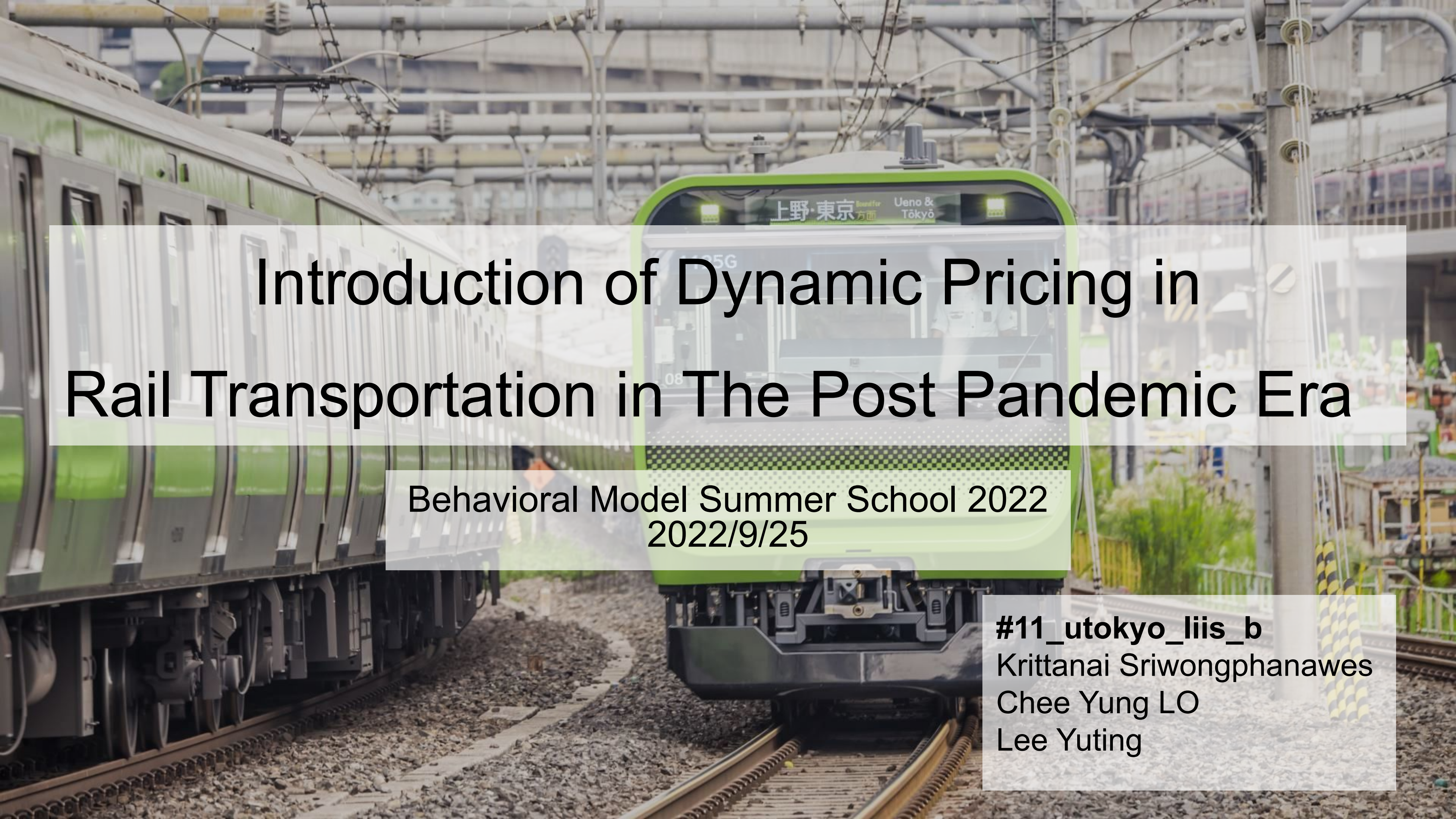

Introduction of Dynamic Pricing in Rail Transportation in The Post Pandemic Era

Behavioral Model Summer School 2022
2022/9/25

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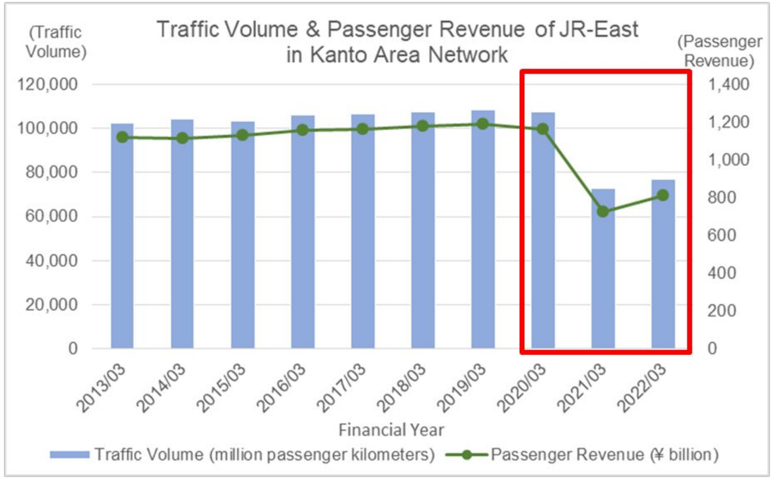
Background: Train Congestion in Tokyo Metropolitan Area

- **Railway Passenger & Revenue of the JR-East:**



- Ridership & revenue were reduced sharply by the COVID-19 pandemic

The Japan Times, 2020/07:

- JR-East considered to introduce a time-based fare system

The Japan News, 2022/03:

- Aim to introduce off-peak commuter pass in 2023 spring
  - Peak hours: fare ↑ ; off-peak hours: fare ↓

Purposes of JR-EAST to impose such policy in the post-pandemic era:

- Reduce train congestion during peak hours
  → Continue to maintain social distance
- Generate sustainable revenue

Background: Train Congestion in Tokyo Metropolitan Area

Objective:

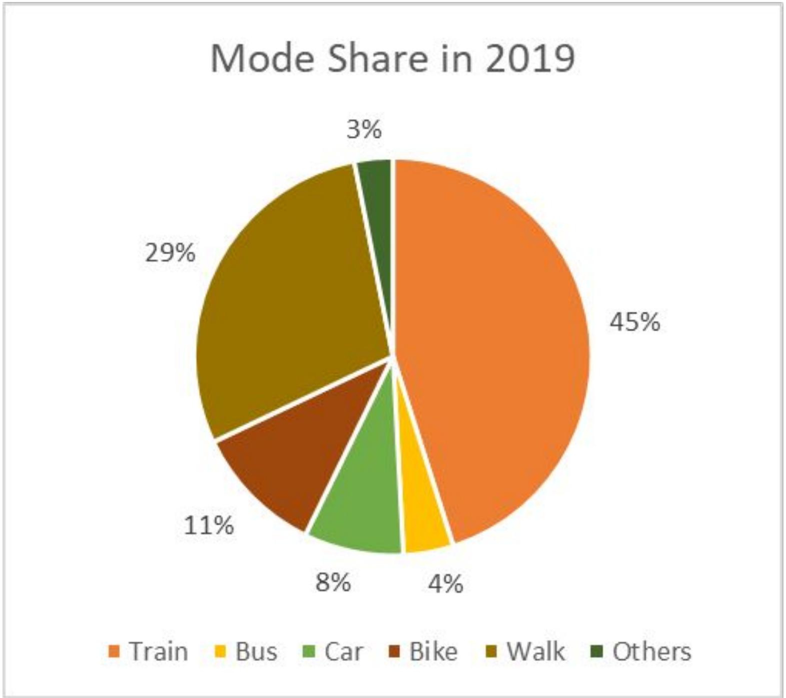
Compare people’s changes in railway price elasticity between 2019 and 2021.

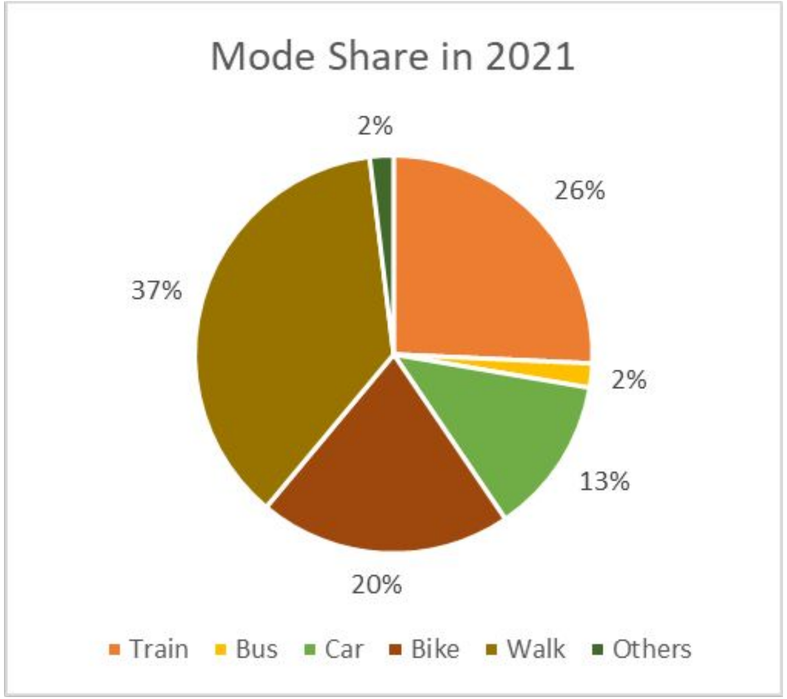
Apply the time-based fare system (increasing fare in peak hours).

Estimate and evaluate the policy’s effectiveness.

Basic analysis

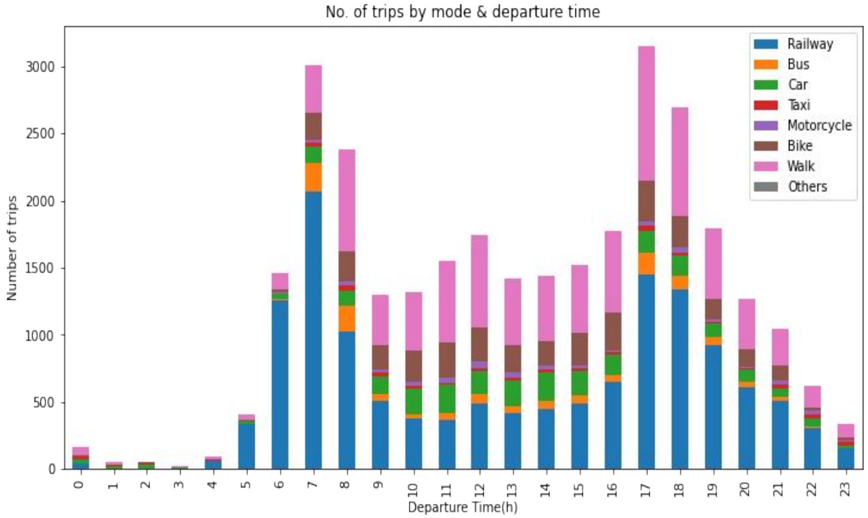
We applied Toyosu PP data because it includes data before and after covid19.



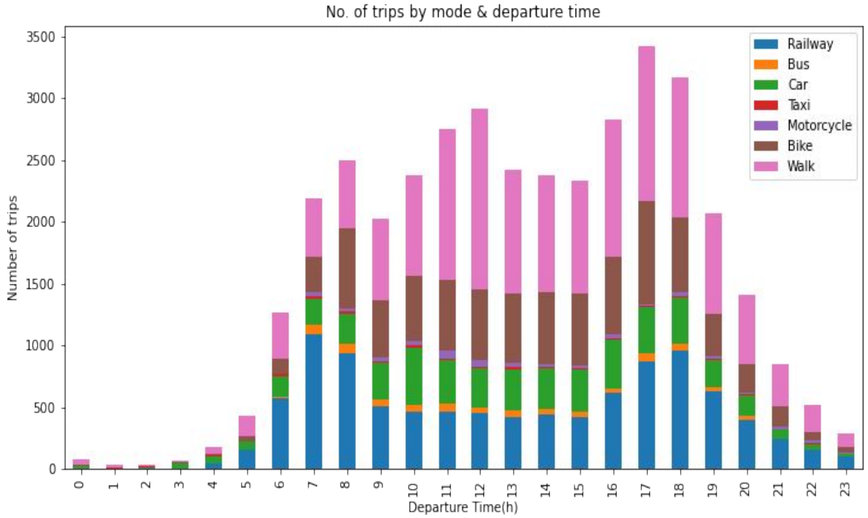


Basic analysis

2019 (Before COVID-19)



2021 (After COVID-19)

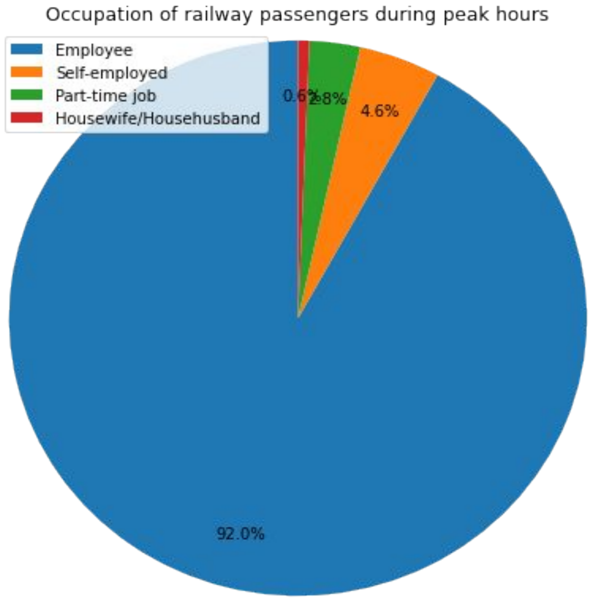


Based on the departure time distribution of railway trips, we set “7am-9am” and “5pm-7pm” as peak hours for railway.

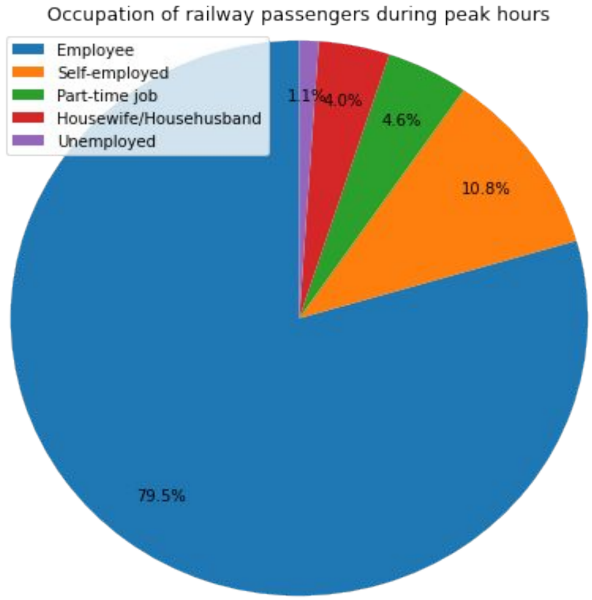
Basic analysis

During peak hours, most of the railway passenger are commuters.

2019 (Before COVID-19)



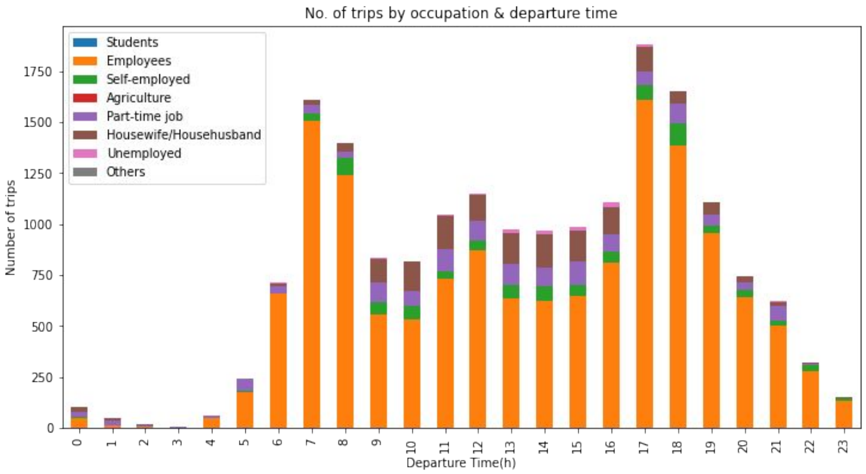
2021 (After COVID-19)



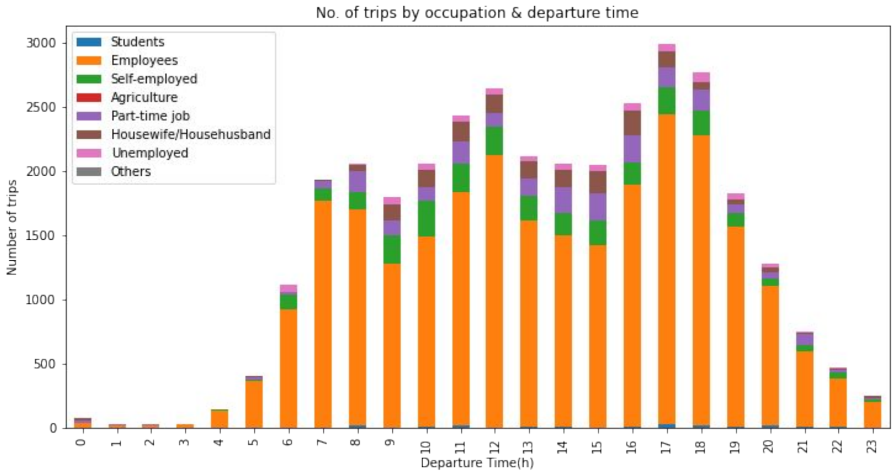
*Unknown occupation is removed here

Basic analysis

2019 (Before COVID-19)



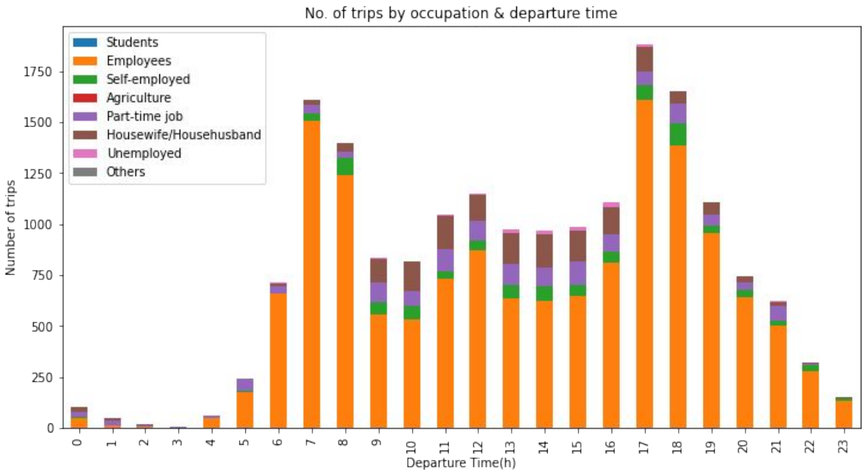
2021 (After COVID-19)



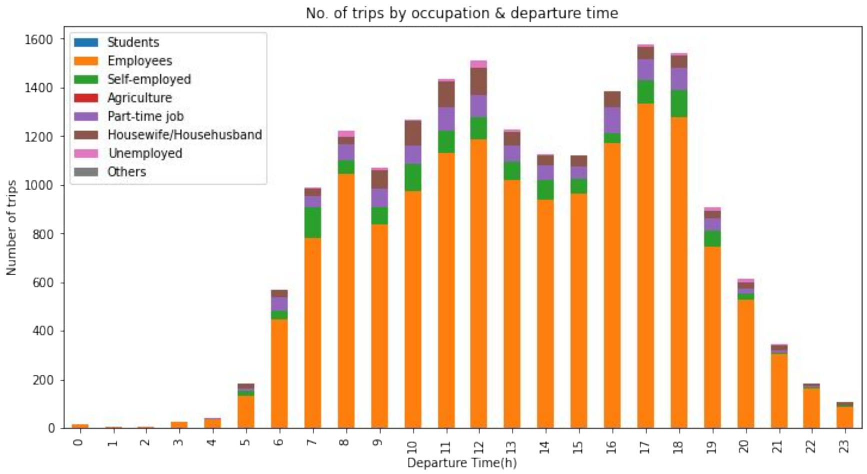
Basic analysis

If the same group of people (n=150) is traced from 2019 to 2021:

2019 (Before COVID-19)



2021 (After COVID-19)



Multinomial Logit Model

Utility Function

$$V_{train} = \beta_1 TT_{train} + \boxed{\beta_2 Fare_{train} + \beta_3 \delta_{peak} Fare_{train} + \beta_4 \delta_{commute} Fare_{train}} + \beta_5 \delta_{young} + \beta_6 \delta_{mid} + \boxed{\beta_7 \delta_{weekday}} + \beta_{0(train)}$$

$$V_{bus} = \beta_1 TT_{bus} + \boxed{\beta_2 Fare_{bus} + \beta_3 \delta_{peak} Fare_{bus} + \beta_4 \delta_{commute} Fare_{bus}} + \beta_5 \delta_{young} + \beta_6 \delta_{mid} + \boxed{\beta_7 \delta_{weekday}} + \beta_{0(bus)}$$

$$V_{car} = \beta_1 TT_{car} + \beta_5 \delta_{young} + \beta_6 \delta_{mid} + \beta_{0(car)}$$

$$V_{bike} = \beta_1 TT_{bike} + \beta_5 \delta_{young} + \beta_6 \delta_{mid} + \beta_{0(bike)}$$

$$V_{walk} = \beta_1 TT_{walk}$$

$$\delta_{peak} = 1 \ \text{if it's peak hour; } 0 \ \text{otherwise}$$

$$\delta_{commute} = 1 \ \text{if individual has job(employee, parttime); } 0 \ \text{otherwise}$$

$$\delta_{young} = 1 \ \text{if individual's age} \leq 29;\ 0 \ \text{otherwise}$$

$$\delta_{mid} = 1 \ \text{if } 30 \leq \text{individual's age} \leq 59;\ 0 \ \text{otherwise}$$

$$\delta_{weekday} = 1 \ \text{if it's weekday; } 0 \ \text{otherwise}$$

Model result

2019

coefficient	Coefficient value	T-value
ASC_rail	1.6504	16.7323
ASC_bus	-0.0932	-0.8501
ASC_car	-1.1160	-17.9950
ASC_bike	-0.5087	-8.7501
Travel time	-1.9273	-29.3221
Fare	-0.0032	-18.5219
peak*Fare	0.0008	4.9272
young	0.8195	6.3294
middle_age	-0.6854	-11.0988
is_weekday	0.8468	11.3371

N = 15148
L(0) = -19706.18
LL = -12213.93
Rho-square = 0.3802
Adjusted rho-square =0.3797

Model result

2021

coefficient	Coefficient value	T-value
ASC_rail	1.8037	25.6000
ASC_bus	0.8903	11.3000
ASC_car	-1.2837	-30.4886
ASC_bike	-0.3032	-7.8495
Travel time	-3.7123	-57.9741
Fare	-0.0058	-38.1840
peak*Fare	0.0001	0.7279
commute*Fare	0.0023	14.7197
young	1.6225	11.8680
middle_age	-0.7309	-17.7384
is_weekday	0.1752	303059

N = 29900
L(0) = -37371.59
LL = -26045.62
Rho-square = 0.3031
Adjusted rho-square = 0.3028

Model result

Aggregated price sensitivity

Year	Multinomial Logit	
	Peak	Off-peak
2019	-0.1322	-0.2295
2021	-0.3943	-0.4933

Policy application

How much should rail company increase the fare after Covid-19?

2021 MNL model → calculate share and revenue → apply dynamic pricing with different increasement → calculate new share and revenue

compare before and after policy

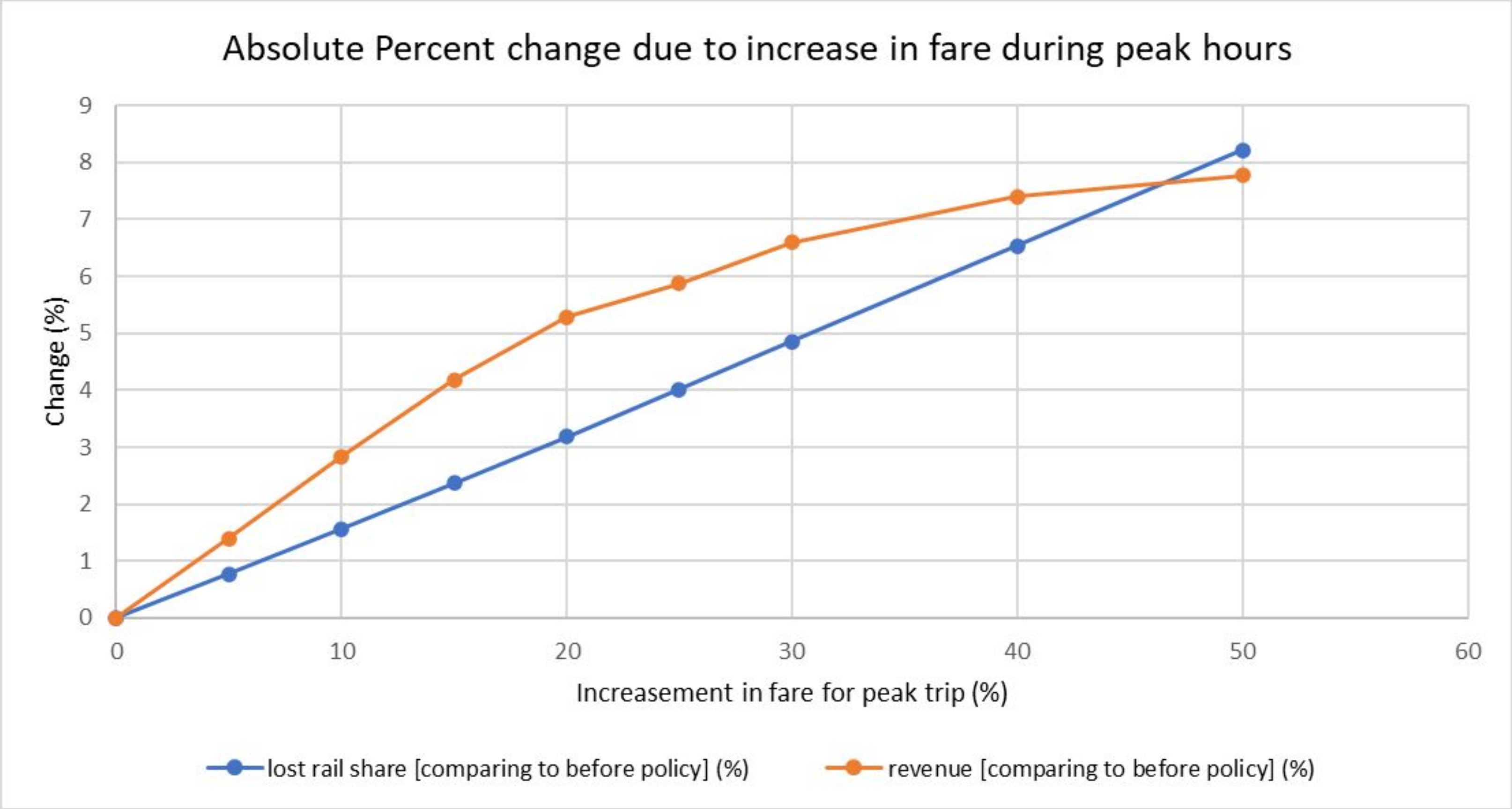
share = the average probability of choosing rail

revenue = the sum of rail fare of all individuals who chose rail

Policy application

Increasement in fare for peak trip (%)	Change in rail share [Comparing to before policy] (%)	Change in revenue [Comparing to before policy] (%)
5	-0.77	1.40
10	-1.56	2.84
15	-2.37	4.18
20	-3.19	5.29
25	-4.02	5.87
30	-4.85	6.60
40	-6.53	7.40
50	-8.22	7.77

Policy application



Discussion

- People are **more sensitive** to rail transportation's price after covid
  - They prefer more safety modes such as walking, biking and driving
- Our results suggest that…
  - price increment should be **applied during peak hours**
  - The increasement in price should lesser than around 47% of current fare in order to gain revenue more than losing share
- However, our model's accuracy is low and simple
  - more accurate model should be investigated
  - use more advanced models to corporate unobserved heterogeneity → Mixed logit