Abstract

Cycling is becoming increasingly important as municipalities move towards providing sustainable transportation choices. This can be a challenge given small survey sample sizes and limited “rule of thumb” information. The City of Calgary addressed this challenge through three phases of investigation. The first phase involved conducting a stated preference cyclist survey to assess the relative attractiveness of bicycle infrastructure and facilities. The relative attractiveness of different bicycle facilities was determined by estimating a model using the stated preference survey results and creating four bicycle modes where the speed was weighted based on cyclist preference. In the second phase, bicycle trip tables were assigned to transportation network using the weighted bicycle modes to determine the impact on route choice. In the final phase, the weighted skims were used to estimate a series of simplified work tour mode choice models to determine the impact on model performance. The weighted bicycle modes improved route choice assignment as the bicycle volume distribution aligned with observed data and used dedicated pathways that the base bicycle modes ignored. The weighted skims also improved model performance by increasing the goodness of fit and improving policy responsiveness.

Statement of Financial Interest

The authors of this paper have no financial interest that would be affected by the acceptance of this brief.

Statement of Innovation

Cycling is becoming increasingly important as municipalities move towards providing sustainable transportation choices, however, incorporating cycling into regional planning tools can be difficult given small survey sample sizes and limited “rule of thumb” information. This brief explores a method to improve bike responsiveness that can be incorporated into operational models by incorporating stated preference route choice preferences in a bicycle path skimming procedure.
Improving Bicycle Responsiveness in Regional Models

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Introduction

In 2009, Calgary City Council approved and adopted a new Calgary Transportation Plan (CTP), a 60 year long range plan for transportation improvements in the city. With the approval of the CTP, there is an increasing requirement to provide transportation choices and focus on sustainability, health, and the environment. This led to the development the Calgary Cycling Strategy which outlined a plan to increase the number of people cycling in Calgary, increase the amount of bicycle infrastructure, improve cycling safety, and increase the level of satisfaction with cycling in Calgary. The Calgary Cycling Strategy was adopted in 2011 and $25 million in operating and capital funds were approved.

Despite being a winter city, Calgary has a robust cycling population. 19% of Calgarians ride at least once per week and 1.3% of Calgarians travel to work by bicycle. Even in the winter, 30% of cyclists on primary cycle routes continue riding in winter conditions. The City has invested heavily in cycling infrastructure and now has one of the most extensive pathway systems in North America; 770 km (480 mi) of multi-use pathways – 300km of which are cleared of snow in the winter, as well as 387 km of on street bikeways, 40km of marked bicycle lanes, and a new 1.2 km cycle track. (The City of Calgary, 2011)

The approval of these plans has highlighted the importance of regional planning tools, such as the Calgary Regional Transportation Model (RTM), to be able to respond to cycle policy and infrastructure changes. There are challenges associated with including bicycle modes in regional models as travel behaviour and influences of cyclists are different from auto or transit users. Typically motorists are modelled using a shortest path method that minimizes travel times, where travel time may not be the most important factor for cyclists. Revealed preference observations of bicycle trips can also be difficult to obtain through household travel surveys because they are a small proportion of daily travel and revealed preference observations do not always reflect the true preference of the cyclist (Hunt & Abraham, 2007). Further, while there are “rules of thumb” that relate the value of time to hourly wage rate for motorists, there is less “rule of thumb” information that can be used to check the results of model estimation work for cyclists (Abraham, McMillan, Brownlee, & Hunt, 2002).

Strategy & Results

Bicycle policy is a priority in Calgary, so it is important that the RTM be able to provide some level of analysis with respect to cyclists. Three phases of investigation have been explored over the past 10 years and this paper is intended to communicate the results of that work. The first phase was to conduct a stated preference survey of regular cyclists to assess their preferences with respect to cycling facilities including transportation network infrastructure and end of journey facilities. This survey was conducted in 2001 and the results of this survey and the model estimation are documented other work (Abraham, McMillan, Brownlee, & Hunt, 2002).

The second phase was to use the survey results to adjust the bicycle skims in the RTM and evaluate the impact on bicycle route choice. The stated preference survey revealed a priority of cycling facilities in the city where separated bicycle paths were preferred over cycling in mixed traffic. The stated preference model estimation results were used to create four separate bicycle modes to represent different bicycle facilities. Cycling on arterials in mixed traffic was the base bicycle mode and was
assigned a speed of 20 km/hr. The remaining bicycle mode speeds were weighted based on model estimation results and are summarized in Table 1. Links where bicycle travel was permitted were coded with a bicycle mode that reflected the facility type.

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Adjusted Mode Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>On arterials in mixed traffic</td>
<td>20 km/hr</td>
</tr>
<tr>
<td>On arterials with wide curb lanes</td>
<td>37 km/hr</td>
</tr>
<tr>
<td>On collector/local roads</td>
<td>46.5 km/hr</td>
</tr>
<tr>
<td>On separated bicycle paths</td>
<td>71.5 km/hr</td>
</tr>
</tbody>
</table>

To examine how the weighted bicycle speeds impacted bicycle route choice, it was necessary to compare assignment results from the model with observed route information. In 2006, The City of Calgary conducted the 2006 Downtown Commuter Cyclist Survey. In this survey, cyclists entering the central business district (CBD) were handed a paper survey to complete and mail back. Cyclists were asked about the characteristics of their journey, seasonal cycling, cycle facilities, and to map their route. The route information was digitized and summarized to produce the route choice distribution in Figure 1 and show a preference towards river pathways and a few key corridors to the north, east, and south of the CBD (The City of Calgary, 2007).

Figure 1: Observed Bicycle Route Distribution

Bicycle trips, with a destination in the CBD during the AM 2 Hour Peak Period, were assigned to the network as an auxiliary transit assignment in Emme Modeller. The bicycle volumes from the unweighted network show a relatively even distribution of bicycle trips into the central business district along the road network. The routes do not take advantage of the extensive pathway system, particularly along the river. The unweighted bicycle volume distribution is shown in Figure 2.
The weighted bicycle volume distribution was generally more representative of the observed route choice patterns as is shown by the increased volume along the river and the key corridors identified in the observed route data. The weighted bicycle volume distribution is shown in Figure 3.

The final phase was to determine what improvement the weighted bicycle skims would have in model performance. This was done by estimating a series of mode choice models using data collected from the 2012 Calgary and Region Travel and Activity Survey. The base mode choice model represents the simplified work tour mode choice model from the ongoing activity based model development; it is a
nested logit model with nests representing four auto-based modes (SOV, HOV 2 person, HOV 3 person, auto access transit), and two walk-based modes (walk, walk access transit) with the bicycle mode choice on a third limb of the logit tree. In keeping with the simplified nature, the model contains only travel time and cost components, alternative specific constants, and two household properties affecting the auto-based modes; the auto ownership status, and the household size. Variations on this base model were estimated using the cycle cost from three different sets of skims:

- the road network distance, which is the most commonly available network for cycle modelling;
- the walk network distance, which is an extension/modification of the road network adding the key links of Calgary’s substantial pedestrian/cycling network – offering many potential short cuts and routes not available to cars;
- and the weighted bicycle skims described above, using the stated preference model to weight the facility types.

In addition to the different networks, three other improvements commonly seen in bicycle/pedestrian modelling were also tested:

- a nonlinear treatment of time, using the travel time squared (which outperformed other formulations, including ln and square root) to represent the diminishing marginal cost of longer cycling journeys;
- the density at the destination, using the square root of the population + employment density (which outperformed other variables, such as the linear or log of this density, as well as a mixed use density – origin density was not significant in the estimation);
- and the slope of the tour, calculated as the absolute difference in elevation between the origin and primary destination centroids divided by the network distance (which outperformed other elevation measures – although it should be noted that a path-specific elevation or slope measure was not available for this work).

Table 2 below summarizes the results of these various estimations.

<table>
<thead>
<tr>
<th>Skims</th>
<th>Improvement</th>
<th>$\rho^2(0)$</th>
<th>$\rho^2(c)$</th>
<th>Log likelihood</th>
<th>Change in log likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>None</td>
<td>0.5630</td>
<td>0.2717</td>
<td>-4434.34</td>
<td>n/a</td>
</tr>
<tr>
<td>Road</td>
<td>Quadratic</td>
<td>0.5633</td>
<td>0.2722</td>
<td>-4431.27</td>
<td>3.07</td>
</tr>
<tr>
<td>Road</td>
<td>Density</td>
<td>0.5631</td>
<td>0.2719</td>
<td>-4433.40</td>
<td>0.94</td>
</tr>
<tr>
<td>Road</td>
<td>Slope</td>
<td>0.5630</td>
<td>0.2717</td>
<td>-4434.20</td>
<td>0.14</td>
</tr>
<tr>
<td>Road</td>
<td>All 3</td>
<td>0.5634</td>
<td>0.2724</td>
<td>-4430.03</td>
<td>4.31</td>
</tr>
<tr>
<td>Walk</td>
<td>None</td>
<td>0.5636</td>
<td>0.2728</td>
<td>-4427.76</td>
<td>6.58</td>
</tr>
<tr>
<td>Walk</td>
<td>Quadratic</td>
<td>0.5637</td>
<td>0.2730</td>
<td>-4426.58</td>
<td>7.76</td>
</tr>
<tr>
<td>Walk</td>
<td>All 3</td>
<td>0.5638</td>
<td>0.2731</td>
<td>-4425.78</td>
<td>8.57</td>
</tr>
<tr>
<td>Weighted Bicycle</td>
<td>None</td>
<td>0.5639</td>
<td>0.2732</td>
<td>-4425.09</td>
<td>9.25</td>
</tr>
<tr>
<td>Weighted Bicycle</td>
<td>Quadratic</td>
<td>0.5641</td>
<td>0.2736</td>
<td>-4422.71</td>
<td>11.63</td>
</tr>
<tr>
<td>Weighted Bicycle</td>
<td>All 3</td>
<td>0.5641</td>
<td>0.2737</td>
<td>-4422.60</td>
<td>11.74</td>
</tr>
</tbody>
</table>
It can be seen that the use of the weighted cycling network produces a substantially better model than the other skims and provides additional policy sensitivity. The minimal benefit from the density and in particular from the slope in the model estimations is probably at least partly attributable to the limited quality of these measures, particularly the simplistic origin vs. destination aspect of the slope. It should be noted that the simple inclusion of a fuller walk/bicycle network provided some benefit, but not as much as the weighted bicycle network.

**Conclusion**

Cycling is an important issue in Calgary as is demonstrated by an increasing level of investment in cycling infrastructure and initiatives. It is, therefore, important that Calgary’s regional planning tools are able to respond to infrastructure and policy changes with respect to bicycles despite the challenges associated with modeling bicycle modes.

Calgary used stated preference survey results to weight the speeds on bicycle facilities around the city. Survey results indicated that cyclist preferred multi-use pathways over mixed traffic and by weighting the attractiveness of different network links, the bicycle route choice in the model was improved. Using unweighted speeds, cyclists in the RTM tended to stay on the road network and did not take advantage of short cuts provided through pedestrian and cycle links. The weighted facilities improved the performance of the assignment so more cyclists were using the off street facilities. The weighted bicycle skims also produced a better model than other skims along with additional policy sensitivity.

The City of Calgary intends to continue to use weighted bicycle skims as they improve model estimation results, increase responsiveness to policy, and improve route choice distributions.
Bibliography


