MODELLING THE IMPACT OF WEATHER ON ACTIVE TRANSPORTATION

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Introduction

Making non-motorized modes transportation feasible alternatives for people's daily travel is a large part of the solution for worldwide problems such as oil depletion, climate change, road congestion and increase in obesity. Researchers have extensively looked at the impact of transportation activities on the environment for several years; however, the reciprocal relationship, the effect of climate and weather on transportation choices, specifically here the choice to walk or cycle, has remained less explored.

The primary objective of this paper is to investigate the influence of weather conditions on walking and cycling mode choice. Research, introduced in the following section, suggests that this impact is significant. However, there are certain gaps in existing research that this study aims to fill. By overcoming some of these drawbacks this paper aims to describe how mode choice decisions of different demographic groups are affected by weather conditions, especially for the walk and bike mode. A secondary objective of this paper is to highlight some of the behavioural differences between pedestrians and cyclists in order to help planners developed more successful policies and provide more effective infrastructure.

To meet the objectives highlighted above the authors explore the multinomial logit (MNL) and nested logit modelling approaches in investigating the impact of weather on the five basic modes of auto drive, auto passengers, transit, bike and walk. The focus of this research is to model behaviour of trip makers who are not captive to a limited choice set of alternatives. Home-based work trips meeting the above criteria are sampled from the 2001 travel survey of the Toronto region. Travel data are combined with hourly weather data reported by Environment Canada for the city of Toronto.

Background

There are some indicators for weather conditions or climate incorporated in active transportation behaviour and mode choice studies conducted by (Dill & Carr, 2003, Winters et al., 2007), amongst others. Such studies can be grouped into two major categories. One group contains those looking at national travel behaviour data, which could be rich on socioeconomic variables but weak in detail on weather condition variables. The second group consists of local studies that usually involve count data. Such studies collect little data on trip-maker characteristics and characteristics if alternative modes, while the weather condition data associated with the counts can be quite detailed and elaborate. Examples of both types of work and the associated advantages and drawbacks are presented here.

It is difficult to draw strong conclusions about relationships between weather and non-motorized mode share without controlling for the more influential factors, namely socioeconomic characteristics. This is especially true at highly aggregate level of trip data, which consequently result in aggregate weather condition variables. Dill and Carr (2003) for instance, in their analysis of bicycle commuting in forty three large cities in the USA included few socioeconomic characteristics such as auto ownership, in addition to other variables such as bike/pedestrian funding and facilities. Aggregate weather variables such as number of rainy days per year and annual inches of rainfall were also included in the analysis. Although the former was found to be significant for mode choice, its influence was shown to be very small. It is anticipated that temperature is also a significant variable and that the impact of precipitation is stronger than that suggested by Dill and Carr (2003); however it was not captured due to the aggregate nature of the data and limited socioeconomic variables.

A recent study by Winters et. al. (2007) looked at climate and socioeconomic characteristics on utilitarian cycling trends in fifty three Canadian cities. The data used in this study is rich with socioeconomic characteristics. The trip data, however, are aggregate and at the city level only. Consequently, the climate data included in the analysis are general and include variables such as number of days/year below freezing temperature, or number of days/year with precipitation. In spite of this level of aggregation the study still finds that every 30-day increase in precipitation is associated with a 16% decrease in annual bicycle mode share, and every 30-day increase in freezing temperatures results in another 9% decrease in bicycle mode share.

The aggregate nature of the data used in the studies introduced above, inhibits further analysis into the interaction between weather variables and different demographic groups. Additionally, it is not possible to associate specific weather conditions with specific trips in order to observe behavioural change at the detailed level. Lastly, more detailed weather condition variables such as different temperature ranges, and different precipitation conditions would provide more insight into trip-makers' behaviour.

The second group of literature introduced below tackles some of these drawbacks by collecting detailed weather data as a component of count surveys, but faces other data disadvantages.

One of the challenges with most count surveys is that little information is collected about the trip-maker's characteristics and the nature of the trip. Brandenburg et. al (n.a.) for instance, in their investigation of commuting and recreational bicycle trips in Vienna, in absence of more trip details, assume that all AM and PM peak period bicycle counts were commuting trips and the remainder to recreational trips. Other information such as age, income, education, and student status is not captured at all in a count survey. At the same time, this method of data collection offers some advantages. Data for this study were collected at the entrance point to recreational cycling paths for duration of one year. This made it possible to record microscale weather condition data on air temperature, vapour pressure, wind speed, cloud cover, and global radiation. Results of this analysis points at the higher sensitivity of recreation cyclists to "bad" weather compared to commuters.

It is evident that while several researchers have taken various approaches in looking at the impact of weather conditions on cycling, there is a smaller number of studies this impact on walking. One recent example is the work of Aultman-Hall et. al. (2009). Pedestrian counts, along with temperature, wind, humidity and precipitation were collected for a period of one year for this study. The authors concluded that there is a large influence of weather on walking in the downtown area. They further suggest that this justifies efforts on policy programs and counter measures for walking in adverse weather.

The higher number of cycling related studies in general may be due to the fact that the higher speed of cycling makes it a competitive mode with transit and even auto while walking is often not considered an alternative mode for longer trips. That said, as suggested by Morency et. al. (2009) walking can be a viable mode for shorter distance trips that make up a large portion of auto trips. Additionally, when comparing the impact of different variables on walking and cycling modes it is important to separate the two. Factors such as gender, street network and topography, for instance, influence these two modes differently. It is anticipated that different weather conditions may have different influences on walking and cycling as well.

Looking at the literature introduced in this section it is evident that there are some gaps in the current state of research on the impact of weather on walking and cycling. Further research into the impact of weather conditions on mode choice of various population groups, such as age groups or genders, can contribute greatly to policies and programs aimed at promoting non-motorized modes of transportation. Additionally, infrastructure provision and maintenance operations can also benefit from further insight into trip makers' preferences and choices in various weather conditions.

Data

The travel data and socio economic characteristics of trip makers used to estimate the models presented in this paper is sampled from the 2001 Transportation Tomorrow Survey (TTS). The TTS is a 5% trip diary survey of the Greater Toronto Area residents 11 years of age and older that is conducted every 5 years (Data Management Group, 2001).The five modes of auto driver, auto passenger, transit, walk and bicycle are sample.

As specified earlier, this study attempts to model behaviour of individuals who are not captive to a limited choice set of travel alternatives and have relatively easy access to all the five modes. Therefore a set of constraints are applied to the sample. These include:

- Restrict sample to individuals with a driver's licence to ensure that the auto driver mode is feasible;
- Restrict sample to individuals living in households with at least one vehicle to ensure that the auto driver or passenger modes are feasible;
- Restrict trips to those with both origin and destination within the city of Toronto boundaries to ensure that some form of reliable public transit (bus, LRT or subway) is available to trip maker;
- Restrict trips to those shorter than 20 km in Manhattan distance to ensure slower modes of transportation are feasible options;
- Restrict the sample to home-based work trips so that skipping the trip under suboptimal conditions is less likely.

The Transportation Tomorrow survey data were collected between September 8th and December 16th of 2001 and May 8th to June 12thof 2002. Hourly weather data corresponding to these time periods, collected at the Toronto Pearson International Airport weather station, which includes temperature, wind speed, humidity and sky conditions was purchased from Environment Canada (Environment Canada, 2008). Temperatures are adjusted for wind-chill and humidex based on equations provided by Environment Canada (Environment Canada, 2010). Several verbal descriptions are used for the sky conditions in the raw weather data. These were reduced by the authors to five mutually exclusive categories of clear, cloud, rain, shower and snow.

Modelling Specifications

In order to analyze the impact of weather conditions on the decision to walk and bike, this research relies upon the utility maximization theory in developing a multinomial logit model (MNL) of mode choice. In addition to a basic MNL model including the weather parameters, two sub-models are also developed. These models explore the interaction between weather and gender and weather and age. These will be referred to as the gender interaction model and the age interaction model, respectively.

Based on the hypothesis that the walk and bike modes have correlated unobserved characteristics nested logit modelling is experimented with. However, results suggested that the nested logit approach is not suitable for modelling the impact of weather on mode choice.

Model results and discussion

Results of the MNL model estimation are presented in Table 1. Significant parameters, along with their level of significance are presented in the table, while all variables with lower than 90% significance were dropped during the model estimation stage. The adjusted ρ^2 value for this model is 0.23, which is within the acceptable range of 0.2 and 0.4(UK Department for Transport, 2006). Based on prediction success analysis 59% of trips are correctly predicted, which is relatively good considering that minor modes of transportation are modeled here.

Weather variables

The parameters for the temperature categories provide some interesting insight into commute mode choice. The estimates suggest that in temperatures higher than 15 degrees the bicycle mode becomes insensitive to temperature, while for temperatures below 15 the utility of cycling gradually decreases. The walk mode is only sensitive to temperatures of 1 to 5 degrees. Moreover, compared to the parameter for walk mode in the 1 to 5 degrees temperature range, the bike mode is affected by cold temperatures twice as much. One can conclude that the walk mode is generally insensitive to temperature, with the exception of temperatures of just above zero, when it is not only cold, but precipitation is not in the form of snow and is therefore more of a deterrent.

Wind speed negatively affects cycling twice as much as walking, which is likely since cycling in windy conditions is much more energy intensive and inconvenient than walking. Similarly, precipitation in the form of showers negatively impacts cyclists about twice as much as pedestrians. It is anticipated that this is due to the fact that pedestrians have more and better alternatives for staying dry such as holding an umbrella. Also intuitively, rain negatively impacts cyclist slightly less than shower. For the walk mode however the rain parameter comes out to be positive, suggesting that the utility of walking increases in rainy conditions. One explanation for this is that there is a shift towards walking from the cycling in rainy conditions.

The probability of being an auto passenger gradually decrease as temperature increases. However, this decision is not affected by temperatures above 10 degrees. It is also surprising to see that the transit mode is seemingly insensitive to all temperatures relative to the auto mode. Another observation that may not be intuitive is that the utility of being an auto passenger decreases in cloudy, rainy and windy conditions. Further explanation on these results will be provided later in the discussion of the interaction models.

Other Variables

The relative magnitude and sign of the travel time and cost coefficients are reasonable. The values of time for auto drivers and transit riders, the two modes that have a cost associated with them, are calculated to be $13.0 and $2.5 respectively. It is expected for the transit mode to have a relatively smaller value of time than the auto mode, however both values are lower than those calculated for other models estimated using the TTS data (Miller et al, 2005, Roorda et al., 2009, McElroy, 2009). It is anticipated that this is due to the very specific nature of the sample used here.

Connectivity of the street network, represented by the intersection density variable, most significantly influences bicycle modeshare followed by walking and transit to lesser extents. Arterial density, which is a measure of auto travel flow in the neighbourhood, has a negative parameter for the bike mode, while positive for all other modes. This makes sense since cyclists often prefer to ride on non-arterial roads where there is less vehicle traffic. Arterial roads, however, are where stores and services are mostly located, so they provide better destinations for pedestrians trips, in addition to more busy and secure walking environments, compared to side roads. Moreover, it is likely that the motorized modes are positively affected by more arterial roads since it implies faster travel times.

The coefficients for all socioeconomic variables are of similar sign and relative magnitude as other mode-choice models and therefore, are not discussed here.

Table 1 Multinomial Logit Model Estimation Results

	Variable	Description	Coefficient
Level of Service Variables	aivtt	Auto in-vehicle travel time	-0.057
	tivtt	Transit in-vehicle travel time	-0.011
	ccost	Auto fuel cost	-0.267
	tcost2	Transit travel cost	-0.267
	pkCost	Parking cost	-0.267
	twaitt	Transit wait time	-0.151
	twalkt	Transit walk time	-0.067
	walkt	Walk time	-0.067
	biket	Bike time	-0.067

	Variable	Description	Auto Passenger	Transit	Bike	Walk
Land-Use Variables	Arterial_ Density	Ratio of kilometers of arterial road over all roads (average of origin and destination zones)	0.417*	0.671	-1.31	0.796
	Population_Density	Number of persons per square kilometer		10.684*		45.663
	Intersection _Density	Number of intersections per square km (sum of origin and destination zones)		0.102	0.155	0.128
Socio-Economic Variables	n_person	number of persons in household	0.345	0.185	0.053**	0.076
	n_vehicle	number of vehicles in household	-0.73	-1.006	-0.965	-0.917
	empft	full time employed		-0.675*		
	emppt	part time employed		-0.582*		
	empwahft	full time employed, work at home	-0.314**	-1.726	-0.405**	-1.145
	empwahpt	part time employed work at home		-1.52		
	male	gender (1 if male)	-1.403	-0.781	0.315	-0.541
	agebelow18	above 18 years of age	2.666	1.753		2.011
	age18_24	between 18 and 24 years old	0.922	1.126	1.183	1.029
	age25_39	between 25 and 39 years old		0.264	0.986	0.377
	age40_54	between 40 and 54 years old	-0.27		0.726	
	ageabove65	above 65 years old		-0.346*	-1.009**	-0.525*
Time-of-Day Variables	amp	AM Peak Period	-0.27	-0.504	-0.488	
	pmp	PM peak Period		0.348		0.477
Weather Variables	tempbelow0	temperature below 0 degrees	0.258*		-0.793*	
	temp1_5	temperature between 1 and 5 degrees	0.189		-0.478	-0.203*
	temp6_10	temperature between 6 and 10 degrees	0.104*		-0.54	
	temp11_15	temperature between 11 and 15 degrees			-0.255*	
	temp16_20	temperature between 16 and 20 degrees				
	temp21_25	temperature between 21 and 25 degrees				
	temp31_35	temperature between 31 and 35 degrees				
	tempaabove35	temperature above 35 degrees				
	cloud	Cloudy skies, no precipitation	-0.082*			
	rain	rainy conditions	-0.125*		-0.309*	0.317*
	showers	showers			-0.412**	0.195**
	wind	Wind speed in km/h	-0.002**		-0.006**	-0.003**
	_cons	Constant	-1.727	0.708*	-3.187	-0.171**

Note: Coefficients indicated with no asterisk are significant at 99%, coefficients indicated with one asterisk (*) are significant at 95% and coefficients indicator with two asterisk (**) are significant at 90%.

In order to gain further insight into the impact of weather variables on mode choice two sub models are also developed using some interaction terms between weather conditions and different demographic groups. The first sub-model looks at the interaction between age groups and weather variables, and the second sub-model explores the interaction between gender and weather variables. Using interaction variables means that there are a smaller number of observations available for parameter estimation for some variables. This has resulted in some interaction terms coming out to be insignificant. However the advantage of estimating these interaction models is that some other interaction terms corresponding to weather conditions that did not come out to be significant for certain modes in the basic MNL model come out to be significant here. The following subsections evaluate the estimated parameters by these two models. Coefficients for travel time and costs, in addition to coefficients for all non-weather related variables for these two models are similar to what is presented in Table 1 and therefore are not discussed here. Similar adjusted ρ^2 values and prediction success results as those presented in Table 4 are also calculated for the interaction models.

Gender interaction model

Results of the gender interaction model are presented in Table 2. Several interesting outcomes are apparent when comparing to the basic MNL results.

Even after controlling for general gender effects on mode choice (see gender coefficients in Table2), females' tendency to bike is about 1.5 times more negatively affected by low temperatures than males. Interestingly however, it appears that males' change in likelihood to bike is more drastically affected by change in temperature than females. Female cyclists appear to be insensitive to wind speed and various sky conditions, while male parameters are similar to those suggested by the basic MNL.

Parameters also suggest that the utility of walking is more positively affected by precipitation conditions compared to the auto mode. This is similar to the results of the basic MNL model and makes little logical sense aside from potential impact of cyclists switching to walking in sub-optimal weather conditions.

In the basic MNL model presented earlier none of the temperature category variables were identified to be significant for the transit mode, which was puzzling. The interaction model results suggest that there in fact is a significant impact by temperature on transit mode choice below 20 degree temperatures. These effects are however different in magnitude for male and female trip makers. This explains why, when grouped together, they would be estimated to be insignificant. As temperatures drop the likelihood of both genders to take transit is negatively affected.

Some interesting results are also evident for the sky condition variables for the transit mode, which all came out to be insignificant in the basic MNL model. The interaction model results suggest that after controlling for general gender effects on transit mode choice males are likely to switch to transit from auto in cloudy and rainy conditions, while females are insensitive to all sky conditions. Similarly, the auto passenger mode results show that in precipitation conditions and high wind speeds being an auto passenger becomes more attractive than driving for male trip makers, while females are again insensitive. This may suggest that while taking transit or being an auto passenger may be a more routine mode of commuting for females, males use transit and auto passenger as an alternative mode in sub-optimal conditions. The auto passenger results in the interaction model make more sense than those suggested by the basic MNL model. Results also suggest that, compared to males, it is more likely for females to switch from auto drive to auto passenger in cold and very hot temperatures.

Table 2 Gender Interaction Model Estimation Results for Weather Variables Only

	AutoPassenger		**Transit**		**Bike**		**Walk**	
	male	**female**	**male**	**female**	**male**	**female**	**male**	**female**
Gender	-1.338	0	-1.048	0	0.494	0	-0.481	0
below 0		0.398*		-0.333*	-0.994*		0.467*	
temp1_5	0.19*	0.255		-0.178*	-0.49*	-0.546*		-0.282*
temp 6_10	0.096**	0.161*	0.079**	-0.237*	-0.427	-0.583		
temp 11_15		0.053**	0.106*	-0.214*	-0.197**	-0.341*		
temp 16_20			0.16*	-0.191*			0.301*	
temp 21_25	base	base	base	base	base	base	base	base
temp 26_30								
temp 31_35		0.682**						1.712**
temp above 35								
cloud	0.398*		0.057**					0.255*
rain	0.255		0.089**		-0.259**		0.192**	0.572
shower	0.161*				-0.512**		0.268**	
wind	0.053**			0.003*	-0.012*			

$\rho^2 = 0.24$

Notes:

The coefficients for the Gender variable are presented here to indicate how much of the variation is captured by the gender variable and how much explained by the weather variables

Coefficients indicated with no asterisk are significant at 99%, coefficients indicated with one asterisk (*) are significant at 95%, coefficients indicator with two asterisk (**) are significant at 90% and insignificant coefficients are blank.

Age Interaction Model

Several parameters of interaction terms between temperature and age categories come out to be insignificant due to very disaggregate data and small sample sizes in this case. Nevertheless, results of the age interaction model, presented in Table 3, provide some interesting insight into the impact of weather on mode choice behaviour of various age groups.

It is interesting to see that younger trip makers are generally more sensitive to colder temperatures than older individuals for the bike and walk modes. Cyclists of 54 years old and younger are negatively influenced by temperatures of below 20 degrees. This influence is most pronounced for younger cyclists of below 25 years old. Similar results are evident for the walk mode for temperatures below 5 degrees. While there are not enough data points to make any conclusions about the impact of temperature on walk and bike mode share of the 55 to 65 and above 65 age groups, one can speculate that these age groups are more negatively influenced by low temperatures, similar to the below 25-year age group.

Similar to the results of the basic MNL model and the gender interaction model the counter intuitive relationship between rainy conditions and the tendency to walk is again apparent here.

Since observations for male and female trip makers are again grouped together in this interaction model, most temperature categories appear to be insignificant to the decision to take transit, while results of the gender interaction model suggests that that is not the case. Nonetheless, in spite of combining males and females, it is interesting to see that for the below 25 years and 55 to 65 years age groups, cold temperatures appear to negatively impact transit riders and encourage them to drive. It is anticipated that a similar observation could have been made for the above 65 age category if the sample size for this group was larger. Another interesting observation for the transit mode is that only the below 25 year age group is affected by rainy conditions. Results suggest that these individuals tend to switch to transit from driving under rainy conditions.

As reported earlier, results of the age interaction model suggested that very warm temperatures encourage females to switch to being auto passengers from auto drivers. Here results of the age interaction model provide further insight on demographic groups that are affected by very high temperatures. It is evident that trip makers of 65 years or older are also likely to switch to being auto passengers in hot temperatures, while all other age groups are insensitive to these conditions.

Table 3 Age Interaction Model Estimation Results for Weather Variables Only

Auto Passenger

		Age				
		below 25	25 to 39	40 to 55	55 to 65	above 65
Temperature	below 5		0.093**	0.226	0.311*	0.72*
	6 to 20					
	21 to 30	base	base	base	base	base
	above 30					1.899*
	wind					
	cloud					
	rain				-0.068**	
	shower					

Transit

		Age				
		below 25	25 to 39	40 to 55	55 to 65	above 65
Temperature	below 5	-0.172**			-0.101**	
	6 to 20					
	21 to 30	base	base	base	base	base
	above 30					
	wind					
	cloud					
	rain	0.308*				
	shower					

Walk

		Age				
		below 25	25 to 39	40 to 55	55 to 65	above 65
Temperature	below 5	-1.092*	-0.557	-0.398*		
	6 to 20	-0.745*	-0.45	-0.276**		
	21 to 30	base	base	base	base	base
	above 30					
	wind		-0.008**			
	cloud				0.162*	
	rain		-0.472*			
	shower		-0.758*			

Bike

		Age				
		below 25	25 to 39	40 to 55	55 to 65	above 65
Temperature	below 5	-0.264**	-0.166**	-0.14**		
	6 to 20					
	21 to 30	base	base	base	base	base
	above 30					
	wind		-0.006**			
	cloud					
	rain		0.234**	0.246**	0.068**	0.261*
	shower			0.281**		

Notes:

Coefficients indicated with no asterisk are significant at 99%, coefficients indicated with one asterisk (*) are significant at 95%, coefficients indicator with two asterisk (**) are significant at 90% and insignificant coefficients are blank.

Conclusions and Future Work

This study is an attempt at exploring the impact of weather conditions on active modes of transportation using the multinomial logit (MNL) and nested logit modeling approaches. While the nested structure proved to be unsuitable for this purposes the MNL model offers several interesting results.

The data used for this analysis is a restricted choice set of home-based work trips made using the five basic modes of auto drive, auto passenger, transit, bike and walk with the auto drive mode as the base alternative. The data is sampled from the 2001 travel survey of the Toronto region. Since this study attempts to model behaviour of individuals who are not captive to a limited choice set of travel modes, a series of constraints are applied to the sample. Travel data is combined with hourly weather data for the city of Toronto obtained from Environment Canada.

In addition to the anticipated impacts of weather condition on walking and cycling this study offers some interesting insights. Younger individuals' tendency to walk and bike is most negatively affected by cold temperature compared to older age groups. The bicycle mode is sensitive to temperatures only in conditions below 15 degrees. Furthermore, walk trips are only sensitive to temperature below 5 degrees and to a smaller extent than bike trips. Wind speeds negatively influence cyclists about twice as much as pedestrians. Similarly, precipitation in the form of showers affects cyclists more than pedestrians. Lastly, females' tendency to bike is about 1.5 times more negatively affected by cold temperatures than men. A puzzling observation is that there is consistently a positive parameter for rainy conditions for the walk mode in all three models.

Results of the mode choice models also offer insight into impact of weather on other travel modes. It appears that even after controlling for general gender effects on transit mode choice, male and female transit riders are very differently affected by cold temperatures. The general conclusion however is that transit becomes less attractive to both genders as temperatures decrease. Males are more likely to switch to transit mode in cloudy and rainy conditions, while females are insensitive to all sky conditions. Similarly, in precipitation conditions and high wind speeds being an auto passenger becomes more attractive than driving for male trip makers, while females are insensitive. Very warm temperatures appear to encourage females to switch to being auto passengers from auto drivers. Similarly, trip makers of 65 years or older are likely to become auto passengers in very warm temperatures, while all other age groups are insensitive to these conditions.

Some of the parameters for non-weather related variables provide further insight into differences between walking and cycling modes. These include population density, arterial density and intersection density. Arterial density is used as a measure of motorized traffic flow while intersection density offers a measure of street connectivity. Results suggest that while the walk mode is strongly affected by population density, cycling is insensitive to this measure. Additionally, while the walk mode share benefits from increased arterial density, the bike mode is negatively affected by presence of arterial roads. Lastly, intersection density appears to positively influence cyclists more than pedestrians.

It is evident that the impact of weather on mode choice, and more specifically on active modes of transportation is significant enough to deserve attention at the research, data collection and planning levels. The analysis provided in this paper provides insight on how mode choice decisions of different genders and age groups are affected by weather conditions, especially for the walk and bike mode. From a policy perspective, these results can significantly help with making active transportation promotional policies more successful by targeting specific age and gender groups. Additionally, by highlighting some of the behavioural differences between the two, this paper can contribute to better and more effective policies and infrastructure provision. Lastly, it is evident that all modes of travel are affected to a certain extent by weather. This provides an area of improvement for future travel surveys collected for Toronto and other regions. It is anticipated that observations may be quite different depending on the season during which travel survey data is collected. This also further impacts the accuracy of forecast models.

The next component of this research will be focusing on applying the developed models to evaluating impacts on mode choice as a result of the anticipated change in the climate of Toronto for the remainder of the century.

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