EXPLORING THE RELATIONSHIP BETWEEN THE LIGHT RAIL TRANSIT AND BUS SERVICES

Is this relationship competition substitution or congestion substitution in Seattle, WA?

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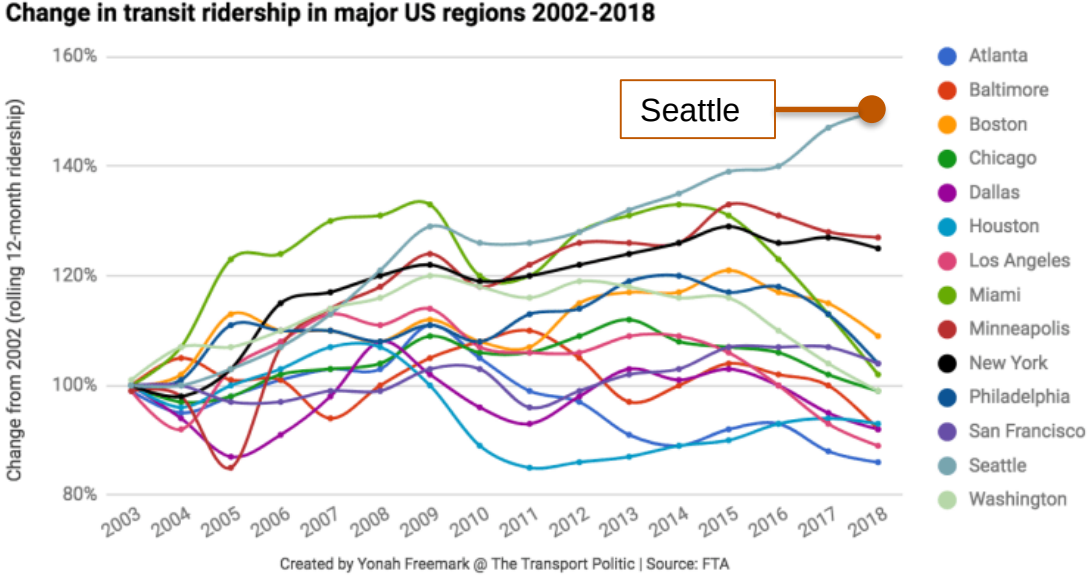
Light rail transit and bus - Background

- Public agencies are working to promote public transit, as the solution to existing transportation issues (Courtenay, 2007; Stewart et al. 2017).



Bus


LRT

Light rail transit and bus – Previous studies

LRT and bus could promote system-wide public transit ridership (Mackett, 1998; Puget Sound Regional Council, 2016).

A significant number of bus riders could change when LRT launch.

- LRT could **substitute** bus systems (Ben-Akiva & Morikawa, 2002; Lavery & Kanaroglou, 2013; Nils et al., 2018; Rahman, Yasmin, & Eluru, 2019).
- The influences on different bus services should be different (Cain et al., 2009).

Few studies explored which type of substitution occur.

Light rail transit and bus – Previous studies

There are two types of substitution (Investopedia, 2019).

Competition substitution

- If the substitution occurs in areas with **small ridership**, LRT should be a competitor **against** the bus system.

Congestion substitution

- If the substitution appears in areas with an **existing large** bus ridership, LRT could be a possible way to **ease** high public transit demand.

Light rail transit and bus – Research purposes

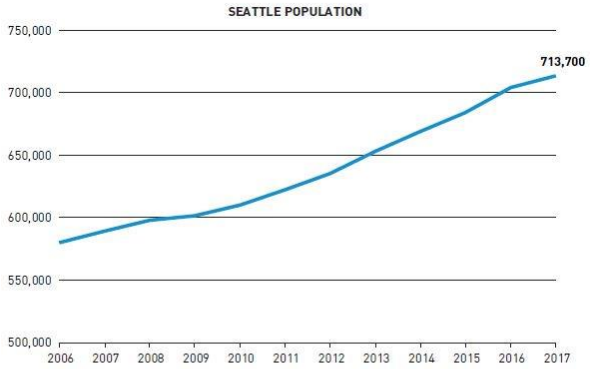
This study aims to explore the relationship between LRT and bus service in Seattle, WA.

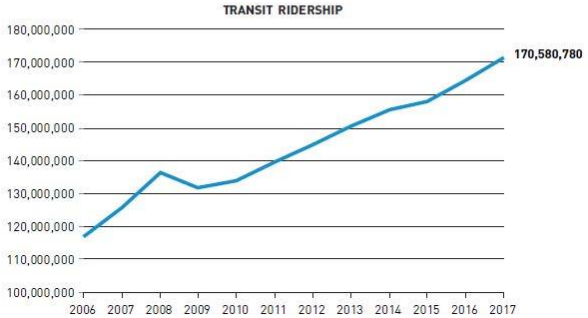
Specifically, we intended to answer two research questions:

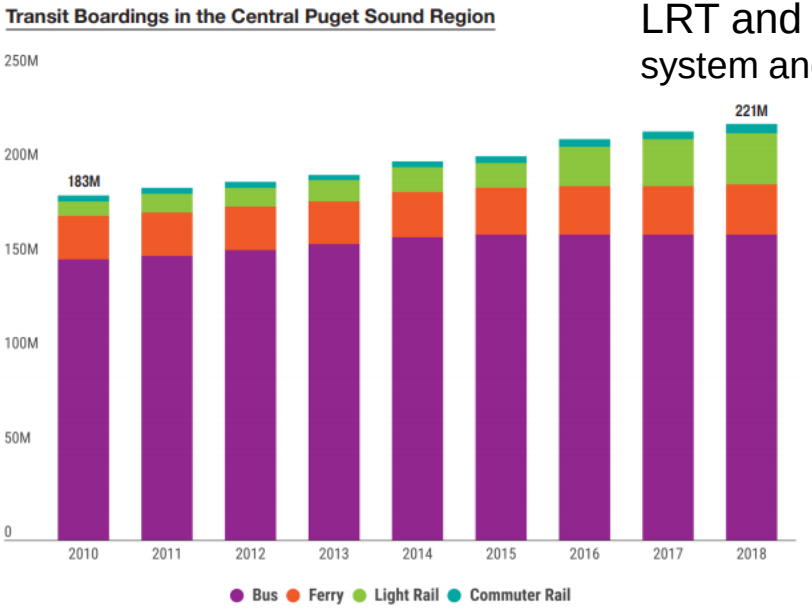
- Is the **relationship** between LRT and bus a substitution in our study area?
- What **kind** of substitution could this relationship be: competition substitution or congestion substitution?

Given the considerable expense of transport infrastructure, the clear investigation could contribute to an appropriate **combination** considering public transit benefits and interactions, and **wisely allocate** future budgets.

Study Design –
Study area conditions







Source: https://www.psrc.org/sites/default/files/trend-transit-growth-20190424.pdf

- Public transit ridership is increasing from 2010 in Puget Sound Region where Seattle locates.
- Public transit system includes LRT and bus Seattle, LRT system and Bus service.

Study Design – Data

Our study includes 2988 bus stops in Seattle.

- Geocoded bus stops and LRT stations
- Created **1-km Euclidean buffers** surrounding bus stops as bus buffers and **2-km Euclidean buffers** surrounding LRT stations as LRT catchments
- Used bus buffers to capture nearby conditions through bus stop buffers and define LRT effects through LRT catchments
- Introduced BRT dummy

Variable (Obs=2988)	Source (Date)	Description (Unit)	Mean (St. Dev.) / Number (%)	Min	Max
Outcome variables					
Ridership on	KCM (2017)	Number of average weekday riders taken on (count)	111.617 (307.948)	0	4319
Ridership off		Number of average weekday riders taken off (count)	111.782 (316.622)	0	5326
Explanatory variable					
LRT dummy		0 means not covered by LRT buffers; 1 means covered by LRT buffers (dummy)	0: 2026 (67.804%) 1: 962 (32.195%)	0	1
Controlling variables – transportation					
Bus rapid transit	KCM (2017)	0 means regular bus; 1 means Bus rapid transit bus (dummy)	0: 2863 (95.816%) 1: 125 (4.183%)	0	1
Bus stop		Number of bus stops within bus buffers (count)	51.085 (28.437)	6	177
Sidewalk rate	WSDOT (2017)	Rate of roads covered by sidewalks within bus buffers	0.660 (0.187)	0.113	0.568
Controlling variables – land-use					
Residential	KCA (2014)	Area of residence land-use within bus buffers (km^2)	1.23 (0.493)	0	2.21
Trade		Area of trade land-use within bus buffers (km^2)	0.141 (0.146)	0	1.108
Service		Area of service land-use within bus buffers (km^2)	0.261 (0.229)	0	1.991
Controlling variables – socio-demographics					
Population	ACS (2017)	Number of people ranging from 18 to 64 within bus buffers (count)	23789.48 (11999.1)	2081	70062
Median age		Median age within bus buffers (year)	37.114 (3.833)	22.9	48.4
Gender		Percent of male within bus buffers	0.503 (0.028)	0.461	0.656
Race		Percent of white-only within bus buffers	0.682 (0.163)	0.207	0.907
Education		Percent of people with college-level or higher degrees within bus buffers	0.35 (0.068)	0.153	0.454
Income		Average annual income within bus buffers (USD)	45124.7 (10515.05)	16208	69875
Vehicle ownership		Percent of car ownership within bus buffers	0.981 (0.044)	0.691	1

Study Design – Method

Quantile regression estimates the **conditional mean** of the response variable given specific values of the predictor variables (Flom, 2017).

$$y_i = \beta_0 + \beta_1 x_{i1} + \cdots + \beta_p x_{ip} + \varepsilon_i \ , \ i = 1, 2, 3, \ldots, n$$

where the response y_i for the i th observation is continuous, and the predictors, $x_{i1}, \ldots, x_{ip}$, represent the main effects that consist of variables (Rodriguez & Yao, 2017).

Log(# of boarding/alighting) ~ LRT dummy + controlling variables

Source: https://libguides.lb.polyu.edu.hk/research_method

Study Design – Analytic plan

Study purposes : explore the relationship between LRT and bus service in Seattle, WA.

Stage 1: LRT versus non-LRT

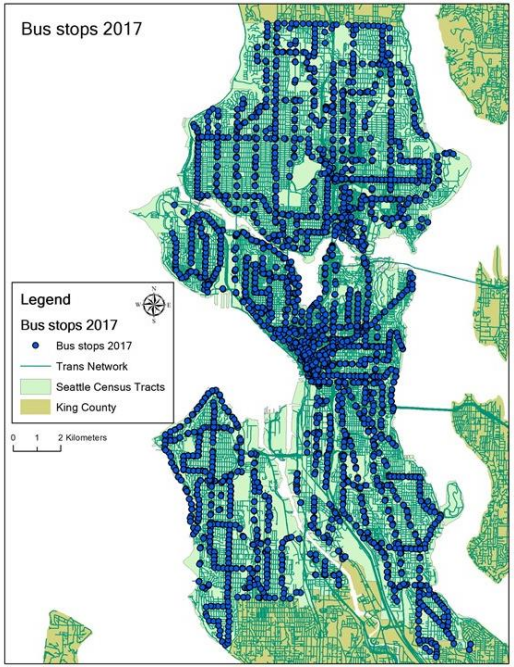
- Categorize bus stops within and out of LRT catchments and compare the differences (number of boarding and alighting, and BRT)

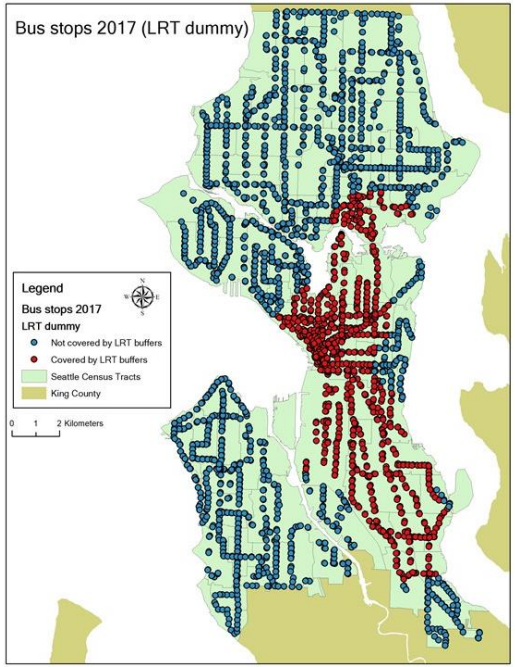
Stage 2: Quantile regression

- Investigated the relationship between LRT and bus service

Results –
LRT versus non-LRT

- Both boarding and alighting covered by LRT catchments are larger than those outside (230.978 and 233.442 vs. 54.941 and 54.015).
- BRT rate of bus stops outside of LRT catchments is higher than those inside (4.837% vs. 2.806%).





	LRT covered (n=962)			LRT not covered (n=2026)		
Variables	**Mean (St. Dev.) / Number (%)**	**Min**	**Max**	**Mean (St. Dev.) / Number (%)**	**Min**	**Max**
Ridership on	230.978 (491.555)	0	4319	54.941 (123.420)	0	2104
Ridership off	233.442 (498.140)	0	5326	54.015 (140.512)	0	3637
Bus rapid transit	0: 935 (97.193%) 1: 27 (2.806%)	0	1	0: 1928 (95.162%) 1: 98 (4.837%)	0	1

Results –
Quantile regression (boarding)

	Dependent variable: Ridership on Method: Quantile regression				
	0.2	**0.4**	**0.5**	**0.6**	**0.8**
LRT dummy	-0.176 (-0.559)	-0.207 (-0.963)	-0.192 (-1.050)	-0.258* (-1.664)	-0.287** (-2.085)
Controlling variables –transportation & land use & socio-demographics					

- LRT effects on number of boarding are significantly negative in the moderate quantile (-23%, 0.6) and highest quantile (-25%0.8) of boarding.

Results –
Quantile regression (alighting)

	Dependent variable: Ridership off Method: Quantile regression				
	0.2	**0.4**	**0.5**	**0.6**	**0.8**
LRT dummy	-0.276 (-1.091)	-0.215 (-1.162)	-0.257 (-0.062)	-0.234 (-0.095)	-0.183** (-1.970)
Controlling variables –transportation & land use & socio-demographics					

- LRT effects on number of alighting are significantly negative in the highest quantile (-17%, 0.8) of alighting.

Discussion –
LRT effects

The relationship of LRT and bus services could be regarded as the congestion substitution.

- The substitution of boarding is significant in the moderate-high quantile and highest quantile; while, the substitution of alighting is significant in the highest quantile.

Discussion – Controlling variables

Outcome: # of boarding

- BRT (+, 0.2~0.8)
- Residential (+, 0.2~0.6); trade (+, 0.2~0.6); service (+, 0.2~0.8)
- Population (+, 0.2~0.8); median age (-, 0.2~0.8); gender (+, 0.6); race (+, 0.4~0.8); education (-, 0.2~0.8)

Outcome: # of alighting

- BRT (+, 0.2~0.8); sidewalk (+, 0.4~0.6)
- Residential (+, 0.2~0.6); service (+, 0.2~0.5)
- Population (+, 0.2~0.8); median age (-, 0.2~0.4); gender (+, 0.6); race (+, 0.8); education (-, 0.2~0.5 and 0.8)

Conclusion

This study investigated the relationship between the light rail transit (LRT) and bus while controlling for existing transportation, land-use, as well as socio-demographic factors based on a dataset of 2988 bus stops of Seattle, WA in 2017.

Based on a specific quantile regression, this relationship could be regarded as the congestion substitution, as substitution appeared in areas with a large existing bus ridership, and LRT could be a way to ease high public transit demand.

Some limitations are also worth noting for future study.

- The socio-demographics of riders were not adequately captured due to the lack of data sources.
- Second, individual bus stops may not be the most appropriate unit of future analysis (Stewart, Moudon, & Saelens, 2017).
- Third, panel analysis should be essential for future study.

Thanks!

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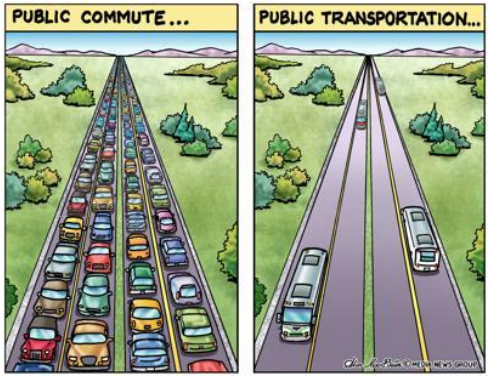

Source: https://www.delcotimes.com/opinion/editorial-local-traffic-bottlenecks-demand-attention/article_114f42b0-08e0-11ea-9287-d7030a02751d.html

CM2 Cooperative Mobility for Competitive Megaregions

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