Portland State University

PDXScholar

TREC Friday Seminar Series

Transportation Research and Education Center
(TREC)

2-2-2018

Evaluation of Route Changes Utilizing High-Resolution GPS Bus Transit Data

Travis Bradley Glick

Portland State University, gllick.travis@gmail.com

Follow this and additional works at: https://pdxscholar.library.pdx.edu/trec_seminar

Part of the [Transportation Commons](#), [Transportation Engineering Commons](#), and the [Urban Studies Commons](#)

Let us know how access to this document benefits you.

Recommended Citation

Glick, Travis Bradley, "Evaluation of Route Changes Utilizing High-Resolution GPS Bus Transit Data" (2018). *TREC Friday Seminar Series*. 141.

https://pdxscholar.library.pdx.edu/trec_seminar/141

This Book is brought to you for free and open access. It has been accepted for inclusion in TREC Friday Seminar Series by an authorized administrator of PDXScholar. Please contact us if we can make this document more accessible: pdxscholar@pdx.edu.

Measuring the Determinants of Bus Dwell Times

New Insights and Potential Data Biases

LEAD-AUTHOR AND PRESENTER
TRAVIS B. GLICK

CO-AUTHOR
MIGUEL A. FIGLIOZZI

Who am I?

- Travis Bradley Glick
- Portland State University
 - Transportation, Technology, and People Lab
 - Transportation Research And Innovation Lab
- Advisor: Miguel A. Figliozi
 - Undergraduate Research and Thesis
 - Ongoing Research (Today's Subject)
 - Master's Thesis
 - Doctoral Research
- 5 peer-reviewed publications
 - 2015, 2016, (2) 2017, and 2018 Transportation Research Record

Project Motivation

- Dwell time contributes to travel-time variability
- Travel-time variability affects operator costs and user satisfaction
- Previous research has studied key factors of dwell time variability
 - Relied on stop-level data
 - Low reliability for stops near signalized intersections
 - Biases when estimating coefficients of passenger movements
- New data sources provide new avenues of research
 - New variables
 - Bias Corrections?

Project Overview

- Individual Stops
 - Midblock Stops
 - Nearside Stops
 - Farside Stops
 - Timepoint Stops
- Pooled Results from all stop types
- New Independent and Dependent Variables

Data Sources – Stop Level

- Stop Level
 - Data collected at the bus stops
 - Ons, Offs, Lift, Dwell, Door Operations, Door Open Time
 - Widespread implementation
 - Widely used to analyze routes, segments, and bus stops
 - Well-studied

Study Area

High-Resolution Data

Data Sources – Combined Data

Dwell Statistics

			Nearest Intersection	Dwell Statistics (seconds)						
				Min	15 th	Median	85 th	Average	Std. Dev.	Max
Stop Near Signalized Intersection	Far-side	EB	39 th ,TP	0	16	30	67	39.2	29.6	196
			82 nd ,TP	0	21	41	102	57.5	45.7	270
			86 th	0	0	13	25	12.7	13.6	82
		WB	39 th ,TP	0	19	31	64	39.9	29.4	230
			82 nd ,TP	0	22	43	118	61.8	48.2	286
	NS	EB	42 nd	0	0	10	32	13.2	16.8	84
		WB	87 th	0	0	13	33	15.0	17.1	94
No Signal Near Bus Stop		Eastbound	34 th	0	0	12	22	12.2	12.1	78
			36 th	0	0	0	16	6.7	9.3	62
			79 th	0	0	11	23	11.3	14.6	88
			90 th	0	0	0	18	7.5	12.1	70
		Westbound	34 th	0	0	13	26	14.0	14.6	81
			36 th	0	0	0	17	8.4	10.3	57
			40 th	0	0	0	17	7.5	9.8	78
			79 th	0	0	10	21	9.8	11.3	60
			84 th	0	0	11	28	14.1	19.5	113

Dwell Statistics

			Nearest Intersection	Dwell Statistics (seconds)						
				Min	15 th	Median	85 th	Average	Std. Dev.	Max
Stop Near Signalized Intersection	Far-side	EB	39 th ,TP	0	16	30	67	39.2	29.6	196
			82nd,TP	0	21	41	102	57.5	45.7	270
			86 th	0	0	13	25	12.7	13.6	82
	NS	WB	39 th ,TP	0	19	31	64	39.9	29.4	230
			82 nd ,TP	0	22	43	118	61.8	48.2	286
			42 nd	0	0	10	32	13.2	16.8	84
No Signal Near Bus Stop		Eastbound	87 th	0	0	13	33	15.0	17.1	94
			34 th	0	0	12	22	12.2	12.1	78
			36 th	0	0	0	16	6.7	9.3	62
			79 th	0	0	11	23	11.3	14.6	88
			90 th	0	0	0	18	7.5	12.1	70
		Westbound	34 th	0	0	13	26	14.0	14.6	81
			36 th	0	0	0	17	8.4	10.3	57
			40 th	0	0	0	17	7.5	9.8	78
			79 th	0	0	10	21	9.8	11.3	60
			84 th	0	0	11	28	14.1	19.5	113

Dwell Statistics

			Nearest Intersection	Dwell Statistics (seconds)						
				Min	15 th	Median	85 th	Average	Std. Dev.	Max
Stop Near Signalized Intersection	Far-side	EB	39 th ,TP	0	16	30	67	39.2	29.6	196
			82 nd ,TP	0	21	41	102	57.5	45.7	270
			86 th	0	0	13	25	12.7	13.6	82
		WB	39 th ,TP	0	19	31	64	39.9	29.4	230
			82 nd ,TP	0	22	43	118	61.8	48.2	286
	NS	EB	42 nd	0	0	10	32	13.2	16.8	84
		WB	87 th	0	0	13	33	15.0	17.1	94
No Signal Near Bus Stop		Eastbound	34 th	0	0	12	22	12.2	12.1	78
			36th	0	0	0	16	6.7	9.3	62
			79 th	0	0	11	23	11.3	14.6	88
			90 th	0	0	0	18	7.5	12.1	70
		Westbound	34 th	0	0	13	26	14.0	14.6	81
			36 th	0	0	0	17	8.4	10.3	57
			40 th	0	0	0	17	7.5	9.8	78
			79 th	0	0	10	21	9.8	11.3	60
			84 th	0	0	11	28	14.1	19.5	113

Stop Activity

			Nearest Intersection	Stops (per day)	Ons (per day)	Offs (per day)	Lift* (per week)	Bus Bay	Shelter
Stop Near Signalized Intersection	Far-side	EB	39 th ,TP	63	162	283	9.0	x	x
			82 nd ,TP	64	256	266	15.0	x	x
			86 th	40	32	55	1.0	x	x
		WB	39 th ,TP	64	268	110	6.0		x
			82 nd ,TP	63	226	155	5.3	x	x
	NS	EB	42 nd	33	12	40	0.3		x
		WB	87 th	38	48	30	1.0	x	
No Signal Near Bus Stop		Eastbound	34 th	45	35	70	2.0		
			36 th	29	11	35	0.3		
			79 th	35	8	63	1.0	x	
			90 th	22	10	26	0.3		x
		Westbound	34 th	45	76	32	2.7		x
			36 th	32	41	16	0.3		
			40 th	31	15	42	1.3		
			79 th	35	54	7	0.0	x	x
			84 th	34	16	71	2.3	x	

Stop Activity

			Nearest Intersection	Stops (per day)	Ons (per day)	Offs (per day)	Lift* (per week)	Bus Bay	Shelter
Stop Near Signalized Intersection	Far-side	EB	39 th ,TP	63	162	283	9.0	x	x
			82nd,TP	64	256	266	15.0	x	x
			86 th	40	32	55	1.0	x	x
	NS	WB	39 th ,TP	64	268	110	6.0		x
			82 nd ,TP	63	226	155	5.3	x	x
		EB	42 nd	33	12	40	0.3		x
No Signal Near Bus Stop	Eastbound	WB	87 th	38	48	30	1.0	x	
			34 th	45	35	70	2.0		
			36 th	29	11	35	0.3		
			79 th	35	8	63	1.0	x	
	Westbound	EB	90 th	22	10	26	0.3		x
			34 th	45	76	32	2.7		x
			36 th	32	41	16	0.3		
			40 th	31	15	42	1.3		
			79 th	35	54	7	0.0	x	x
			84 th	34	16	71	2.3	x	

Stop Activity

			Nearest Intersection	Stops (per day)	Ons (per day)	Offs (per day)	Lift* (per week)	Bus Bay	Shelter	
Stop Near Signalized Intersection	Far-side	EB	39 th ,TP	63	162	283	9.0	x	x	
			82 nd ,TP	64	256	266	15.0	x	x	
			86 th	40	32	55	1.0	x	x	
		WB	39 th ,TP	64	268	110	6.0		x	
			82 nd ,TP	63	226	155	5.3	x	x	
	NS	EB	42 nd	33	12	40	0.3		x	
		WB	87 th	38	48	30	1.0	x		
No Signal Near Bus Stop			Eastbound	34 th	45	35	70	2.0		
				36 th	29	11	35	0.3		
				79 th	35	8	63	1.0	x	
				90 th	22	10	26	0.3		x
			Westbound	34 th	45	76	32	2.7		x
				36 th	32	41	16	0.3		
				40 th	31	15	42	1.3		
				79 th	35	54	7	0.0	x	x
				84 th	34	16	71	2.3	x	

Variables (Stop Level Data)

- **Ons:** number of passengers boarding a bus at a specific stop (passengers board only from front door)
- **Offs:** number of passengers alighting a bus at a specific stop (passengers alight from both doors)
- **Lift:** number that indicates wheelchair lift operation
- **Early:** number of minutes ahead of schedule at a time-point
- **Stop:** binary variable equal to one if a bus stopped to serve passengers and equal to zero otherwise

Variables (Combined Data)

- **Length:** distance in-between consecutive GPS coordinates before and after the bus stop
- **Speed:** average speed of bus in the segment immediately before and immediately after the bus bay
- **Nearside:** Binary variable indicating if a stop is located on the nearside of a signalized intersection
- **Farside:** Binary variable indicating if a stop is located on the farside of a signalized intersection

Nearside Stop

Farside Stop

Variables (Combined Data)

- **Intersection:** binary variable, equal to one if a GPS point is located on the other side of a signalized intersection with respect to a bus stop. This variable has non-zero values only for near-side or far-side stops
- **Int-far:** binary variable, equal to one if a GPS point is located on the nearside of a farside bus stop
- **Int-near:** binary variable, equal to one if a GPS point is located on the farside of a nearside bus stop

Intersection

Models

- A, B – Dwell Time from the stop-level data as the dependent variables
 - Only passenger activity variables are included.
- C, D – Dwell time from the stop-level data as the dependent variable
 - All available dependent variables are included.
- E, F - Interval time from the combined data as the dependent variable
 - All available dependent variables are included.
- A, B, C (no lift movements)

R^2_{adj}

		Bus Stop Location	(B) Dwell ~Stops + Ons + Offs + Lift	(D) Dwell ~Stops + Ons + Offs + Lift + Avg. Speed + Early + Intersection	(F) Interval ~Stops + Ons + Offs + Lift + Avg. Speed + Length + Early + Intersection
Time- points	EB	Powell & 39 ^{th,FS}	0.165	0.499	0.600
		Powell & 82 ^{nd,FS}	0.135	0.414	0.574
	WB	Powell & 39 ^{th,FS}	0.189	0.431	0.476
		Powell & 82 ^{nd,FS}	0.122	0.250	0.471
Regular Stops	Eastbound	Powell & 34 th	0.670	0.671	0.666
		Powell & 36 th	0.787	0.787	0.578
		Powell & 42 ^{nd,NS}	0.553	0.553	0.522
		Powell & 79 th	0.611	0.623	0.587
		Powell & 86 ^{th,FS}	0.737	0.737	0.737
		Powell & 90 th	0.731	0.733	0.699
	Westbound	Powell & 34 th	0.719	0.719	0.693
		Powell & 36 th	0.847	0.848	0.729
		Powell & 40 th	0.811	0.814	0.842
		Powell & 79 th	0.795	0.795	0.788
		Powell & 84 th	0.554	0.561	0.533
		Powell & 87 ^{th,NS}	0.687	0.701	0.684

NS = near-side bus stop FS = far-side bus stop

R^2_{adj}

		Bus Stop Location	(B) Dwell ~Stops + Ons + Offs + Lift	(D) Dwell ~Stops + Ons + Offs + Lift + Avg. Speed + Early + Intersection	(F) Interval ~Stops + Ons + Offs + Lift + Avg. Speed + Length + Early + Intersection
Time- points	EB	Powell & 39 ^{th,FS}	0.165	0.499	0.600
		Powell & 82 ^{nd,FS}	0.135	0.414	0.574
	WB	Powell & 39 ^{th,FS}	0.189	0.431	0.476
		Powell & 82 ^{nd,FS}	0.122	0.250	0.471
Regular Stops	Eastbound	Powell & 34 th	0.670	0.671	0.666
		Powell & 36 th	0.787	0.787	0.578
		Powell & 42 ^{nd,NS}	0.553	0.553	0.522
		Powell & 79 th	0.611	0.623	0.587
		Powell & 86 ^{th,FS}	0.737	0.737	0.737
		Powell & 90 th	0.731	0.733	0.699
	Westbound	Powell & 34 th	0.719	0.719	0.693
		Powell & 36 th	0.847	0.848	0.729
		Powell & 40 th	0.811	0.814	0.842
		Powell & 79 th	0.795	0.795	0.788
		Powell & 84 th	0.554	0.561	0.533
		Powell & 87 ^{th,NS}	0.687	0.701	0.684

NS = near-side bus stop FS = far-side bus stop

Relative Contribution for Midblock Stops

82nd Model F

Pooled Results

	Model (F) – Interval			
	Coefficient	Relative Contribution	Std. Error	Variance Inflation Factor
Intercept	-0.501		0.788	
Stops	16.43***	13.04%	0.392	1.450
Ons	4.041***	9.81%	0.139	1.387
Offs	1.929***	5.16%	0.143	1.246
Ons ²	-0.132***	4.11%	0.012	1.160
Offs ²	-0.107***	2.03%	0.014	1.093
Lift	24.01***	1.79%	1.124	1.038
Length	0.041***	1.12%	0.002	1.023
Avg. Speed	-0.281***	3.90%	0.032	1.161
Intersection	2.219***	0.47%	0.633	1.002
Early	5.700***	2.79%	0.003	1.020
Far-side	6.493***	6.52%	0.392	1.307
Near-side	7.252***	0.15%	0.758	1.003
Int-Far	25.67***	2.67%	1.185	1.053
Int-Near	-5.260***	0.13%	1.168	1.003
Bus-bay	0.707*	1.65%	0.322	1.083
R ²	0.5533			
Adj. R ²	0.5528			
Num. Ob.	15,872			
Residual Std. Error	0.4886			

Pooled Results

	Model (F) – Interval			
	Coefficient	Relative Contribution	Std. Error	Variance Inflation Factor
Intercept	-0.501		0.788	
Stops	16.43***	13.04%	0.392	1.450
Ons	4.041***	9.81%	0.139	1.387
Offs	1.929***	5.16%	0.143	1.246
Ons ²	-0.132***	4.11%	0.012	1.160
Offs ²	-0.107***	2.03%	0.014	1.093
Lift	24.01***	1.79%	1.124	1.038
Length	0.041***	1.12%	0.002	1.023
Avg. Speed	-0.281***	3.90%	0.032	1.161
Intersection	2.219***	0.47%	0.633	1.002
Early	5.700***	2.79%	0.003	1.020
Far-side	6.493***	6.52%	0.392	1.307
Near-side	7.252***	0.15%	0.758	1.003
Int-Far	25.67***	2.67%	1.185	1.053
Int-Near	-5.260***	0.13%	1.168	1.003
Bus-bay	0.707*	1.65%	0.322	1.083
R ²	0.5533			
Adj. R ²	0.5528			
Num. Ob.	15,872			
Residual Std. Error	0.4886			

Pooled Results

	Model (F) – Interval			
	Coefficient	Relative Contribution	Std. Error	Variance Inflation Factor
Intercept	-0.501		0.788	
Stops	16.43***	13.04%	0.392	1.450
Ons	4.041***	9.81%	0.139	1.387
Offs	1.929***	5.16%	0.143	1.246
Ons ²	-0.132***	4.11%	0.012	1.160
Offs ²	-0.107***	2.03%	0.014	1.093
Lift				
Length				
Avg. Speed				
Intersection				
Early				
Far-side				
Near-side				
Int-Far				
Int-Near				
Bus-bay				
R ²				
Adj. R ²				
Num. Ob.				
Residual Std. Error

Pooled Results

	Model (F) – Interval			
	Coefficient	Relative Contribution	Std. Error	Variance Inflation Factor
Intercept	-0.501		0.788	
Stops	16.43***	13.04%	0.392	1.450
Ons	4.041***	9.81%	0.139	1.387
Offs	1.929***	5.16%	0.143	1.246
Ons ²	-0.132***	4.11%	0.012	1.160
Offs ²	-0.107***	2.03%	0.014	1.093
Lift	24.01***	1.79%	1.124	1.038
Length	0.041***	1.12%	0.002	1.023
Avg. Speed	-0.281***	3.90%	0.032	1.161
Intersection	2.219***	0.47%	0.633	1.002
Early	5.700***	2.79%	0.003	1.020
Far-side	6.493***	6.52%	0.392	1.307
Near-side	7.252***	0.15%	0.758	1.003
Int-Far	25.67***	2.67%	1.185	1.053
Int-Near	-5.260***	0.13%	1.168	1.003
Bus-bay	0.707*	1.65%	0.322	1.083
R ²	0.5533			
Adj. R ²	0.5528			
Num. Ob.	15,872			
Residual Std. Error	0.4886			

Pooled Results

	Model (F) – Interval			
	Coefficient	Relative Contribution	Std. Error	Variance Inflation Factor
Intercept	-0.501		0.788	
Stops	16.43***	13.04%	0.392	1.450
Ons	4.041***	9.81%	0.139	1.387
Offs	1.929***	5.16%	0.143	1.246
Ons ²	-0.132***	4.11%	0.012	1.160
Offs ²	-0.107***	2.03%	0.014	1.093
Lift	24.01***	1.79%	1.124	1.038
Length	0.041***	1.12%	0.002	1.023
Avg. Speed	-0.281***	3.90%	0.032	1.161
Intersection	2.219***	0.47%	0.633	1.002
Early	5.700***	2.79%	0.003	1.020
Far-side	6.493***	6.52%	0.392	1.307
Near-side	7.252***	0.15%	0.758	1.003
Int-Far	25.67***	2.67%	1.185	1.053
Int-Near	-5.260***	0.13%	1.168	1.003
Bus-bay	0.707*	1.65%	0.322	1.083
R ²	0.5533			
Adj. R ²	0.5528			
Num. Ob.	15,872			
Residual Std. Error	0.4886			

Pooled Results

	Model (F) – Interval			
	Coefficient	Relative Contribution	Std. Error	Variance Inflation Factor
Intercept	-0.501		0.788	
Stops	16.43***	13.04%	0.392	1.450
Ons	4.041***	9.81%	0.139	1.387
Offs	1.929***	5.16%	0.143	1.246
Ons ²	-0.132***	4.11%	0.012	1.160
Offs ²	-0.107***	2.03%	0.014	1.093
Lift	24.01***	1.79%	1.124	1.038
Length	0.041***	1.12%	0.002	1.023
Avg. Speed	-0.281***	3.90%	0.032	1.161
Intersection	2.219***	0.47%	0.633	1.002
Early	5.700***	2.79%	0.003	1.020
Far-side	6.493***	6.52%	0.392	1.307
Near-side	7.252***	0.15%	0.758	1.003
Int-Far	25.67***	2.67%	1.185	1.053
Int-Near	-5.260***	0.13%	1.168	1.003
Bus-bay	0.707*	1.65%	0.322	1.083
R ²	0.5533			
Adj. R ²	0.5528			
Num. Ob.	15,872			
Residual Std. Error	0.4886			

Pooled Results

- i. Intercept
- ii. Avg. Speed
- iii. Ons²
- iv. Offs²
- v. Early
- vi. Length

Previous Model Biases

- Overestimate the coefficients of passenger movements
- Report results that exclude dwells with lift events or near intersections
- Pooled Results:
 - Ons, Ons², Offs, Offs², On-time performance, and time-of-day
 - $R^2 = 0.34$
 - With lift, $R^2 = 0.28$

Conclusions

- Our Pooled Results account for 55% of the data variability when looked at all stop types.
- Account for non-linearity in passenger movements, including lift events
- Capture the effect of traffic around a stop
- Capture the effect of traffic signals without having direct data
- More detail in paper

Thank you!

Any Questions?