A Stated Preference Survey for Passenger Sensitivities to Travel Costs in the Greater Toronto Hamilton Area

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ABSTRACT

Metrolinx conducted a stated preference survey on passenger sensitivity to transit fare, cost, and other service factors in the Greater Toronto Hamilton Area (GTHA). This project is the largest fare sensitivity survey conducted within the GTHA (3,500+ responses collected from September to October, 2016), and the first fare sensitivity study completed in the region in decades. The results include elasticities for various travel segments broken down by time of day, origin/destination, and mode of travel, enabling better forecasts of how specific groups of passengers (e.g., off-peak GO Rail users, automobile users, local transit users) might respond to changes in price and service. This work can help evaluate existing and future pricing strategies, service changes, and other projects that may affect revenue and ridership across the entire GTHA.

1. Introduction

Understanding when and why people switch travel modes in response to travel price changes is central to a transit agency's operations. For Metrolinx, the regional transit agency for the Greater Toronto Hamilton Area (GTHA), knowing the sensitivity of passenger trip demand relative to changes in price is a necessary input when conducting business case analysis for new transit projects, programs and policies. To date however, any transit planners or financial analysts in the GTHA who sought to measure and isolate the impact of a given fare change on trip demand for the same travel mode would have had to rely on:

- GTHA fare elasticities from studies undertaken in the 1970s (1) or earlier; we are not aware of any regional data based studies undertaken in the years following
- Rules of thumb developed from observing recent fare changes in practice
- Fare elasticities estimated for other major cities in Canada
- Fare elasticities estimated for major cities in the US and/or the UK where fare levels and competitive contexts for travel modes can be very different to that in the GTHA

With this in mind Metrolinx conducted a survey-based analysis into the sensitivity of passengers, both existing and potential, to various changes in transit fares within the GTHA. The study will allow us to evaluate existing and future pricing strategies, service changes and other aspects of our current and future plans to better analyze revenue and ridership impacts. Results from this study will also inform future modelling, economic analysis and Metrolinx's business cases.

The work estimated fare elasticities for various travel segments broken down by time of day, origin/destination and mode of travel, enabling us to better forecast how specific groups of passengers (off-peak GO rail users, GO bus users, local transit users etc.) will respond to changes in price and service. This study did not only look at Metrolinx operated modes (GO rail and GO bus), but rather all major regional modes of transportation including automobile, local bus and streetcar services, subway and users of a combination of modes.

This paper describes the stated preference survey that was used to find new fare elasticities of demand for GTHA transportation modes. We detail the survey design, recruitment, approach and geographical distribution of responses. Steps taken on data preparation and the modelling work done to produce final fare elasticities of demand are also highlighted. Elasticities are then examined and broken down by time, mode and location. This highlights the key findings of this research: there are significant benefits to customizing fare policy, time matters, mode matters and location of travel matters when setting prices. Lastly, a summary of these results and project on the whole are discussed.

2. Background

Metrolinx, an agency of the Government of Ontario, was created in 2006 to improve the coordination and integration of all modes of transportation in the Greater Toronto and Hamilton Area. In the decade since, Metrolinx's responsibilities have grown to include medium- and long-range regional transportation planning, the construction and delivery of regional rapid transit projects such as the Eglington Crosstown LRT and the operation of GO Transit, the PRESTO electronic fare card system and the Union-Pearson (UP) Express airport rail service. Within Metrolinx's Planning and Policy division is the Research and Planning Analytics (RPA) team. The mandate of RPA is *to inform* corporate *strategic and* *tactical decision making through rigorous research and analytics including leading edge quantitative modelling and analysis.* Areas of work under the umbrella of this mandate include transportation modelling, ridership forecasting, writing business case guidance documentation and conducting economic analysis and research. This fare sensitivity work was sponsored in partnership between Metrolinx's Finance and RPA teams.

3. The Survey

3.1 Design and Implementation

Transit fare elasticities refer to the sensitivity of demand to a change in fare price. A survey is a sound method available to collect the data required to calculate price elasticities of demand for regional transportation modes. This is because a survey captures data on GTHA-residents' travel-choice behaviour directly from said users. The survey was designed as a stated preference (SP) survey. This means that respondents were asked to choose their preferred mode of travel based on alternative scenarios for travel costs and times. The travel mode choices offered to respondents were based on the characteristics of their reported trip, known as revealed preference (RP). This ensured that the alternative modes of travel offered to respondents were for the same trip (i.e., same start and end point) and for travel modes which the respondent considered feasible and relevant. The distinction between the two methods is that revealed preference covers existing travel choices while stated preference examines potential travel choices. The survey was conducted online and consisted of four parts:

- Part 1 asked respondents about "a recent trip made within the municipal boundaries of the GTHA – a trip made regularly, at least once per week" – referred to as the revealed preference (RP) trip. This provided the basis for determining a respondent's primary travel mode (e.g., are they a car driver, GO Rail users). It was asked that the RP trip be one made at least on a weekly basis to ensure that respondents had a good understanding of the trip and thus could accurately answer questions around mode choice, travel time and cost.
- Part 2 asked how respondents would make their trip if their primary travel mode were not available (i.e., if they had to choose another mode of travel).
- Part 3, the stated preference component of the survey, asked respondents to select their preferred travel option in eight different scenarios – each consisting of differing travel modes, times and costs for the same revealed preference trip described in parts 1 and 2. Results from this section formed the basis of the statistical analysis work.
- Part 4 asked eight optional demographic information questions around age, gender, household size, car availability and income level.

In Part 1 of the survey, respondents were assigned a primary travel mode after they reported their RP trip. Naturally, many reported trips used multiple modes of travel between origin and destination. Thus, it was essential to determine which one of the reported modes represented the primary mode of travel for the RP trip. This was done as follows. First, any trip using GO rail for at least one leg was assigned GO rail as the primary mode of travel. For trips that used transit (i.e. local bus/streetcar and/or subway/rapid transit and/or GO bus) in more than one trip leg, the mode with the highest travel time was assigned as the primary mode. If none of the transit modes were used, the following order was used to assign the primary mode: car driver, car passenger, taxi/Uber, and walk/cycle. Hence, all trips that had walk/cycle as the primary mode did not use any other mode of travel.

Part 3 was based on an adaptive random design. This meant that for the first four SP questions, respondents were offered trip choices where their primary travel mode (as determined in the RP section of the survey) was rendered progressively less attractive in travel cost (increasing cost) as compared to travel cost of the alternative travel modes. The next four SP questions offered respondents' trip choices where the primary travel mode was rendered progressively less attractive in travel time terms (longer travel times) as compared to the travel time of their alternative travel modes.

Surveying began in mid-September of 2016 and ran until the end of October. Invitations (see Figure 1) to complete the online survey were handed out at regional rapid transit stations and malls. As well, online invitations were sent to a random sample of GO rail and bus users as well as AskingCanadians respondent panels. The surveying process obtained 4,388 completions.

Figure 1: Survey Invitation Handout

3.2 Survey Approach

Sensitivity to fares was examined across three main contexts: Mode of Travel, Location and Time of Day. Modes of travel included in the survey were as follows:

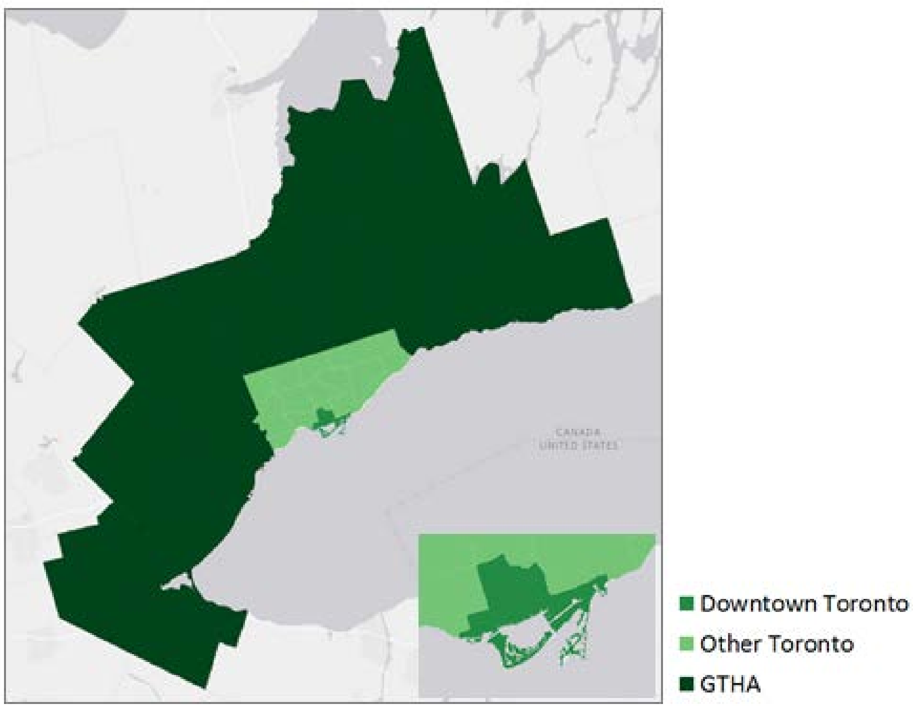
1. Car Driver (including a car share / rental vehicle)
2. Car Passenger (including carpooling)
3. GO bus
4. GO rail or UP Express
5. Local bus or Streetcar
6. Subway or Rapid Transit
7. Taxi or Uber
8. Walk or Cycle
9. Not Used

The GTHA travel market was segmented into six geographic segments in order to better understand how travel mode choices differ across origin-destination pairs. This allowed for the tracking of target survey responses by market segment. It also provided the ability to ensure that the survey results were representative of actual travel patterns in the region (e.g., suburbs to downtown, suburb to suburb). Specifically, trips within the GTHA were segmented based on geography (origin and destination) and time-of-day of the trip. The location component was segmented into three geographical areas (see Figure 2): Downtown Toronto, Other Toronto and Other GTHA. Origin-destination combinations between these three distinct areas allows for six possible origin-destination pairings:

1. **Trips within Downtown Toronto**
   This market segment was roughly defined as Toronto's Planning District 1 (PD 1), bounded by Bathurst Street, Dupont Street, Rosedale Valley Road, the Don River, Eastern Avenue, and Woodbine Avenue and also including the Fort York / Exhibition / eastern Liberty Village area. It is well-served by frequent local transit (streetcar or bus) and portions of two subway lines. Trip lengths are generally short, which makes active transportation (walking and cycling) more attractive.
2. **Trips between Downtown Toronto and the Remainder of Toronto ("Other Toronto")**
   This market segment represents all trips between Downtown Toronto and the rest of the city, including the inner suburbs of Etobicoke, North York, and Scarborough. Much of this market is well-served by transit, but some portions of the inner suburbs require long transit trips to reach downtown, thereby increasing the relative attractiveness of using a car.
3. **Trips between Downtown Toronto and the Remainder of the GTHA ("Other GTHA")**
   This market segment includes trips between Downtown Toronto and the remainder of the GTHA, including Durham, York, Peel, and Halton Regions and the City of Hamilton. This market is predominantly served by GO rail (primarily in peak periods), GO bus (primarily in off-peak periods) or by auto. Note that trips between downtown Toronto and other portions of southern Ontario, such as Barrie, Kitchener, and Peterborough, were excluded from consideration in this market segment and in the overall project. While these municipalities are served by GO rail and bus services, they lie outside the official boundaries of the GTHA.

4. **Trips within Other Toronto**
   This market segment represents trips within Toronto that do not start or end in downtown/PD1. Transit availability varies; some areas are well-served by subway but most transit trips within this segment would require segments on buses or streetcars.
5. **Trips between Other Toronto and Other GTHA**
   This market segment includes trips between the inner suburbs or adjacent Downtown neighbourhoods and the outer suburbs making up the rest of the GTHA. Transit availability varies but generally requires use of local buses as the subway does not extend outside of Toronto. GO rail and bus are options in limited areas.
6. **Trips within Other GTHA**
   This market segment represents all trips within the region that start and end outside of Toronto, including trips within a single non-Toronto municipality (such as the Region of Peel) and trips between non-Toronto municipalities. Most of this area is suburban, with sporadic higher-density pockets and lower-density rural areas on the outskirts. It also contains more limited transit service, and transit is generally much more time-consuming than a comparable auto trip.

Figure 2: GTHA Map of Three Segmented Zones



Time of day was applied to each of these six geographic segments. To do this, all six segments were divided by peak and off-peak, forming a total of 12 market segments. Peak trips are defined as trips starting between 6:00 AM and 8:59 AM in the morning or 3:30 PM and 6:29 PM in the afternoon. Off-peak trips consist of trips starting at all other times or on weekends.

3.3 Survey Completions

The survey was designed to achieve a representative set of responses across the region by mode, geographic segment and time. It also focussed on transit markets of particular interest to Metrolinx, such as GO rail users. These two objectives were achieved by setting specific target responses by segment and by primary travel mode. Minimum target responses for specific segments ranged from 25 (for Car Passengers across all geographic segments and time periods), to 60 (GO rail users from Other GTHA to Downtown Toronto in the off-peak). The survey target of 3,000 completed responses was well surpassed with a final figure of 4,388 completions.

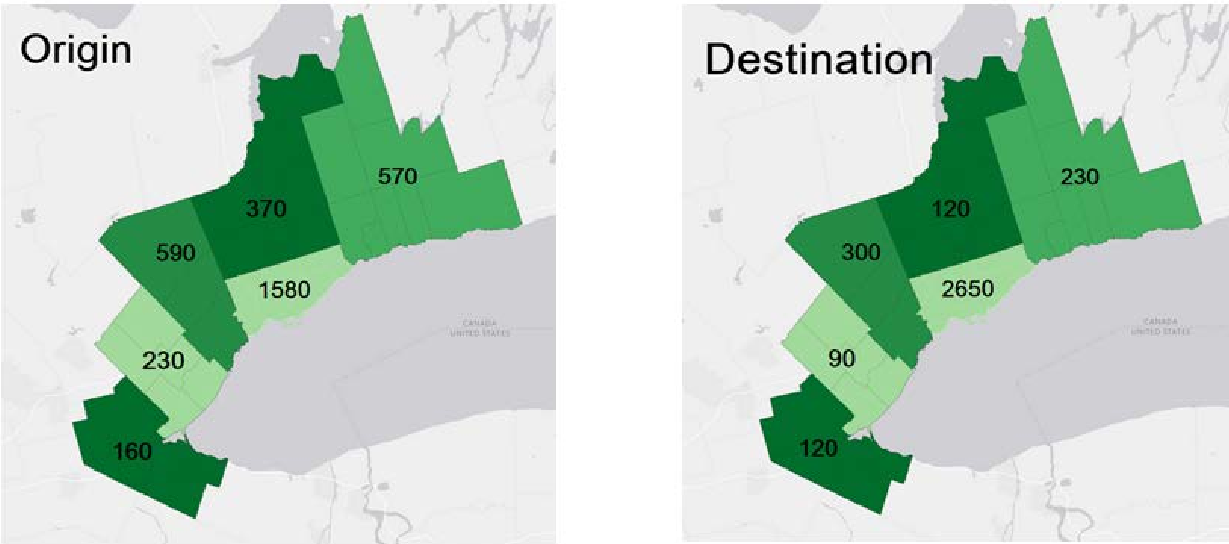
Table 1 shows completed surveys by geographic segment and by respondents' primary mode of travel. The results show that the survey responses achieved a majority of response targets. Cells with bold and italicized figures indicated segments where target responses were not achieved. For example, target responses of 50 car drivers (and 25 passengers) per segment were not achieved for several geographic segments such as Other Toronto to Downtown. In addition, the minimum 200 responses per segment were not achieved for the Within Downtown geographic segment despite surveying attempts to boost responses here. Minimum respondent quotas by primary travel mode were achieved for all modes, except car passengers. To spatially represent this data, Figure 2. shows respondent origin and destination totals by GTHA region and municipality, those being Durham, Halton, Hamilton, Peel, Toronto and York.

Table 1: Completed Survey Responses by Segment

	Within DT		Other TO - DT		Other GTHA - DT		Within Other TO		Other GTHA - Other TO		Within Other GTHA		Total				
	Peak	*Off-peak*	*Peak*	*Off-peak*	*Peak*	*Off-peak*	*Peak*	*Off-peak*	*Peak*	*Off-peak*	*Peak*	*Off-peak*	*Peak*	*Off-peak*	*Total*	*Min. Responses*	*Mode Targets*
Car Driver	***11***	***9***	***38***	53	65	63	76	92	141	153	201	209	532	579	1111	500	1200
Car Passenger	***1***	***6***	***12***	***8***	***12***	28	***10***	31	***20***	36	39	60	94	169	263	250	
GO Bus	1	1	4	2	32	56	12	14	68	44	***24***	***17***	141	134	275	210	520
GO Rail or UP Express	3	5	89	32	729	157	5	1	80	41	28	11	934	247	1181	175	
Local Bus or Streetcar	22	29	93	69	***22***	17	104	127	***49***	***47***	***52***	73	342	362	704	300 joint bus-subway	500 bus only
Subway or Rapid Transit	13	28	173	131	36	27	60	76	12	15	5	6	299	283	582		300 subway only
Taxi or Uber	8	4	10	8	2	2	5	15	5	7	3	4	33	40	73		

Walk or Cycle	26	27	20	26	9	4	17	31	2	5	10	22	84	115	199	180	180
Total	***85***	***109***	**439**	**329**	**907**	**354**	**289**	**387**	**377**	**348**	**362**	**402**	**2459**	**1929**	**4388**		

Figure 3. Respondent Origin and Destination Totals by GTHA Region



4. Data Preparation

Before the completed survey data could be used to calculate fare elasticities, extreme outliers and survey responses with implausible or inconsistent response values were identified in a data cleaning process. This was first done for the typical trip which respondents reported as part of their RP trip component of the survey and then for the stated preference responses. Once identified, problem survey responses were excluded from the data set in their entirety (i.e., the entire RP and SP responses were excluded for the respondent under consideration). The data cleaning process used a rule-based approach to filter out trips where reported travel times, distances and costs far exceeded or understated expected and plausible values. These filters removed a total of 864 outliers. Thus, out of the initial 4,388 completed surveys the final dataset contained 3,524 clean observations. These are shown in Table 2, distributed by primary mode of travel and market segment. Overall, 58% of trips (N=2,057) were taken during the peak period and 42% (N=1,467) during the off-peak period.

Table 2: Number of Respondents by Mode of Travel* and by Market Segment

Primary Mode	Within DT		Other TO - DT		Other GTHA - DT		Within Other TO		Other GTHA - Other TO		Within Other GTHA		Total		
	Peak	*Off-peak*	*Peak*	*Off-peak*	*Peak*	*Off-peak*	*Peak*	*Off-peak*	*Peak*	*Off-peak*	*Peak*	*Off-peak*	*Peak*	*Off-peak*	*Total*
Car Driver	3	2	31	36	51	40	58	71	126	128	164	161	**433**	**438**	**871**
Car Passenger	1	1	11	6	8	19	10	20	13	34	34	45	**77**	**125**	**202**
GO Bus	0	0	2	1	29	46	9	9	48	30	20	13	**108**	**99**	**207**
GO Rail or UP Express	0	0	80	25	631	132	4	1	67	23	17	6	**799**	**187**	**986**
Local Bus or Streetcar	17	23	84	57	20	14	89	102	40	34	43	57	**293**	**287**	**580**
Subway or Rapid Transit	11	20	161	114	30	20	48	58	10	11	4	4	**264**	**227**	**491**
Taxi or Uber	3	1	6	5	2	1	3	6	4	7	3	2	**21**	**22**	**43**
Walk or Cycle	23	22	12	21	8	2	10	18	2	3	7	16	**62**	**82**	**144**
Total	**58**	**69**	**387**	**265**	**779**	**274**	**231**	**285**	**310**	**270**	**292**	**304**	**2057**	**1467**	**3524**

Note: (*) Mode of travel is the primary travel mode assigned to each respondent.

GO rail had the highest mode share at 28% of all RP trips, followed by 25% for car drivers. Local bus/streetcar and Subway/rapid transit have similar mode shares, with 16% and 14% of overall trips respectively. Subway/rapid transit had the dominant mode share for trips between Downtown and Other Toronto with a 42% share in the peak. Bus/streetcar had the dominant mode share for trips Within Other Toronto with just under a 40% mode share. GO rail dominated RP trip choices for respondents traveling between Other GTHA and Downtown, with 81% and 48% shares in the peak and off-peak respectively. GO bus plays an important role in the off-peak period for trips between Other GTHA and Downtown, where it has a 17% mode share.

Given the oversampling of GO trips in the survey responses a weighting exercise occurred to ensure that our results matched actual mode shares in the GTHA. To best reflect GTHA mode shares the fare sensitivity results were weighting against the 2011 Transportation Tomorrow Survey (TTS). This survey occurs every five years in Southern Ontario and aims to capture 5% of all residents travel patterns. Once cleaned, this 5% is expanded to match population levels in Southern Ontario and form a best estimate of how the region's residents travel. Using TTS mode shares reported for 2011, survey responses were weighted to reproduce the TTS mode shares by market segment for the both peak and off-peak periods. This ensured an accurate reflection of mode choice and geographic distribution amongst survey responses.

Since travel modes in TTS do not exactly match the primary travel modes used in the fare sensitivity survey, some assumptions were required to assign TTS observations to a unique mode. Specifically, "Joint Subway and Bus/Streetcar" trips in TTS were re-assigned either to "Subway" trips or to "Bus/Streetcar Trips" depending on the likely primary travel mode for these trips by geographic segment. Trip information for Taxi/Uber in TTS data was not available, thus Taxi trips were not weighted.

4.1 Demographic, Household and Trip Characteristics of Respondents

Key highlights of respondent's demographic and household characteristics include:

- **Gender:** 45% of respondents identified as male (N=1,585) and 53% identified as female (N=1,883).
- **Age:** 66% of respondents were between the ages of 25 and 54 and 49 respondents reported being under the age of 18.
- **Trip purpose:** 58% of respondents reported a work commute trip for their RP trip. The second and third most popular trip purposes are social or recreational (14%) and shopping (8%). Business related trips comprised 5% of trips.
- **Employment status:** 78% of respondents were either full-time employees (61%), part-time employees (10%) or self-employed (7%), while 8% of respondents were in school.
- **Number of persons in household:** with respect to household composition, 32%, 20% and 19% of respondents reported being in 2, 3 and 4 person households respectively. People living alone represent 16% of respondents.
- **Number of vehicles available in household:** the survey asked respondents how many vehicles they own, lease, or have available for regular use by the people who currently live in their household. 42% of respondents reported having access to one vehicle, 30% have access to two vehicles and 18% do not have access to a vehicle.
- **Household income group:** respondents were distributed fairly equally between the seven available income bands, with shares varying between 7% and 15%. 15% of respondents reported to be within the $50,000-$74,999 as well as $75,000-$99,999 bands. However, 20% of respondents chose not to answer this question.
- **Highest level of education attained:** Almost 60% of respondents have a university degree, 24% have a college degree and 16% a secondary or high school diploma.

5. Model Calibration

The mode choice model was calibrated using the stated preference choice data collected in the fare sensitivity survey. Multiple model specifications were tested before calculating final elasticities for the peak (AM & PM) and off-peak (Midday & Evening). In this calibration effort, multiple model specifications were tested, including multinomial as well as hierarchical/nested logit models. The multinomial models turned out to produce the best model results. The preferred multinomial model, referred to as Model 0, was one where the choice of primary travel mode depended on travel costs and travel time, but where the time and cost sensitivity of mode choice did not differ by travel mode. For example, GO rail users were assumed to have similar cost sensitivity as car users or transit users (but not necessarily the same fare elasticity value, since the latter depends on the value of travel cost and travel time when any change in fare occurs). Other types of models were tested (e.g. where cost and/or time sensitivity differed by travel mode), but none of these performed better than the preferred model. The preferred model was calibrated separately for the peak and off-peak periods, thereby generating a separate set of elasticities for the two periods.

The results for Model 0 for the peak period are presented in Table 3 below. Note that a separate set of result for the off-peak model are omitted here due to space considerations. These results were based on the dataset following the cleaning and weighting procedures discussed above.

Table 3: Results for Multinomial Logit Model 0 (Peak Period)

Mode	Model 0 (Peak Period)			
	ASC	*Time Coefficient*	*Cost Coefficient*	*VOT ($/minute)*
Car Driver		-0.0175 (0.00158)	-0.07518 (0.00745)	$0.23
Car Passenger	-0.49052 (0.0774)			
GO Bus	-1.14964 (0.20589)			
GO Rail or UP Express	-0.25145 (0.17047)			
Local Bus or Streetcar	-1.5452 (0.1049)			
Subway or Rapid Transit	-1.01582 (0.13317)			
Taxi or Uber	-1.49747 (0.14887)			
Change Destination	-5.50454 (0.26322)			
Not Travel	-3.89824 (0.15313)			
Walk/Cycle	-0.83297 (0.12117)			
Log Likelihood	-1806.87			
Chi-squared	2814.99			
Prob [chi squared > value]	0.000001			

Note: all coefficients are significant at 99% level except ASC for GO rail; values in parenthesis are standard errors.

6. Elasticities

An elasticity of demand with respect to fares summarizes the responsiveness of user demand (i.e., number of trips) for a particular mode of transportation to a change in the fare charged for said mode. In other words, it is the percentage change in ridership as a result of a percentage change in fares/price. According to the results, to be discussed in detail later, GO rail users have a peak period elasticity of -0.21. Thus, a 1% increase in GO rail fares would result in a 0.21% reduction in GO rail trips. If the fare increase were 10% then a 2.1% reduction in trips would occur.

In the current context, the reported elasticities are derived from a mode choice model which is itself a summary representation of mode choice behaviour in practice. Travellers are assumed to choose among the travel modes available to them that which will maximize their utility (i.e. their well-being). These choices are subject to travel time and budget constraints (i.e., they only have so much time and budget available). In the case of public transit, the choices are also subject to schedule constraints (i.e., transit services are subject to a fixed timetable), including schedule constraints set by the return journey. Hence, mode choice behaviour can be quite complicated in practice. It follows that any demand model is necessarily a simplification of actual mode choice behaviour.

In addition, once a preferred demand model is in place, the elasticity must be derived for a certain set of travel costs and times. For example, for the same demand curve/model a fare elasticity can be very high in absolute terms if calculated at a high fare level (i.e., on the steep portion of a downward-sloping demand curve) or much lower if calculated at a low. In this work, elasticities were derived using travel costs and times for each individual RP trip and then aggregated, providing more accurate estimates.

There are several other features of elasticities which are important to take into account when applying them to any change in fares. First, the magnitude of the fare change can make a difference. The elasticities reported below were derived from a small change in fares (1%). However, the elasticity calculation was also undertaken for greater changes (10% and upwards) and displayed no material change in elasticity values.

Second, the elasticities reported below capture the change in demand for one travel mode resulting from a change in fare for the same mode, assuming that the fares, travel costs and travel times of competing modes remain unchanged. In other words, the elasticity captures the demand response to fare changes alone. This is an extremely valuable property of elasticities – separating the fare impact from all other impacts that affect travel demand (e.g., population changes, service changes, network changes, new travel modes). Interestingly, it is also the reason why elasticities are superior to rules of thumb based on practical experience, which cannot easily isolate the impacts of different demand drivers.

Third, elasticities apply to a particular time period – in this case, a time period consistent with the stated preference questions answered by respondents. For these results, the time period is relatively short (ranging from 3-6 months to up to two years). This is the time period over which the full demand response, as represented by the elasticity values in this section (without induced demand), are reached.

These short-term fare elasticities (without induced demand) are likely an under-estimate of the true short-term demand responses to fare changes. This is because respondents to the RP questions did not have the option to 'not travel' or 'change destination' when choosing alternative modes of travel in Part 2 of the survey. These same options, which were available in Part 3 (stated preference) were likely under-reported in part because these can take longer to think through than other survey questions. As a result, a sensitivity analysis was undertaken for both the peak and off-peak period results in order to incorporate these two options (henceforth referred to as 'induced demand'). For Part 2 of the survey, it was assumed that the 'not travel'/'change destination' options would have a 'mode share' of half the magnitude of all the other modes. Given that induced demand is likely to be more important in the off-peak period, the assumption used for that period is that the two options have the same mode share as all the other modes combined. The results with the induced demand should thus be interpreted as a set of sensitivity results pointing to the high end of the range of plausible results.

In order to obtain fare elasticities, first, travel cost elasticity of demand had to be calculated for a given mode (mode x) and was based on the following steps:

i) Calculate the overall mode shares based on the observed/declared travel characteristics (i.e., with the RP trip travel costs and times for each observation) using the sample enumeration method.
ii) Increase the travel cost of mode x for all individuals in the sample by 1%.
iii) Re-calculate the overall mode shares based on the updated travel characteristics (increased travel cost for mode x and unchanged observed/declared travel costs for all other modes) using a sample enumeration method.
iv) Calculate the elasticity for mode x based on the difference in the share of mode x between Step (i) and (iii).

6.1 Results by Time and Mode

Table 4 shows short-term fare elasticities during the peak period, both without and with induced demand. The results indicate that GO bus users would have the highest demand response to a fare change. The elasticities for GO rail users are the second highest, but are much closer to the elasticity values for the other transit modes which are split into three categories. This split was done for several reasons: (i) there are a significant share of joint bus/subway trips in Toronto; (ii) these trips tend to have a higher fare/cost ratio relative to other trips with transit as a primary travel mode, and hence, may be subject to different fare elasticities; and (iii) joint bus/subway trips are usually subject to a single transit fare (i.e., there is a free transfer between TTC subways and buses).[1]

Table 4: Fare Elasticities of Demand for Selected Modes (Peak Period)

Primary Mode	Fare Portion of Total Costs	Short-Term Fare Elasticities	
		Without Induced Demand	With Induced Demand (**)
Car Driver(*)	86%	-0.05	-0.10
GO Bus	83%	-0.48	-0.53
GO Rail or UP Express	81%	-0.21	-0.32
Local Bus or Streetcar only(1)	87%	-0.16	-0.20
Subway or Rapid Transit only(2)	85%	-0.15	-0.20
Joint Bus/Subway(3)	98%	-0.18	-0.22

1. *Some survey respondents erroneously reported double transit fares for their RP trip (e.g. a fare component for both bus and subway legs). This would have affected the value of the fare options offered to respondents in the stated preference component of the survey, but it was decided not to remove these responses from the survey because it is not clear that these would impart a particular bias to the responses.*

Notes: (*) Demand elasticities with respect to fuel costs. (**) Elasticity estimates adjusted for induced demand by incorporating Not Travel and Changed Destination as two additional choices available to users in response to changes in fares.
(1) Trips which include one or more Local Bus/Streetcar legs and no other transit mode.
(2) Trips which include one or more Subway/Rapid Transit legs and no other transit mode.
(3) Trips which include both Local Bus/Streetcar and Subway/Rapid Transit legs.

Table 5 shows the off-peak fare elasticities. As would be expected from trips which are more likely to be discretionary, the elasticity response is higher compared to the peak period (when users are likely completing non-discretionary trips to work or school). This is clearly the case for GO rail users, where the off-peak elasticity is about 45% higher than in the peak. Meanwhile, GO bus elasticities are very similar between peak and off-peak periods. The elasticities for bus-only users (i.e. for users whose RP trip includes only one or more bus legs and no other transit mode) are very similar to those for subway-only users – at just under -0.2 in absolute terms. This is the case for both the peak and off-peak periods, with the elasticity response for the off-peak about 10% higher than for the peak period. This may reflect the fact that these users may have limited alternative mode options. However, joint bus/subway users (i.e., users whose RP trip includes at least one bus/streetcar leg and one subway/rapid transit leg) have slightly higher elasticities than the bus-only and subway-only users (both in the peak and off-peak periods). This is plausible in that joint bus-subway users probably have more alternative mode options than subway-only or bus-only users (e.g., a number of these users could conceivably switch to bus-only legs, albeit probably at the expense of longer travel times). In addition, the off-peak elasticity response for these users is about 10% higher than for the peak period.

The lowest elasticity responses reported are for car users (i.e., those whose reported primary travel mode is automobile) in both the peak and off-peak. This suggests that these users are generally more difficult to shift away from their primary travel mode through fare changes – when compared to those who are already users of one or more transit modes. This is also consistent with the fact that perceived travel costs for car users (i.e., fuel, parking and toll costs) tend to be lower than for other travel modes. Moreover, the elasticity response for the off-peak period is slightly lower than for the peak. The peak elasticity may not be materially different than the off-peak value, but it is also conceivable that off-peak car users may feel they have even fewer attractive travel options than peak period users.

Table 5: Fare Elasticities of Demand for Selected Modes (Off-Peak Period)

Primary Mode	Fare Portion of Total Costs	Short-Term Fare Elasticities	
		Without Induced Demand	With Induced Demand
Car Driver	91%	-0.04	-0.11
GO Bus	81%	-0.46	-0.52
GO Rail or UP Express	76%	-0.42	-0.50
Local Bus or Streetcar only	88%	-0.19	-0.24
Subway or Rapid Transit only	89%	-0.17	-0.24
Joint Bus/Subway	99%	-0.20	-0.27

From Tables 4 and 5 we are able to make multiple observations when comparing fare elasticities by mode:

Car vs GO rail

- Across the GTHA, car users are least sensitive to changes in price (fuel cost)
- Compared to car, GO rail users (without induced demand) are roughly four times as sensitive to changes in the price in the peak, and ten times as sensitive in the off-peak

GO vs Local Transit

- GO rail users are slightly more sensitive to changes in price than local transit users in the peak
- In the off-peak, GO rail and bus users are roughly twice as price sensitive to price as transit users

GO Bus vs GO Rail

- Go bus users are over twice as price sensitive as GO rail users in the peak period
- However, in the off-peak sensitivities between GO bus and rail are nearly identical

Local Transit

- For local transit, subway-only trips are least sensitive to price changes when compared to joint bus/subway or bus-only trips

Fare elasticities are not reported for car passengers, because the cost borne by passengers is ambiguous (some respondents report zero cost; others report a share of overall auto operating costs). Taxi/Uber elasticities are not reported due to the small sample size gained. Walk/cycle elasticities are not reported because there is no perceived cost in almost all cases, so the concept of elasticities is not relevant. Further, confidence intervals for the peak and off-peak period fare elasticities, both without and with induced demand, were calculated. Specifically, the fare elasticity for each mode lies within the range of the lower and upper bound at a 95% confidence level.

6.2 Results by Location (Market Segment)

Tables' 6 through 9 report selected elasticity values for individual market segments, where the number of survey responses supports a meaningful interpretation. Tables' 6 and 7 present the segment-specific elasticities for the model without induced demand (peak and off-peak respectively). Table 8 and Table 9 present the segment-specific elasticities for the model with induced demand (peak and off-peak respectively). The rationale for computing fare elasticities for these selected segments is that the elasticities may differ from the "All Segments" value due to (i) differences in travel times and costs by mode between these segments (for the same travel mode) and (ii) differences in the ratio of fares to total costs across segments (for the same travel mode). Further, it allows for a finer level of analysis beyond simply looking at elasticities by time and mode, allowing us to better understand specific regional travel markets and form the basis of our key findings.

Table 6: Fare Elasticities of Demand for Selected Modes and Market Segments without Induced Demand (Peak Period)

Primary Mode	Within DT	Other TO - DT	Within Other TO	Other GTHA – DT	Other GTHA - Other TO	Within Other GTHA	All Segments
Car Driver	-0.05			-0.24	-0.04	-0.04	-0.05
GO Bus				-0.58	-0.44		-0.48
GO Rail or UP Express		-0.33		-0.16	-0.37		-0.21
Local bus or Streetcar only	-0.16				-0.21	-0.17	-0.16
Subway or Rapid Transit only	-0.15						-0.15
Joint Bus/Subway trips	-0.17						-0.18

Table 7: Fare Elasticities of Demand for Selected Modes and Market Segments with Induced Demand (Peak Period)

Primary Mode	Within DT	Other TO – DT	Within Other TO	Other GTHA - DT	Other GTHA - Other TO	Within Other GTHA	All Segments
Car Driver	-0.08			-0.31	-0.11	-0.09	-0.10
GO Bus				-0.58	-0.53		-0.53
GO Rail or UP Express		-0.38		-0.29	-0.48		-0.32
Local Bus or Streetcar only	-0.18				-0.29	-0.20	-0.20
Subway or Rapid Transit only	-0.15						-0.20
Joint Bus/Subway trips	-0.18						-0.22

Table 8: Fare Elasticities of Demand for Selected Modes and Market Segments without Induced Demand (Off-Peak Period)

Primary Mode	Within DT	Other TO - DT	Within Other TO	Other GTHA – DT	Other GTHA - Other TO	Within Other GTHA	All Segments
Car Driver	-0.04			-0.17	-0.05	-0.04	-0.04
GO Bus				-0.50	-0.48		-0.46
GO Rail or UP Express		-0.60		-0.36	-0.42		-0.42
Local Bus or Streetcar only	-0.19				-0.22	-0.18	-0.19
Subway or Rapid Transit only	-0.13						-0.17
Joint Bus/Subway trips	-0.19						-0.20

Table 9: Fare Elasticities of Demand for Selected Modes and Market Segments with Induced Demand (Off-Peak Period)

Primary Mode	Within DT	Other TO – DT	Within Other TO	Other GTHA - DT	Other GTHA - Other TO	Within Other GTHA	All Segments
Car Driver	-0.10			-0.28	-0.16	-0.11	-0.11
GO Bus				-0.57	-0.56		-0.52
GO Rail or UP Express		-0.62		-0.48	-0.43		-0.50

Local Bus or Streetcar only	-0.24		-0.29	-0.23	-0.24
Subway or Rapid Transit only	-0.18				-0.24
Joint Bus/Subway trips	-0.26				-0.27

Examining GO rail elasticities by location demonstrates the benefit of segment specific results, in this case, the Other GTHA to Downtown Toronto versus Other Toronto to Downtown markets. The peak period GO rail segment (without induced demand) for users travelling between Other GTHA and Downtown Toronto was the only travel segment where GO rail users demonstrated less price sensitivity than car users. This finding fits with the fact that a majority of GO rail users originate from Toronto's suburban communities and satellite cities in the 905 area code (classified at Other GTHA in this survey), making trips to and from downtown Toronto during the peak periods. For many people, driving to and from these communities in the peak is a less attractive option compared to GO rail services. This is due to lengthy travel times, congestion, fuel costs and parking availability downtown. Few other alternatives exist for Other GTHA to Downtown Toronto travellers other than GO rail. Thus they display low price sensitivity for this mode.

GO rail's service network is not only located in the 905 area code. Within the City of Toronto several stations service the inner suburban communities of Etobicoke, North York and Scarborough (classified as Other Toronto in this survey). Stations located here have peak period services just like the outer suburban stations. However, peak period GO rail users located within Other Toronto display price sensitivities nearly double that to Other GTHA to Downtown Toronto users. While both market segments have the same downtown destination in the morning, and point of origin in the evening (Toronto's Union Station), they noticeably differ in price sensitivity. This is likely due to the fact that competitive alternative modes exist to service this trip. Travellers from the Other Toronto segment can utilize the Toronto Transit Commission, active transportation options or drive. Car use showed minimal price sensitivity in this market segment as travel times are lower to downtown than for trips originating in the Other GTHA segment.

7. Summary

Understanding when and why people switch travel modes in response to changes in travel price is central to the operations of a transit agency. Prior to the release of these fare elasticity results, transit planning and business case analyses in the GTHA had to rely on elasticities from outdated and differing sources. The stated preference travel survey detailed here helps to fill this gap in the GTHA. To our knowledge this was both the largest fare sensitivity survey conducted (3,500+ responses collected from September to October, 2016), and the first such study completed in the region in decades. Because of this work, Metrolinx is now equipped with current and contextually appropriate price elasticities of demand for specific travel and modal segments by time period.

The key findings from this study are that time, mode and location matter when setting fare levels. In other words, there are significant benefits to fare policy customization. Fare pricing is a crucial factor in optimizing ridership growth for all transit modes across the entire Greater Toronto Hamilton Area. These new elasticities will enable Metrolinx and other regional transit providers to better evaluate how fares impact ridership and revenues. It must be noted that these results apply within two years of a change in price. Over longer periods, users may change location of residence or employment based on travel prices. Thus, this work will hopefully be the first in several more studies to come.

8. References

1. Toronto Transit Commission (TTC). 1977. *Toronto Fare Policy Study*. Toronto, ON: Toronto Transit Commission