

# Can New Urban Rail Transit Lines Reduce Car Ownership?

**The Science of Cities Symposium 2023**

**5<sup>th</sup> October**

**DAI Fangzhou**

Research Fellow at NUS Cities, NUS



**SING Tien Foo**

Provost's Chair Professor at the  
Department of Real Estate, NUS



**DIAO Mi**

Professor at School of Architecture and  
Urban Planning, Tongji University

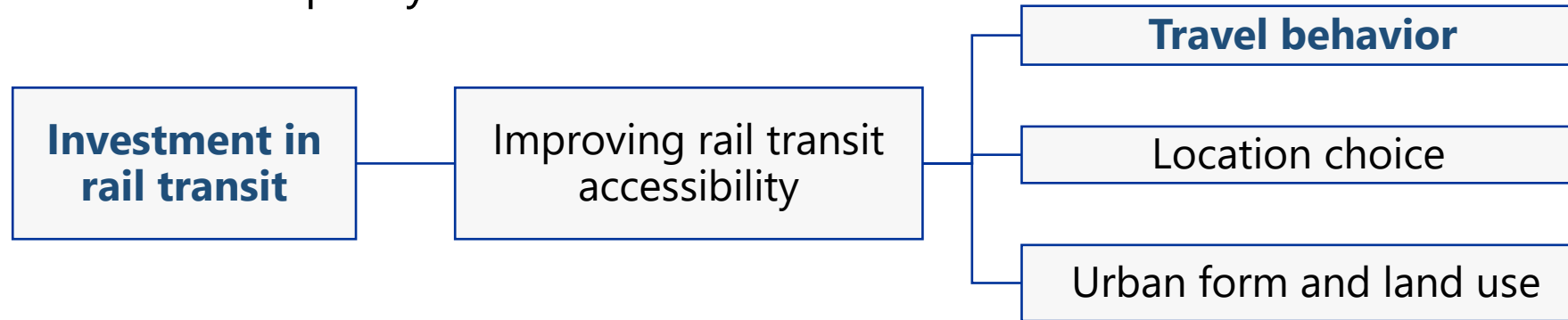




# **Research Context**

# Research Background

To address transport challenges (e.g., congestion and pollution), many countries have implemented various policy interventions.



## Research Gaps

- **ongoing debates** on the impact of rail transit access on car ownership
- Methodological challenges hinders verification (i.e., scarcity of panel data, **overlook spatial and temporal heterogeneity**)
- Singapore's local context and the role of MRT

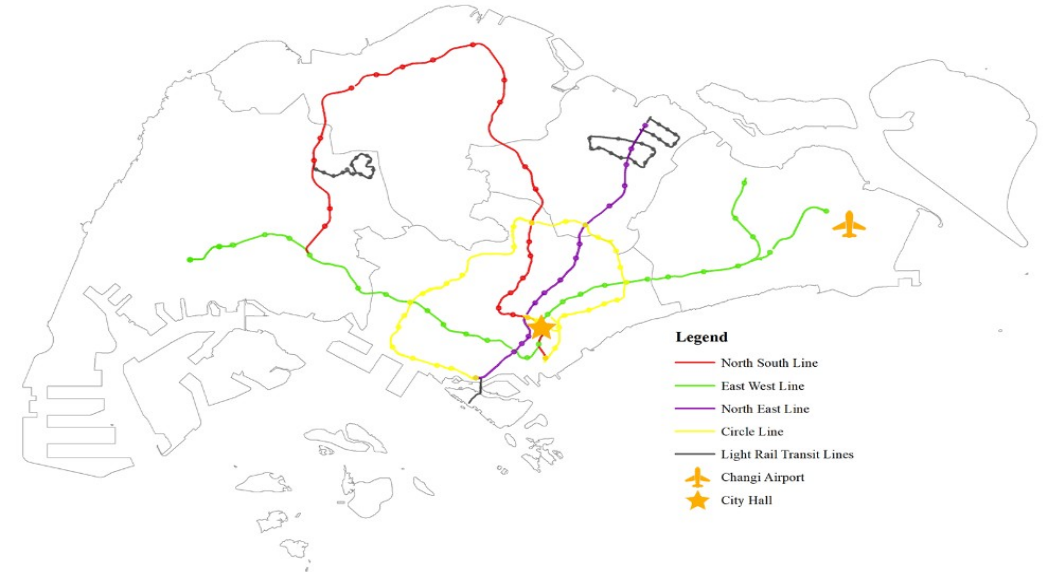
# Car Ownership in Singapore & MRT

Motor Vehicle Population

Year	(1) Private Cars	(2) Total Population	(3) Car Ownership (%)
2008	476,634	4,839,396	9.8
2009	497,116	4,987,573	10.0
2010	511,125	5,076,732	10.1
2011	520,614	5,183,688	10.0
2012	535,233	5,312,437	10.1
2013	540,063	5,399,162	10.0
2014	536,882	5,469,724	9.8
2015	519,645	5,535,002	9.4
2016	504,160	5,607,283	9.0

Source: LTA

Map of MRT Lines in 2012



## MRT

- the **Circle Line (CCL)** opened in multiple stages from 2009 to 2011, which spans 35.7 km across 30 stations, circling around the city center and connecting with other MRT lines
- The CCL is treated as a quasi-natural experiment to assess **effect of its opening on car ownership**.



# Methodology

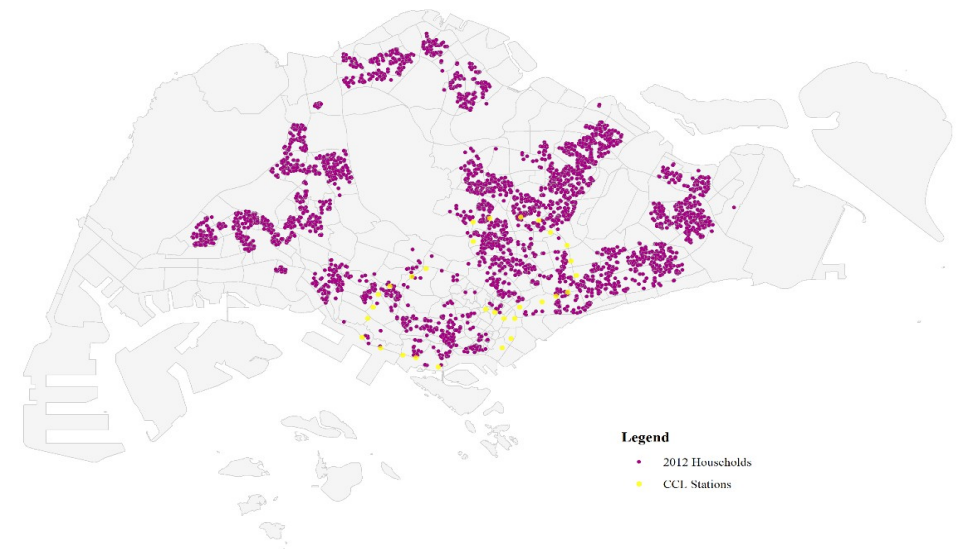
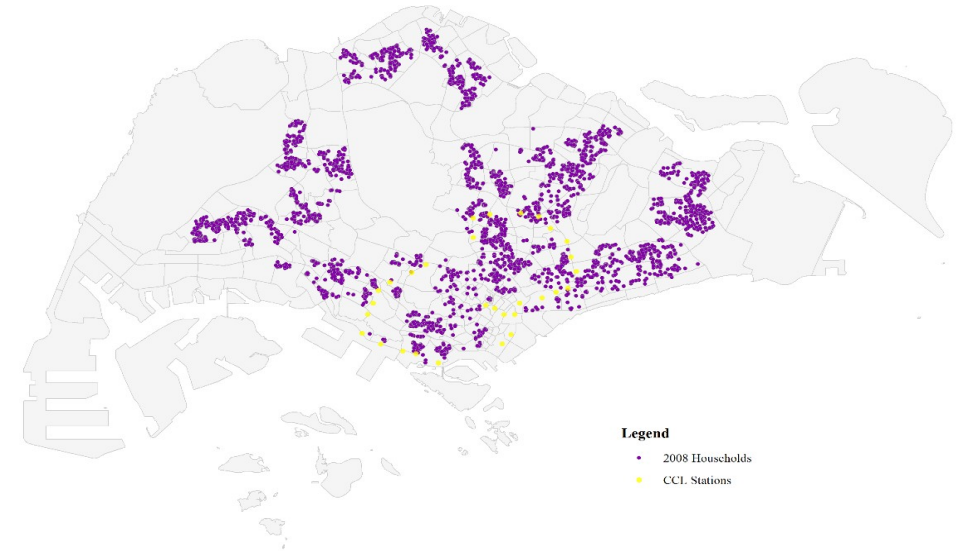
# Datasets

## Household Interview Travel Survey (HITS )

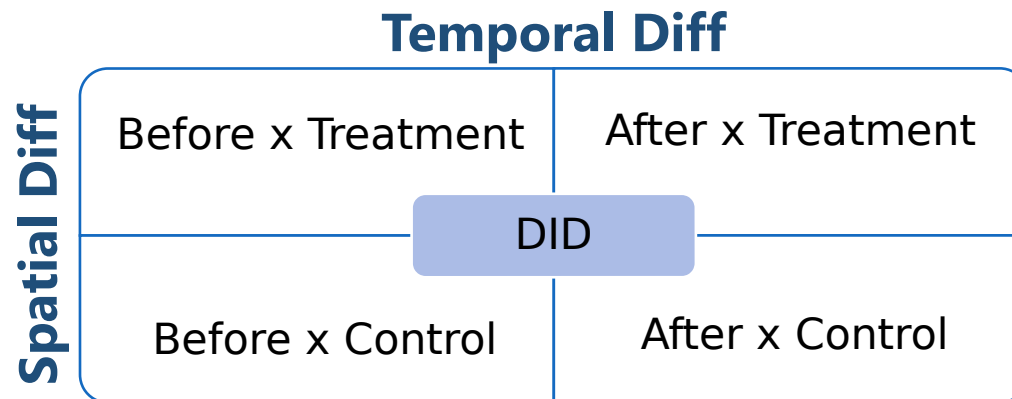
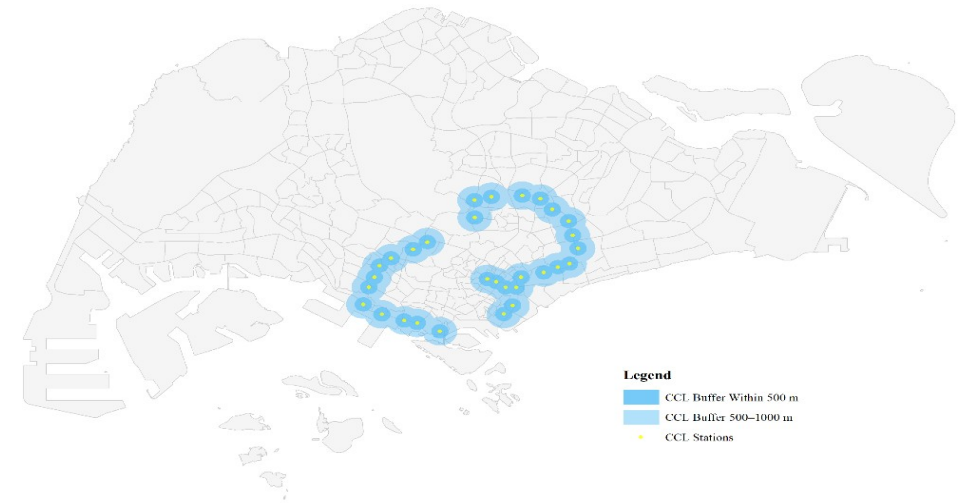
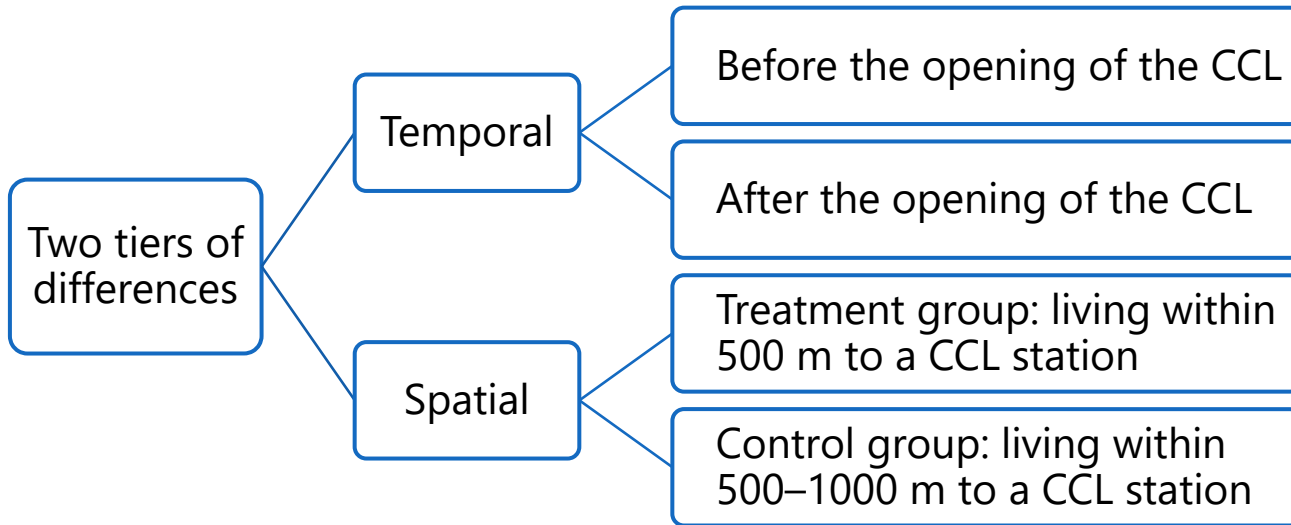
- main datasets: **HITS 2008 and HITS 2012**
- LTA conducted by means of interviews every 4-5 years
- collects the information on **travel patterns with socio-economic characteristics**

### Acknowledgements

I would like to express my thanks to Land Transport Authority and the Singapore-MIT Alliance for Research and Technology (SMART) for their data support.



# Methods: Difference-in-Differences



# Methods: Difference-in-Differences

## Baseline model

- “ $Y$ ” is the dependent variable, which is the car ownership level (the number of cars divided by the number of family members)
- “ $\alpha$ ” acts as the **DID estimator** to capture the treatment effect of the CCL opening
- “ $\delta$ ” is a spatial boundary dummy variable:
  - $Treat = 1$ , if the observation lives in the treatment zone (500 m)
  - $Treat = 0$ , if the observation lives in the control zone (500 – 1000 m).

—————> **Spatial Difference**
- “ $\gamma$ ” is a time dummy variable:
  - $After = 1$ , if the observation occurs after the CCL (belonging to HITS 2012)
  - $After = 0$ , if the observation occurs before the CCL (belonging to HITS 2008).

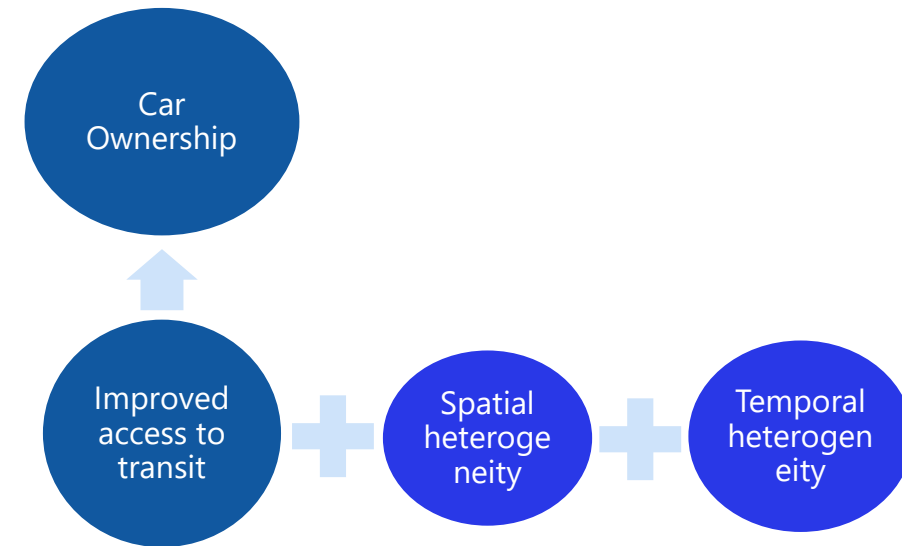
—————> **Temporal Difference**
- “ $X$ ” is a set of control variables (**dwelling type, income level, age group, gender, employment status**)



# Methods: Self-Selection and PSM

## Heterogeneity issues

- travel-based residential self-selection—**spatial heterogeneity**, may overestimate the MRT effect
  - households choose where to live based on their preferred way of travelling
  - RSS is overlooked in most repeated cross-sectional studies
- transit-induced gentrification—**temporal heterogeneity**, which may underestimate the MRT effect
  - investment in rail infrastructure has often capitalized into land and housing prices
  - more high-income households relocate in the station areas during the 4-year study period



# Methods: Self-Selection and PSM

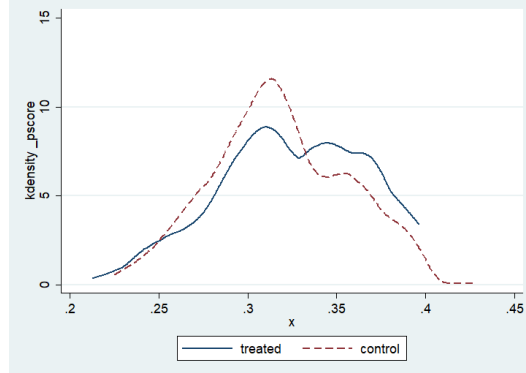
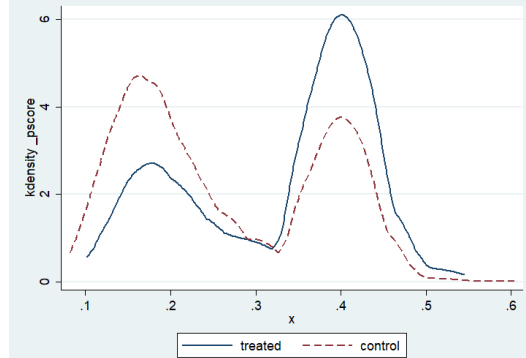
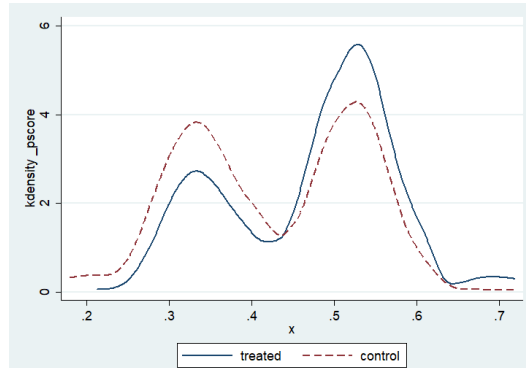
## Solution: Two-Dimensional Propensity Score Matching

- use four subgroups to create and combine three matched sets
- software-“Stata 14”, use a logit model based on control variables in DID model, one to one matching
- remove the demographic heterogeneity along the spatial and temporal dimensions and obtain more robust estimations of the treatment effect of the CCL



# Methods: Self-Selection and PSM

Before

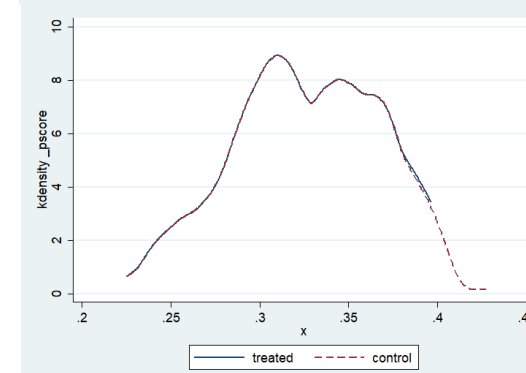
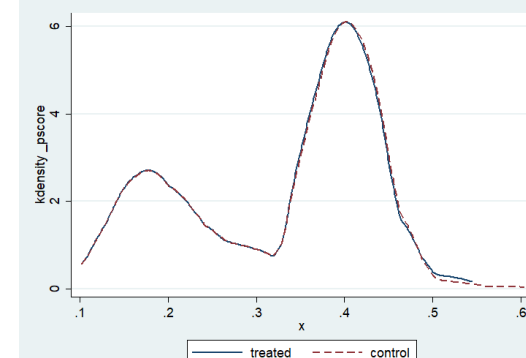
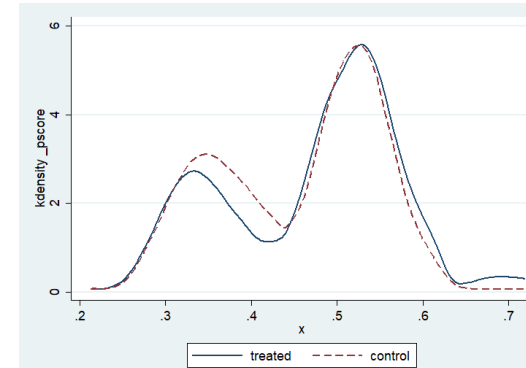



Treatment After and  
Treatment Before

Treatment After and  
Control Before

Treatment After and  
Control After

After





# **Results & Discussions**

# Results: Car Ownership


Variables	1) Before PSM	2) After PSM	3) Workplace	4) Own car or not
Key Dummies				
Year	-0.007	0.001	0.001	0.017
	(0.008)	(0.013)	(0.016)	(0.031)
Treatment	0.009	0.028**	0.016	0.045
	(0.010)	(0.013)	(0.016)	(0.031)
Treatment x After	-0.025*	-0.037**	-0.011	-0.094**
	(0.015)	(0.018)	(0.022)	(0.044)
T x After x Workplace			0.105**	
			(0.051)	
Constant	-0.018	-0.031	-0.033	-0.030
	(0.019)	(0.025)	(0.036)	(0.058)
Control Variables	Yes	Yes	Yes	Yes
Total Observations	2,455	1,412	776	1,408
R-Squared	0.236	0.263	0.056	0.315

# Findings

- The opening of the CCL **reduces the car ownership level per household** by **2.5 percentage points** in the treatment area (living < 500 m to the CCL) compared to the control area (500–1000 m to the CCL).
- Results imply that improved rail transit access can **significantly restrict** car ownership along the transit corridors.
- The restriction effect on car ownership increases to **3.7 percentage points** after applying PSM.
- The spatial and temporal heterogeneity brings **substantial downward bias** when investigating the treatment effect of the CCL, may be due to a transit-induced gentrification process



# Findings

- Households who **both live and work close to CCL station** have lower car ownership level.
- Extensive and intensive margins  **Two-Stage Regression**
  - **extensive margins**: calibrate a linear probability model of the discrete decision of individuals to own a car or not using the full sample
  - **intensive margins**: model the continuous decision of how many cars each household decides to own, only keep households that own car(s)
- The opening of the CCL **significantly affects** households' decisions on whether to **purchase their first car**, while its effects on the number of cars owned is not significant.
- The effect of the CCL on restricting car ownership level **stays robust** after:
  - testing parallel trend assumption
  - changing the boundaries of treatment and control zones
  - running placebo tests

# Discussions

## Contributions of the study

- an improved method for estimating the treatment effect of a new rail transit line on car ownership using repeated cross-sectional data while controlling for individual-level heterogeneity—**methodological contribution**
- new evidence that supports the effectiveness of rail transit investment in reducing the level of car ownership—**scholarly contribution**
- different policy implications for diverse stakeholders
  - When designing new rail transit lines, the policy makers should attach importance to the role of MRT, **individual and household characteristics**, and the issues of **residential relocations** to better restrict car dependency and achieve sustainable transportation.



The background features a complex, abstract pattern of overlapping, semi-transparent blue triangles and polygons. The colors range from a deep, dark blue on the left to a very light, almost white blue on the right, creating a sense of depth and movement. The pattern is dense and organic, resembling a crystalline or molecular structure.

**Thank You**

[daifz@nus.edu.sg](mailto:daifz@nus.edu.sg)