress_Max.to.1layhid3	-5.94274268856	0.04162397678
APress_Min.to.1layhid3	5.93386858434	1.01063664037
Prec_Avg.to.1layhid3	-0.24654815735	-0.04688598939
Bis_Court_E.to.1layhid3	5.50849205542	-0.98267529326
B_Court_W.to.1layhid3	3.88405382877	0.56525407357
Burgum.to.1layhid3	-2.08273650319	-0.28390785602
Churchhill.to.1layhid3	1.62295430228	0.80185931520
Dinan.to.1layhid3	-1.00012587150	-0.11572444846
UV_Apts.to.1layhid3	-9.32699885822	5.90215022101
Intercept.to.1layhid4	-0.75031482968	-0.27375534909
Day_TypeW_End.to.1layhid4	-1.40494336000	2.60570679396
HolidayYes.to.1layhid4	2.91820391525	1.16701334786
Residency.to.1layhid4	-0.64147273662	0.86941309031
SemesterSpring.to.1layhid4	-2.22958000160	0.73239246231
SemesterSummer.to.1layhid4	-0.11451440813	-0.99930372575
Enrollement.to.1layhid4	-0.09598444883	-1.35891051639
T_Max.to.1layhid4	0.20480014444	0.84818166876
DP_Max.to.1layhid4	0.73832578510	-0.27736494679
WS_Max.to.1layhid4	-0.17154235037	0.15448718780
APress_Max.to.1layhid4	-0.33657884617	0.83102130391

APress_Min.to.1layhid4	0.40135274504	0.39686559684
Prec_Avg.to.1layhid4	-0.12721480221	-0.11911617461
Bis_Court_E.to.1layhid4	1.28873801294	-3.10332462511
B_Court_W.to.1layhid4	2.13780169606	4.22247278567
Burgum.to.1layhid4	-0.90344538819	0.37102931951
Churchhill.to.1layhid4	-0.27677579375	2.24171335192
Dinan.to.1layhid4	-0.83379585990	-0.58464158081
UV_Apts.to.1layhid4	-1.55901831627	2.11913679459
Intercept.to.2layhid1	-2.37335180785	-0.08155106543
1layhid.1.to.2layhid1	-3.78307516203	17.86356160625
1layhid.2.to.2layhid1	52.65944448543	-4.53328034667
1layhid.3.to.2layhid1	-18.80609541400	-5.86898132332
1layhid.4.to.2layhid1	191.54501115198	8.16356310342
Intercept.to.2layhid2	0.25340825818	1.11410193179
1layhid.1.to.2layhid2	-3.26444628535	3.38116265387
1layhid.2.to.2layhid2	16.23061831019	-2.73608085236
1layhid.3.to.2layhid2	-1.04155754003	0.65017970138
1layhid.4.to.2layhid2	3.20645436363	2.00668867031
Intercept.to.2layhid3	-0.28962296389	1.13129040588
1layhid.1.to.2layhid3	1.79253243813	3.39996078830
1layhid.2.to.2layhid3	15.88318778848	-7.81034488450
1layhid.3.to.2layhid3	-1.37810708822	-4.01942498647
1layhid.4.to.2layhid3	20.02975325588	6.85344740691
Intercept.to.Ridership_Sum_D	0.59326150634	0.94741178646
2layhid.1.to.Ridership_Sum_D	-1.39000154285	-1.04044518790
2layhid.2.to.Ridership_Sum_D	-2.26938233632	1.46202851189
2layhid.3.to.Ridership_Sum_D	2.18728497451	-2.24984488522

Table A-4 NN Model 02 – Routes (31 – 35/TapRide)

	1	2
error	250.435275811697	240.303054849449
reached.threshold	0.089183042899	0.096717560389
steps	332792.000000000000	435675.000000000000
Intercept.to.1layhid1	-1.737854576068	-1.666667810566
Day_TypeW_End.to.1layhid1	5.089738951861	0.057005853886
HolidayYes.to.1layhid1	2.029575171014	0.259487520069
Residency.to.1layhid1	-14.111420140599	0.355139085653
SemesterSpring.to.1layhid1	0.027103641566	-1.930950566300
SemesterSummer.to.1layhid1	-0.534284254368	-0.733687209566
Enrollement.to.1layhid1	0.669550526355	0.254512209484
T_Max.to.1layhid1	-9.394261611046	-1.145641460626
DP_Max.to.1layhid1	4.787719060256	-0.637885653864
WS_Max.to.1layhid1	-4.209681711498	-0.953640421961
APress_Max.to.1layhid1	2.325293061989	0.315596617887
APress_Min.to.1layhid1	-5.025942021850	-1.415543142272
Prec_Avg.to.1layhid1	-7.509839232999	-0.449146605396
Bis_Court_E.to.1layhid1	2.689214802151	-0.828719049500
B_Court_W.to.1layhid1	-2.800852695200	2.064691741570
Burgum.to.1layhid1	-1.500825195703	1.095803702886
Churchhill.to.1layhid1	2.493834328556	-0.199645242806
Dinan.to.1layhid1	1.676400676031	0.670358822133
UV_Apts.to.1layhid1	4.435919454374	-1.735216075237
Intercept.to.1layhid2	-1.846252696012	3.036570846571
Day_TypeW_End.to.1layhid2	-4.261296756297	-3.108257965328
HolidayYes.to.1layhid2	-0.287444017717	-12.986854458832
Residency.to.1layhid2	0.239687878281	0.045287480595
SemesterSpring.to.1layhid2	-0.863536176979	8.026381535511
SemesterSummer.to.1layhid2	1.166014509937	-5.623704800683
Enrollement.to.1layhid2	2.430786596459	3.005100499335
T_Max.to.1layhid2	-1.847962280254	-7.656171048340
DP_Max.to.1layhid2	1.157344774100	2.414001642016
WS_Max.to.1layhid2	0.439240711033	-15.764583789068
APress_Max.to.1layhid2	1.243548168317	-4.713259862992
APress_Min.to.1layhid2	-1.393809763503	2.185233975770
Prec_Avg.to.1layhid2	0.007577179355	-0.235007356577
Bis_Court_E.to.1layhid2	1.146027157902	23.454061113746
B_Court_W.to.1layhid2	3.940129993951	-20.660072193097
Burgum.to.1layhid2	0.149800121235	-1.005226944535
Churchhill.to.1layhid2	1.066335946584	5.478037615049
Dinan.to.1layhid2	-0.445973060643	0.044844856100
UV_Apts.to.1layhid2	1.943993484831	-17.255702012615
Intercept.to.1layhid3	2.112588283023	-1.856377967982
Day_TypeW_End.to.1layhid3	3.549950165328	-0.950240792796
HolidayYes.to.1layhid3	3.608060044489	0.889060111623
Residency.to.1layhid3	-3.170252356962	0.784209760268

SemesterSpring.to.1layhid3	0.943144268030	-1.664187346319
SemesterSummer.to.1layhid3	0.057140860026	0.753035356864
Enrollement.to.1layhid3	1.903833032946	-1.228031831109
T_Max.to.1layhid3	-0.183759180049	-0.220329137366
DP_Max.to.1layhid3	-0.236411038074	0.433334317025
WS_Max.to.1layhid3	-0.053599164003	-0.019696520664
APress_Max.to.1layhid3	-0.032710738702	0.222045164731
APress_Min.to.1layhid3	-0.083290855169	0.117625712974
Prec_Avg.to.1layhid3	0.013698177967	-0.160737193627
Bis_Court_E.to.1layhid3	-1.732035092640	-0.686772328731
B_Court_W.to.1layhid3	3.269377546054	2.678241479801
Burgum.to.1layhid3	-0.387099440655	-0.566866923334
Churchhill.to.1layhid3	3.510863894057	-0.713586530806
Dinan.to.1layhid3	-1.977734405304	-0.369843397110
UV_Apts.to.1layhid3	0.268819951153	-0.563283659909
Intercept.to.1layhid4	-1.590636584765	0.323387083769
Day_TypeW_End.to.1layhid4	-6.692801705792	2.802430639273
HolidayYes.to.1layhid4	-3.931768144152	2.805989304090
Residency.to.1layhid4	0.139350712218	0.532932987025
SemesterSpring.to.1layhid4	-2.102209842827	-3.262772051852
SemesterSummer.to.1layhid4	1.584175376123	1.998698767145
Enrollement.to.1layhid4	-1.716822199780	6.801761258680
T_Max.to.1layhid4	0.333875870545	-2.956659915861
DP_Max.to.1layhid4	-1.540984003897	0.305439571565
WS_Max.to.1layhid4	-1.078027859097	-0.233966006044
APress_Max.to.1layhid4	0.344804054368	0.067589812594
APress_Min.to.1layhid4	-1.187551416492	2.755837712858
Prec_Avg.to.1layhid4	0.501096815358	0.087081150036
Bis_Court_E.to.1layhid4	-4.874021564948	1.004961976923
B_Court_W.to.1layhid4	5.114384867529	0.722044832997
Burgum.to.1layhid4	-0.233497988192	-0.056530554368
Churchhill.to.1layhid4	6.930324782858	-1.352819641479
Dinan.to.1layhid4	-5.471155219033	0.285698651925
UV_Apts.to.1layhid4	0.693412695826	-3.549164097119
Intercept.to.1layhid5	-1.161093376809	5.368990283031
Day_TypeW_End.to.1layhid5	1.814031391663	-5.265169659845
HolidayYes.to.1layhid5	-0.994985878733	-7.290887798676
Residency.to.1layhid5	-0.477243917528	-1.403773766438
SemesterSpring.to.1layhid5	1.809068732292	-5.809246939918
SemesterSummer.to.1layhid5	1.619312986426	-0.196841177068
Enrollement.to.1layhid5	-0.850313479348	-2.494610191079
T_Max.to.1layhid5	0.951896128686	5.515914016025
DP_Max.to.1layhid5	0.145935465503	-3.604445015929
WS_Max.to.1layhid5	-0.147551322967	-2.152981004132
APress_Max.to.1layhid5	-0.181472451748	-0.003533341305
APress_Min.to.1layhid5	0.350830219984	2.729387396236
Prec_Avg.to.1layhid5	-0.057617001362	2.882780964708
Bis_Court_E.to.1layhid5	0.941563651727	-4.703064243684
B_Court_W.to.1layhid5	-1.568314050151	-13.323712468147
Burgum.to.1layhid5	-0.716937552452	-1.403738251409
Churchhill.to.1layhid5	0.601182170761	-9.207372914593
Dinan.to.1layhid5	0.426754532506	2.225500035755
UV_Apts.to.1layhid5	2.577801826292	-2.635661431575
Intercept.to.1layhid6	-0.607630185465	0.356736851298
Day_TypeW_End.to.1layhid6	0.895036409840	0.697335434164
HolidayYes.to.1layhid6	-0.771042727573	-1.958585982293
Residency.to.1layhid6	-1.446725695934	0.549548926542
SemesterSpring.to.1layhid6	2.692111301619	3.196658337860
SemesterSummer.to.1layhid6	2.420255479618	0.568075991704
Enrollement.to.1layhid6	-1.270019349406	5.090795830988
T_Max.to.1layhid6	3.824649411026	2.124022661879
DP_Max.to.1layhid6	-2.692036947692	2.411631181022
WS_Max.to.1layhid6	0.986674748894	0.106057205158
APress_Max.to.1layhid6	-1.504698760522	-0.833103805231
APress_Min.to.1layhid6	2.730008093065	1.801348824224
Prec_Avg.to.1layhid6	0.620112364183	0.337038587676
Bis_Court_E.to.1layhid6	-0.240306058173	-2.360326914231
B_Court_W.to.1layhid6	12.636981961498	1.564607865054
Burgum.to.1layhid6	-3.248706090681	-1.409109094996
Churchhill.to.1layhid6	1.235431625283	0.593787229837
Dinan.to.1layhid6	0.348912469567	-0.868680263295
UV_Apts.to.1layhid6	3.144866089382	-3.857605101831
Intercept.to.1layhid7	-0.187602058918	-0.955686007039
Day_TypeW_End.to.1layhid7	-4.368529271686	-1.704130379193
HolidayYes.to.1layhid7	2.456821652438	-0.556511027153
Residency.to.1layhid7	-0.193967257792	1.905502078512
SemesterSpring.to.1layhid7	-0.488042291907	-6.966724437283
SemesterSummer.to.1layhid7	1.779163925027	-0.335692599994

Enrollement.to.1layhid7	1.085049010486	-0.768687221794
T_Max.to.1layhid7	-0.319102773593	-3.248038266087
DP_Max.to.1layhid7	0.534591417747	0.149273197428
WS_Max.to.1layhid7	-0.333431780317	-1.116886115718
APress_Max.to.1layhid7	-0.378575977451	0.810121719741
APress_Min.to.1layhid7	0.470481459495	-0.141646052312
Prec_Avg.to.1layhid7	-0.164963794319	0.427593569605
Bis_Court_E.to.1layhid7	-0.590623612424	0.251395434083
B_Court_W.to.1layhid7	3.979077982735	-2.666295095212
Burgum.to.1layhid7	-2.320033102512	-2.140307421153
Churchhill.to.1layhid7	3.427123039146	-1.601905297886
Dinan.to.1layhid7	-0.505457002174	0.068017843136
UV_Apts.to.1layhid7	-1.581557681319	2.009069281302
Intercept.to.1layhid8	-25.458225442476	1.106333690564
Day_TypeW_End.to.1layhid8	-26.664631156672	4.760724788935
HolidayYes.to.1layhid8	-11.715086326466	3.920780163692
Residency.to.1layhid8	-2.821365947279	1.254958396543
SemesterSpring.to.1layhid8	25.847832633180	-1.685361997740
SemesterSummer.to.1layhid8	5.141871890425	2.350162726321
Enrollement.to.1layhid8	74.919201809482	-0.017353579593
T_Max.to.1layhid8	21.418242679690	-2.520256735872
DP_Max.to.1layhid8	-9.134583887549	0.121236789380
WS_Max.to.1layhid8	9.031700714668	-1.038101671085
APress_Max.to.1layhid8	6.762992495392	0.856575248908
APress_Min.to.1layhid8	4.650571293801	-0.216328765057
Prec_Avg.to.1layhid8	5.233829520691	0.124565374142
Bis_Court_E.to.1layhid8	14.174805772804	0.849856888949
B_Court_W.to.1layhid8	-25.920713611863	-0.680445167835
Burgum.to.1layhid8	-0.674508182170	-2.190805127668
Churchhill.to.1layhid8	10.471808474213	-1.744072124343
Dinan.to.1layhid8	-2.897504841670	0.492451400843
UV_Apts.to.1layhid8	3.816986513488	0.559308803977
Intercept.to.1layhid9	17.322311242643	-2.021317447730
Day_TypeW_End.to.1layhid9	-9.588820601721	3.299777738786
HolidayYes.to.1layhid9	-68.323777988433	2.346941340998
Residency.to.1layhid9	3.770699676354	-1.303189656607
SemesterSpring.to.1layhid9	-78.296850881303	45.829104262221
SemesterSummer.to.1layhid9	9.751932412788	-1.128391038210
Enrollement.to.1layhid9	-182.003381289653	-1.391176128015
T_Max.to.1layhid9	8.725796396925	20.075332435898
DP_Max.to.1layhid9	-48.369492101907	15.170397655975
WS_Max.to.1layhid9	-12.481674303862	39.936836116387
APress_Max.to.1layhid9	11.611758892490	-4.009700850888
APress_Min.to.1layhid9	-92.309463482252	10.607914597099
Prec_Avg.to.1layhid9	-12.289279368440	35.608344236775
Bis_Court_E.to.1layhid9	157.851435380536	113.396216555159
B_Court_W.to.1layhid9	29.658149958574	56.001690669752
Burgum.to.1layhid9	0.331382376013	0.662703064872
Churchhill.to.1layhid9	106.575438930223	-2.221125125620
Dinan.to.1layhid9	-0.109496789053	0.693565560309
UV_Apts.to.1layhid9	6.119601407850	-4.849381420982
Intercept.to.1layhid10	-2.706799882687	-1.168663211380
Day_TypeW_End.to.1layhid10	-2.588795966082	-0.788341484638
HolidayYes.to.1layhid10	-1.867059937680	-0.514345682513
Residency.to.1layhid10	0.979312883622	0.268967830142
SemesterSpring.to.1layhid10	1.907281830216	-1.940028164641
SemesterSummer.to.1layhid10	0.875047207343	-1.248764925584
Enrollement.to.1layhid10	7.026965797193	-0.693083730502
T_Max.to.1layhid10	1.724606566778	-1.672861748484
DP_Max.to.1layhid10	-1.863373887295	0.662058442531
WS_Max.to.1layhid10	-0.462359228202	-0.376163736624
APress_Max.to.1layhid10	-2.202336218901	0.548486477590
APress_Min.to.1layhid10	2.414453671517	0.042466556605
Prec_Avg.to.1layhid10	0.014658200638	0.183002130919
Bis_Court_E.to.1layhid10	-6.223051741200	0.877269855839
B_Court_W.to.1layhid10	-6.293176031222	0.765208626958
Burgum.to.1layhid10	5.409610184742	-1.768948385942
Churchhill.to.1layhid10	1.563744816622	-3.267045076577
Dinan.to.1layhid10	-0.514793878123	-1.310904337864
UV_Apts.to.1layhid10	-2.478489848529	0.574926593130
Intercept.to.1layhid11	0.210098989568	0.038719393430
Day_TypeW_End.to.1layhid11	1.415523821208	2.104156032803
HolidayYes.to.1layhid11	1.903829133100	-27.298543860523
Residency.to.1layhid11	0.446246688548	2.211823321205
SemesterSpring.to.1layhid11	-0.600124228368	-3.055931860720
SemesterSummer.to.1layhid11	1.447748839721	0.100936661478
Enrollement.to.1layhid11	0.133785614428	1.816226497413
T_Max.to.1layhid11	-0.336268191636	-0.400571091622

DP_Max.to.1layhid11	-0.495961361940	6.163525212410
WS_Max.to.1layhid11	-0.009334105466	1.785396642534
APress_Max.to.1layhid11	-0.433301432868	0.868569227297
APress_Min.to.1layhid11	0.213065024711	2.138224855261
Prec_Avg.to.1layhid11	-0.004830425634	-0.917512589303
Bis_Court_E.to.1layhid11	-1.880808502447	-1.840829402870
B_Court_W.to.1layhid11	1.173573982705	-54.518429936688
Burgum.to.1layhid11	0.445928670323	1.271169910008
Churchhill.to.1layhid11	0.851319202534	-7.311660796776
Dinan.to.1layhid11	0.163108988133	0.016702865751
UV_Apts.to.1layhid11	0.135650360626	3.888800934989
Intercept.to.2layhid1	-5.293695275524	1.390601051144
1layhid.1.to.2layhid1	2.641061836996	-1.464650360578
1layhid.2.to.2layhid1	-8.076517613101	11.954106733537
1layhid.3.to.2layhid1	5.482705949468	13.212228858496
1layhid.4.to.2layhid1	-1.587657398640	-27.413885884051
1layhid.5.to.2layhid1	41.157714894471	10.094338169907
1layhid.6.to.2layhid1	1.352126317007	2.248912024240
1layhid.7.to.2layhid1	-7.402854907924	11.411660747223
1layhid.8.to.2layhid1	-12.857891255757	2.979151917792
1layhid.9.to.2layhid1	13.319184519765	2.974591973804
1layhid.10.to.2layhid1	-13.034552713543	0.401708441996
1layhid.11.to.2layhid1	51.824388953153	-11.271647730210
Intercept.to.2layhid2	-0.429653689118	-4.814990886435
1layhid.1.to.2layhid2	-9.234310705097	2.547304038924
1layhid.2.to.2layhid2	2.794448956360	0.068736058622
1layhid.3.to.2layhid2	-28.458415205787	26.377563456683
1layhid.4.to.2layhid2	6.238904157518	-3.242526871173
1layhid.5.to.2layhid2	8.756508741287	-1.054547086653
1layhid.6.to.2layhid2	-2.100019440964	-1.186571746913
1layhid.7.to.2layhid2	7.296746563493	0.750817239433
1layhid.8.to.2layhid2	4.912202218103	-14.442478447317
1layhid.9.to.2layhid2	-11.689730211305	1.238526816017
1layhid.10.to.2layhid2	1.719365340660	3.716964978198
1layhid.11.to.2layhid2	-9.884642834598	-2.700235241744
Intercept.to.2layhid3	3.281134190680	-1.815531102742
1layhid.1.to.2layhid3	2.694237701119	-1.156470812621
1layhid.2.to.2layhid3	2.982724873795	-0.320582335056
1layhid.3.to.2layhid3	-21.256103984839	-3.004591313555
1layhid.4.to.2layhid3	6.127772356302	-3.656813668353
1layhid.5.to.2layhid3	-2.346474740028	-0.342615856483
1layhid.6.to.2layhid3	-6.981973780919	0.464942200617
1layhid.7.to.2layhid3	-20.960135870102	-22.767062388685
1layhid.8.to.2layhid3	0.498584910440	34.856452264036
1layhid.9.to.2layhid3	4.299755949873	-0.387888747144
1layhid.10.to.2layhid3	4.166050477273	-0.742610958180
1layhid.11.to.2layhid3	-4.060824043437	-0.366364606558
Intercept.to.2layhid4	1.674808587094	4.820757454817
1layhid.1.to.2layhid4	6.832755144821	198.214493633998
1layhid.2.to.2layhid4	-11.502572073265	38.307028870899
1layhid.3.to.2layhid4	104.193285150962	-1058.751572627362
1layhid.4.to.2layhid4	22.346660881587	-114.832001442901
1layhid.5.to.2layhid4	18.327097575663	3.057044492021
1layhid.6.to.2layhid4	3.429146555770	84.010932944598
1layhid.7.to.2layhid4	-65.986478235561	119.030576654924
1layhid.8.to.2layhid4	-0.192667654161	-153.076520857060
1layhid.9.to.2layhid4	10.310751417999	-77.269693938395
1layhid.10.to.2layhid4	-12.104204276215	-69.611568087637
1layhid.11.to.2layhid4	3.769996052285	61.253531141892
Intercept.to.2layhid5	1.017071863792	-0.859838085518
1layhid.1.to.2layhid5	2.431648695859	-1.349782798654
1layhid.2.to.2layhid5	-2.931454400436	-0.334916763644
1layhid.3.to.2layhid5	-48.222351370831	6.305602240363
1layhid.4.to.2layhid5	1.885866752943	-0.189461700562
1layhid.5.to.2layhid5	2.543265514463	0.903222349661
1layhid.6.to.2layhid5	0.509902635569	1.503732605335
1layhid.7.to.2layhid5	4.050375629240	1.153814960638
1layhid.8.to.2layhid5	0.374596845120	-16.299204283175
1layhid.9.to.2layhid5	1.254915328958	-0.699922657773
1layhid.10.to.2layhid5	-1.611499353017	-2.716284840913
1layhid.11.to.2layhid5	8.719173102237	0.731080067743
Intercept.to.2layhid6	5.896570531731	4.920958457893
1layhid.1.to.2layhid6	2.661296728709	-3.560195224341
1layhid.2.to.2layhid6	-7.429629547693	0.053386633331
1layhid.3.to.2layhid6	-2.404056797186	-25.108150883376
1layhid.4.to.2layhid6	-4.021766253326	-0.064927556235
1layhid.5.to.2layhid6	22.105089912261	-2.033082843444
1layhid.6.to.2layhid6	-6.167104172101	1.756470821195

1layhid.7.to.2layhid6	-4.400507835012	0.357190461562
1layhid.8.to.2layhid6	2.271024048707	-2.616330025275
1layhid.9.to.2layhid6	-1.748217103590	-1.733243204007
1layhid.10.to.2layhid6	-7.533707303748	-1.655284589918
1layhid.11.to.2layhid6	24.926218556435	-0.668967161949
Intercept.to.2layhid7	-3.060332890736	16.839717650907
1layhid.1.to.2layhid7	-0.225399103625	-15.900962996066
1layhid.2.to.2layhid7	-2.513834135729	0.057782908869
1layhid.3.to.2layhid7	30.505973588351	116.850925550903
1layhid.4.to.2layhid7	-0.215131543629	-2.948304271546
1layhid.5.to.2layhid7	-3.693528214550	-18.330359419316
1layhid.6.to.2layhid7	4.330409781041	2.448287641928
1layhid.7.to.2layhid7	4.205611946506	6.495690151951
1layhid.8.to.2layhid7	4.807542036574	74.972252683442
1layhid.9.to.2layhid7	0.617961789393	-9.423841032329
1layhid.10.to.2layhid7	0.183743908874	-98.363483011338
1layhid.11.to.2layhid7	-15.270988325926	-25.434405069183
Intercept.to.2layhid8	-0.762563956628	10.225996732939
1layhid.1.to.2layhid8	0.678443066779	12.966836047700
1layhid.2.to.2layhid8	-1.472218241716	-9.007468757909
1layhid.3.to.2layhid8	-8.368732667965	136.752247799472
1layhid.4.to.2layhid8	-4.044889939336	9.372544715358
1layhid.5.to.2layhid8	-5.360966211004	3.730628674881
1layhid.6.to.2layhid8	2.029295698267	1.502626700978
1layhid.7.to.2layhid8	6.402025613146	-18.595707352160
1layhid.8.to.2layhid8	5.199130493198	3.672192679748
1layhid.9.to.2layhid8	-0.386014215567	-5.862054202758
1layhid.10.to.2layhid8	-0.320441142551	-9.620491013125
1layhid.11.to.2layhid8	-3.906700597163	5.899161894361
Intercept.to.3layhid1	0.114157902758	-0.197632755702
2layhid.1.to.3layhid1	-4.629735751151	4.737615245807
2layhid.2.to.3layhid1	-5.786110895530	19.141324819746
2layhid.3.to.3layhid1	-9.563229628044	-65.982440451661
2layhid.4.to.3layhid1	3.790594526739	-6.903322096933
2layhid.5.to.3layhid1	5.030120888023	2.178701401734
2layhid.6.to.3layhid1	5.994250619479	27.768462134465
2layhid.7.to.3layhid1	2.882562102055	-4.107907317794
2layhid.8.to.3layhid1	-1.964856291266	-22.919200936859
Intercept.to.3layhid2	-0.480605173889	0.556675779280
2layhid.1.to.3layhid2	0.677691972204	2.033773380206
2layhid.2.to.3layhid2	0.476256266327	0.019391635348
2layhid.3.to.3layhid2	2.096001736087	-41.600221838909
2layhid.4.to.3layhid2	-1.077615516768	-0.573836642046
2layhid.5.to.3layhid2	-2.946478173704	-1.900968197161
2layhid.6.to.3layhid2	-0.104825469336	2.584408593595
2layhid.7.to.3layhid2	-0.405011991193	-23830.221298768371
2layhid.8.to.3layhid2	1.308201908804	-0.295166361474
Intercept.to.3layhid3	0.906797267983	-0.928976020174
2layhid.1.to.3layhid3	-2.069772180813	-1.209315371999
2layhid.2.to.3layhid3	-5.196764149211	0.034904474644
2layhid.3.to.3layhid3	-9.214592561679	-2.926317215446
2layhid.4.to.3layhid3	4.317359678419	0.015581876364
2layhid.5.to.3layhid3	7.347357089400	6.755708209289
2layhid.6.to.3layhid3	2.470408975557	0.839551254877
2layhid.7.to.3layhid3	1.080637156185	0.577116950917
2layhid.8.to.3layhid3	-1.379580084987	-4.605048717940
Intercept.to.3layhid4	-3.047898541520	0.530029359596
2layhid.1.to.3layhid4	-6.884981941271	-1.914803253791
2layhid.2.to.3layhid4	-5.815239445382	13.130695913190
2layhid.3.to.3layhid4	-9.974700987336	25.129249506179
2layhid.4.to.3layhid4	5.376283589562	0.950338779357
2layhid.5.to.3layhid4	4.957123697721	2.921991645060
2layhid.6.to.3layhid4	9.490898669437	-2.898962918222
2layhid.7.to.3layhid4	-3.071310882822	0.127952350863
2layhid.8.to.3layhid4	6.814108501513	0.487902045911
Intercept.to.3layhid5	-3.555697233595	-1.723928841254
2layhid.1.to.3layhid5	-1.193993142531	1.351925330212
2layhid.2.to.3layhid5	-2.530681237673	-0.195415176560
2layhid.3.to.3layhid5	-4.667654331308	-18.099361093248
2layhid.4.to.3layhid5	3.677860554044	-0.643040058987
2layhid.5.to.3layhid5	4.335810162117	-0.539870879208
2layhid.6.to.3layhid5	1.581116741662	1.428702306784
2layhid.7.to.3layhid5	0.320293228062	1.087037679691
2layhid.8.to.3layhid5	4.168888572336	-0.138429555684
Intercept.to.Ridership_31_D	-2.623194703588	0.055518261756
3layhid.1.to.Ridership_31_D	-0.635156115111	1.232396266475
3layhid.2.to.Ridership_31_D	7.671448039593	1.175012371521
3layhid.3.to.Ridership_31_D	3.111619625228	-1.522442391897

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3layhid.4.to.Ridership_31_D         -2.518383955768     -0.862736860649
3layhid.5.to.Ridership_31_D         -0.025699795942      3.642240124062
Intercept.to.Ridership_32_D         -2.570569322427     -3.048693030126
3layhid.1.to.Ridership_32_D         -2.755232869809      1.342686861302
3layhid.2.to.Ridership_32_D          6.489504964642      2.291869269393
3layhid.3.to.Ridership_32_D          5.134787276138     -2.402876796456
3layhid.4.to.Ridership_32_D         -1.449238439726      2.239794561746
3layhid.5.to.Ridership_32_D         -0.935802981674      4.207570151272
Intercept.to.Ridership_33_D         -0.055191416219     -0.998613936522
3layhid.1.to.Ridership_33_D         -0.719818613113     -0.044548600594
3layhid.2.to.Ridership_33_D          1.706577246877      1.569488314106
3layhid.3.to.Ridership_33_D          0.977087447870      0.882036715129
3layhid.4.to.Ridership_33_D         -2.652936790165      0.114548481224
3layhid.5.to.Ridership_33_D          1.248340645246      3.525602745167
Intercept.to.Ridership_34_D         -2.074232130674     -0.576985943875
3layhid.1.to.Ridership_34_D         -4.500452434975      0.449555003197
3layhid.2.to.Ridership_34_D          5.714545164836      2.901651454001
3layhid.3.to.Ridership_34_D          3.823800816042     -0.084940664173
3layhid.4.to.Ridership_34_D         -0.277263266394     -0.089782166273
3layhid.5.to.Ridership_34_D          1.631739962194     -0.250806580546
Intercept.to.Ridership_35_Tap_D      0.278970414479     -2.476725290914
3layhid.1.to.Ridership_35_Tap_D     -0.996357313034      3.202480331666
3layhid.2.to.Ridership_35_Tap_D      4.297230232433      1.501149149163
3layhid.3.to.Ridership_35_Tap_D      1.021072388731     -2.224745359462
3layhid.4.to.Ridership_35_Tap_D     -1.290217957897      1.740495393632
3layhid.5.to.Ridership_35_Tap_D     -1.098520004058      3.183335548283
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