

Inter-regional truck route choice modelling with revealed preference and stated preference approaches

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Motivation

- Highway ON-401 is among the most congested roadways in North America (Business Insider, 2012)



Motivation

Toronto

Rival plans for Highway 413 take centre stage as Ontario election campaign gets underway



29-day campaign period kicks off ahead of June 2 vote

[Lucas Powers](#) · CBC News · Posted: May 04, 2022 8:33 AM ET | Last Updated: May 5

Source: <https://www.cbc.ca/news/canada/toronto/ontario-election-campaign-day-one-2022-1.6440752>

Motivation

- Highway 403 (preferred route)
- Highway 401 (preferred route)
- Highway 401 (primary route)



<https://www.highway413.ca/>

Route Choice Factors

Factors	Attributes	Example References
Time	<ul style="list-style-type: none"> • Travel Time • Travel Time Variability • Delay • Congestion 	<ul style="list-style-type: none"> • Hunt and Abraham (2004) • Knorrning, He and Kornhauser, (2005) • Kawamura, (2000) • Kong et al., (2018)
Cost	<ul style="list-style-type: none"> • Toll Cost • Payment method • Fuel Consumption • Late Delivery Penalty 	<ul style="list-style-type: none"> • Holguín-Veras et al. (2006) • Wang and Goodchild, (2014) • Zhou et al., (2009) • Arentze et al., (2012)
Other	<ul style="list-style-type: none"> • Vehicle Type • Contract Type • Road Type • Distance • Commodity Type 	<ul style="list-style-type: none"> • Rowell, Gagliano and Goodchild, (2014) • Ben-Akiva et al., (2016) • Sun et al., (2013) • Quattrone and Vitetta, (2011)

Route Choice Modelling

- Route choice models can predict the redistribution of traffic along alternative corridors

Developed with
GPS data



Revealed
Preference

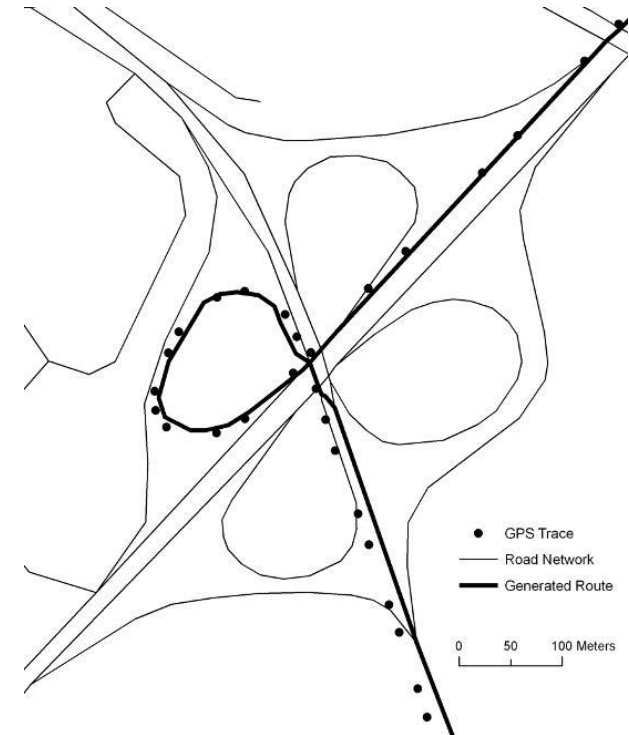


Stated Preference

Developed with
survey data

Map Matching

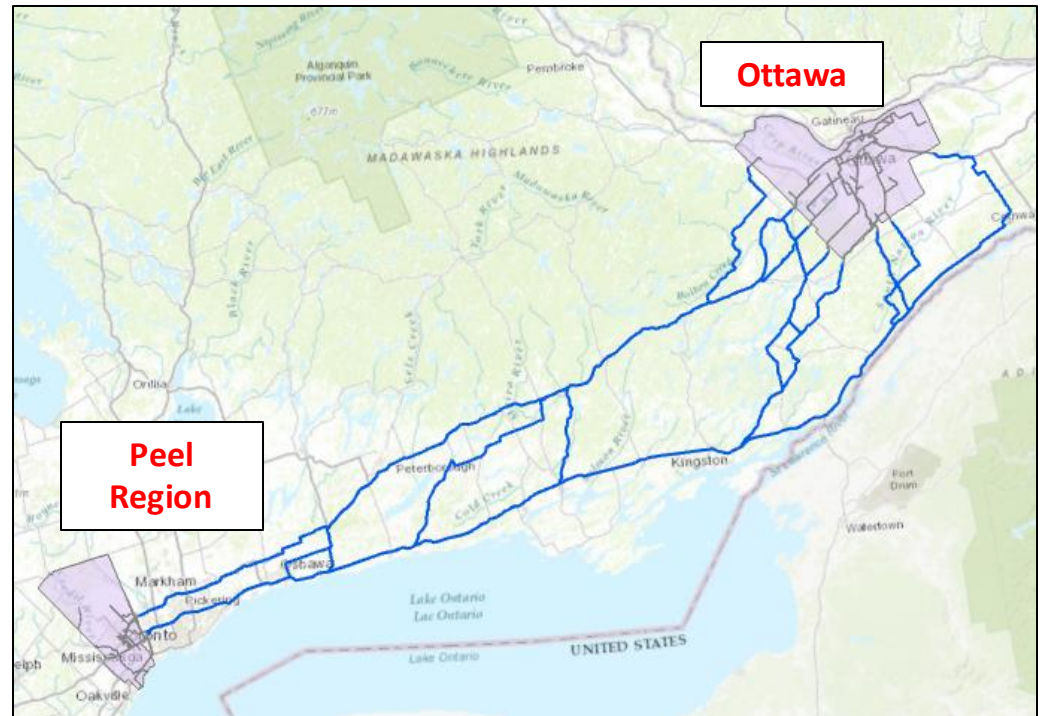
- GPS pings are map-matched:
 - using ArcGIS Network Analyst
 - Tool developed by Dalumpines and Scott (2011)
 - Data observed for a 1 week period in March 2016



Source: Dalumpines & Scott 2011

Routes and Trips

- **OD-pairs** represent the origin and destination regions for a trip
- **Trip paths** that have high degrees of overlap are grouped into routes
- **Routes** represent unique paths between a given OD-Pair



Commonality Factor

- Unique routes defined using Commonality Factor (CF):

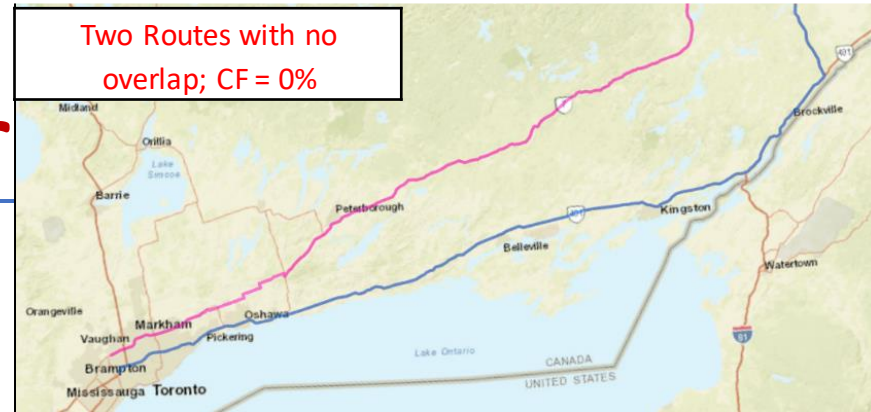
$$CF_{ij} = \sum_j \frac{l_{ij}}{\sqrt{L_i L_j}}$$

Where:

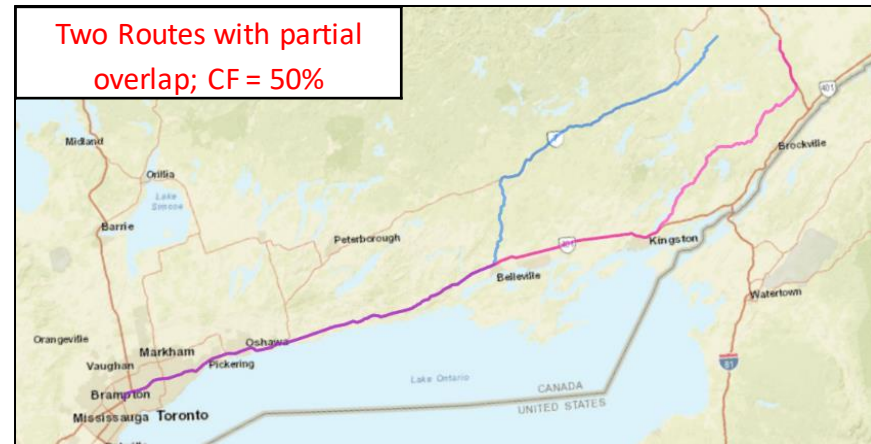
- i and j are observed routes
- L_i and L_j = the lengths of routes i and j , respectively;
- l_{ij} = shared length between route i and j .

- Initial testing assumed CF $\leq 85\%$ for unique routes

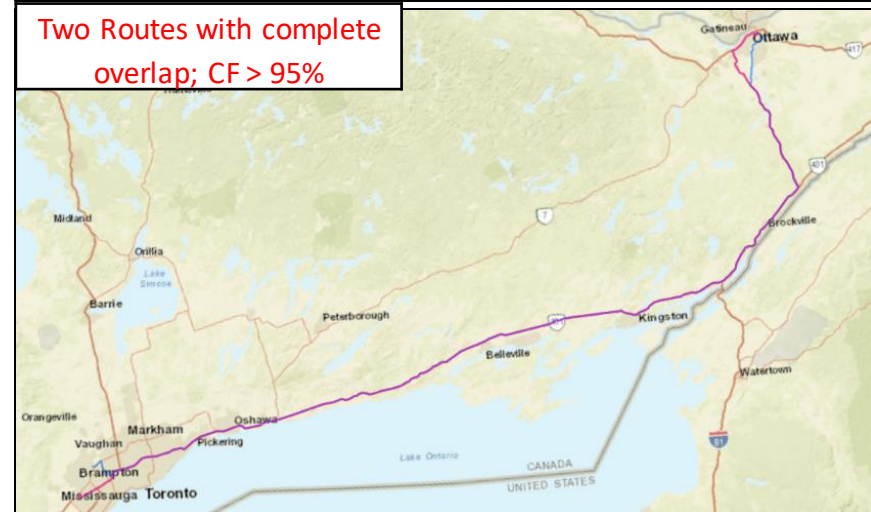
Two Routes with no overlap; CF = 0%



Two Routes with partial overlap; CF = 50%



Two Routes with complete overlap; CF > 95%



GPS trips assigned to unique routes

- OD-pairs with only one route are removed from the model
- The number of alternatives (routes) for each OD-pair varied from 2 to 16

Final Model Data

37,111 trips

577 OD-pairs

2,220 routes

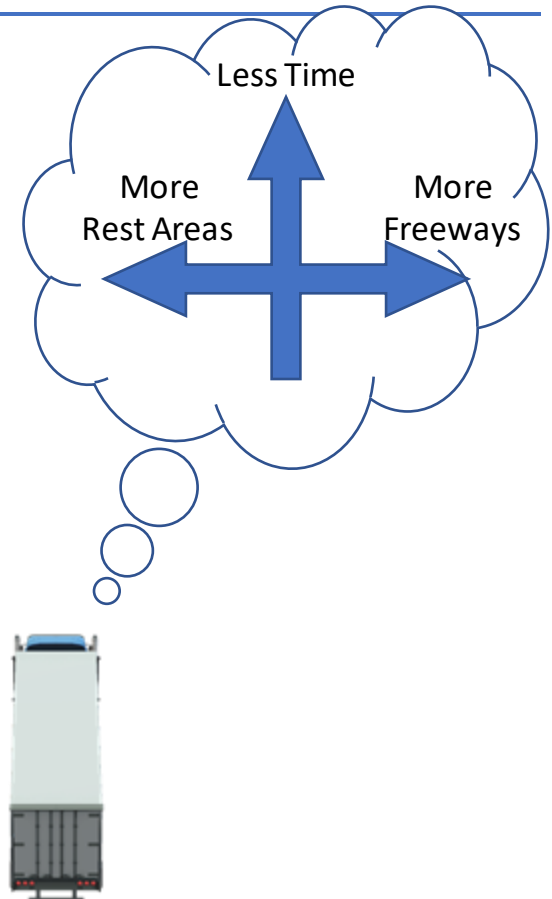
Modelling

- C-Logit discrete choice model

$$P_i = \frac{\exp(\sum_n (\beta_{in} X_{in}) + \beta_{CF} \cdot CF_i)}{\sum_{j \in C} \exp(\sum_n (\beta_{jn} X_{jn}) + \beta_{CF} \cdot CF_j)}$$

Where:

- P_i is the probability of a given decision maker selecting alternative i
- β are parameters estimated by the model
- X are input variables
- CF are commonality factors



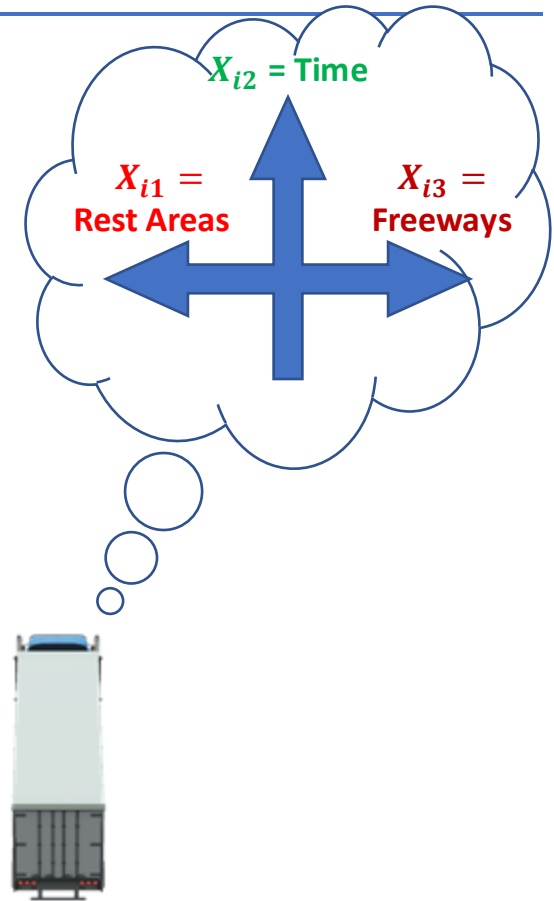
Example Factors

- C-Logit model uses the CF to account for route overlap

$$P_i = \frac{\exp(\beta_{i1}X_{i1} + \beta_{i2}X_{i2} + \beta_{i3}X_{i3} + \beta_{CF} \cdot CF_i)}{\sum_{j \in C} \exp(\beta_{j1}X_{j1} + \beta_{j2}X_{j2} + \beta_{j3}X_{j3} + \beta_{CF} \cdot CF_j)}$$

Where:

- P_i is the probability of a given decision maker selecting alternative i
- β are parameters estimated by the model
- X are input variables
- CF are commonality factors



C-Logit Model Results

- A limited number of variables can be included due to correlations
- One example model is given below:

Variable	Coefficient	T-Statistic	Direct Elasticity
<i>Minimum Travel Time</i>	-1.65***	-68.11	-3.306
<i>Freeway Proportion</i>	1.17***	22.53	0.212
<i>Proportion of Hwy401</i>	1.999***	40.21	0.166
<i>Number of Diesel Stations</i>	0.180***	54.74	0.101
<i>Number of Intersections</i>	-0.003***	-9.62	-0.069
<i>CF</i>	0.264***	3.42	n/a
LL(0)	-38523.49		
LL(β)	-17344.63		
Naïve ρ^2	0.550		
Observations	34,625		

*** indicates the parameter is statistically significant with 99% confidence

Note: Model based on CF threshold (for unique routes) set to 65%

Limited Results for Revealed Preference

- The previous model is valuable but....
- Variables such as time and distance are correlated
- Limited sample available for tolls to measure the impact of pricing
- A stated preference approach is discussed in the next section

Value of Time for Trucks

- **VOT** is the amount that a traveler would be **willing to pay** in order to **save time**. (Small, 2012)

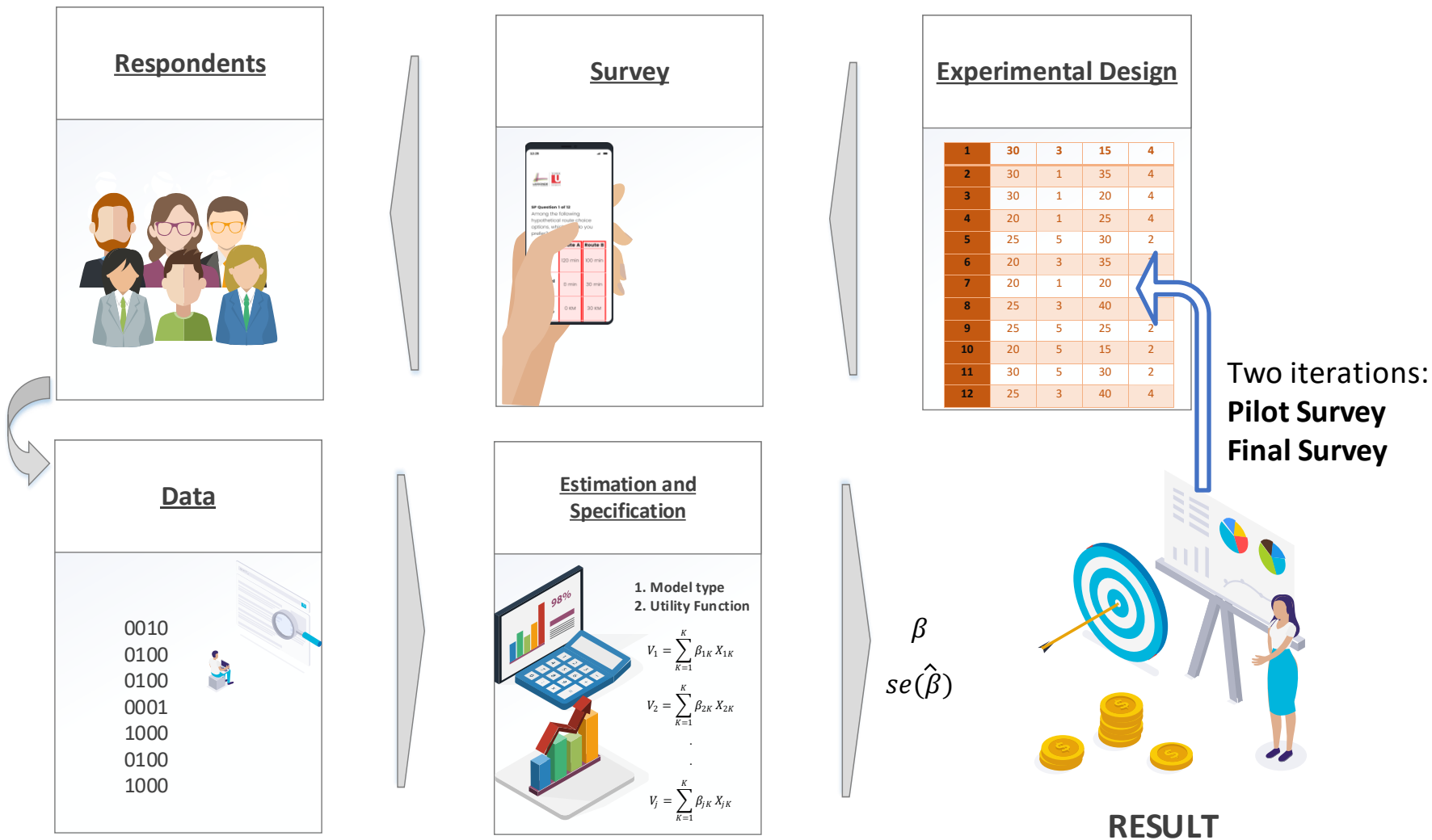
Reference	VOT (\$CAD/hr)	Study Area
(Zhou et al., 2009)	\$53.87	Texas
(Kawamura, 2000)	\$47.15	California
(Wang and Goodchild, 2014)	\$36.51	Washington
(Tsirimpa, Polydoropoulou and Tsouros, 2019)	\$79.98	Portugal
(Toledo et al., 2020)	\$64.64	Texas / Illinois / Ontario
(Smalkoski and Levinson, 2005)	\$88.96	Minnesota
(Ismail, Sayed and Lim, 2009)	\$121.87	British Columbia
(De Jong et al., 2014)	\$69.76	The Netherlands
Average VOT = CAD\$74.78/hr		



https://encrypted-tbn0.gstatic.com/images?q=tbn%3AANd9GcT71lwRWwhdOmHzDcasONPQf554x0wACHFNQNAy6mab0E_15Rr&usqp=C&AU

All values have been converted to Year 2020 and Canadian currency

Methodological Approach



Methodological Approach



Stated Preference
Survey Design
Hypothetical
Scenarios



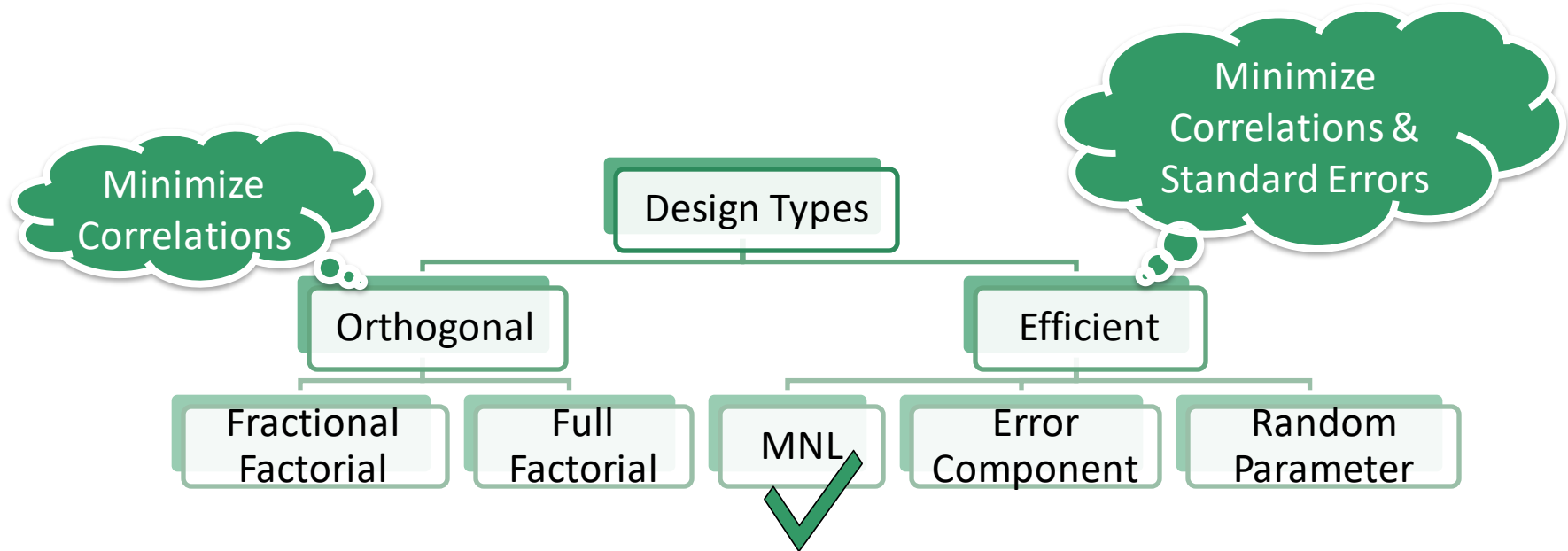
Qualtrics
Online Survey
Platform



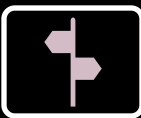
Modeling
Multinomial Logit
Probabilities



SP Design Type



Survey Questions



1. Stated Preference Survey

- Route Choice Hypothetical Scenarios



2. Respondent Characteristics

- Age, Experience, Role, Vehicle Size



3. Company Characteristics

- Contracts, Role, Commodities, Behavior, Trips, HOS



4. Descriptive Questions

- Technology, Navigation, e-Commerce, EDI

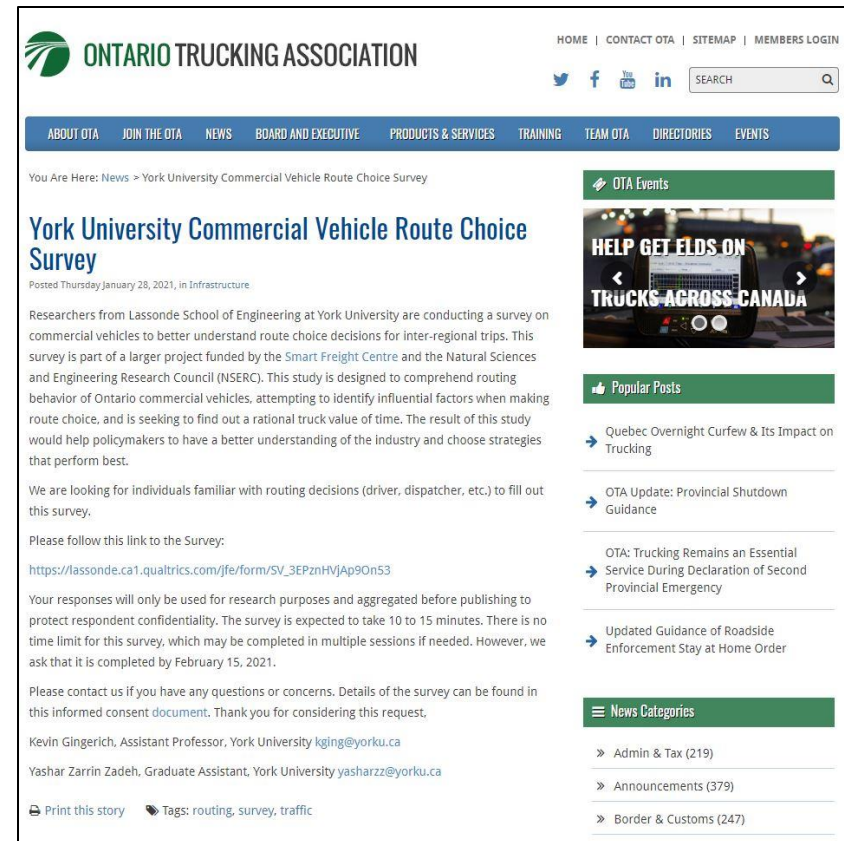
Choice	Task	Block	Org	Choice situation	route a.tt	route a.ttv	route a.dist	route a.tc	route b.tt	route b.ttv	route b.dist	route b.tc
1	1	1		4	120	0	0	50	100	30	30	0

choice	task	block	A1_1	A1_2	A1_3	A1_4	A2_1	A2_2	A2_3	A2_4
1	1	1	3	0	0	1	2	4	2	0

	Route A	Route B
Travel Time	120 min	100 min
Potential Delay	0 min	30 min
Extra Distance	0 KM	30 KM
Toll Cost	\$50	\$0

Survey Distribution

- Truck carrier contacts retrieved from Yellow Pages
 - Updated using Amazon Mechanical Turk
 - **1691** email addresses for Ontario trucking companies
- An advertisement was also posted by the Ontario Trucking Association (OTA)



The screenshot shows the Ontario Trucking Association (OTA) website. The header includes the OTA logo, navigation links (HOME, CONTACT OTA, SITEMAP, MEMBERS LOGIN), and social media icons. A search bar is also present. The main navigation menu lists: ABOUT OTA, JOIN THE OTA, NEWS, BOARD AND EXECUTIVE, PRODUCTS & SERVICES, TRAINING, TEAM OTA, DIRECTORIES, and EVENTS.

The article title is "York University Commercial Vehicle Route Choice Survey", posted on Thursday, January 28, 2021, in the Infrastructure category. The text of the article reads: "Researchers from Lassonde School of Engineering at York University are conducting a survey on commercial vehicles to better understand route choice decisions for inter-regional trips. This survey is part of a larger project funded by the Smart Freight Centre and the Natural Sciences and Engineering Research Council (NSERC). This study is designed to comprehend routing behavior of Ontario commercial vehicles, attempting to identify influential factors when making route choice, and is seeking to find out a rational truck value of time. The result of this study would help policymakers to have a better understanding of the industry and choose strategies that perform best. We are looking for individuals familiar with routing decisions (driver, dispatcher, etc.) to fill out this survey. Please follow this link to the Survey: https://lassonde.ca1.qualtrics.com/jfe/form/SV_3EPznHVjAp90n53 Your responses will only be used for research purposes and aggregated before publishing to protect respondent confidentiality. The survey is expected to take 10 to 15 minutes. There is no time limit for this survey, which may be completed in multiple sessions if needed. However, we ask that it is completed by February 15, 2021. Please contact us if you have any questions or concerns. Details of the survey can be found in this informed consent document. Thank you for considering this request. Kevin Gingerich, Assistant Professor, York University kging@yorku.ca Yashar Zarrin Zadeh, Graduate Assistant, York University yasharzz@yorku.ca Print this story Tags: routing, survey, traffic

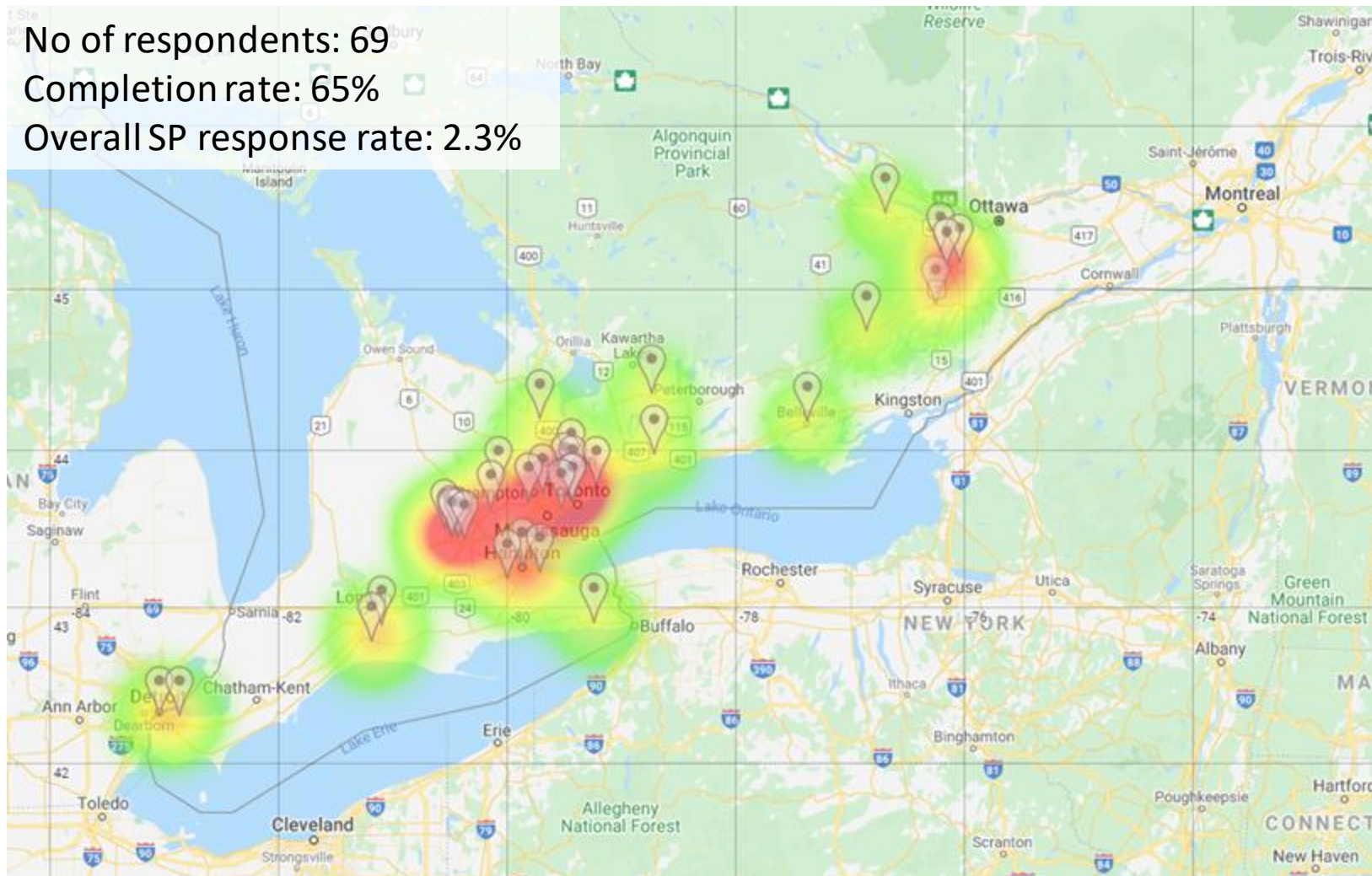
On the right side of the page, there are sections for "OTA Events" with a featured image titled "HELP GET ELDS ON TRUCKS ACROSS CANADA", "Popular Posts" listing "Quebec Overnight Curfew & Its Impact on Trucking", "OTA Update: Provincial Shutdown Guidance", "OTA: Trucking Remains an Essential Service During Declaration of Second Provincial Emergency", and "Updated Guidance of Roadside Enforcement Stay at Home Order", and "News Categories" listing "Admin & Tax (219)", "Announcements (379)", and "Border & Customs (247)".

Response Rate

No of respondents: 69

Completion rate: 65%

Overall SP response rate: 2.3%



Model Results

- Random parameter logit (mixed) with panels

Variable	Coefficient	T-Statistic	St. Deviation
Constant (non-toll route)	0.281	0.50	
Travel Time (both routes)	-0.060***	-6.67	0.025***
Delay (both routes)	-0.039***	-4.40	
Toll Cost (toll route)	-0.045***	-4.78	0.022***
Extra Distance (non-toll route)	-0.039***	-5.48	
LL[0] = -324.4	Naïve $\rho^2 = 0.412$	No. of Respondents = 39	
LL[C] = -264.3	Restricted $\rho^2 = 0.279$	No. of Observations = 468	
LL[F] = -190.5	Adjusted $\rho^2 = 0.268$	Panel Groups = 12	

*** indicates the parameter is statistically significant with 99% confidence

External Dummy Variables

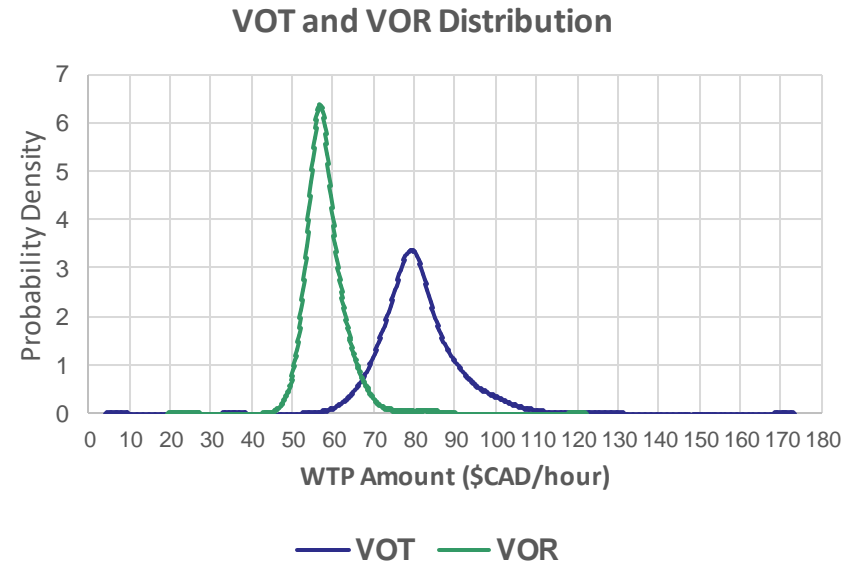
- Additional variables added (one at a time) to the previous model (toll alternative)

Variable Category	Mixed Logit with Panels		
	Variable	Coefficient	T-Statistic
Compensation Method	Actual Distance	-1.147*	-1.90
	Time		
	Fixed		
Establishment Characteristics	20 years or younger	-1.250**	-2.10
	More than 21 years old	0.954*	1.95
	Micro/Small Enterprise	-1.038**	-2.11
	Medium/Large Enterprise	1.171**	2.19
Shipment Characteristics	Truckload	-0.843	-1.58
	Less-Than-Truckload	0.192	0.38
Vehicle Characteristics	Single Unit	1.197**	2.23
	Single Trailer	-0.769	-1.37
	Multi Trailer	2.649**	2.36

Micro/Small Enterprises are less likely to use the toll route.

Measured Value of Time (VOT)

Statistic	VOT (\$/hr)	VOR (\$/hr)
Mean	81.01	58.18
St. dev.	10.09	5.84
Maximum	171.23	120.69
Minimum	6.74	20.87



- A normal distribution is assumed for the above results
- The measured value of time (VOT) = \$81.01 CAD is similar to the average value found in literature

Conclusions

- The revealed preference models confirm travel time as a primary factor
- The stated preference model generates results for toll-specific scenarios
- Results from these models can be used to assign probabilities for truck routes or convert costs using VOT

Recall: Motivation

Toronto

Rival plans for Highway 413 take centre stage as Ontario election campaign gets underway



29-day campaign period kicks off ahead of June 2 vote

[Lucas Powers](#) · CBC News · Posted: May 04, 2022 8:33 AM ET | Last Updated: May 5

Thanks for watching!

- Funding sources: NSERC, York University
- Questions?