THE FAR SIDE STORY

Measuring the benefits of bus stop location on transit performance

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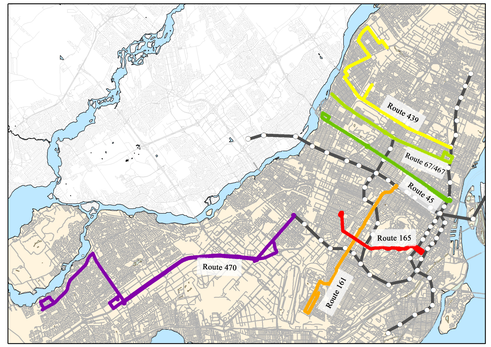
ABSTRACT

This article aims to evaluate the impact of **bus stop location** on bus **dwell time** and **dwell time variation**. It uses stop-level data collected from the Société de **transport de Montréal (STM)**'s automatic vehicle location (AVL) and automatic passenger count (APC) systems, in Montréal, Canada.

The study findings show that dwells occurring on the **near side** of intersections are in average **5.0 seconds slower** than dwells occurring on the **far side** of intersections, with no impact on dwell time variation, while controlling for the impacts of traffic lights and right turn lanes.

INTRODUCTION

Whether a bus stop should be located at the near side of the intersection or the far side of the intersection has been a **source of debate**. Many transit agencies tend to locate bus stops at the near side of intersections, without **clear understanding** of this impact on the service dwell time and its variation.



Routes
- Route 45
- Route 67/467
- Route 161
- Route165
- Route 439
- Route 470

- Metro stops
- Metro lines
- Streets
- Water bodies

0 1 2 4 km
0 1 2 4 mi
N

Data Source: STM & DMTI

Projection: NAD 1983 MTM 8

METHODOLOGY

In this research, we will be concentrating on **two statistical models** to capture and isolate the effects of the stop location on dwell time and its variation, namely, **dwell time (DT)** and **DT variation** models.

- About **449,170 stop level** observations are included in the the DT model.
- For the **DT variation model**, data have been aggregated according to the **following criteria**: Stop unique name, time of the day, type of bus, route number, and direction.
- After this process, **1708 groups** of dwells are kept for analysis, with an average group size of 260 dwells and standard deviation of 192 dwells.
- Then, the **coefficient of variation (CV) of dwell time** has been calculated by dividing the DT standard deviation for a group by the group average DT and, then, multiplying the outcome by one hundred.

DESCRIPTIVE STATISTICS

Route	Dir.	Route length (km)	Running time (min)	Number of stops	Near-side stops	Far-side stops	Mid-block stops	Signalized intersection	Right-turn lane	Stop shelter
45	North	11.2	39.6	43	34	1	8	32	26	18
	South	12.7	41.4	43	37	3	3	37	24	21
67	North	9.2	39.8	38	37	0	1	34	28	19
	South	9.7	40.4	41	37	2	2	36	30	26
161	East	10.3	38.7	44	37	4	3	30	27	12
	West	11.8	42.6	48	44	2	2	32	37	13
165	North	6.6	26.8	31	25	2	4	19	13	8
	South	7.7	35.2	35	26	4	5	23	17	13
439	North	10.8	26.0	19	9	3	7	9	5	3
	South	15.1	41.1	23	15	4	4	15	16	10
467	North	9.1	27.7	16	15	1	0	15	13	9
	South	9.7	33.5	18	17	1	0	17	16	10
470	East	22.3	26.0	24	19	2	1	16	19	17
	West	22.6	24.5	23	17	3	1	14	17	11
Total				446	369	32	41	329	288	190

Route	Dir.	Average by stop*				Average coefficient of variation by stop*				
		boarding	Alighting	Passenger activity	Dwell time (s)	Time per passenger (s)**	CV boarding	CV Alighting	CV Passenger activity	CV Dwell time	CV Time per passenger ***
45	North	1.90	2.85	4.75	23.03	4.85	143.2	86.8	63.1	69.3	1.10
	South	2.81	2.08	4.89	26.71	5.46	122.9	130.1	65.9	72.4	1.10
67	North	1.97	2.96	4.73	25.90	5.47	131.4	89.8	63.4	75.3	1.19
	South	2.77	2.10	4.87	25.17	5.17	107.3	138.2	66.6	76.1	1.14
161	East	2.56	1.97	4.52	20.35	4.50	88.3	166.0	64.1	73.4	1.15
	West	1.77	2.60	4.37	19.94	4.57	182.3	81.1	62.8	71.9	1.14
165	North	1.75	3.96	5.71	22.17	3.88	191.8	84.7	63.6	69.2	1.09
	South	3.69	2.53	6.23	29.14	4.68	116.0	154.7	64.1	68.7	1.07
439	North	1.87	6.42	8.30	20.31	2.45	155.0	55.6	53.5	65.6	1.23
	South	4.80	1.79	6.59	26.40	4.01	73.4	222.0	66.9	74.5	1.11
467	North	3.83	5.02	8.85	36.00	4.07	104.4	76.5	65.1	67.5	1.04
	South	5.73	3.85	9.58	39.34	4.11	82.8	114.2	64.4	61.8	0.96
470	East	2.35	0.47	2.83	13.46	4.73	86.8	301.6	69.7	84.0	1.20
	West	0.39	2.30	2.69	12.77	4.74	286.4	69.2	66.2	85.2	1.29

* Without including metro stops boardings and alightings
** Time per passenger (s) = average dwell time (s) / average total passenger activity per dwell
*** CV per passenger= average CV dwell time / CV passenger activity per dwell

ANALYSIS

1 DWELL TIME MODEL

Variable	Coefficients	t-stat	95% Conf. Interval	
Constant	-1.03***	-6.15	-1.36	-0.70
AM peak	-1.83***	-20.38	-2.01	-1.65
PM peak	-0.28***	-3.08	-0.45	-0.10
Night	-2.10***	-27.24	-2.25	-1.95
Midnight and early morning	-3.64***	-24.40	-3.93	-3.34
Door 1 boarding	3.31***	272.86	3.28	3.33
Door 1 alighting	1.90***	88.15	1.86	1.94
Door 2 boarding	3.04***	12.37	2.55	3.52
Door 2 alighting	1.12***	53.28	1.08	1.16
Door 3 boarding	2.14***	6.54	1.50	2.78
Door 3 alighting	0.52***	21.81	0.47	0.57
Total passenger activity^2	-0.01***	-47.17	-0.01	-0.01
Passenger load	-0.11***	-39.86	-0.12	-0.11
Friction	0.15***	22.21	0.13	0.16
Delay at the start (s)	-0.01***	-14.03	-0.01	0.00
Metro stop	18.99***	59.19	18.36	19.62
Metro stop boarding	0.13***	7.16	0.10	0.17
Metro stop alighting	-0.44***	-23.58	-0.47	-0.40
Wind chill temperature	0.01**	2.44	0.00	0.02
Rainfall (mm)	0.12***	3.55	0.05	0.19
Rainfall^2	-0.01***	-4.79	-0.02	-0.01
Snow on ground (cm)	-0.06***	-5.15	-0.09	-0.04
Snow on ground^2	0.01***	4.89	0.01	0.00
Near-side	5.01***	36.51	4.74	5.28
Right-turn lane	2.96***	39.28	2.82	3.11
Signalized intersection	9.24***	95.23	9.05	9.43
Midblock stop	6.77***	34.96	6.39	7.15
Bus reserved lanes in operation	-1.38***	-11.68	-1.61	-1.15
Car private/public Entrance	-1.69***	-23.29	-1.83	-1.54
Stop Shelter	1.16***	18.50	1.04	1.28
More than one route	-1.14***	-12.98	-1.31	-0.97
Inbound	-0.41***	-6.75	-0.52	-0.29
Route 45	3.56***	34.17	3.36	3.77
Route 67	4.77***	42.39	4.55	4.99
Route 165	5.87***	46.39	5.62	6.11
Route 439	3.02***	13.83	2.59	3.45
Route 467	6.94***	43.48	6.62	7.25
Route 470	-2.11***	-14.82	-2.39	-1.83
N	449,170			
R2	0.51			
F statistics	(37, 449169) 12,563			
F significance (Prob > F)	0.00			

Bold indicates statistical significance
*** Significant at 99% ** Significant at 95% * Significant at 90%

ANALYSIS, CONT'D

2 CV DWELL TIME MODEL

Variable	Coefficients	t-stat	95% Conf. Interval	
Constant	39.29***	5.66	25.67	52.91
AM peak	2.620	1.50	-0.81	6.05
PM peak	5.364***	3.73	2.54	8.19
Night	4.149***	2.85	1.29	7.01
Midnight and early morning	5.179**	2.46	1.05	9.30
CV Door 1 boarding	0.011***	2.65	0.00	0.02
CV Door 1 alighting	0.016***	3.20	0.01	0.03
CV Door 2 boarding	-0.001**	-2.13	0.00	0.00
CV Door 2 alighting	0.008***	3.31	0.00	0.01
CV Door 3 boarding	-0.003***	-4.01	-0.01	0.00
CV Door 3 alighting	0.005*	1.77	0.00	0.01
CV total passenger activity^2	0.016***	3.40	0.01	0.03
CV passenger load	0.022	0.95	-0.02	0.07
CV Friction	0.079***	5.17	0.05	0.11
CV Delay at start	0.000	-0.66	0.00	0.00
Metro stop	-15.36*	-1.84	-31.74	1.02
CV metro stop boarding	0.061**	1.96	0.00	0.13
CV metro stop alighting	0.118	0.97	-0.12	0.36
CV Wind chill temperature	-0.046	-1.52	-0.11	0.01
CV Rainfall	0.026**	1.98	0.00	0.05
CV Snow on ground	-0.019	-0.64	-0.08	0.04
Near-side	0.042	0.02	-4.01	4.09
Right-turn lane	-2.948***	-2.66	-5.13	-0.77
Signalized intersection	9.102***	6.64	6.41	11.79
Midblock stop	2.488	0.88	-3.05	8.02
Bus reserved lanes in operation	1.094	0.65	-2.23	4.42
Car private/public Entrance	3.828***	3.55	1.71	5.94
Stop Shelter	-0.621	-0.66	-2.45	1.21
More than one route	-1.069	-0.80	-3.69	1.55
Inbound	-2.128**	-2.26	-3.97	-0.28
Route 45	-2.978*	-1.68	-6.46	0.50
Route 67	1.584	0.76	-2.52	5.69
Route 165	-5.053**	-2.28	-9.40	-0.71
Route 439	-0.610	-0.20	-6.65	5.43
Route 467	-5.219**	-2.01	-10.32	-0.12
Route 470	8.868***	3.60	4.04	13.69
N	1708			
R2	0.21			
F statistics	(35, 1707) 12.4			
F significance (Prob > F)	0.00			

Bold indicate statistical significance
*** Significant at 99% ** Significant at 95% * Significant at 90%

Near vs. Far side stops

Dwells occurring on the **near side** of intersections are in average **5.0 sec slower** than dwells occurring on the **far side** of intersections, with no impact on dwell time variation.

Right-turn lane

A right-turn lane at near-side stop is expected to **increase** dwell time by **8.0 sec**, while **decreasing** dwell time variation by **3.0%**. In other words, dwells taking on near-side stops with right-turn lane are **consistently slower** than other dwells.

Traffic lights

The existence of **traffic light** has a statistically significant impact on dwell time and its variation, **increasing dwell time** by **9.2 sec**, while increasing **its variation** by **9%** compared to other mid-block stops or stops at stop signs.

Stop Shelters & Reserved lanes

Stop shelters is expected to **increase** dwell time, by **1.2 sec** compared to stops without shelters. **Reserved lanes** are found to have a positive effect on dwell time, decreasing it by **1.4 sec**. Both variables have **no effects** on **dwell time variation**.

Car entrances & Routes overlap

Car entrances are expected to decrease dwell time by 1.7 sec, while increasing it variation by 3.8%. Dwells at bus stops served by **more than one bus routes** are expected to be slightly shorter by **1.1 sec**, with no impacts on variation.

CONCLUSION

The main aim of the article is to understand the effects of bus stop location on bus dwell time (DT) and its variation. Dwells at the **near-side stops** are **5 sec** slower than the **far-side**, with no impact on DT variation. The existence of **right-turn lane** consistently adds **3 sec** of delay.

Since it is rare to find **DT variation** models in the literature, one important finding of the model is related to **passenger alighting** from the **bus first door**. It adds more variance to DT than boarding from any other door.

If we considered Route 165 that has 23 near-side stops per direction. **Moving stops** from near-side to far-side along this route would save about **115 sec** (1.9 min) on total route-direction travel time **(about 6.1%)**.

If we account for the **absence of turning right lanes**, we will achieve additional **45 sec** of saving, increasing the total saving to **8.5%** in travel time. Thus, this shift from near-side to far-side stops would increase the bus frequency by **9 trips** per weekday and direction.

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