

1  
2 **MODELING BIKE SHARE STATION ACTIVITY: THE EFFECTS OF**  
3 **NEARBY BUSINESSES AND JOBS ON TRIPS TO AND FROM STATIONS**  
4

5 **Xize Wang**

6 PhD in Urban Planning and Development Program<sup>+</sup>

7 [xizewang@usc.edu](mailto:xizewang@usc.edu)

8 Phone: +1-612-805-6403

9 (Corresponding Author)

10  
11 **Greg Lindsey**

12 Professor and Associate Dean\*

13 [linds301@umn.edu](mailto:linds301@umn.edu)

14 Phone: +1-612-625-3375

15  
16 **Jessica E. Schoner**

17 Master of Urban and Regional Planning Program\*

18 Master of Science in Civil Engineering Program<sup>^</sup>

19 [schoner082@umn.edu](mailto:schoner082@umn.edu)

20 Phone: +1-612-412-4273

21  
22 **Andrew Harrison**

23 Master of Urban and Regional Planning Program\*

24 [harr1436@umn.edu](mailto:harr1436@umn.edu)

25 Phone: +1-252-294-8527

26  
27 <sup>+</sup> Sol Price School of Public Policy

28 University of Southern California

29 650 Childs Way

30 Los Angeles, CA 90089

31  
32 \*Humphrey School of Public Affairs

33 University of Minnesota – Twin Cities

34 301 19<sup>th</sup> Avenue South

35 Minneapolis, MN 55455

36  
37 <sup>^</sup>Department of Civil Engineering

38 University of Minnesota – Twin Cities

39 500 Pillsbury Drive SE

40 Minneapolis, MN 55455

41  
42 **Submitted at Aug 1<sup>st</sup>, 2012 to TRB's 92<sup>nd</sup> Annual Meeting and Publication in the**  
43 ***Transportation Research Record***  
44

45  
46 Total words: 5,031 + 250\* (3 Figures + 3 Tables) = 6,531

**1 ABSTRACT**

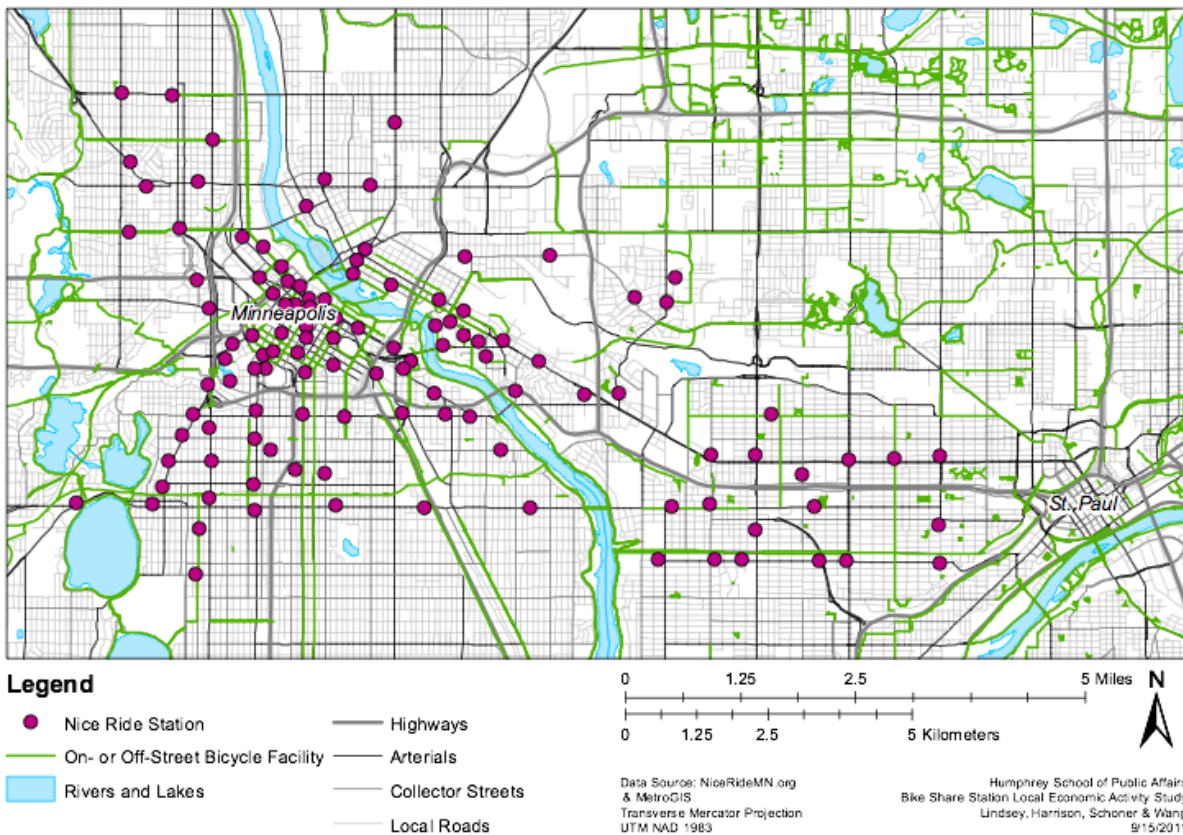
2 Bike sharing systems have been established in several cities across North America. An objective  
3 of all bike sharing programs is to maximize the number of trips to and from bike share stations.  
4 The purpose of this research is to identify correlates of bike station activity, with special  
5 emphases on the association of trips to and from bike stations with the number of nearby  
6 businesses and jobs. Using data on 2011 trips from Nice Ride stations in Minneapolis-St. Paul,  
7 we introduce three ordinary least square regression models to evaluate the marginal effects of the  
8 presence of businesses on annual total station trips, trip origins and trip destinations. Our models  
9 include 19 variables in four general categories, including, in addition to the presence of different  
10 types of businesses and jobs, sociodemographic, built environment, and transportation  
11 infrastructure variables that are used as controls. Our result shows the number of trips at Nice  
12 Ride stations is positively and significantly associated with food-related destinations near the  
13 station and job accessibility but not with general retail establishments. Use of bike share stations  
14 also is correlated with race, age, proximity to the central business district, proximity to water,  
15 accessibility to trails, and distance to other bike share stations. This research is important for  
16 planners, academics, and policymakers because the findings will facilitate the understanding of  
17 bike share operations, help planners locate new stations, evaluate the potential of implementing  
18 new bike share programs, assess economic activity associated with bike share trips, and  
19 minimize costs of operations.  
20

1 **INTRODUCTION**

2 Bike share systems are being established in major cities across North America and throughout  
3 the world. These systems are designed to provide inexpensive bicycle rental at strategic  
4 locations throughout a city for quick, one-way trips from station to station. Planners,  
5 policymakers, and bicycling advocates believe these systems will induce mode shifts away from  
6 driving, increase physical activity levels, and complement existing transit networks. To achieve  
7 these benefits, government agencies must invest considerable sums in start-up capital for bike  
8 share systems and manage operations to maximize ridership. Research on bike share systems is  
9 burgeoning, but few studies have identified factors that influence ridership at stations, and none  
10 has focused on the relationships between station activity and the presence of specific types of  
11 businesses near bike share stations.

12 In this paper, which is part of a larger study to identify economic activity associated with  
13 the Nice Ride Minnesota bike share system in Minneapolis and St. Paul, Minnesota, we assess  
14 whether bike share station activity is associated with the presence of retail businesses and job  
15 accessibility, in addition to other sociodemographic, built environment, and infrastructure  
16 variables. We test these relationships with three different regression models.

17 The Nice Ride Minnesota bike share system has attracted large numbers of bike  
18 commuters, leisure cyclists, and new cyclists in its first two years since it began in spring 2010.  
19 The Nice Ride system initially had 65 stations in the Central Business District (CBD), other  
20 commercial areas, and on or near the University of Minnesota in the city of Minneapolis. By the  
21 end of the 2011 season, Nice Ride had expanded to include 116 stations throughout Minneapolis  
22 and St. Paul (Figure 1), had enrolled 3,693 subscribers and provided bicycles for thousands of  
23 daily users. The total number of Nice Ride bike trips for 2011 surpassed 217,000.

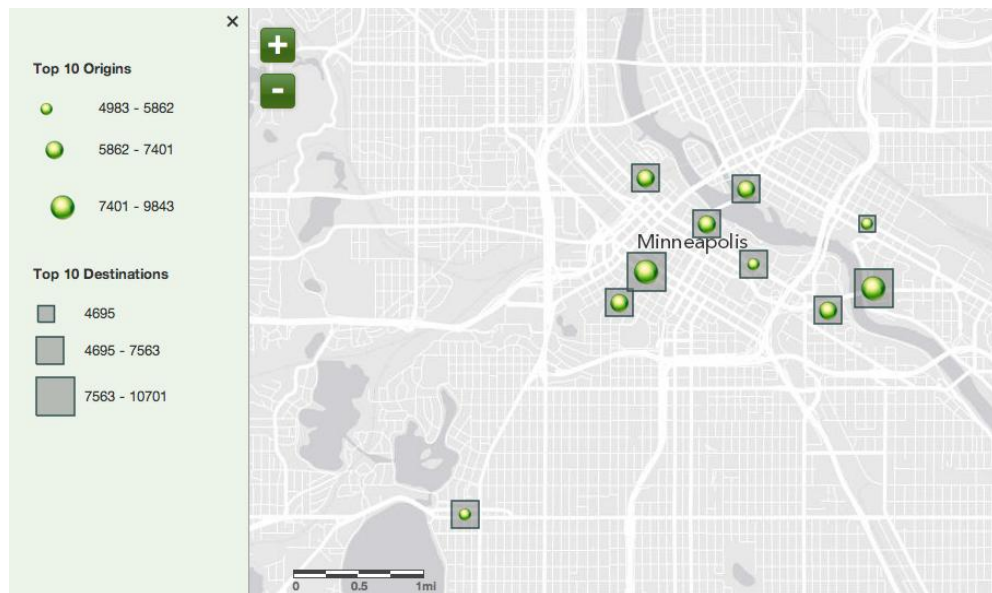


**FIGURE 1 Nice Ride Stations by the End of the 2011 Season**

1 Nice Ride Minnesota initially located bike share stations to maximize ridership through  
2 practical and intuitive understanding of factors believed to be associated with ridership. These  
3 factors included presence in the CBD, proximity to retail and commercial businesses, proximity  
4 to other destinations or features (university campus, libraries, lakes, parks, etc.), higher density  
5 residential, nearby bike infrastructure, and other factors that have been shown to be associated  
6 with bicycling. These decisions generally were made with a understanding of neighborhoods  
7 characteristics but not detailed research on the presence of specific types of businesses. A  
8 community outreach program helped inform expansions in to North Minneapolis and St. Paul.

9 Nice Ride Minnesota has tracked use of stations, shared station trip records with a  
10 number of research organizations, and adjusted operations based on its records of station usage.  
11 As shown in Figure 2, eight of the top 10 most used stations are located among high  
12 concentrations of retail destinations: six are near the Minneapolis CBD, one is near a major retail  
13 hub in Calhoun Square in the trendy Uptown neighborhood south of the CBD, and one is at the  
14 periphery of the University of Minnesota campus where many restaurants and shops are located  
15 nearby. The remaining two are on the University of Minnesota campus. Conversely, the 10 least  
16 used stations - measured in average trips per day - are in areas with lower concentrations of retail  
17 and consumer-oriented businesses.

18 Economic theories of transportation demand suggest that the availability of bicycle  
19 stations for inexpensive public use throughout a city should affect travel and consumption  
20 patterns, though the extent of these effects is not known. Bicycle share stations selectively  
21 increase accessibility to areas around each station by increasing the number of people who can  
22 reach particular places within a reasonable travel time. Increases in accessibility also increase  
23 the potential for changes in local economic activity (i.e., consumption and spending). If bike  
24 share stations are associated with local economic activity, we hypothesize that the number of  
25 trips to and from stations should be positively associated with higher concentrations of nearby  
26 retail and food-related destinations and accessibility to jobs.



28  
29 **FIGURE 2 Top 10 Origin and Destination Stations in 2011**

30  
31 To test our hypotheses quantitatively, we estimate three regression models that use,  
32 respectively, the total number of trips, trip origins, and trip arrivals or destinations as dependent

1 variables. Independent variables related to economic activity include number of retail  
2 establishments, number of food-related retail establishments, and job accessibility. Control  
3 variables in the model include socio-demographic, built environment and transportation  
4 infrastructure variables.

5 Part 2 of this paper is a brief review of recent studies of bike sharing and non-motorized  
6 transport modeling. Part 3 summarizes our data and the methods we used to estimate our models.  
7 Part 4 presents results, including the three models: a model for total station activity, a model for  
8 trip origins, and a model for trip destination for the 116 Nice Ride stations that were in operation  
9 in 2011. Part 5 discusses potential applications for our models in transportation planning and  
10 management. Part 6 summarizes our main findings, notes the limitations of our study, and  
11 suggests areas for future research.

## 12 **LITERATURE REVIEW**

### 13 **Bike Sharing**

14 DeMaio's review (1) of bike sharing history serves as the baseline for this study. DeMaio found  
15 that, globally, there are over 120 bike share programs and that new programs are being  
16 established annually. Many studies of bike share business models and the potential impacts of  
17 bike share programs on mode share, public health, transit connectivity, and the environment have  
18 since been published. These studies generally document the potential benefits of programs. Few  
19 have focused on factors that correlate with use of bike share stations.

20  
21  
22 In the United States, bike sharing has attained popularity, partially owing to increasing regional,  
23 national and global energy and environmental sustainability concerns and partially owing to  
24 success of prior programs (2). Looking forward, bike share system research is likely to focus on  
25 ongoing refinement of practical bike share system operations (e.g., predicting and meeting  
26 demand; improving redistribution of bicycles across stations) as well as understanding customer  
27 behavior and local bike sharing impacts (3).

### 28 **Methods of Non-Motorized Traffic Modeling**

29 Among papers that attempt to model non-motorized traffic, a recent quantitative analysis of the  
30 August 2010 rentals of 65 Nice Ride stations is most relevant for this study (4). In this research,  
31 the author found that the monthly rentals are related to trip generation factors, trip attraction  
32 factors and transportation network factors. Trip generation factors include population, vehicle  
33 ownership, income, alternative commuters and high-income job opportunities. Trip attraction  
34 factors include jobs, attractors (such as shopping centers or cultural sites) and being near to  
35 college or parks. The Transportation network factors include transit intensity, bus stops, distance  
36 to rail, bikeways and bike-share spaces.

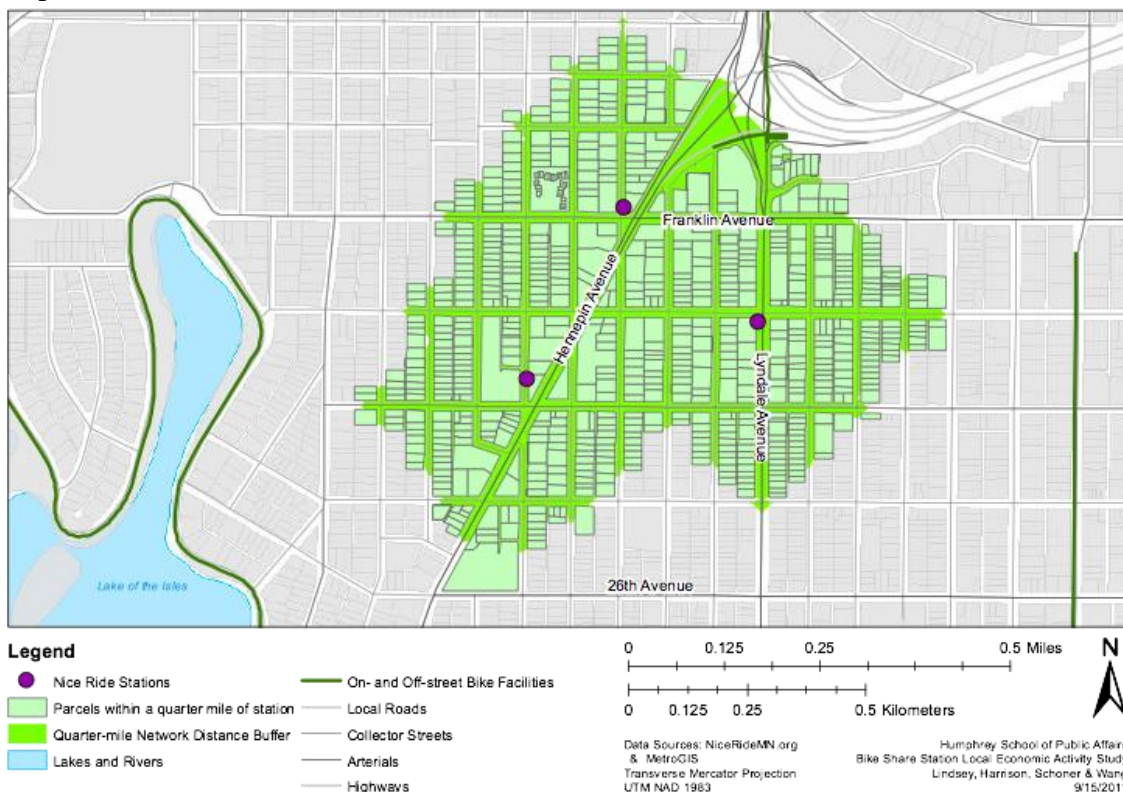
37 Many studies (e.g., (5) and (6)), show that non-motorized traffic volumes on particular  
38 segments of transportation infrastructure are correlated with the sociodemographic  
39 characteristics of nearby populations, characteristics of the built environment or urban form (7),  
40 linked transportation infrastructure (4), and other factors, including weather (8). Higher  
41 population density is related to higher levels of bicycling and walking (9). Another important  
42 factor is land use mix. It is believed mix land uses are associated with higher physical travel  
43 activities. Frank et al. (10) found entropy, a measurement of the land use mix, was positively  
44 related to people's active travel levels.  
45  
46

1 Another important factor is the transportation infrastructure. Research shows that higher  
 2 supply of the bicycle and pedestrian infrastructures will help to increase the non-motorized  
 3 transportation level. Such examples include bike lanes, separate bike paths and “bicycle  
 4 boulevards” (11). Safety is also believed to be important to active travel levels. More crime rates  
 5 in the neighborhood are usually related to lower bicycle and pedestrian travel levels (12).

6 Because each of these general categories of variables– sociodemographic, built  
 7 environment, and transportation infrastructure – have been shown to be related to the non-  
 8 motorized traffic volumes, they will be used as control variables in this study.

9  
 10 **DATA AND METHODS**

11 We use regression modeling to identify the relationship between station activity during the 2011  
 12 season and 19 different variables that reflect different relevant characteristics of the station area,  
 13 which we define as area with a ¼ mile walking distance buffer for each station. Figure 3  
 14 contains an example of these station areas from the Lowry Hill East neighborhood in  
 15 Minneapolis.



16  
 17 **FIGURE 3 Quarter Mile Walking Distance Buffer around Lowry Hill East Stations**

18  
 19 **Correlates of Nice Ride Station Activity**

20  
 21 *Dependent Variables*

22 For the purposes of this study, we define bike share “station activity” through three measures: (1)  
 23 the sum of trip origins and trip destinations, (2) the number of trip origins, and (3) the number of  
 24 trip arrivals (i.e., destinations). The descriptive statistics of the trips to and from the 116 Nice  
 25 Ride stations are shown in Table 1. The total trip (both trip origins and trip destinations) numbers  
 26 of the 116 stations ranges from 83 to 20,544, the average annual trips of 2011 is 3,749. The trip

origins range from the minimum number of 37 to the maximum number of 9,843 with an average of 1,875. The trip destinations range from 39 as the lowest to 10,701 as the highest. The average of trip destinations is 1,874. The patterns are similar among the three variables. These statistics show that the distributions of the three dependent variables are skewed by the higher station values, which, as discussed below, makes the logarithm transformation is appropriate in the ordinary least square modeling.

**TABLE 1 Descriptive Statistics of Nice Ride Station Activity in 2011**

	<b>Average</b>	<b>Maximum</b>	<b>Minimum</b>
Total trips	3,749	20,544	83
Trip origins	1,875	9,843	37
Trip destinations	1,874	10,701	39

We modeled each of these three station activity measures as a function of four categories of independent variables: (a) sociodemographic characteristics, (b) built environment characteristics, (c) transportation infrastructure and (d) indicators of economic activity. The complete list of the independent variables for these models is in Table 2.

#### *Sociodemographic Variables*

Three sociodemographic control variables are constructed for a 1/4 mile walking distance buffer around each station (“station area”) using 2010 US Census data. The variable *whitepct* controls for the racial structure of the analytical units, specifically, the proportion of the residents who are white/Caucasian. The variable *ynoldpct* controls for the age structure of the analytical units; it is the proportion of the residents who are younger than five or older than 64. The variable *medhhinc* is the median household income of the neighborhood the Nice Ride station locates. The variable *crimerate* is measured at the neighborhood level and reflects the safety level around Nice Ride stations. It is the violent crime number (sum of homicide, rape, robbery and aggravated assault) per 10,000 populations in the neighborhood that contains the station. We expect station activity to have a positive correlation with higher neighborhood income, lower crime rates, and a larger percentages of Caucasian and middle-aged people.

#### *Built Environment Variables*

To control for the effects of the built environment around each station on station activity, we constructed variables for population density, land use, and proximity to various notable destinations that are suspected to be trip attractors or generators. The variable *popdens* measures the population density in people per square meter using all census blocks in the quarter mile walking distance buffer around the station; the data comes from the 2010 US Census. The variable *lumix* is an entropy index of land use that measures how varied the land use types are in the quarter mile walking distance buffer; *lumix* was estimated using land use classification data from the Metropolitan Council, the regional planning governmental agency that serves the metropolitan region. The values of *lumix* range from 0 to 1, with higher values indicating a more even mix of a larger variety of land use types. The variables *diswater*, *discbd*, and *dispark* measure the proximity of the station in meters to the nearest lake or river, downtown Minneapolis or St. Paul central business district, and park. The *campus* dummy variable indicates whether the station is located on the University of Minnesota campus. We expect station activity to be positively associated with population density, more varied land use mix, closer proximity to parks, water, and downtown, and campus locations.

1 **TABLE 2 Independent Variables Used in Modeling the Usage Frequency of the Nice Ride Stations.**

variable	description	mean	Units/notes	exp. sign
	<i>Social Demographic Variables</i>			
whitepct	Proportion of the residents which are white/Caucasian. <sup>1</sup>	0.60	Unit: all census blocks interacting with the ¼ mile station buffer area.	+
ynoldpct	Proportion of the residents which are less than 5 or more than 64 yrs old. <sup>1</sup>	0.13	Unit: all census blocks interacting with the ¼ mile station buffer area.	-
crimerate	Violent crime rate (per 10,000 populations) of 2010. <sup>1,2</sup>	136.30	Unit: neighborhood of Minneapolis and St. Paul.	-
medhhinc	Median household income. (in 1,000 US dollar). <sup>3</sup>	44.56	Unit: neighborhood of Minneapolis and St. Paul	+
	<i>Build Environment Variables</i>			
popdens	Population density. (per square meter). <sup>1</sup>	0.0038	Unit: all census blocks interacting with the ¼ mile station buffer area.	+
lumix	Entropy Index of land use. <sup>4</sup>	0.59	Unit: ¼ mile station buffer area. Index: ranges 0-1, higher value indicates a more mixed land use structure.	+
diswater	Distance to the nearest water body. <sup>4</sup>	997.33	In meters.	-
discbd	Distance to the nearest CBD in Minneapolis and St Paul. <sup>4</sup>	2,903.56	In meters. CBD is defined to the centroid of the downtown reduced-fee areas from Metro Transit.	-
dispark	Distance to the nearest park land use type. <sup>4</sup>	236.59	In meters. Park is defined as the land use type 170.	-
campus	Station at the University of Minnesota Campus. <sup>4</sup>	0.10	Equals 1 if the station is on the campus, else 0.	+
	<i>Transportation Infrastructure Variables</i>			
trail	Presence of the paved trail in the station area. <sup>4</sup>	0.27	Equals 1 if paved trail in the ¼ mile station area buffer, else 0.	+
bklane	Presence of the bike lane in the station area. <sup>4</sup>	0.48	Equals 1 if paved trail not in and bike lane in the ¼ mile station area buffer, else 0.	+
nofacility	No presence of paved trail or bike lane in the station area. <sup>4</sup>	0.25	Equals 1 if neither paved trail or and bike lane in the ¼ mile station area buffer, else 0.	(base case)
board	Total number of transit boarding in the station area. <sup>5</sup>	3,091.73	Unit: ¼ mile station buffer area.	+
neardis	Distance to the nearest station.	514.23	Unit: meter.	-
opdate	Days operating of the station in 2011.	167.95	The last day of service in 2011 is at Nov. 6 <sup>th</sup> , 2011.	+
	<i>Economic Activity Variables</i>			
access	Total jobs in 30 minutes' transit ride in 2006. <sup>6</sup>	37,237.86	Unit: all census blocks interacting with the ¼ mile station buffer area.	+
shop	Total number of business in "shopping" category. <sup>7</sup>	4.47	Unit: 1/8 mile station buffer area.	+
food	Total number of business in "food" category. <sup>7</sup>	3.97	Unit: 1/8 mile station buffer area.	+
ttlbusi	Total number of business across categories. <sup>7</sup>	46.52	Unit: 1/8 mile station buffer area.	+

2 <sup>1</sup> Data source: 2010 Census. 2 Crime data from the Minneapolis and St. Paul Police Departments. <sup>3</sup> Neighborhood population data from Wilder Research.3 <sup>4</sup> GIS data from the Metropolitan Council. <sup>5</sup> Data from Metro Transit. <sup>6</sup> Data from (13). <sup>7</sup> Data from Reference USA

### 1 *Transportation Infrastructure Variables*

2 Like most of the socio demographic variables, transportation infrastructure variables are defined  
 3 for 1/4 mile station area buffers around each station. Transportation infrastructure such as bike  
 4 trails or bike lanes is hypothesized to support the Nice Ride station activities since it increases  
 5 access to individual stations. Variables *trail* and *bklane* indicate whether a paved trail or bike  
 6 lane exists in the 1/4 mile station network buffer area. There is also a base case variable  
 7 *nofacility*, which indicates no paved trail or bike lane exists within the station area. The variable  
 8 *board* shows the total number of transit boarding opportunities, defined by the number of bus  
 9 routes that stop within each station area and the number of times each bus stop during the day.  
 10 Variable *neardis* is the distance to the next nearest Nice Ride station. Variable *opendate*, which  
 11 is the operating dates of the stations of 2011, serves as a control variable to ensure the variation  
 12 of the Nice Ride station activity is not because some stations were not open for the whole season.  
 13 We expect station activity to be positively related to the presence of paved trails and bike lanes,  
 14 greater transit boarding opportunities, closer proximity to the next nearest bike share station, and  
 15 number of days the stations was open during the 2011 season).

16

### 17 *Economic Activity Variables*

18 After controlling for the sociodemographic, built environment and transportation infrastructure  
 19 variables described previously, we isolate the marginal relationship between indicators of  
 20 economic activity and station activity (trips). The variable *access* calculates job accessibility,  
 21 measured as the total number of jobs accessible within a 30 minute transit ride from the station  
 22 using 2006 transit and employment data as per Fan et al. (13). Variables *shop* and *food* indicate  
 23 the total number of businesses categorized as “shopping” or “food” within a 1/8 mile walking  
 24 distance buffer around the station. These businesses were identified using the ReferenceUSA  
 25 business database and categorized by NAICS according to the protocol developed by Horning,  
 26 El-Geneidy, and Krizek (14) for measuring non motorized accessibility. The last variable, *ttlbusi*,  
 27 measures the total number of businesses across all categories within the same 1/8 mile station  
 28 network buffering areas. All business activity variables are expected to be positively associated  
 29 with 2011 station activity.

30

### 31 **Model Development and Estimation**

32 We use log-linear regression to estimate our three station activity models. Because trip origins,  
 33 trip destinations, and total trip counts are non-negative integer values, their distributions are  
 34 inherently skewed from the normal distribution. We therefore use a natural logarithm  
 35 transformation of the trip counts as our dependent variables.

36 The estimation method used is ordinary least squares (OLS). However, because the  
 37 dependent variables are transformed into the natural logarithm form, the marginal effect of the  
 38 independent variables will be different from basic OLS models. Specifically, if the coefficient of  
 39 an independent variable is  $\beta$ , an increase of the variable by one unit is correlated with  
 40  $100 * (\exp(\beta) - 1) \%$  increase of the dependent variables, or to its  $\exp(\beta)$  times. The adjusted R-  
 41 square can be a measurement of the goodness-of-fit of the models.

42 The three models are:

- 43 • Total activity model: The dependent variable is the natural logarithm of total station  
 44 activity (trip origins plus trip destinations) in the 2011 season.
- 45 • Trip origin model: The dependent variable is the natural logarithm of station trip  
 46 origins in 2011.

- Trip destination model: The dependent variable is the natural logarithm of station trip destinations in 2011.

## RESULTS

The result of the three models is shown in Table 3. All of the three models have very high fits: the adjusted R-square values are from 0.8657 to 0.8696. This statistic means that more than 86% of the variation in trip activity across stations can be explained by these sets of variables.

Overall, 9 out of the 19 variables are significant at least 0.1 significant level, and the signs of the coefficients of 8 additional variables are in the expected direction in each of the three models.

**TABLE 3 Station Activity Regression Models**

variables	Model 1 – logarithm of total activity (origin + destination)		Model 2 – logarithm of origins		Model 3 – logarithm of destinations	
	coefficient	t-statistics	coefficient	t-statistics	coefficient	t-statistics
<b><i>Social demographic</i></b>						
whitepct	1.609617	5.5***	1.642	5.53***	1.57799	5.41***
ynoldpct	-1.759717	-2.02**	-1.7427	-1.97**	-1.77836	-2.04**
crimrate	-0.0002167	-0.37	-0.0002	-0.34	-0.00023	-0.39
medhhinc	0.0028307	0.9	0.002	0.68	0.00352	1.12
<b><i>Build Environment</i></b>						
popdens	24.36703	0.7	24.403	0.69	24.34763	0.7
lumix	-0.2232655	-0.65	-0.212	-0.6	-0.23642	-0.69
diswater	-0.0004468	-3.64***	-0.0004	-3.37***	-0.00047	-3.87***
discbd	-0.0001522	-2.84***	-0.00014	-2.62***	-0.00016	-3.03***
dispark	-0.0004455	-1.26	-0.00044	-1.22	-0.00045	-1.28
campus	0.3998993	1.38	0.370	1.26	0.43113	1.49
<b><i>Transportation Infrastructure</i></b>						
trail	0.5134097	3.33***	0.53350	3.42***	0.49427	3.22***
bklane	0.0491655	0.34	0.06487	0.45	0.03371	0.24
board	-0.0000081	-0.32	-0.0000069	-0.27	-0.00001	-0.38
neardis	0.0005974	1.96*	0.001	1.66*	0.00068	2.23*
opdate	0.0107227	8.47***	0.0108493	8.46***	0.0106168	8.42***
<b><i>Economic Activity</i></b>						
access	0.0000127	2.21**	0.0000131	2.25**	0.00001	2.14**
shop	-0.010715	-0.83	-0.0128571	-0.99	-0.0085434	-0.67
food	0.0436912	2.48**	0.0423646	2.37**	0.0451566	2.57**
ttlbusi	-0.0006909	-0.47	-0.0005949	-0.4	-0.0007918	-0.54
<b>Constant</b>	4.81179	7.31***	4.060252	6.09***	4.168671	6.35***
<b>No. of observations</b>	116		116		116	
<b>Adjusted R-square</b>	0.8687		0.8657		0.8696	

Note: \* p<0.1; \*\* p<0.05; \*\*\*p<0.01

### Total Activity Model

Among the sociodemographic variables, *whitepct* and *ynoldpct* are significant at the 5% significance level, indicating they have non-random effects on the 2011 annual station activity

1 after controlling for other factors. The coefficient of *whitepct* is positive, indicating more  
 2 Caucasian residents around the Nice Ride stations is correlated with more bike sharing trips. The  
 3 coefficient of *ynoldpct* is negative, showing that more children and seniors in the buffer area are  
 4 correlated with lower bike sharing trips. Variables *crimerate* and *medhhinc* are not significant in  
 5 this model.

6 Two of the six built environment variables are significant at 5% level. As hypothesized,  
 7 there is a negative effect of *diswater* and *discbd* on the 2011 total Nice Ride station activities:  
 8 bike share stations nearer to water bodies and to the CBD have more trips. Other variables,  
 9 including population density, land use mix, distance to park and campus dummy are not  
 10 significant.

11 Three of the five transportation infrastructure variables are significant at 10% level in this  
 12 model. *Trail* has a positive effect, indicating that more trips occurred at stations connecting to  
 13 paved trails. Opposite to predicted, there is no significant effect of the existence of the bike lanes  
 14 on station activities. There is a positive effect of *neardis*, which indicates stations with further  
 15 distances to its nearest stations tend to have more trips. That might be because the location of  
 16 several stations in close proximity may serve the same group of people and reduce the usage of  
 17 individual stations. The variable *opdate* also has a positive effect, indicating the number of days  
 18 a station was open is correlated with number of trips. The boarding opportunities are not  
 19 significantly correlated to the station activity levels.

20 As to the economic activity variables of interest, two of four are significant at 5% level.  
 21 The stations in areas with higher job accessibility (variable *access*) tend to have more bike share  
 22 trips. The variable *food* is also significant, showing that the number of bike share trips at a  
 23 station is strongly and positively correlated with the number of restaurants, cafeterias, and cafes  
 24 around the stations. Specifically, the presence of one additional food related business is  
 25 correlated with 4.47% more station trips. However, the variable *shop* is not significant, which  
 26 means there is no correlation with the number non-food related shopping facilities in close  
 27 proximity to the Nice Ride stations. The total number of businesses within the 1/8 mile buffer  
 28 also is not related to the station activities.

### 30 **Trip Origin Model and Trip Destination Model**

31 The significant variables and signs of all the variables in the trip origin and the trip designation  
 32 models are all the same as those of the total activity model (Table 3). The only differences are in  
 33 the value of each coefficient; this result indicates that while the same variables affect origins and  
 34 destinations, the magnitude of their effects differs..

35 As to the economic activity variables of our interest, variables *access* and *food* are  
 36 significant at the 0.05 significance level. In the trip origin model, the coefficient of *food* is 0.042.  
 37 These results mean that, on average, one more food business in the 1/8 mile station buffer area is  
 38 correlated with a 4.3% increase of the bike share trip origins. In the trip destination model, the  
 39 coefficient of *food* is 0.045, which means that one additional food business in the 1/8 mile station  
 40 buffer area is correlated with a 4.62% increase in bike share station arrivals or destinations. This  
 41 result indicates that the presence of food-related businesses has a slightly greater effect on more  
 42 trip destinations than trip origins.

### 44 **MODEL APPLICATIONS**

45 Planners, public policy decision makers, and bike share system managers can use these models in  
 46 a variety of situations. First, people can use the models to understand the marginal effects of  
 47 locating stations in close proximity to food-related businesses and in areas with higher job

1 accessibility. In simple terms, bike stations close to more retail food-related establishments can  
2 expect a four to five percent increase in total trips for each additional establishment. Stations in  
3 locations with greater accessibility to jobs also will have more use. Bike share management  
4 organizations can use these results to promote cooperation with the local food businesses, and  
5 bike share advocates can use them to raise funds to support operation and expansion of bike  
6 share programs.

7 Practitioners in the planning field can also get a general understanding of marginal effects  
8 of other correlates on the bike share stations. For instance, the factors with the most significant  
9 levels ( $p < 0.01$ ) in the models are: race, distance to water, distance to CBD, trail existence,  
10 operational date; the factors with the second most significant levels ( $p < 0.05$ ) are age, job  
11 accessibility and food businesses; and the factors with some significance ( $p < 0.01$ ) is distance to  
12 the nearest station. People can use these facts to do rough estimates about the potential of  
13 developing bike share stations before calculating with the complete models.

14 Planners in and outside the Minneapolis-St. Paul Metropolitan Area can use these models  
15 to evaluate the bike share potential of particular areas. For example, planners can obtain values  
16 for the socio demographic, built environment, transportation infrastructure, and economic  
17 activity variables in the models for a particular location and then use the model equations to  
18 estimate the annual trip origins, trip destinations and total trips at that location. The result will  
19 help the planners and the public policy makers to make decision about whether and where to  
20 develop new bike share stations in the existing system, or analyze the feasibility to introduce a  
21 new bike share system to a city such as (4).

22 The models can also be applied in the bike share system management field. After  
23 estimating the annual trip origins and trip destinations, bike share system managers can project  
24 the approximate “net gain” and “net loss” of the existing bike share stations. This use of the  
25 models will help the bike share operations team plan their bicycle transport system and operate  
26 more efficiently. Use of these models in planning potentially can reduce the total costs by  
27 optimizing system logistics, specifically, by helping to ensure that each station has a sufficient  
28 number of bikes for the commuters, leisure bicycle users and occasional cyclists.

## 30 CONCLUSION

31 In the research, we present a set of three OLS regression models of the Nice Ride station trips.  
32 Regression modeling of station activity and the characteristics of the surrounding station area  
33 revealed a positive and statistically significant relationship between the number of food-related  
34 businesses and trips at any given station. Each additional food related business within a 1/8 mile  
35 walking distance buffer from the station corresponds to a 4.47% increase in station activity - the  
36 number of trips arriving at and leaving from that station.

37 Notably, while food businesses were significantly related to trip activity, there was no  
38 statistically significant relationship between the number of non-food shopping businesses and  
39 activity. This suggests that bike share system managers should focus on food-related businesses  
40 more than overall all retail businesses when seeking to locate stations to maximize trips.

41 This result persisted even after controlling for many factors that are usually associated  
42 with levels of bicycling, including proximity to trail infrastructure, percent of station area  
43 residents that are white, and a station area population that is neither very young nor very old. A  
44 high level of job accessibility in a station area also had a positive relationship with trips,  
45 indicating the importance of bike share programs for workers. All other factors equal, locating  
46 stations closer to jobs will result in higher levels of use. Distance to the nearest station was

1 another important control factor: too many stations near one another may dilute demand across  
2 stations, resulting in marginally lower trip rates at each one. This is not necessarily a bad thing  
3 or a reason to disperse stations widely; more densely spaced stations may have a network effect  
4 that isn't captured in this measure. Controlling for the opening date of the station was necessary  
5 to ensure that we were comparing activity across stations fairly; naturally, stations that were  
6 open for the full season had more trips than stations that didn't open until the season was  
7 partially over.

8 These models can be applied in planning and bike share system management in many  
9 different ways. The potential applications include estimating and understanding the marginal  
10 effect of the food business on the trip activities; evaluating the potential of developing new bike  
11 share stations in the existing system; evaluating the feasibility of introducing bike share system  
12 to a new city, and minimizing bike share system operational costs.

13 While these models increase understanding of neighborhood factors that affect bike share  
14 use, additional research is needed. For example, station areas were defined as a 1/4 mile walking  
15 distance buffer given existing literature on typical walking distances to transit stations. This  
16 method assumes that bike share operates like an individual, on-demand transit system. Further  
17 study could identify the sensitivity levels of station area features to walking distance to the  
18 station using a gravity model that discounts features that are farther away from the station.  
19 Additional research could explore further the specific characteristics of food-related businesses  
20 that are correlated with bike share system use.

## 21 22 **ACKNOWLEDGEMENT**

23 We appreciate the funding support from the Bikes Belong Foundation; we also thank Mr. Mitch  
24 Vars from Nice Ride Minnesota and Mr. Tony Hull from Transit for Livable Communities for  
25 their help and support.

## 26 27 **REFERENCES**

- 28 1. DeMaio, P. Bike-sharing: History, Impacts, Models of Provision, and Future. *Journal of*  
29 *Public Transportation*, Vol.12, No.4, 2009, pp. 41-56.
- 30 2. Shaheen, S. A., S. Guzman, and H. Zhang. Bikesharing in Europe, the Americas, and Asia:  
31 Past, Present and Future. In *Transportation Research Record: Journal of the Transportation*  
32 *Research Board*, No. 2143, Transportation Research Board of the National Academies,  
33 Washington, D.C., 2010, pp.159-167.
- 34 3. Vogel, P., and D. C. Mattfeld. Modeling of Repositioning Activities in Bike-Sharing  
35 Systems. In: Proceedings of 12th World Conference on Transport Research. Lisbon,  
36 Portugal, 2010.
- 37 4. Maurer, L. Feasibility Study for a Bicycle Sharing Program in Sacramento, California.  
38 Presented at 91st Annual Meeting of the Transportation Research Board, Washington D.C.  
39 2012.
- 40 5. Hankey, S., G. Lindsey, X. Wang, J. Borah, K. Hoff, B. Utecht, and Z. Xu, Estimating Use of non-  
41 motorized infrastructure: Models of bicycle and pedestrian traffic in Minneapolis, MN. *Landscape*  
42 *and Urban Planning*, 2012, DOI: 10.1016/j.landurbplan.2012.06.005
- 43 6. Lindsey, G., J. Wilson, E. Rubchinskaya, J. Yang, and Y. Han, Estimating urban trail traffic:  
44 Methods for existing and proposed trails. *Landscape and Urban Planning*. Vol.81, 2007,  
45 pp.299-315.

- 1 7. Stinson, M.A. and C. R. Bhat, Frequency of Bicycle Commuting: Internet-Based Survey  
2 Analysis. In *Transportation Research Record: Journal of the Transportation Research*  
3 *Board*. No.1878. Transportation Research Board of the National Academies, Washington,  
4 D.C., 2004, pp.122-130.
- 5 8. Parkin, J., M. Wardman, and M. Page.2008. Estimation of the Determinants of Bicycle Mode  
6 Share for the Journey to Work Using Census Data. *Transportation*, No.35, pp.93-109.
- 7 9. Handy, S. L., M. G. Boarnet, R. Ewing, and R. E. Killingsworth. How the Built Environment  
8 Affects Physical Activity: Views From Urban Planning. *American Journal of Preventive*  
9 *Medicine*, Vol. 23, No.2S, 2002, pp.64 -73.
- 10 10. Frank, L. D., M. A. Andresen, and T. L. Schmid, Obesity relationships with community  
11 design, physical activity, and time spent in cars. *American Journal of Preventive Medicine*,  
12 Vol. 27, No.2, 2004, pp.87-96.
- 13 11. Dill, J. Bicycling for Transportation and Health: The Role of Infrastructure. *Journal of Public*  
14 *Health Policy*. Vol.30, 2009, pp.95-110.
- 15 12. Joh, K, M. T. Nguyen, and M. Boarnet. Can Built and Social Environmental Factors  
16 Encourage Walking among Individuals with Negative Walking Attitudes? *Journal of*  
17 *Planning Education and Research*, Vol. 32, No.2, 2012, pp.1-18.
- 18 13. Fan, Y., A. Guthrie, and D. Levinson. Impact of Light Rail Implementation on Labor Market  
19 Accessibility: A Transportation Equity Perspective. *Journal of Transport and Land Use*, Vol.  
20 5, No. 3, 2012.
- 21 14. Horning, J., El-Geneidy, A., and Krizek, K. 2008. Parcel Level Land Use Data Acquisition  
22 and Analysis for Measuring Non-Auto Accessibility. Minnesota Department of  
23 Transportation Research Services Section, Access to Destinations Study. Report #6.  
24 <http://www.cts.umn.edu/access-study/research/8/index>. Accessed Aug. 1, 2012.