Unconventional Transit: Predicting Use of Public Bicycle Sharing at the 2008 Political Conventions

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I. Purpose of the Study

City leaders are increasingly becoming aware of the resource demands and resultant impacts and vulnerabilities of cities. Coupled with rising demand and more competition for limited resources, demand will increase to integrate more sustainability in the form of fuel-independence into transportation plans (Rotmans and Kemp 2003). Economic, climate change and public health factors are likely to contribute to changes in urban transportation. One tool employed by a growing number of cities to address some of these issues is public bicycle sharing (PBS) systems.

PBS systems involve a fleet of bicycles linked through a network of stations made available to the public for short-term use at minimal cost. Past bicycle sharing programs have usually been ad hoc in design, comprised of used bikes, often painted the same distinctive color and offered for free or for a coin deposit in city centers (DeMaio 2003). These programs nearly always fail due to theft, vandalism, and lack of adequate maintenance and support. Largely acknowledged as not being a viable system, this type of ad hoc PBS is still occasionally tried in the hopes that it will somehow succeed.

The newest generation of PBS systems relies on sophisticated automated stations, specially designed bicycles with integrated electronic monitoring components (DeMaio and Gifford 2004) and better administration. PBS bicycles connect to software at stations, notifying administrators of bicycle locations, maintenance needs and usage. Users are required to provide contact and credit card information as collateral, creating incentive for responsible use and proper return of bicycles. These PBS systems are now present in dozens of cities worldwide, and are poised to make a large appearance in North America in the near future, with popular media reporting that several cities, including Denver, Boston, Philadelphia, San Francisco and New York are actively pursuing bids or implementation of PBS systems.

Purpose and Rationale

In Europe, PBS systems are changing the face of urban transportation. Dozens of cities have launched PBS systems (Conlin 2007) with goals of reducing traffic congestion and lowering carbon emissions. Several U.S. cities have announced intentions to launch PBS systems of their own, using varied methods of planning, design and execution. As efforts advance, specifics as to how a population steeped in generations of American car culture will react to a system of publicly shared bicycles for transportation remain unknown (Badland and Schofield 2006).

However, PBS systems allow for rethinking of urban transportation strategies to encourage reduced car dependence in an urban setting. Because 41% of trips made in the U.S. are less than two miles (Pucher and Dijkstra 2003), bicycles are well suited as a mode of transportation. Shared bicycles can enhance the ability of transit systems (Martens 2004) to reach individual destinations with more speed and flexibly than traditional transit modes such as bus and rail alone. These characteristics could serve to
enhance the appeal of transit systems to potential users accustomed to individual transportation modes and make leaving a car at home a viable option (Badland and Schofield 2006). In order to effectively begin integrating PBS systems into U.S. cities, there is a need to foster an improved understanding of likely user characteristics.

The largest implementation of a PBS system to date in the United States occurred during the 2008 national political conventions. The Freewheel!n temporary PBS systems were set up for public use in both Denver and Minneapolis-St. Paul; each comprised of 1,000 bicycles available from numerous stations for the four-day duration of each convention. Both systems were open to the public, with users required to register, sign a waiver and provide a credit card for collateral. Users were not charged for system use, and could check out bicycles at any time between 7:00 am and 7:00 pm while the systems were active.

Attendees at both conventions were encouraged to register to use the PBS systems in each city through promotional materials sent before the events, as well as through other strategies aimed at informing hotel staff of the availability of PBS systems. Additionally, convention volunteers and greeters were equipped with information to help event attendees understand the purpose and locations of the PBS stations.

At registration, certain demographic information was collected from each participant and entered into the administrative database. These data were used to explore the specific research question: How well does the combination of gender, age group, which event attended and local or visitor status predict amount of PBS system use?

**II. Methods**

*Research Design and Data Collection*

The research design is an exploratory study of self-selected participants who registered as users in the temporary PBS systems at the national political conventions. Data are collected as post-test only, indicated by amount of PBS system use measured in miles. Humana health care company was a major sponsor of the PBS systems at the conventions and provided the administrative system to register users and record system usage. The Humana administrative system was also used to record mileage attributable to each individual user session. The data in this study are derived from data collected through this administration of the PBS systems.

*Variables*

The dependent (outcome) variable of this study is amount of PBS system use, operationally defined as participation measured in miles recorded in the administrative system. Data categories and increments were determined by the availability of type of data collected, the design of which was not expressly for research purposes.

Independent (predictor) variables include demographic information collected into
dichotomous groupings of gender (0 = male; 1 = female), age (0 = younger than 30; 1 = 30 and older), which convention attended (0 = Republican National Convention (RNC); 1 = Democratic National Convention (DNC)), and locality status (0 = visitor; 1 = resident of host state).

Sampling strategy and sample characteristics

Participants were self-selected by registering to use the PBS systems. To register, users entered a station and an attendant collected registration information through a computer interface. Upon completion of registration, users were then allowed to check out a bicycle. After the conventions ended, Humana provided a de-identified dataset with select demographic information and system mileage for all of the 6,990 individual users of the systems. Participants include the entire group of users who self-selected to participate in the PBS systems.

User demographics included people from all 50 states and Washington D.C. and participants from 27 countries. Minimum age for participation was 18, and all age groups up to 60+ were represented. Males and females, as well as those local to the state of each convention and visitors from elsewhere all participated. The Statistical Package for Social Sciences (SPSS) was used to generate frequencies from the data set for registered PBS users according to independent variables, which may be seen in Table 1. Only those users for which there were valid data for these items were included in the figures in the table.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Valid Frequency</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3136</td>
<td>59.7</td>
</tr>
<tr>
<td>Female</td>
<td>2115</td>
<td>40.3</td>
</tr>
<tr>
<td>Total</td>
<td>5251</td>
<td>100</td>
</tr>
<tr>
<td><strong>Event Attended</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RNC</td>
<td>1810</td>
<td>26.1</td>
</tr>
<tr>
<td>DNC</td>
<td>5121</td>
<td>73.9</td>
</tr>
<tr>
<td>Total</td>
<td>6931</td>
<td>100</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;30</td>
<td>1680</td>
<td>40.1</td>
</tr>
<tr>
<td>≥30</td>
<td>2508</td>
<td>59.9</td>
</tr>
<tr>
<td>Total</td>
<td>4188</td>
<td>100</td>
</tr>
<tr>
<td><strong>Locality Status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visitor</td>
<td>3576</td>
<td>51.2</td>
</tr>
<tr>
<td>Local</td>
<td>3414</td>
<td>48.8</td>
</tr>
<tr>
<td>Total</td>
<td>6990</td>
<td>100</td>
</tr>
</tbody>
</table>

Data collection
At registration, each user provided demographic information. Demographic items relevant to this study and used as predictor variables include gender, age group, state of residence, and convention attended. Each participant was issued a PBS registration card with a barcode, which was scanned with a handheld device before and after each use session. A bar code on each bicycle was then scanned, linking the bicycle to the user, and mileage data were recorded from the bicycle’s odometer at checkout and check-in. Mileage was hand recorded by an attendant who entered the number into the handheld device. The human element in this process created potential for error. The resultant total mileage of use recorded for each participant as measured by the administrative system is the outcome variable in this study.

**III. Measurement Strategies**

The dependent variable was measured through the use of an electronic odometer device to measure distance traveled, installed on each bicycle used in the PBS systems. Station attendants recorded mileage displayed on the odometer screen upon each checkout and check-in procedure for individual bicycles. Attendants scanned a bar code on the user’s system registration card and on the bicycle, then read the display screen of the cycle-computer and entered the mileage manually into a handheld wireless device connected to the administrative database. The database tallied cumulative distance ridden for each user.

*Reliability and validity evidence*

The measurement techniques used in the collection of data were not without cause for concern in addressing the issue of reliability. Although station attendants were trained in the use of the hand-held scanning devices, the possibility for the introduction of random errors existed during data collection. Entry of users’ registration numbers and bicycle identification bar codes was done with a laser device on the scanner and signaled by an audible sound for success, so were not highly subject to human error. However, mileage information had to be read manually from the odometer screen and entered manually using a number pad on the hand-held device. If a number were entered erroneously or a decimal point were placed incorrectly, a station attendant had the capability of correcting the entry, but it is likely that some such errors were not caught and incorrect data were entered during either checkout or check-in procedures. This factor may have contributed to over and under counted mileage. This is the largest source of doubt concerning reliability of the dependent variable.

During registration, users were required to provide certain demographic information, but some of these items are missing for some of the participants. Whether this information was collected and not correctly entered, or if it was for some reason not collected from some individuals is unknown. Complete data were available for only 3,963 of the 6,990 participants.

Even though some potential for random error potentially affecting reliability existed
in the collection of demographic data and mileage data, the validity of the measurement likely remains fairly sound. Demographic data is static, and quantity of use of the PBS systems is best measured in terms of either mileage or number of trips, or a combination of the two. In any case, future systems would benefit from more rigorous testing and calibration of measurement instruments and data collection devices to ensure reliability and validity of the measures.

**IV. Data Analysis Strategies**

Backward Multiple Regression was conducted to determine the best linear combination of the four independent variables for predicting the amount of PBS system use in miles. Since there were no prior ideas as to which variable would create the best predictor equation, and since the outcome variable of this study is a scale variable and the predictor variables are all dichotomous variables, the multiple regression statistic was appropriate for analysis (Leech, Barrett, and Morgan 2008).

To begin, the linear regression statistic was conducted with a request for the creation of a new variable of Studentized residuals. The Studentized residual variable was used to check the assumptions of linearity and normality through the examination of matrix scatterplots generated of the errors and the Studentized residuals variable and the four independent variables. QQ plots were created with each of the independent variables and the Studentized residuals. The results of this output indicated a positively skewed dependent variable. Therefore, a Log10 transformation was applied to each of the dependent variable values. Following the transformation of the dependent variable a new Studentized residual variable was produced, and examination of new scatter plots and QQ plots constructed with the transformed variable indicated that the assumption of linearity was met. The residual plot of errors versus the Studentized Residuals indicated the transformed data also met the assumptions of heteroscedasticity and independence of error distribution. The QQ plots of each of the variables showed no significant curvatures, so the assumption of normality was met. The value of the Studentized residuals variable was examined to check for the assumption of outliers, and since the value was within the absolute value of four as required, this assumption was met. To meet the condition of multicollinearity, tolerance values were examined and found to have acceptable values of higher than 1 - $R^2$, meeting the condition.

**V. Results**

Backward multiple regression was conducted to determine the best linear combination of gender, age group, which event attended and locality status for predicting miles of PBS system use. The combination of gender, which event attended, and locality status significantly predicted miles of PBS system use, $F(4, 3,962) = 119.72, p < .001$. The age variable was removed through the backwards regression from the model as it was found to not be a significant contributor. The means, standard deviations, and intercorrelations are shown in Table 2, with the mean and standard deviation of the
dependent variable, use in miles shown un-transformed.

Table 2
Means, Standard Deviations, and Intercorrelations for Use in Miles of Public Bicycle Sharing Systems (N=3,963)

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Us in Miles</td>
<td>8.05</td>
<td>3.36</td>
<td>-.27**</td>
<td>-.13**</td>
<td>0.01</td>
<td>-.12**</td>
</tr>
</tbody>
</table>

Predictor variables
1. Event Attended (0 = RNC; 1 = DNC)
   0.74 | 0.44 | - | 0.03 | -.04* | -.08** |
2. Gender (0 = Male; 1 = Female)
   0.41 | 0.49 | - | -.07** | 0.02 |
3. Age (0 = <30; 1 = ≥30)
   0.59 | 0.49 | - | -.07** | 0.02 |
4. Locality status (0 = Visitor; 1 = Local)
   0.47 | 0.50 | - | -.07** | 0.02 |

*p < .05; ** p < .01

Gender (t = -18.73, p = < .001), event attended (t = -7.70, p = < .001), and locality status (t = -9.04, p = < .001) all significantly contributed to the model. After un-transforming the beta weights using inverse Log10 (10^-X), the following multiple regression equation was produced: Miles of public bicycle use = 18.97 -.46 (event attended) – .75 (gender) - .72 (locality status). These beta weights are presented in Table 3 and suggest that a one-unit increase in event attended (in other words, attending the DNC instead of the RNC), miles of PBS use decrease by .46; as gender increases by one unit, miles of PBS use decrease by .75; and as locality status increases by one unit, miles of PBS use decrease by .72, after un-transforming the betas and holding everything else constant. The adjusted R squared value is .11 which indicates that 11% of the variance in miles of PBS use was explained by the model. This is a small effect size according to Cohen (Leech, Barrett, and Morgan 2008).

Table 3
Backward Multiple Regression Analysis Summary for Use in Miles of Public Bicycle Sharing Systems (N=3,963)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SEB</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event Attended (0 = RNC; 1 = DNC)</td>
<td>-0.46</td>
<td>0.02</td>
<td>-.52**</td>
</tr>
<tr>
<td>Gender (0 = Male; 1 = Female)</td>
<td>-0.75</td>
<td>0.02</td>
<td>-.77**</td>
</tr>
</tbody>
</table>
VI. Discussion and Critique

The results of this study indicate that amount of PBS system use at the two national political conventions measured in miles is affected by location and user demographics. Attending the DNC instead of the RNC negatively influenced the individual miles of PBS use. Being a female user or a resident of the hosting state also exerted negative influences on the amount of PBS system use. However only 11% of the variance is explained by the three variables in the final model, which suggests that these variables are only somewhat indicative of amount of PBS use. During the following discussion, it should be noted that there is much that is still unknown about predicting PBS use through examining key demographic characteristics of PBS users.

The inclusion of gender in the final model is supportive of evidence (Garrard, Rose, and Lo 2007) suggesting that men are more likely to ride bicycles than women. This is also seen in the differential in gender according to registration. Of registered users who provided gender information, 3,136 were men and 2,115 were women. Both Denver and Minneapolis-St. Paul are relatively bicycle friendly cities by American standards, but the use of bicycles as a transportation mode is minimal in the United States (Pucher and Dijkstra 2000). This might suggest that women are more sensitive to concerns of safety than men when it comes to choosing a bicycle for transportation. The improvement of on and off street bicycle-supportive structures facilities to attract more transportation bicycling use (Dill and Carr 2003) might be a prerequisite to enticing more women to bicycle using PBS systems.

As an independent variable, locality status is of interest. During both conventions, each location was subject to a large influx of visitors, as well as the many volunteers and other occupants of the PBS service area who were locals. The final model suggests that there was a higher tendency for visitors to accumulate more miles of PBS system use. The likelihood of a visitor having decreased access to a car versus a local suggests that at least some of the PBS use by visitors was displacing trips that might otherwise have been made using temporarily accessed motorized modes, such as taxis, rented cars and buses. Frequencies of the data show that there were 3,576 participants designated as visitors, versus 3,414 locals. These figures are close to being equal. However, the fact that visitors recorded more miles than locals suggests that the PBS systems appealed to people less likely to have convenient access to motorized modes.

It is somewhat surprising that age was not a significant predictor for amount of PBS use. Younger, more active people might be hypothetically more inclined to ride bicycles
in an urban area. During both conventions, there was no shortage of younger attendees and activists who might have been predicted to use the free, readily accessible, and conveniently located PBS systems. However, an examination of the frequencies indicates that of those who responded, 1,680 participants were less than 30 years old, while 2,508 were 30 or over. This might indicate that PBS bicycles for transportation appeal to a wide age range of users, not exclusively to any single age group.

The inclusion of which event attended in the final model requires some careful interpretation. The tendency for higher miles at the RNC versus the DNC on an individual basis does not necessarily reflect other differences in PBS use attributable to design differences between the two cities. The total mileage and trip figures were 26,582 miles and 5,552 trips for Denver (DNC), and 15,141 miles and 1,971 trips for Minneapolis-St. Paul (RNC). So, the DNC system experienced more trips for shorter distances, while the RNC system had fewer trips for longer distances. To interpret this observation, it must noted that the DNC had most of its venues and hotels within an approximate two square mile area, and the RNC events were more spread out, up to about 9 miles apart. Therefore the purpose of trips at each site was likely different, due to the distance required to go from one place to another. It may also be that the perspective of alternative transportation varied according to the predominant political points of view between likely participants of each convention, contributing to some variance. While this is an item of potential interest, political affiliation of participants was not measured.

Limitations of Study

The current study was limited by techniques and type of data collected. Data collection of the dependent variable, mileage of PBS system use, was subject to a variety of errors, potentially threatening internal validity. For the temporary system using bicycles that were not specifically designed and equipped for PBS system use, the majority of human error and equipment-related shortcomings of measurement techniques was likely unavoidable, and for future fully automated systems, design features will eliminate much of the possibility of these types of error. Although the data collection strategy was not ideal, the errors were random, so this study might still reveal some insight into behaviors related to public bicycle sharing system use. The DNC and RNC PBS systems under examination are the only large-scale PBS systems to date in the United States. The study had a large sample size, but it is clear that the demographic data available was not sufficient to adequately predict PBS system use more than a small effect size. Improvements to data collection reliability would improve internal validity. In addition, the identification and collection of more informative data might improve the predictive capacity of a model.

Because of the unique and temporary nature of the PBS systems implemented during the 2008 national political conventions, external validity and capability of replication elsewhere might be fairly limited. However, the apparent success in both places of the temporary PBS system indicates that for other short-term special events
where automobile traffic is restricted, such as the Olympics, public bicycle sharing might contribute to useful transportation utility for visitors and locals alike. This study was an initial and exploratory inquiry into the characteristics of PBS users, using available data not specifically designed for this study. Improvements to measurement techniques, as well as longer measurement periods would improve reliability, validity and increase the precision of analysis.

**Implications for Future Research**

Future studies of similar applications of public bicycle sharing would benefit from improved data collection techniques and more in-depth data collection from participants. To improve the recording of mileage, it would be advantageous to automate mileage collection to remove the potential for human error. Additional demographic and behavioral data collection might include indicators for individual physical fitness level, type of employment or purpose for being in the PBS service area, access to a car at an event, some measure of comfort level in riding a bicycle in traffic, as well as a variety of others.

Ecological and environmental influences on individual action could also be helpful in predicting PBS use. It would be helpful to create an evaluation of the PBS service area for supporting bicycles as a transportation mode (McCormack, Masse, Bulsara, Pikora, and Giles-Corti 2006). Features of the built environment have an effect on behavior, therefore obesity is in part a result of urban design (Frank, Andresen, and Schmid 2004). An area designed for the prevalence of car traffic over other modes might be reflected through the behaviors of a local population less likely to use alternative modes. The existence and quality of bicycle supportive infrastructure in an area could be an important external predictor for individual behavior. In addition, a greater understanding of how the bicycles were used during the events might contribute to understanding of use and enhance predictive capacity. This might be accomplished through GPS tracking of PBS use (Dill 2009) or surveys of users.

Some of these data collection factors and strategies will be addressed in permanent PBS applications, as are likely to be implemented in U.S. cities in the near future. The use of special bicycles designed for PBS system use goes a long way toward automating usage data collection, and a more robust registration procedure will ensure that the majority of PBS system users have full data sets.

This study has been an initial exploration into data collection and analysis for PBS system use. It is unlikely to be the last, but the results of this study are significant in that it appears as though the appeal of PBS use is not localized to a specific demographic. However, much is yet to be understood. It is the hope that future studies, perhaps with the ability to focus for a longer term on permanent city-scale PBS systems will reveal more about how public bicycles might serve to address some of the urban sustainability issues of the coming century.
Resources


