

Estimating Transit Fare Elasticity using Panel Models

Metro Vancouver Case Study

Mohamed Salah Mahmoud, PhD
Senior Modeller, Forecasting

Transit Fare Elasticity

"Elasticity values in the APTA study varied from −0.12 to −0.85 among the 52 transit systems"

[TRB's TCRP REPORT 95]

- For a 10% increase in fares in Metro Vancouver:
  the difference between an assumed elasticity of
  -0.2 and -0.7 is ~20M boardings per year

- That is ~$30M annually!

Panel-data

- Time-series: 1990 – 2017 (monthly)
- Cross-sectional units:
  - 53 SkyTrain stations
  - 8 Bus depots
- Panel dimension (unbalanced) – long panel
  - n = 61 (cross-sectional units)
  - T = 5 - 323 (time periods)
  - N = 11,926 (total observations)

Econometric Model

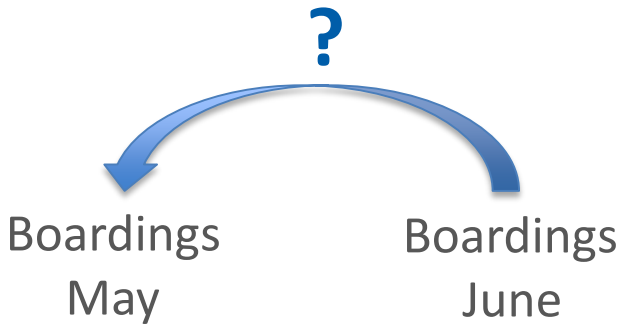
$$Y_{it} = X_{it}\beta + u_{it}$$

- Y_{it} is the number of boardings at station/depot *i* in month-year *t*
- X_{it} is a series of independent variables
- β is a vector of coefficients to be estimated
- u_{it} is the error term ($u_{it} = \underbrace{\alpha_i}_{\text{Individual effects}} + \underbrace{\varepsilon_{it}}_{\text{i.i.d}}$)

Econometric Model

- The underlying data generating process characterizes the econometric model structure

  - Static
  - Dynamic



Econometric Model

- Static Model $Y_{it} = X_{it}\beta + \alpha_i + \varepsilon_{it}$
  - Auto-correlation in the idiosyncratic errors
- Dynamic Model $Y_{it} = \varphi Y_{it-n} + X_{it}\beta + \alpha_i + \varepsilon_{it}$
  - φ is significant and close to 1
  - Persistent auto-correlation in the idiosyncratic errors
- Omitted variable that is autoregressive?
  - The DGP is not truly dynamic but rather static with an error term that is autoregressive

Econometric Model

- Fixed-effects (within estimator) Model with AR(1) Errors:

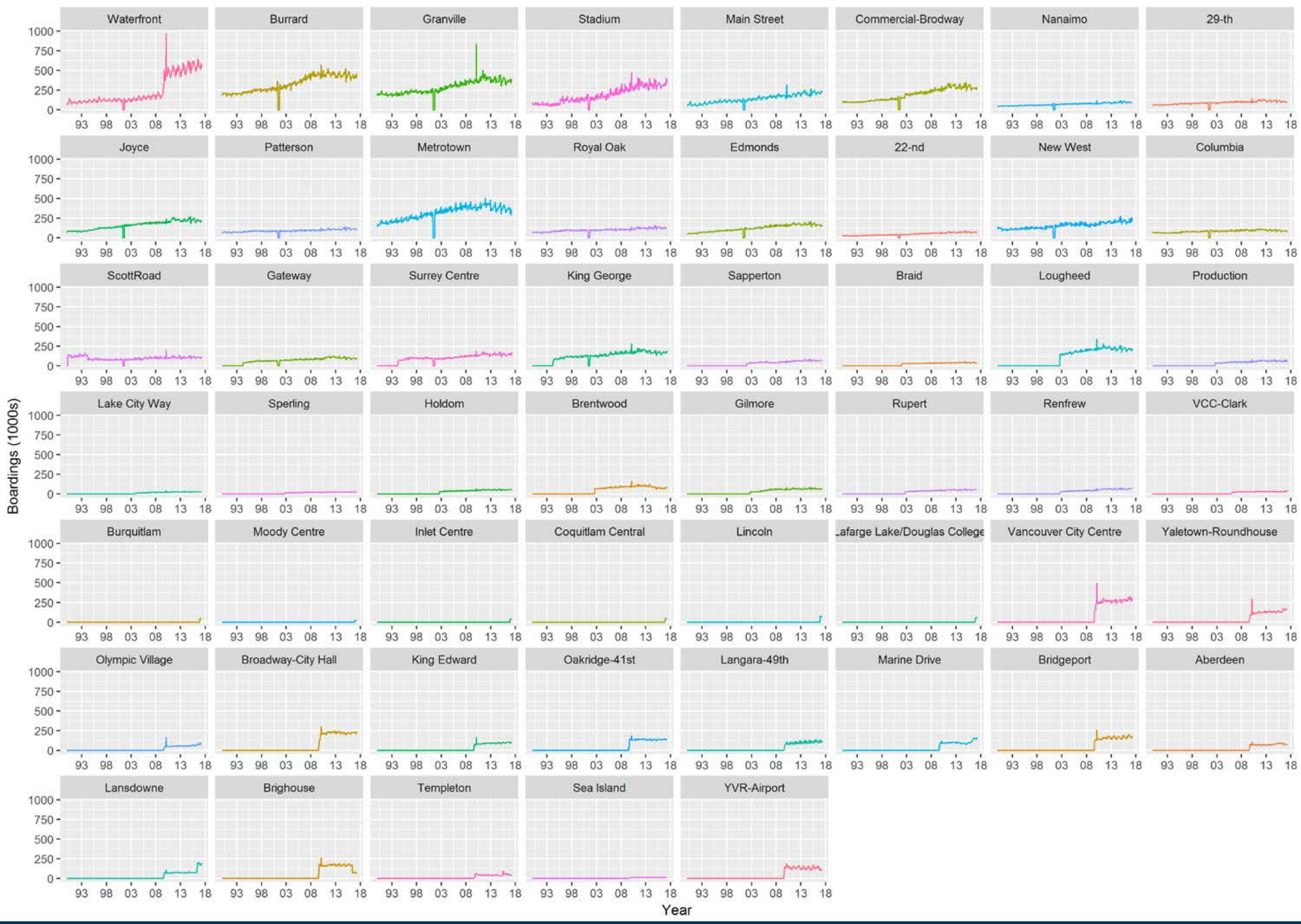
$$Y_{it} = X_{it}\beta + \alpha_i + \varepsilon_{it} \qquad i = 1, \dots, N;\ t = 1, \dots, T$$

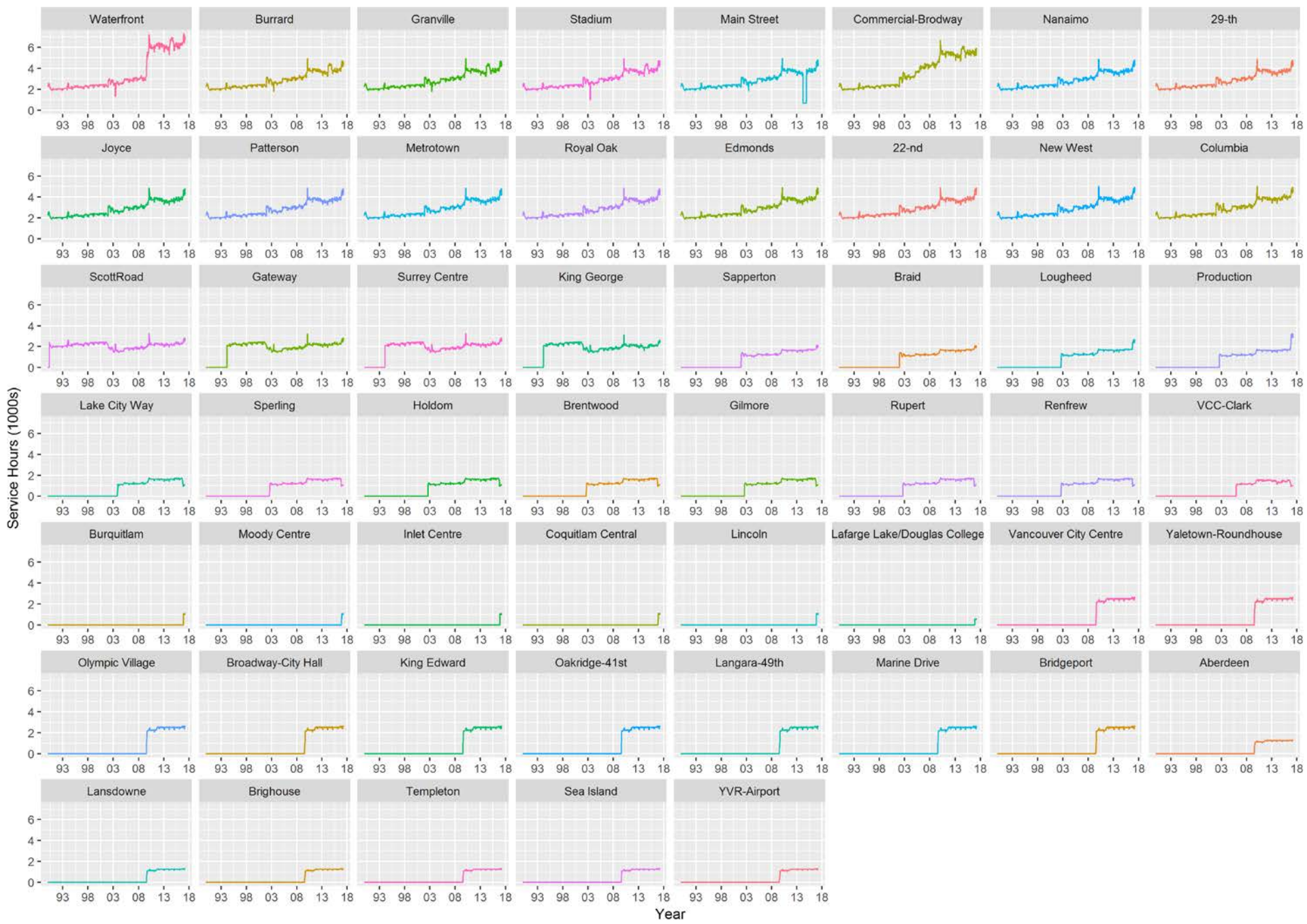
$$\varepsilon_{it} = \rho\, \varepsilon_{it-1} + \eta_{it}$$

  - $|\rho|$ is <1
  - η_{it} is independent and identically distributed (i.i.d) with mean 0 and variance σ_η^2
  - α_i is the individual-specific fixed-effects

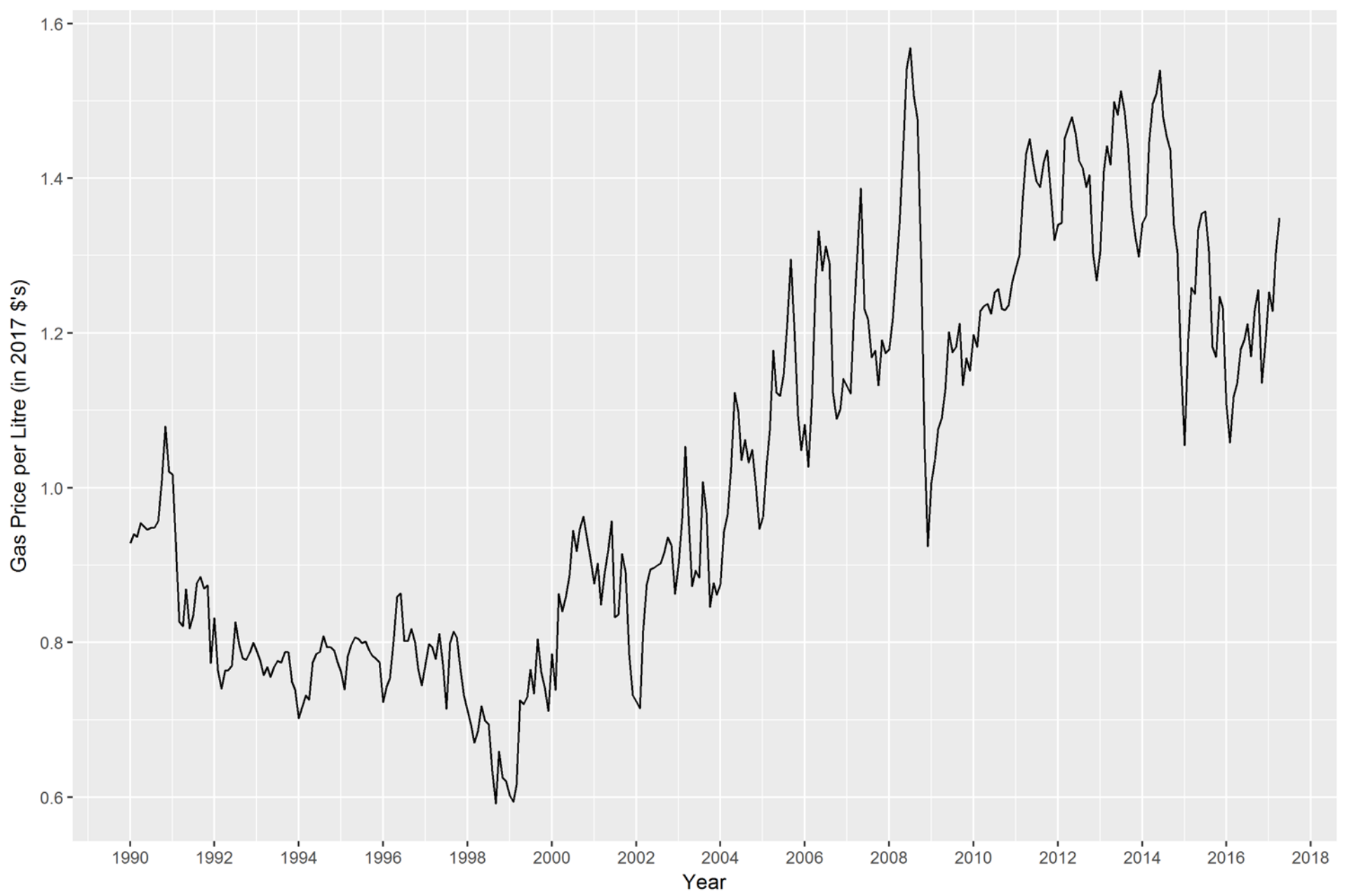
Variables

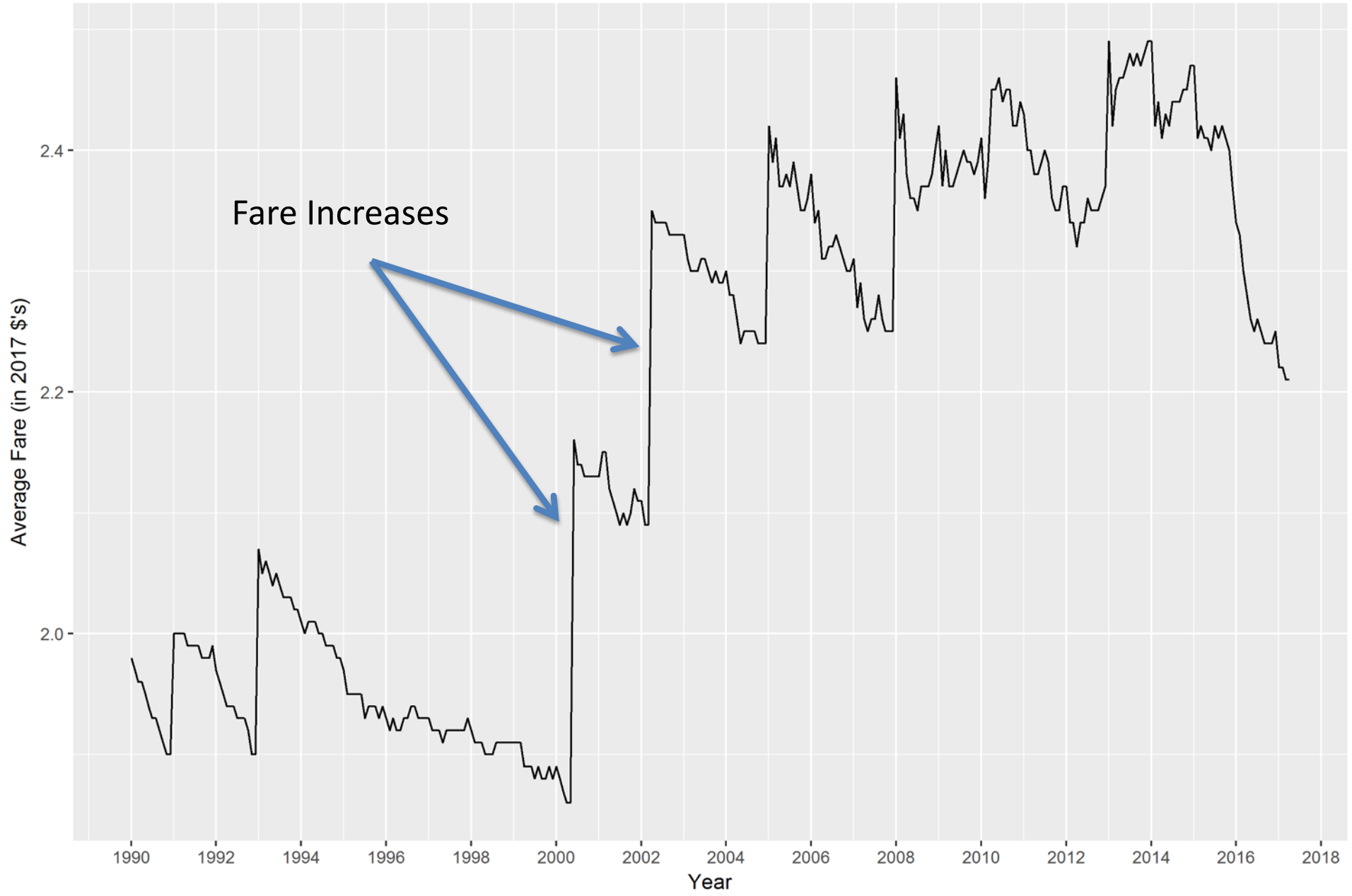
- Demand (number of boardings) ← Dependent Variable
- Supply (number of service hours) ← Instrumented (endogeneity)
- Employment
- Gas prices
- Transit fare


Waterfront
Burrard
Granville
Stadium
Main Street
Commercial-Brodway
Nanaimo
29-th
Joyce
Patterson
Metrotown
Royal Oak
Edmonds
22-nd
New West
Columbia
ScottRoad
Gateway
Surrey Centre
King George
Sapperton
Braid
Lougheed
Production
Lake City Way
Sperling
Holdom
Brentwood
Gilmore
Rupert
Renfrew
VCC-Clark
Burquitlam
Moody Centre
Inlet Centre
Coquitlam Central
Lincoln
afarge Lake/Douglas College
Vancouver City Centre
Yaletown-Roundhouse
Olympic Village
Broadway-City Hall
King Edward
Oakridge-41st
Langara-49th
Marine Drive
Bridgeport
Aberdeen
Lansdowne
Brighouse
Templeton
Sea Island
YVR-Airport
Boardings (1000s)
0
250
500
750
1000
93
98
03
08
13
18
Year


Waterfront
Burrard
Granville
Stadium
Main Street
Commercial-Brodway
Nanaimo
29-th
Joyce
Patterson
Metrotown
Royal Oak
Edmonds
22-nd
New West
Columbia
ScottRoad
Gateway
Surrey Centre
King George
Sapperton
Braid
Lougheed
Production
Lake City Way
Sperling
Holdom
Brentwood
Gilmore
Rupert
Renfrew
VCC-Clark
Burquitlam
Moody Centre
Inlet Centre
Coquitlam Central
Lincoln
Lafarge Lake/Douglas College
Vancouver City Centre
Yaletown-Roundhouse
Olympic Village
Broadway-City Hall
King Edward
Oakridge-41st
Langara-49th
Marine Drive
Bridgeport
Aberdeen
Lansdowne
Brighouse
Templeton
Sea Island
YVR-Airport
Service Hours (1000s)
0
2
4
6
93
98
03
08
13
18
Year


1400
1200
1000
800
Adjusted Employment (1000s)
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year


Gas Price per Litre (in 2017 $'s)
1.6
1.4
1.2
1.0
0.8
0.6
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year

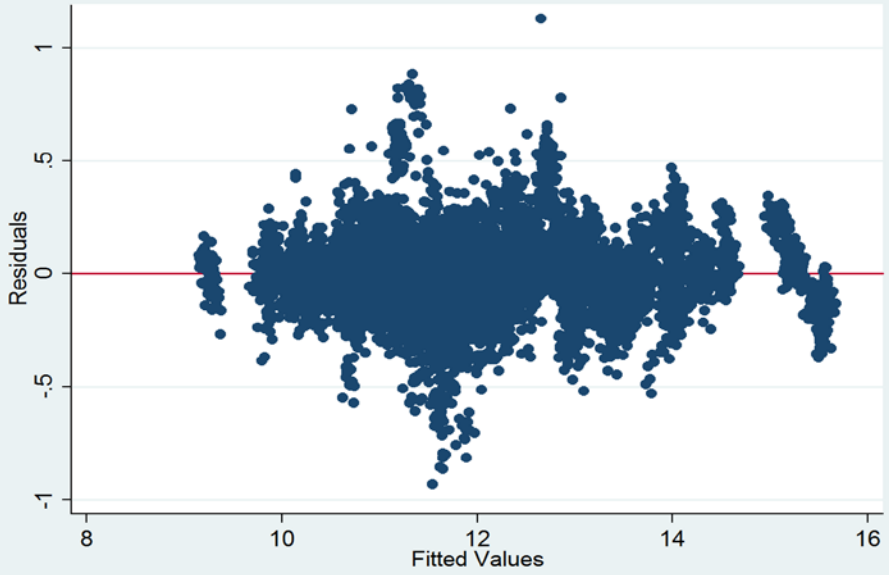

Fare Increases
Average Fare (in 2017 $'s)
2.4
2.2
2.0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year

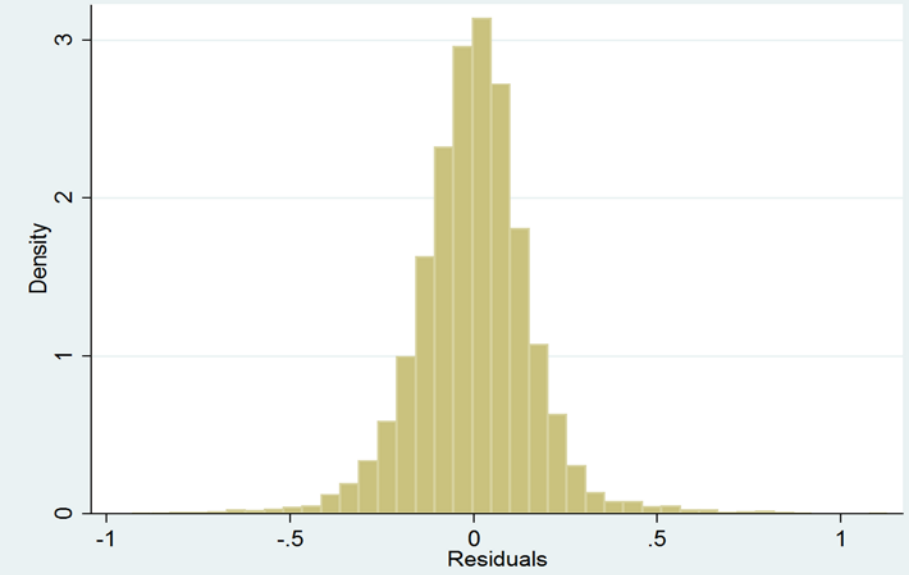
Model Results

- Fare elasticity ~ –0.3%
  - A 1% increase in transit fares is associated with a 0.3% drop in ridership.

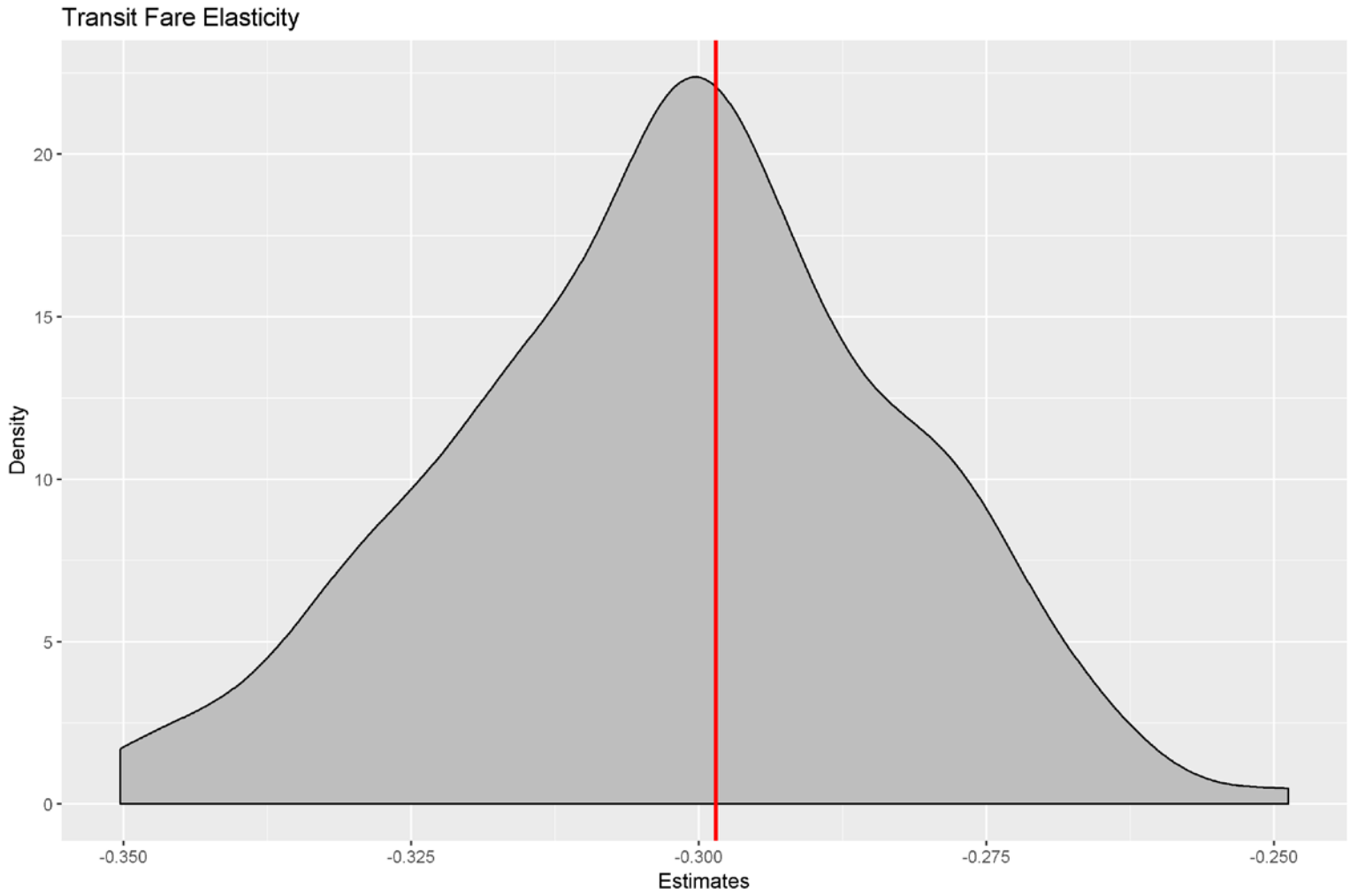
- Gas elasticity ~ 0.08%
  - A 1% increase is gas prices is associated with a 0.08% increase in ridership.

Model Diagnostics



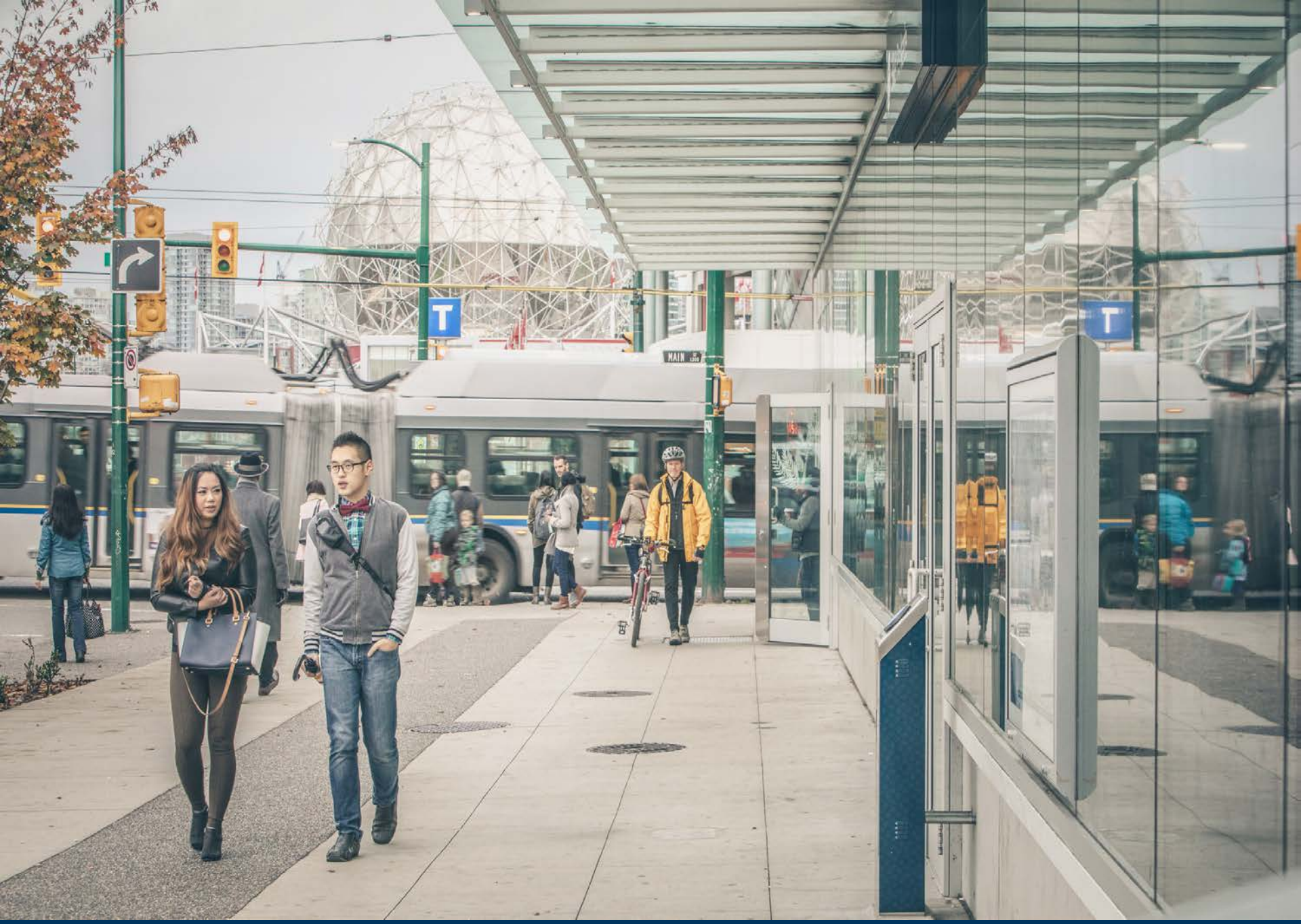


Model Validation



Acknowledgement

- Mark Pickup, Associate Professor, Simon Fraser University
- Jacob Fox, Senior Planner, TransLink


T
MAIN
T