Accessibility Matters

Determinants of public transport use across income groups in Canada

Boer Cui[1], Geneviève Boisjoly[2], Luis Miranda-Moreno[1], Ahmed El-Geneidy[1]

[1]McGill University, [2]Polytechnique Montréal

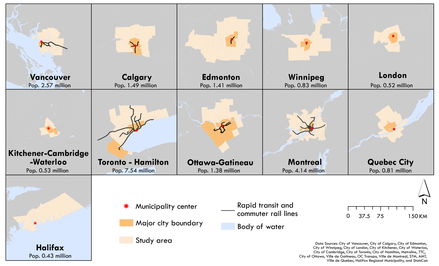
TRAM Transportation Research at McGill

CIRRELT McGill

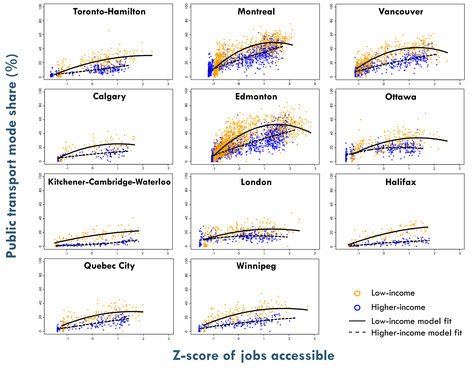
ABSTRACT

- Planning for accessibility is increasingly being considered in the development of equitable transport plans and has been shown to positively influence public transport use
- However, this influence has not been examined across income groups and in geographic regions of varying sizes
- This study aims to quantify the **relationship** between **accessibility to jobs** by public transport and **public transport use** for **low-** and **higher-income** groups in eleven Canadian metropolitan regions
- We found that accessibility is a predictor of mode share and its **predicting power is higher** for **low-income** commuters
- In addition, the relationship between accessibility and mode share tends to be **non-linear**

STUDY AREAS



PREVIOUS BIVARIATE ANAYLSIS



DATA & METHODOLOGY

Explanatory variables

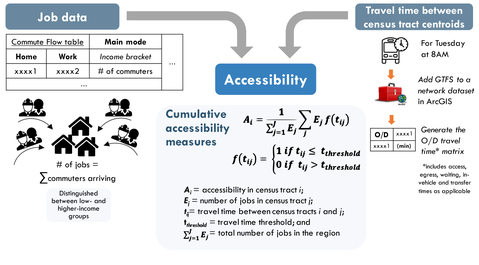
1. **Accessibility**
2. **Control variables**

Dependent variable

3. **PT mode share**

4. **Series of linear regression models**

1 Accessibility measure



Cumulative accessibility measures

$$A_i = \frac{1}{\sum_{i=1} E_j} \sum E_j f(t_{ij})$$

$$f(t_{ij}) = \begin{cases} 1 \text{ if } t_{ij} \leq t_{threshold} \\ 0 \text{ if } t_{ij} > t_{threshold} \end{cases}$$

A_i = accessibility in census tract i;
E_j = number of jobs in census tract j;
t_{ij} = travel time between census tracts i and j;
$t_{threshold}$ = travel time threshold; and
$\sum_{j=1} E_j$ = total number of jobs in the region

2 Control variables

3 PT mode share

Commute Flow table		Main mode
Home	Work	*Income bracket*
xxxx1	xxxx2	# of commuters
...		

Public transport mode share = % commuters leaving by public transport*

*Public transport includes bus, subway, elevated and light rail, streetcar, commuter train, and passenger ferry

4 Linear regression models

$$PT_i = \beta_0 + \beta_1 Access_i + \beta_2 Access^2_i + \beta_3 Density_i + \beta_4 Age_i + \beta_5 HHsize_i + \beta_6 Index_i + \beta_7 Station_i + \beta_8 Highway_i$$

Used to model the non-linear relationship between accessibility and mode share

i = census tract i;
PT_i = predicted public transport mode share of commuters leaving i;
$Access_i$ = accessibility to jobs by public transport of i;
$Access^2_i$ = squared value of accessibility to jobs by public transport of i;
$Density_i$ = population density of i;
Age_i = average age of people living in i;
$HHsize_i$ = average household structure of i;
$Index_i$ = decile ranking of i in terms of social deprivation;
$Station_i$ = network distance to the nearest rapid public transport station from centroid of i;
$Highway_i$ = network distance to the nearest highway ramp from centroid of i; and
$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ = parameters to be estimated.

Done **separately** for
- Commuters in different metropolitan regions
- Low-income and higher-income groups

RESULTS

Selected summary statistics

	All Regions		Toronto-Hamilton		Montreal		Vancouver		Calgary		Edmonton		Halifax		Kit-Cam-Wat		London		Ottawa-Gatineau		Quebec City		Winnipeg	
	Higher	Low	Higher	Low	Higher	Low	Higher	Low	Higher	Low	Higher	Low	Higher	Low	Higher	Low	Higher	Low	Higher	Low	Higher	Low	Higher	Low
Total jobs (10,000)	604.9	269.9	205.4	88.1	122.9	52.2	68.9	31.5	39.0	19.6	36.3	18.8	12.6	5.5	16.1	6.6	13.6	6.3	39.2	21.3	27.6	9.9	24.3	10.1
Modal split (%)																								
PT	17.8	26.1	21.0	29.5	23.4	29.4	17.1	29.2	13.4	19.4	9.5	18.3	10.1	18.0	3.7	14.3	4.4	16.0	16.9	23.9	10.7	19.1	11.3	22.9
Car	75.7	62.4	74.0	59.9	68.5	58.0	75.1	58.1	80.9	71.9	86.6	73.4	79.7	67.2	91.1	74.6	90.1	71.3	74.2	63.4	79.9	65.3	82.3	66.7
Active	6.6	11.5	5.0	10.6	8.1	12.5	7.9	12.7	5.6	8.7	3.8	8.3	10.2	14.8	5.3	11.1	5.5	12.7	8.8	12.6	9.4	15.6	6.4	10.5
Commute time (min)																								
Average	58.0	49.8	62.0	52.4	53.7	45.9	52.1	47.4	58.7	56.8	73.2	53.6	61.5	54.2	47.1	45.9	44.3	51.4	60.6	50.0	53.5	45.5	43.0	42.4
Median	49.5	43.5	54.6	47.0	45.4	39.4	44.5	40.8	53.9	52.1	49.7	44.4	47.4	44.7	42.3	42.3	41.9	44.2	47.2	43.7	46.5	40.1	39.7	38.6
Average accessibility																								
Access (%)	19.3	11.9	11.8	6.0	17.2	11.8	17.4	12.5	28.8	17.3	20.3	13.3	23.4	20.9	14.8	15.4	18.4	22.1	22.3	17.3	22.7	15.4	25.7	23.4
Access (thous. jobs)	18.8	4.4	24.2	5.3	21.2	6.2	12.0	3.9	11.2	3.4	7.4	2.5	3.0	1.1	2.4	1.0	2.5	1.4	8.5	3.7	6.2	1.5	6.2	2.4

Regression results

Largest-sized metropolitan regions | Medium-sized metropolitan regions

	Toronto-Hamilton		Montreal		Vancouver		Calgary		Edmonton		Ottawa-Gatineau	
	Higher-income	Low-income	Higher-income	Low-income	Higher-income	Low-income	Higher-income	Low-income	Higher-income	Low-income	Higher-income	Low-income
Accessibility Measures												
Access (%)	**0.88** ***	**4.24** ***	**0.63** ***	**1.48** ***	**0.43** ***	**1.70** ***	0.05	**0.20** **	**0.16** ***	**0.60** ***	**0.18** ***	**0.53** ***
Access^2 (%^{2})	-0.003	**-0.12** ***	**-0.01** ***	**-0.02** ***	**-0.003** **	**-0.03** ***	-0.001	-0.002	-0.002	**-0.01** ***	**-0.003** **	-0.005
Control Variables												
Density (thous. persons/km^2)	0.22 ***	-0.15 ***	0.38 ***	0.29 ***	-0.06	-0.37 ***	-0.05	0.08	0.55 ***	-0.03 ***	0.39	0.40
Age	0.02	-0.30 ***	-0.19 ***	0.10	-0.35 ***	-0.40 ***	-0.21 **	-0.12	-0.19 ***	-0.14	-0.01	0.19
HHstructure	0.81	-0.95	-2.05 **	2.98 ***	-4.95 ***	-1.80 *	-0.61	0.25	-2.37 ***	-0.69	1.43	9.04 ***
Index (decile)	0.93 ***	1.86 ***	0.66 ***	1.89 ***	0.73 ***	0.68 ***	0.29 ***	1.40 ***	0.45 ***	1.32 ***	0.70 ***	2.19 ***
Station (km)	-0.48 ***	-0.26 ***	-0.36 ***	-0.49 ***	-0.20 ***	-0.28 ***	-0.66 ***	-0.64 ***	-0.20 ***	-0.35 ***	-0.36 ***	-0.45 ***
Highway (km)	0.28 ***	0.12	0.09	0.05	-0.27 ***	-0.42 ***	0.38 ***	0.17	0.16 ***	0.04	0.13	0.14
Constant	3.68	19.77 ***	24.01 ***	-1.32	37.89 ***	40.32 ***	23.75 ***	16.27 **	18.65 ***	16.93	9.11	-23.65 **
R-squared value	0.757	0.738	0.739	0.781	0.702	0.649	0.497	0.668	0.674	0.710	0.432	0.641

Small-sized metropolitan regions

	Halifax		Kit-Cam-Wat		London	
	Higher-income	Low-income	Higher-income	Low-income	Higher-income	Low-income
Accessibility Measures						
Access (%)	-0.13	0.13	-0.02	0.13	**0.15** **	**0.80** ***
Access^2 (%^{2})	0.002	-0.002	**0.004** **	-0.00003	-0.002	**-0.01** ***
Control Variables						
Density (thous. persons/km^2)	0.22	-0.48	0.20	1.03 **	0.22	-0.73
Age	0.03	-0.40	-0.23 ***	-0.30	-0.16	-0.51 ***
HHstructure	-2.92	-9.58	-2.51 ***	-1.63	-3.33 ***	-2.95
Index (decile)	0.84 **	1.64 ***	0.27 ***	1.35 ***	0.36 **	0.82 **
Station (km)						
Highway (km)	-0.20 ***	-0.32 ***	0.04	-0.25	0.08	0.19
Constant	12.23	49.01 **	16.30 ***	19.44	14.35 **	28.00 **
R-squared value	0.472	0.588	0.725	0.680	0.627	0.756

	Quebec City		Winnipeg	
	Higher-income	Low-income	Higher-income	Low-income
Accessibility Measures				
Access (%)	**0.28** ***	**0.48** ***	0.06	0.16
Access^2 (%^{2})	**-0.003** ***	-0.005	-0.0003	-0.003
Control Variables				
Density (thous. persons/km^2)	0.54 ***	0.53 **	0.82 ***	1.32 ***
Age	-0.13	0.26	-0.23 ***	-0.11
HHstructure	-2.91	10.13 ***	-2.37 ***	-4.40 ***
Index (decile)	0.64 ***	1.80 ***	0.82 ***	1.73 ***
Station (km)			-0.13 *	-0.40 ***
Highway (km)	-0.16 **	-0.54 ***	-0.05	0.08
Constant	14.62 *	-28.57 **	20.22 ***	26.71 **
R-squared value	0.740	0.643	0.762	0.750

*p<0.1 ** p<0.05 ***p<0.01

Control variables

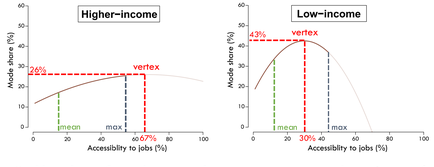
Impact on public transport mode share of:

	Higher-income commuters	Low-income commuters
Average age	−	−
Average HH size	− −	−
Social deprivation ranking	+	+
Distance to rapid transit	−	− −
Distance to highway ramp	−	− −

DISCUSSION & CONCLUSIONS

- Accessibility has a **greater impact** on the public transport mode share of low-income commuters
  - → Mode share of low-income group is **more sensitive to increases in accessibility**
  - → Low-income commuters are not necessarily captive to transit
- Non-linear relationship is observed between accessibility and mode share where **increasing accessibility** has a **positive impact on mode share** until the **vertex** past which the **impact becomes negative**
  - → This relationship is most strongly observed in the **three largest metropolitan** regions, specifically for **low-income** commuters

Vancouver example:



- → **Uptake of active modes** may occur at locations of very high accessibility by public transport as these areas may also have high accessibility by active **modes**

Policy implications

- Increasing accessibility not expected to lead to increases in mode share at very high levels of existing accessibility
- **Ridership gains** are **more likely** to occur when transit improvements **target low-income** commuters
- **More value** in improving accessibility in **areas of low existing accessibility** rather than improving public transport accessibility in already highly accessible regions
- Accessibility value at the vertex can be used as an optimal value to maximize public transport mode share

ACKNOWLEDGEMENTS

The work was partially funded by the Social Sciences and Humanities Research Council of Canada (SSHRC). The authors would like to thank Robbin Deboosere for the transit travel time information.