WHO IS PAYING TIME IN THE PENALTY BOX?

An Assessment of Transit Penalty and its Effect on Transit Ridership for Different Income Groups in Montréal, Canada

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INTRODUCTION

- "Transit Penalty" is defined as the ratio of travel time by public transit to travel time by car between an origin and destination.

- Efforts to increase transit ridership and design equitable transport systems rely on a clear understanding of the mechanics behind mode choice.

- This study investigates transit penalty among different income groups and its impact on public transport mode share.

Public transit route
Travel time: 40 min
— Walk
— Wait
— In-transit

Car route
Travel time: 20 min
— Driving
— Parking

Origin
5min Transit stop 1
5min 11min
Transit stop 2 4min 9min
5min Destination 6min
15min

Transit Penalty

$$\frac{40min}{20min} = 2$$

Conceptual depiction of transit penalty

METHODS

- **Data:** 2018 Montreal Origin-Destination survey (25,114 trips).

- **Travel time:** R5R travel time routing with OpenStreetMap (OSM)
  Transit: General Transit Specification (GTFS) data
  Car: Prediction model fit to Google API-generated congested travel time matrix

- Multilevel logistic regressions were used to reveal the relationship between mode choice and transit penalty, for different income groups.

Dependent variable — Independent variables
- Personal characteristics
- Household composition
- Trip attributes

Public transit mode share (One for each income group)

ANALYSIS/RESULTS

Transit Penalty in Montreal

Average Transit Penalty: 2.0 2.5 3.0 3.5 4.0+ No Data
Transit Mode Share: 5% 20% 45% 60% 100% No Data
— Major transit lines
0 5 10 km N

Average transit penalty and public transport mode share, by census tract

Regression Results

Model results for low, medium, high, and very high per capita income groups

Predictors	Low Income Odds Ratios	Medium Income Odds Ratios	High Income Odds Ratios	Very High Income Odds Ratios
Intercept	32.87 ***	50.88 ***	21.63 ***	49.16 ***
Personal characteristics				
Gender	0.61 ***	0.71 ***	1.11	1.19 *
Age	0.98 ***	0.98 ***	0.98 ***	0.98 ***
Work status	0.74 **	0.83	1.21	0.77
Household vehicles	0.11 ***	0.16 ***	0.17 ***	0.25 ***
Household composition				
Children (age <13)	0.9 *	1.02	1.02	1.01
Children (age 13-18)	1.02	1.1	0.98	0.94
Adults (age >18)	2.1 ***	1.91 ***	2.22 ***	1.82 ***
Retired adults	1.49 ***	1.94 ***	2.39 ***	1.62 **
Trip attributes				
Transit penalty	0.43 ***	0.28 ***	0.24 ***	0.2 ***
Jobs within 45min via transit	1.01 ***	1.01 ***	1.01 ***	1.01 ***
Trip distance	1.02 ***	1.04 ***	1.04 ***	1.03 ***
Random effects				
ICC	0.01	0.04	0.05	0.12
N	835 CTUID	867 CTUID	835 CTUID	800 CTUID
Observations	5,422	8,194	5,951	5,547
Marginal R2 / Conditional R2	0.670 / 0.673	0.678 / 0.693	0.675 / 0.692	0.649 / 0.690

* p<0.05   ** p<0.01   *** p<0.001

Sensitivity Analysis

The sensitivity analysis shows the predicted probability of using public transport at various transit penalty levels for each income group. Trip distance and regional transit accessibility measures are set to the sample-wide mean values.

Income levels*
— Low Income (<= $32,000)
— Medium Income ($32,000- $58,000)
— High Income ($58,000-$80,000)
— Very High Income ($80,000+)

*per capita

Transit penalty and mode share sensitivity analysis

Bivariate Map

The combination of low income and high transit penalty in areas that also have high public transit mode share represent populations experiencing a heightened burden from poor transit service.

Transit Penalty Low — High
Median Income Low / High
No data
— Major transit lines
0 5 20 km N

Bivariate transit penalty and median income, by census tract

CONCLUSION

- The transit penalty measure allows us to both observe the relationship of travel time to mode choice and view the spatial distribution for who and where travel time burdens are greatest.

- Lower income individuals are more likely to continue riding public transit as transit penalty increases, compared to those with higher income.

- Improving transit penalty in higher-income communities has the highest potential return on investment in terms of increased ridership.

- Transit penalty's strong and statistically significant relationship to public transport mode share makes it an effective measure for understanding ridership.

- Aiming for a city-wide transit penalty of 2.25 would bring Montréal's regional target of 38% public transit mode share within reach.

- Given the disproportionate burden of transit penalty on low-income groups, areas with high concentrations of low-income residents should be prioritized for transit improvements.

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