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All minutes are not equal: travel time and the effects of congestion on commute satisfaction in Canadian cities

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Abstract Despite decades of research, it is unclear under which circumstances travel is most onerous. While studies have found that some individuals derive positive utility from aspects of commuting, others have shown that traffic congestion can entail important time, monetary, and mental stress costs. Moreover, responses to traffic congestion-related stressors differs by individual characteristics. In response, this research captures how exposure to traffic congestion events, the duration of this exposure, and individual trait susceptibility to congestion affect the utility of commuting. Working through the lens of individual satisfaction with the duration of their commute, we show that not every minute of travel is valued the same by car commuters in Canadian cities. Results suggest a complex relationship between travel time, congestion, and individual predisposition to congestion-related stress. While improvements in travel time matter for increasing commute satisfaction, it is reductions in travel in congested conditions that matter most, particularly among those susceptible to congestion-related stressors.

Keywords Transportation costs · Commuting · Commute satisfaction · Value of travel time · Congestion · Commute stress · Regional planning

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Introduction

Travel is broadly understood as an activity that entails some element of disutility or burden, and these costs have traditionally been operationalized in research in different ways. The most common measurement of travel cost in research and practice is travel time, and planners, policymakers, and engineers prescribe travel time reductions as a way to lower the burden of travel. Likewise, several studies have been undertaken to determine how individuals value travel time, and this work has produced a broad range of value estimates (Hensher 2001).

In economic and transportation geography, travel time informs a great deal of research on the spatial and temporal distribution of economic activity over space since the work of von Thünen (1966). From this, travel time is instrumental in the conception of the standard urban model of Alonso (1964), Muth (1969), and Mills (1972), which establishes a theoretical framework for understanding the link between transportation and urban form.

This focus on travel time extends to other fields as well. The literature on excess commuting and jobs-housing balance for example often considers travel time as a primary travel cost (Kanaroglou et al. 2015). In transportation engineering, travel time is an essential element in modeling and forecasting travel demand through the four-step model. Furthermore, transportation economists estimate the value of travel time savings in benefits-cost analysis by monetizing the value of project-induced travel time savings (regardless of mode or reference travel times) to estimate total project benefits. These estimates are then used to justify large transportation programs based on potential travel time savings and the implicit quality of life welfare gains that accrue from a shorter or more satisfactory commute.

However, despite decades of research, several important questions concerning the nature of transportation costs in urban environments and their implications for policy remain unanswered. First, it is unclear under which conditions travel in and of itself is actually onerous. Mokhtarian and Salomon (2001) reveal some positive utility associated with work and non-work tripmaking for certain individuals. From this, other recent research on "travel liking" has revealed positive utility associated with commuting (Mokhtarian et al. 2001; Morris and Guerra 2015; Ory and Mokhtarian 2005; Ory et al. 2004; Páez and Whalen 2010; St-Louis et al. 2014), which calls into question the general notion that travel should always be minimized.

But while travel in some cases may be associated with positive utility, the utility of travel, or satisfaction with travel is ultimately sensitive to different travel scenarios or contexts. For example, the literature reviewed in the following section details how congestion events measured in terms of commute impedance and variability entail an additional travel cost that is distinct from travel time. Monetarily, congestion causes wear and tear on motor vehicles and consumes more fuel than free-flow traffic. Socially, it entails time costs from travel delay and unreliability that can affect an individual's participation in other activities, and can increase health costs from exposure to pollutants. Furthermore, incidences of traffic congestion have also been shown to effect significant stress costs on drivers that can lead to other negative outcomes. In this sense, individual exposure to different levels of congestion should correspond to different reductions in commuting utility.

Moreover, it seems likely that each minute of travel in general is not valued the same, and as proposed by Hensher (1976), one would expect a nonlinear relationship between commuting satisfaction and travel time. However, if congestion events do indeed reduce

the utility of commuting travel, it remains unclear how utility is affected by the duration of an individual's exposure to different congestion events. Previous studies (e.g. Gottholmseder et al. 2009; Sposato et al. 2012) suggest that a minute spent in congestion is also not valued the same as a minute spent in free-flow conditions. On top of this, research (e.g. Gulian et al. 1989b; Stephens and Groeger 2009; Stutzer and Frey 2008) has demonstrated that individual susceptibility to congestion-related stress can magnify the negative effects of exposure to congestion events, and this should further exacerbate the effects above.

In response to these questions, this research captures how exposure to congestion events, the duration of this exposure as measured by travel time, and individual responses to congestion as a stressor affect the utility of commuting. Working through the lens of individual satisfaction with their commute duration, this study utilizes data from the 2010 General Social Survey to reveal that not every minute of travel is valued equally for car commuters in Canadian cities. The paper proceeds with an overview of the previous literature and commuting trends in Canada, followed by the estimation of models, discussion of results, and implications for research and policy.

Background

Previous literature

Some research has provided evidence that travel in general (Mokhtarian and Salomon 2001), and commuting travel specifically (Mokhtarian et al. 2001; Ory and Mokhtarian 2005; Redmond and Mokhtarian 2001) may not be viewed as particularly onerous by individuals. This literature has revealed that some positive aspects of utility can be derived from commuting, including the thrill of driving, listening to music, or enjoying valuable alone time or transition time between work and home life. However, other studies have uncovered negative social effects associated with travel as measured on several outcomes.

Impedance, variability, duration, and travel mode

Several authors have found a link between traffic congestion and stress. A survey by Duffy and McGoldrick for example found that over half of bus drivers listed traffic congestion as a major source of stress. Evans and Carrère (1991) found a high association between peak traffic and stress in bus drivers, and later, Evans et al. (1999) found that a separated bus lane along the most congested portions of a bus route led to a reduction in driver stress. However, other authors have attempted to directly specify the effects of congestion, as well as travel in general, on commuter stress and satisfaction. Although not mutually exclusive, research on commuting burden has focused on the concepts of impedance, variability, duration, and travel mode.

Early research in this area investigated congestion as a source of *impedance* on car commuting and its link to individual stress. Stokols et al. (1978) conceptualize congestion as an environmental stressor that impedes one's movement between two points, and is associated with higher levels of stress in drivers measured through blood pressure, mood, physiology, and task performance. In similar studies, Novaco et al. (1979, 1990, 1991) show how greater congestion-induced impedance leads to less satisfaction with commuting and a greater desire to change residence. Shaeffer et al. (1988) show how impedance

causes stress in drivers and reduces individual satisfaction with commuting, but also find that this stress is reduced for single-occupant drivers compared to those carpooling. Koslowsky et al. (1996) similarly find that traffic impedance leads to stress.

Research by Kluger (1998) further identifies *commute variability* as a significant source of strain for commuters. According to Kluger, if the daily commute has low variability in terms of travel conditions, individuals can still maintain a sense of perceived control and report lower stress. Even if movement is regularly impeded, if this impedance is predictable, system users report lower stress. On the other hand, a commute that is highly variable, even if this variability is predictable, is more stressful as it produces a higher cognitive load on commuters. This finding is reinforced by the work of Evans et al. (2002) in terms of commute variability and stress for rail commuters, and later by Wener and Evans (2011) who show higher levels of stress for car commuters than transit users attributable to greater commute unpredictability. Similarly, Gatersleben and Uzzell (2007) show that car commuting is associated with higher stress than both public and active transport modes, with stress arising from commuting delays and the actions of other drivers. Sweet and Chen (2011) have also shown that greater commute variability for auto drivers in Chicago is associated with mode switching to transit.

Beyond *impedance* and *variability*, research has sought to further isolate sources of commuting stress in terms of not only individual exposure to incidences traffic congestion, but the *duration* of their exposure. For example, Wener et al. (2003) show that commute duration for rail commuters can cause stress as it can reflect longer exposure to environmental stressors. In terms of commuting *distance*, research by Novaco and Collier (1994) has shown that high impedance and long-distance commutes were associated with higher stress. Here the negative impact of commuting stress on family life was also found to be a major driver of interest in trying carpooling and transit. However, this stress can be offset by ride sharing. Long distance commuting has also been shown to be stressful for rail commuters (Evans and Wener 2006) and lead to lower measures of subjective health among those commuting by car, and to a lesser degree for those commuting by motorcycle or public transit in the UK (Künn-Nelen 2015).

Beyond the separate approaches above, two papers have sought to isolate the simultaneous effects of impedance, duration, and commute predictability on commuting stress. Gottholmseder et al. (2009) find that travel time, travel mode, and unpredictability lead to higher levels of perceived stress. Likewise, Sposato et al. (2012) find that individual perceived control, commute duration, predictability, and impedance all affect commuter stress simultaneously.

Finally, travel *mode* in general has been shown to lead to different levels of stress and satisfaction with commuting. Páez and Whalen (2010) find that car commuting is more stressful in general compared to other modes. Similar findings are reported by St-Louis et al. (2014).

Research outcomes

While aspects of travel influence stress, travel can influence other social outcomes linked with individual well-being across several indicators. First, van Hoof (2013) found that stressful commuting delays negatively affect the ability of employees to recover their health and wellbeing after work. Driver stress has also been linked to aggressive driving (Gulian et al. 1989a, b; Hennessy and Wiesenthal 1997). This has been shown to cause angry drivers to drive faster and more aggressively in studies by Mesken et al. (2007) and Stephens and Groeger (2009). On the other hand, Morris and Hirsch (2015) find only a

small association between individual emotions and mood and driving in peak periods in large cities in the United States, leading the authors to conclude that congestion's impact on drivers is limited. Still, by using peak period travel as a proxy for congestion, this study does not directly capture incidences or the severity of congestion events on emotions or mood.

Second, beyond stress and individual satisfaction with their commutes, others have explored how an individual's commute affects their overall life satisfaction, happiness, or subjective wellbeing (SWB). Stutzer and Frey (2008) find that people with longer commuting times report lower SWB. Olsson et al. (2012) find that greater commute satisfaction leads to greater life satisfaction. Choi et al. (2013) find that increasing commute duration leads to a decrease in individual SWB, and because it increases commute duration, congestion leads to a further decrease in SWB. Similarly, Sandow (2014) shows that long-distance commutes are associated with greater risks of couples separating in Sweden. Using the same data as the present study, Hilbrecht et al. (2014) find that an individual's perception of traffic congestion as a serious problem for them helped explain how commute time negatively affects life satisfaction and increases time pressure. However, in contrast to the studies above, Morris and Guerra (2015) find that travel in general does not significantly affect individual mood or happiness, suggesting a weak link between travel and SWB.

Ettema et al. (2010) take a different perspective, arguing that travel can be associated with a net positive or negative impact on SWB, but the effects are mediated by activity participation. Essentially, travel allows individuals to engage in daily activities and the burden or amenity of travel depends on the SWB benefits of participating in these activities. From this, Ettema et al. (2011) find a small association between car travel, shorter-distance bus travel, and activity participation. Bergstad et al. (2011) find that car use is associated with an increase in SWB, and is mediated with activity participation. Abou-Zeid and Ben-Akiva (2012) find that satisfaction with activities is positively associated with SWB and greater satisfaction with travel to the activity. Finally, Sweet and Kanaroglou (2016) find no link between travel time and SWB among men and women in Canada, but that greater activity participation can lead to higher SWB for women.

Commuter response heterogeneity

Research provides evidence that not all commuters respond to sources of commuting stress in the same way. These differences stem both from individual traits and the typical preferences associated with sociodemographic groups. Individual driver state, or trait susceptibility, influences the degree to which traffic congestion is viewed as stressful or problematic. Gulian et al. (1989b) found that factors such as drivers being in a hurry, reporting issues at work or at home, sleep issues, or even bad weather exacerbated their ability to adapt to congested commuting conditions. Similar findings were reported by Hennessy and Wiesenthal (1997, 1999), who noted that high trait stress drivers experienced the greatest stress levels in response to traffic congestion. Likewise, Stephens and Groeger (2009) find that while all drivers become angry when impeded, only high trait anger drivers become angry and behave aggressively. In contrast, a study by Lucas and Heady (2002) showed that drivers who had flexible work hours felt less time urgency and less driver stress and higher commute satisfaction.

Individual socioeconomic and demographic characteristics also inform susceptibility and responses to congestion-induced stress. Novaco and Collier (1994) find that women in particular perceive commuting stress from long-distance commutes to spillover into their work and home life. Roberts et al. (2011) demonstrate that commute duration has

detrimental effects on the psychological health of women, but not men. They attribute this difference to gender roles that place a greater responsibility for daily household tasks on women, such as childcare and housework, which leads to feelings of greater time urgency. Feng and Boyle (2014) find a higher risk of negative mental health effects associated with long journeys to work for women, particularly those with children. Likewise, Sandow et al. (2014) show that long-distance commuting is associated with significantly higher mortality risk for women, particularly those with less income and education. Others have found competing evidence. For example, Sweet and Kanaroglou (2016) have found that it is not commuting burden which is linked with lower SWB among women, but a gap in the capacity to participate in activities compared with men.

Summary

Taken together, the literature demonstrates that there are clear costs associated with travel under certain conditions. Long trips and congestion present a cost to commuters in terms of stress and wellbeing. Furthermore, congestion increases impedance and the unpredictability of travel times. In doing so, congestion can reduce an individual's perceived control over their commute duration, which is associated with increases in stress levels among commuters. From this, long commutes in congested conditions appear to be the most onerous on drivers. While these factors can negatively impact an individual's commute satisfaction, other research has shown that commuting and congestion can negatively impact an individual's overall wellbeing, either directly or by reducing their participation in other activities that they value.

Still, these negative aspects of commuting must be weighed against some of the positive utility associated with commuting, such as providing a personal time buffer between activities. Moreover, the effects of congestion on driver stress are mediated by individual characteristics or trait susceptibility to congestion-related stressors. In response, the literature suggests that an individual's measure of utility or satisfaction with commuting is heavily context-dependent. The present paper seeks to isolate how these effects influence commute satisfaction and reveal the conditions under which commuting presents the greatest burden on car commuters in Canada.

Commuting in Canada

What are the general commuting trends in Canada? Despite several sources of data, long-term trends are difficult to ascertain. Round-trip travel times for the trip to work have been collected as part of four time-use waves of the Canadian General Social Survey (GSS) between 1992 and 2010 and are included as part of the new National Household Survey (NHS), a voluntary replacement for the long-form census in 2011. Comparing these cross sections in Table 1 reveals that average commute travel times in Canadian regions for all modes of transportation have not remained stable and some cities have seen dramatic reductions in travel time.

As the determinants of commuting in urban areas are highly complex, a full account of the temporal shifts in commuting across Canadian cities since 1992 is beyond the scope of the present paper. Nevertheless, one major source of travel time variability specific to the Canadian context is that estimates of commuting travel time are not directly comparable across all surveys as the nature of the travel time question changed between 2005 and 2010. The question employed in the 2005 and earlier waves of the GSS considered the total round trip travel time between home and work, which crucially includes any side trips such

Table 1 Average round-trip commute times in Canadian cities, 1992–2011 (min). *Sources*: [a] General Social Survey, [b] 2011 National Household Survey

	1992[a]	1998[a]	2005[a]	2010[a]	2011[b]
Canada total	54	59	63	52	51
Toronto	68	76	79	66	66
Montréal	62	65	76	62	60
Vancouver	70	68	67	60	57
Ottawa-Gatineau	57	62	65	54	52
Calgary	52	64	66	52	54
Edmonton	50	58	62	46	51

as dropping children off at school. In contrast, only the direct trip between home and work is collected in the 2010 GSS and the 2011 NHS, offering measures more analogous to those used in the American Community Survey. As Turcotte (2011) notes, if all side trips taken on the commute to and from work are included when considering the numbers from the 2010 GSS, average travel times in Canada actually increased to 65 min rather than the 52 min captured by the revised question.

Still, such commuting trends are often used to justify spending on new transportation infrastructure as a means of reducing travel times and alleviating traffic congestion. Transportation policy priorities in the United States for example have shifted over the last 20 years from encouraging large-scale road building programs towards policy that encourages public transit, cycling, and walking, though the total amount of money spent on highways continues to be several orders of magnitude greater than that for transit (FHWA 2013). In Canadian urban regions, the policy shift is similar.

Despite this, it remains unclear whether the costs of inaction or the benefits of action are as high as commonly discussed. Previous research has argued that it is basic human nature to adhere to relatively constant travel time budgets of 1.1–1.3 h daily (Metz 2008; Mokhtarian and Chen 2004; Schafer 2000; Zahavi 1974). Such a time budget can result in a long-run re-equilibration of the jobs-housing balance despite functioning out of equilibrium in the short term. While the authors cited earlier note some elements of positive utility associated with certain commutes, travel times do not rise indefinitely. Some transportation costs are clearly at work to limit travel times.

But while policy action continues to be justified on the basis of travel time savings, researchers need to better understand those elements of travel which might be most impactful on general commute satisfaction. Measures of typical travel times are useful in monitoring system performance, but better public policy can be advanced by understanding and linking these metrics and changes in them with changes in social welfare. We expect different commuting travel times, levels of exposure to traffic congestion, and individual sensitivity to traffic congestion to provide a more nuanced picture of how shaping travel conditions may influence commuting satisfaction. Identifying those elements of travel which are most burdensome can better prepare policymakers for transformative transportation policymaking.

Data and methods

The primary data source for this analysis is the 2010 edition of the Canadian GSS, and a detailed overview of survey as it relates to commuting can be found in Turcotte (2011). Our sub-population for the present analysis consists of a sample of 3319 individuals who are at

least 16 years of age, live in any of Canada's 33 Census Metropolitan Areas (CMAs), are employed full-time or part-time, and commute to work by car for the entire trip.

Model variables

We utilize several variables from the 2010 GSS selected according to our interest in predictors of commuting satisfaction, including commute characteristics, congestion, sociodemographic traits, and location (Table 2). A brief overview of key variables related to the commute to work is provided below.

Commute to work

To estimate the links between commute times, congestion, and satisfaction with commute length, several variables relating to individual commuting characteristics are employed from the 2010 Canadian GSS.

Table 2 Sample descriptive statistics

Vector	Mean (prop.)	SD
Dependent variable		
Commute dissatisfaction (1–4)	1.86	0.82
Very satisfied	(35.4)	
Satisfied	(48.6)	
Dissatisfied	(10.1)	
Very dissatisfied	(5.9)	
Independent variables		
Commuting		
One-way travel time (min)	24.26	16.80
Frequency of congestion (1–4)	2.14	1.19
Never	(41.8)	
1–2 days per week	(24.9)	
3–4 days per week	(10.5)	
Every day	(22.8)	
Congestion as a serious problem (1–4)	2.03	0.95
Not at all serious	(34.4)	
Not very serious	(37.7)	
Serious	(18.3)	
Very serious	(9.5)	
Socio-economic and demographic		
Age category (1–7)	3.24	1.23
Male (0–1)	(0.58)	0.49
Visible minority (0–1)	(0.17)	0.37
Bachelor's degree or above (0–1)	(0.66)	0.82
Location		
Greater Toronto area (GTA) (0–1)	(0.24)	0.43
Montréal (0–1)	(0.13)	0.34
Vancouver (0–1)	(0.08)	0.27
N		3319

Commute dissatisfaction The dependent variable for this research is an individual's stated dissatisfaction with the duration of their commute. Respondents to the GSS were asked "Overall, how satisfied are you with the amount of time it took you to get to work/school last week?" Answers were reverse recoded to be on a scale of 1–4 ranging from 'very satisfied' to 'very dissatisfied'. This focus in the GSS on commute duration is notably different from an individual's *overall* satisfaction with their commute. While more constrained than a general metric of commute satisfaction, satisfaction with duration enables a more precise analysis of the impact of congestion as an agent of impedance and variability on one's commute. For example, in addition to travel time and congestion, a general question of commute satisfaction might capture whether a respondent is unsatisfied with their commute due to factors such as the choice of mode, routing, aggressive drivers, unruly passengers, or even the quality of one's automobile. Focusing on satisfaction with commute duration eliminates the need to control for such confounding factors, allowing us to isolate the extent to which travel costs measured in travel time and congestion translate into less satisfactory commute durations.

In this sense, we interpret satisfaction with duration as capturing the gap between an individual's commuting reality and their expectations. Commutes are in part shaped by individual or household self-selection of their places of residence and places of work, subject to constraints. Such constraints include preferences for local amenities like schools and consideration of the commuting patterns of all household members as a collective unit (Cropper and Gordon 1991). From this, if impedance and variability from commuting in congested conditions creates a disconnect between what commuters are doing and what they would prefer to be, or expected they would be doing based on these choices, it should become a stressor that leads to lower levels of satisfaction. On the other hand, if a commute meets their budgeted expectations, it may be viewed as satisfactory.

One-way travel time The travel time variable captures an individual's stated one-way commute travel time through the question "On a usual day last week, how many minutes did it take you to go one way from home to work/school?" To account for the positive skew in the distribution of travel times, this variable is log-transformed in our model. Travel time was truncated to remove a very small number of commutes <5 min and over 90 min in duration, as it was felt that such trips were not representative of automobile commuting in general.

Frequency of congestion Respondents were asked "Last week, how often did you experience traffic congestion during your commute to work/school?" with answers coded on a scale of 1–4 ranging from 'never' to 'every day'. Congestion is defined in the GSS as traffic jams, start–stop conditions or moving at <20 km per h. Increases in congestion frequency are moderately correlated with travel time (0.409). From Table 2, more than half of our sample typically experiences traffic congestion during their commute to work, with 23% commuting in congested conditions every day. Still, approximately 42% of respondents report not encountering any congestion during their drive to work, which may reflect the large numbers of commutes taking place in smaller and less-congested Canadian CMAs.

Congestion as a serious problem The literature indicates that commuters respond to the stress of congestion in different ways. Hennessy and Wiesenthal (1997) for example use a series of 11 questions to capture individual trait susceptibility to congestion. Unfortunately,

the GSS does not account for trait susceptibility in a similar way. Still, in addition to travel time and incidences of congestion, the GSS does ask respondents "Overall, how serious a problem is traffic congestion for you?" with answers coded on a scale of 1–4 ranging from 'not at all serious' to 'very serious'. While 23% of the sample experiences daily congestion, only 10% view it as a serious problem, which suggests that individuals respond to congestion in different ways. Correlation coefficients confirm that this variable is capturing a dimension of congestion separate from incidences of traffic congestion (0.549) and travel time (0.343).

As such, while loosely defined in the GSS, we interpret this variable as partly reflective of two related concepts: individual feelings of time pressure that result from incidences of congestion, and trait susceptibility to congestion as a stressor. For example, some individuals that regularly drive in congested conditions may come to see it as a part of daily life and plan accordingly. Such commuters may not view the impedance from congestion as a serious problem that affects their satisfaction with the duration of their commute. In contrast, congestion that causes high levels of variability in commute duration and elevates their stress levels may cause others to see congestion events as a serious problem that affects their satisfaction. In this sense, we utilize this variable to control for any possible mediation effects in the relationship between travel time, incidences of congestion, and commute satisfaction. Hilbrecht et al. (2014) employ this variable in a similar fashion, although in their case they seek to control for the influence of individual responses to congestion as a stressor on wellbeing and time pressure.

Socioeconomic and demographic variables

Previous research has demonstrated response heterogeneity to different commuting scenarios based on individual socioeconomic and demographic characteristics. In response, several control variables were initially considered to control for these factors, but only a small subset of these variables added predictive power to the model: gender, a categorical age variable, education, which is measured as the achievement of a bachelor's degree or higher, and whether an individual identified themselves as a visible minority. Income controls are not introduced to models due to endogeneity issues documented in the urban economic literature, whereby income not only influences travel behavior decisions, but workers are more highly compensated for inconvenient commutes (Timothy and Wheaton 2001).

Locational variables

Three locational dummy variables indicate whether respondents are located within the CMAs of Montréal, Vancouver, or the GTA to capture any variations in commuting conditions unique to each city. Variables representing other CMAs were initially considered for this analysis, however only these three were found to have any statistically significant effect in predicting an individuals' commute (dis)satisfaction.

Model specification

We employ multinomial logistic regression (MNL) to estimate the effects of commute duration and congestion on commute satisfaction. Given the dependent variable's ordered scale, it would appear to be a natural fit for an ordered logistic regression (OL) model.

However, the OL model assumes that the relationship between all predictors and the response categories of the dependent variable are proportional, resulting in parallel linear relationships across each level of commute satisfaction. Diagnostics from model runs using OL reveal this assumption is too restrictive as it relates to the present research. In contrast, the MNL model treats each incremental change in the levels of commuting dissatisfaction as being potentially unequal in magnitude. This results in estimates for each covariate for each incremental step in commuting dissatisfaction, showing a more complex but ultimately more informative picture of the effects of the variables of interest.

Within the MNL framework, we specify two models to estimate the marginal change in an individual's satisfaction with their commute duration as travel time and congestion increase. The first consists of only main effects, while the second incorporates an interaction between travel time and incidences of congestion. This second specification tests the hypothesis that every minute spent commuting differs in value according to travel time and incidences of congestion while controlling for heterogeneity in individual trait susceptibility to congestion.

Results

Table 3 displays model results. The dependent variable category 'very satisfied' acts as the reference group for the analysis. In this case, positive model coefficients indicate an increase in *commute dissatisfaction*. The reference category for the frequency of congestion and perceptions of congestion as a serious problem variables are the response groups corresponding to those that never experienced congestion on their commute to work and who responded 'not at all serious' respectively. Specific results are discussed below.

Focusing on Model 1, results show that increasing travel time causes a statistically significant increase in dissatisfaction across all categories of the dependent variable. Because of the natural logarithmic transformation of travel time, the relationship is interpreted as multiplicative. For example, a doubling of travel time results in one being almost seven times more likely to be 'very dissatisfied' with their commute duration relative to those who are very satisfied, all else being equal. Increasing incidences of congestion also have a significant effect on increasing commute dissatisfaction, particularly for congestion 3–4 days and every day per week. Likewise, results for those that are 'dissatisfied' and 'very dissatisfied' confirm that there are trait susceptibility effects at work, with individuals viewing congestion as a 'serious' or 'very serious' problem more likely to report lower levels of commute satisfaction in general.

Of the location variables, no consistent effects can be determined. This suggests that location does not appear to play a large role in commute satisfaction above and beyond the effects captured by the travel time and congestion variables, or that congestion and travel time affect commute dissatisfaction in a similar way across individuals in the sample. However, the utility of this variable may be limited by the coarse definition of CMA geography.

In Model 1, other variables generally perform as expected. An increase in age of 10 years corresponds to a slight increase in commute satisfaction, suggesting older individuals maintain a higher tolerance for commuting, all else being equal. Males were also more likely to be 'very satisfied' with their commutes compared to females. Although the effect is not statistically significant among those that are 'dissatisfied', this reinforces previous literature that has found a higher burden of commuting for women. Individuals

Table 3 Model results

Commute dissatisfaction (*reference: very satisfied*)	Model 1			Model 2		
	2. Satisfied	3. Dissatisfied	4. Very dissatisfied	2. Satisfied	3. Dissatisfied	4. Very dissatisfied
Commuting						
One-way travel time	1.469***	2.449***	2.443***	1.551***	2.745***	0.569**
Congestion frequency						
Never	(*Reference category*)			(*Reference category*)		
1–2 days	0.870***	0.860***	0.138	1.547***	0.612	−7.949***
3–4 days	2.178***	3.493***	1.476***	2.348**	4.093*	−2.797
Every day	1.568***	3.290***	2.374***	0.415	2.608	−8.681***
Congestion frequency × travel time						
Never				(*Reference category*)		
1–2 days				−0.230	0.054	2.574***
3–4 days				−0.054	−0.168	1.502**
Every day				0.428	0.311	3.510***
Congestion as a serious problem						
Not at all serious	(*Reference category*)			(*Reference category*)		
Not very serious	0.347***	0.941***	−0.873***	0.357***	0.939***	−0.846**
Serious	0.182	2.325***	0.538*	0.186	2.316***	0.540*
Very serious	−0.451**	1.473***	1.404***	−0.469**	1.493***	1.417***
Socioeconomic and demographic						
Age	−0.061*	−0.148**	−0.149*	−0.066*	−0.159**	−0.132*
Male	−0.235**	0.047	−0.476**	−0.237**	−0.066	−0.425**
Visible minority	0.473***	0.411*	0.087	0.486***	0.411*	0.159
Bachelor's degree plus	−0.289***	−0.144	−0.270	−0.295***	−0.162	−0.286
Location						
Greater Toronto area	−0.067	−0.312	−0.176	−0.053	−0.323	−0.239

Table 3 continued

Commute dissatisfaction (*reference: very satisfied*)	Model 1			Model 2		
	2. Satisfied	3. Dissatisfied	4. Very dissatisfied	2. Satisfied	3. Dissatisfied	4. Very dissatisfied
Greater Montréal area	−0.386***	−0.409*	−0.169	−0.368**	−0.407*	−0.227
Greater Vancouver area	0.516**	−0.360	0.616*	0.511**	−0.397	0.517
Intercept	−4.076***	−10.976***	−9.234***	−4.312***	−11.931***	−3.736***
N			3319			3319
Log-likelihood at convergence			4585			4503
Pseudo R^2 (McFadden)			0.289			0.300
Pseudo R^2 (Nagelkerke)			0.532			0.547

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

identifying as a visible minority have a higher probability of being 'satisfied' with their commute, implying a higher tolerance for commuting. The attainment of a Bachelor's degree also increases the probability of being 'very satisfied' relative to those that are 'satisfied', though again no effects are seen for higher levels of dissatisfaction.

To examine whether there are any additional effects associated with not only an individual's exposure to congestion, but the duration of their exposure, Model 2 adopts an interaction between travel time and congestion frequency. Compared to Model 1, this interaction results in a different interpretation for the main effects and provides a more nuanced portrait of the joint effects of travel times and congestion. Travel time remains associated with a statistically significant decrease in commute satisfaction, although the interaction means it is interpreted as the change in commute satisfaction for travel when there is no congestion. Similarly, the base congestion frequency variable corresponds to the change in commute satisfaction when travel time is zero. From this, the interaction reveals the change in dissatisfaction with commute duration given different combinations of travel time and incidences of congestion.

Results indicate that travel time remains a significant predictor of commute dissatisfaction in general, particularly for individuals that report being 'satisfied' and 'dissatisfied'. However, the lack of statistical significance on the interaction effect for these groups shows that an individual's exposure to incidences of congestion, and the duration of their exposure, is not associated with greater levels of dissatisfaction relative to those that are 'very satisfied'. In contrast, time spent travelling in congested conditions is associated with a significant increase in being 'very dissatisfied'.

Taken together, the interaction effects offer insight into a complex relationship, one where the joint effects of traffic congestion and long travel times are strongly linked with the highest levels of commute dissatisfaction. Exposure to congestion events, and the duration of exposure, is not a significant predictor of being 'satisfied' or 'dissatisfied'. Here dissatisfaction with commute duration appears to instead be influenced by only travel time rather than congestion, all else being equal. However, this effect occurs only up to a certain point, after which the relationships between these variables shift. For the final group, rather than travel time alone, the probability of being 'very dissatisfied' increases with every minute of travel in congested conditions. Put another way, the frequency of exposure to traffic congestion events, and the duration of exposure, is associated with the highest levels of individual dissatisfaction with their commute duration. From this, travel times matter, but it is travel in congested conditions that matters most.

Marginal effects

To offer further insight into the value of time spent commuting in congestion, this section plots predicted probabilities from the MNL model (Fig. 1). Probabilities are predicted from Model 2 and reflect the marginal change in commute dissatisfaction with increases in travel time, incidences of congestion, and individual perceptions of congestion as a serious problem.

First, to simplify the interpretability of the following plot, we reduce the dimensions of key variables by combining predicted probability categories. The dependent variable's categories are collapsed to a binary measure of commute dissatisfaction by combining the 'dissatisfied' and 'very dissatisfied' categories. Next, our proxy for trait susceptibility is reduced to congestion being either being a 'serious' or 'not serious' problem. Due to being nearly indistinguishable when plotted, the 'never' and '1–2 days per week' congestion categories are combined. Finally, we plot the model's predicted cumulative probability of

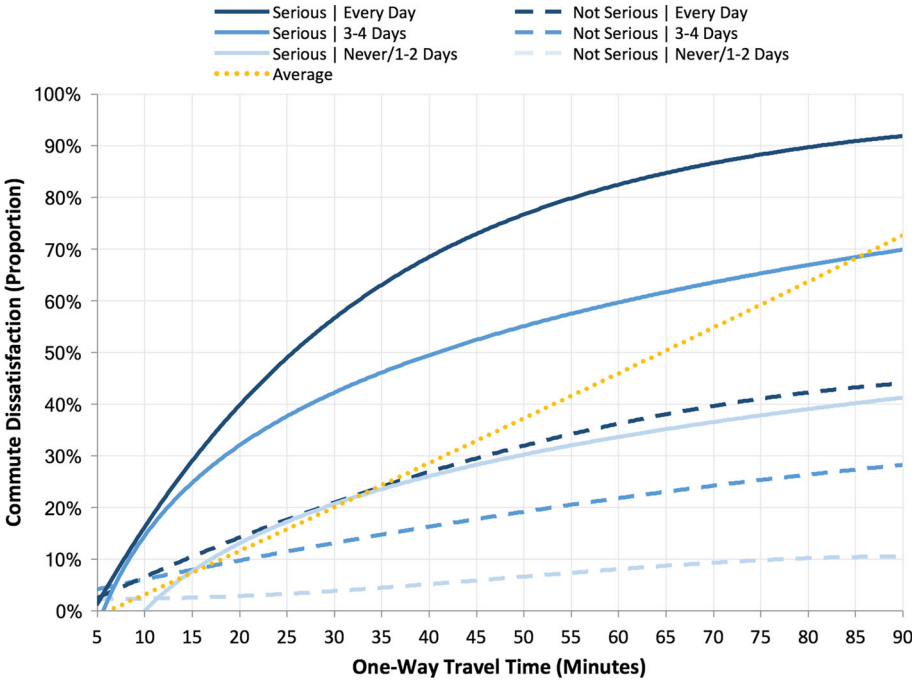

Fig. 1 Dissatisfaction with commute by travel time and level of congestion

commute dissatisfaction according to the respondent's one-way commute travel time, incidences of congestion, and trait susceptibility to congestion and polynomial trend lines are then fit to the plotted points.

Figure 1 reinforces model results by demonstrating that increasing congestion and travel time has a profound effect on increasing commute dissatisfaction. An immediate conclusion is that relationships among variables are non-linear, signifying a variable rate of decay in satisfaction as combinations of travel times and incidences of weekly congestion increase. Furthermore, a perception of congestion as a serious problem plays a key role in determining the magnitude and rate of decay in satisfaction.

Focusing on those who view congestion as a serious problem, we see very high rates of decay in satisfaction with commute duration as travel time increases. For those in the combined 'never' and '1–2 days per week' category, it is not until we see travel times of 90 min that rates of dissatisfaction begin to approach 50%. In contrast, experiencing traffic congestion 3–4 days per week causes a majority of drivers to become dissatisfied at a one-way travel time of approximately 40 min, while congestion every day lowers this further to around 25 min. Those that view congestion as not a serious problem exhibit much lower rates of overall dissatisfaction. With one-way travel times of 90 min in daily congestion the model predicts that only 43% of these individuals would be dissatisfied with their commute and only 10% would be dissatisfied while experiencing free-flow and low congestion conditions.

Clearly there are differences in the magnitude of commute dissatisfaction predicted by travel time, congestion, and individual perceptions of or responses to congestion. But Fig. 1 also offers further evidence of the implications of the differences between measures of the disutilities of travel more generally. The curve labeled 'Average' plots the decay in

satisfaction by travel time predicted by the MNL model when traffic congestion and individual trait susceptibility to it are *not* explicitly considered. Here it can be seen that average dissatisfaction largely increases with travel time in a linear manner. From this, research that employs only travel time as a measure of impedance and omits measures of congestion and individual responses to it is at risk of overestimating the costs of travel time for those traveling in low-congestion conditions and underestimating the costs of congestion for those that are regularly stuck in traffic.

Discussion and conclusions

The results of this research suggest that the value of a minute spent commuting is dependent on travel context. Broadly speaking, increasing incidences of congestion encountered during commuting decrease an individual's satisfaction with the duration of their commute. In this sense, as the previous literature predicts, congestion that increases impedance and variability leads to lower levels of commuter satisfaction. But more importantly, the results also show that it is not only individual exposure to congestion that matters, but also the duration of that exposure. Compared to drivers who experience only infrequent congestion, those who spend more time commuting in congested conditions show drastically different tolerances for travel times.

Individual internalization of congestion mediates this relationship. Within our study, we interpreted individual perceptions of congestion as a serious problem as a partial proxy for time pressure and trait susceptibility to congestion-related stressors. Indeed, results indicate that those who view congestion as a serious problem place a high value on minutes spent commuting in congested and uncongested conditions and show much higher rates of dissatisfaction with their commute duration overall. Conversely, those for whom congestion is not a serious problem show lower rates of dissatisfaction, even with long commutes in daily traffic congestion. For these individuals, the positive aspects of commuting may be interacting with their lower predisposition to congestion-related stress to produce a commute duration that is satisfactory.

Notably, very large proportions of drivers remain very satisfied with their commute duration. Even with a one-way travel time of 60 min in daily congestion, which is more than double the Canadian national average commute in Table 1, our model predicts that approximately 65% of drivers who do not see congestion as a serious problem will still be satisfied. In free-flow and low-congestion conditions, this increases to more than 90%. This is also reflected in the summary statistics of the sample, wherein 84% of individuals reported being either 'satisfied' or 'very satisfied' with their commute duration, mirroring Baldassare's (2002) study of commute satisfaction in California and reinforcing the results of the 'travel liking' literature.

That a majority of commuters in our sample are satisfied with their commutes likely reflects several trends. Commutes are in part shaped by individual or household self-selection of their places of residence and places of work, subject to constraints. Within this framework, we hypothesized that congestion may be impacting individual satisfaction with the duration of their commute by increasing travel times and travel time unreliability relative to some desired or assumed optimum duration based on the selection of home and work locations. For the majority however, their 'commuting bargain' appears to be proceeding as anticipated. Here, the context of their commute may not have a great effect on their budgeted travel time expectations and the duration is thus deemed satisfying.

Taken together, our findings highlight a complex interplay between congestion, travel time, trait susceptibility, and satisfaction with commute duration, from which several conclusions for research and policy can be drawn. For research, Fig. 1 shows that a model that utilizes only travel time as a measure of commuting burden risks significantly overestimating the value of time for individuals in free flow commuting and underestimating the costs of congestion. As such, researchers need to look beyond travel time and incorporate congestion into their understanding of the costs of commuting if their measures of impedance are to better reflect the disutilities of travel.

For policy, this complexity also highlights potential differences in the efficacy of policy prescriptions designed to improve commute satisfaction. In short, it is clear that a focus on only travel time reductions may not address the needs of those facing the most burdensome commutes. For example, Fig. 1 shows that if, as suggested in Table 1, one-way average commute times for Canadians actually decreased from 31.5 to 25.5 min between 2005 and 2011, average levels of dissatisfaction would fall from approximately 57 to 50% among individuals that view congestion as a serious problem and drive in congested conditions every day. Similar reductions in travel times would produce only a negligible increase in satisfaction for those that commute in generally free-flow conditions and don't view congestion as a serious problem.

In contrast, the greatest increase in satisfaction comes from a combination of not only reducing travel times, but by shifting individuals to a different curve altogether by reducing individual exposure to congestion events. Results indicate that in the absence of policies that directly focus on congestion reduction, such as peak-period road pricing, other policy actions which strictly focus on travel time savings may have very weak capacities to actually improve driver commute satisfaction.

Still, the above findings are subject to some limitations. First, the design of the commuting questions in the GSS is imprecise. While we employ perceptions of congestion as a serious a problem as a proxy for trait susceptibility to congestion-related stress, a more precise operationalization of this concept can be obtained through the directed questions utilized by Hennessy and Wiesenthal (1997). Moreover, the GSS does not capture other aspects of commuting, such as information on commuting patterns relative to other life and locational choices. A lack of destinations means we also cannot test how satisfaction differs across commuting patterns. It might be that the highest rates of dissatisfaction arise from peak-period peak-direction commutes for example.

Second, satisfaction with one's commute duration cannot be conflated with overall life satisfaction or SWB. In the present case, it remains unknown the degree to which an individual's exposure to traffic congestion and the duration of this exposure are associated someone's general levels of happiness. From this, whether individuals would be willing to pay for reductions in commuting dissatisfaction, such as through road pricing, in exchange for an improved quality of life is also unknown. Previous research by Morris and Hirsch (2015) for example finds only a weak association between congestion and SWB. On the other hand, if reductions in congestion and travel times allow individuals to engage in activities they value, research by Abou-Zeid and Ben-Akiva (2012), Bergstad et al. (2011), and Ettema et al. (2011) suggests that reducing travel times and congestion may have a large but indirect effect on SWB, particularly for women in Canada (Sweet and Kanaroglou 2016).

Nevertheless, despite these limitations, the present research does reveal a strong signal between travel time, incidences of congestion, individual internalization of congestion-related stressors, and satisfaction with commute duration. From this, not every minute

spent commuting is equal. Future research should seek to further explore these findings and capture the heterogeneity in individual responses to different commute contexts.

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