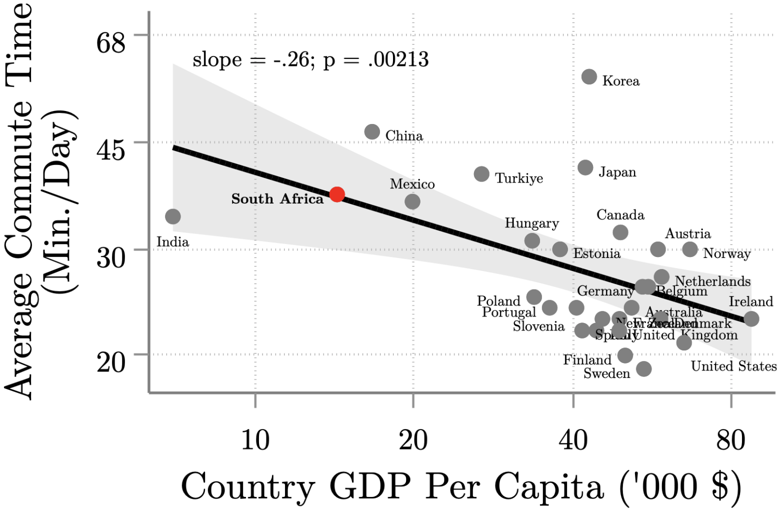
Are There Too Many Minibuses in Cape Town?

Privatized Provision of Public Transit

Lucas Conwell

April 2023

Long Commutes in Lower-Income Countries



Typical Recommendation: Formal “Bus Rapid Transit”

Sources: ODA Ltd.; Creamer Media’s Engineering News

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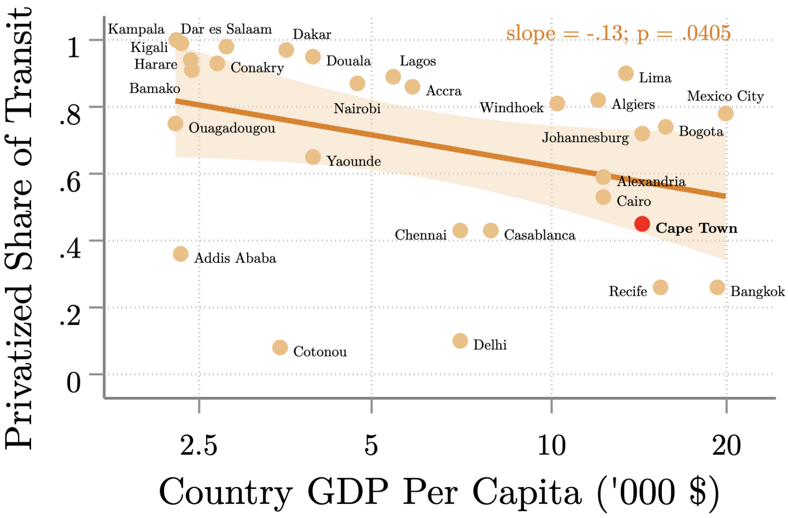
The Limits of Bus Rapid Transit: A Cape Town Case Study

Why BRT isn't right for every city.

- Bloomberg

Alternative: Privatized Shared Transit



This Paper: Efficiency of Privatized Shared Transit

- Model of privatized shared transit
  1. Minibuses enter + match with passengers ⇒ wait times
  2. Commuter home + work + mode choice [time + quality]

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- **Data**, newly-collected
  1. $\frac{\text{buses}}{\text{passenger}} \Rightarrow$ **wait times** [ID: demand shocks w/i 44 routes]
  2. **Stated preferences** of commuters [ID: randomized time, quality]

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  1. **Social Planner:** optimally increase fares on longer routes
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▸ Under Discussion

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↓

commute time/quality + relocation + environmental

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Literature

- Public transit and (developing-country) city structure
  Glaeser, Kahn, Rappaport '08; Ahlfeldt, Redding, Sturm, Wolf '15
  Heblich, Redding, Sturm '20; Balboni, Bryan, Morten, Siddiqi '20
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  $\Rightarrow$ Privatized transit.

- Road congestion
  Allen and Arkolakis ’21; Almagro, Barbieri, Castillo, Hickok, Salz ’22
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  $\Rightarrow$ Wait times and fares $\Rightarrow$ privatized transit policies.

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  ⇒ Wait times and fares ⇒ privatized transit policies.

- **Decentralized** transport markets
  Brancaccio, Kalouptsidi, Papageorgiou '20
  Brancaccio, Kalouptsidi, Papageorgiou, Rosaia '22

  ⇒ Urban transport.

Today's Talk

Context and Facts

Model

Data and Estimation

Model Fit

Transport Policies

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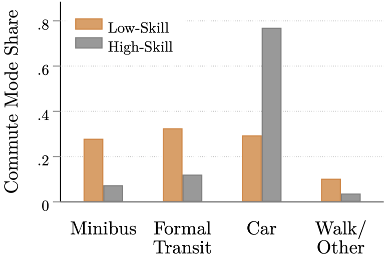
Minibuses in Cape Town

- Large market share

  $\frac{1}{3}$ of low-skill commuters



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- **Large market share**
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- **Small firms** avg. < 2 buses
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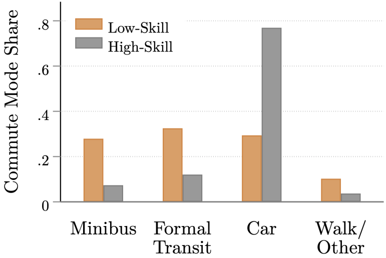

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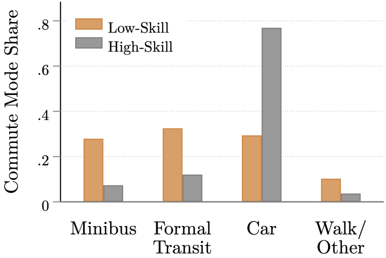

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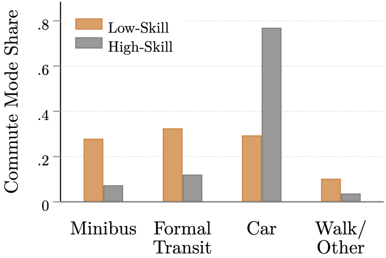
- **Fares:** distance-based

  set by gov't + route "association."



▸ Local market shares ▸ Networks ▸ Boarding/Alighting ▸ Entry description ▸ Fares

➊ Wait Times Large; Bus Entry: Ambiguous Effect

1. Off-bus wait
   avg. $\approx$ 9 min.

❶ Wait Times Large; Bus Entry: Ambiguous Effect

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   avg. ≈ 9 min.

   Queues, especially during certain times of the day are impossibl[y long].
   -“Pros Cons of Minibus Taxis” on Medium

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> *One…inefficient practice…is that minibus taxis generally only leave when they are full.* -World Bank (2018)

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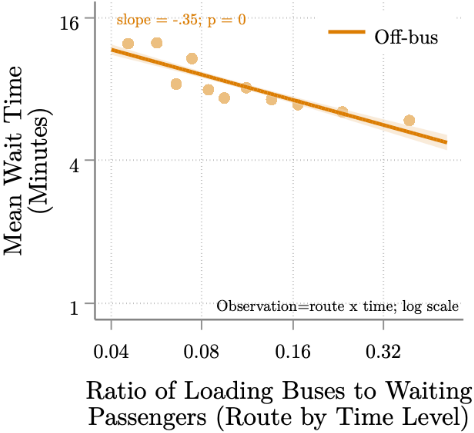

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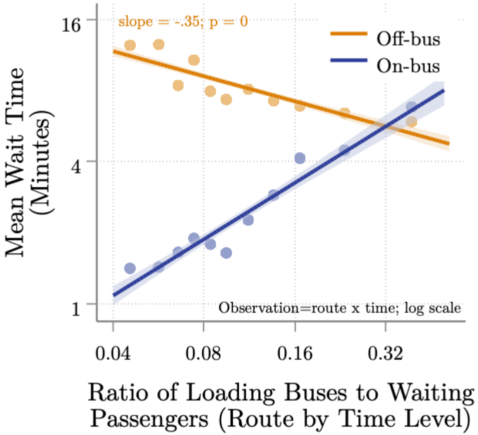

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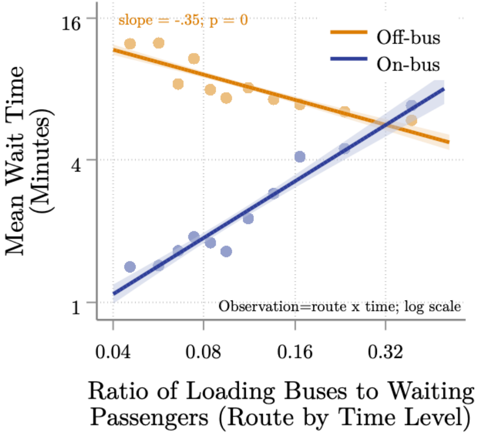
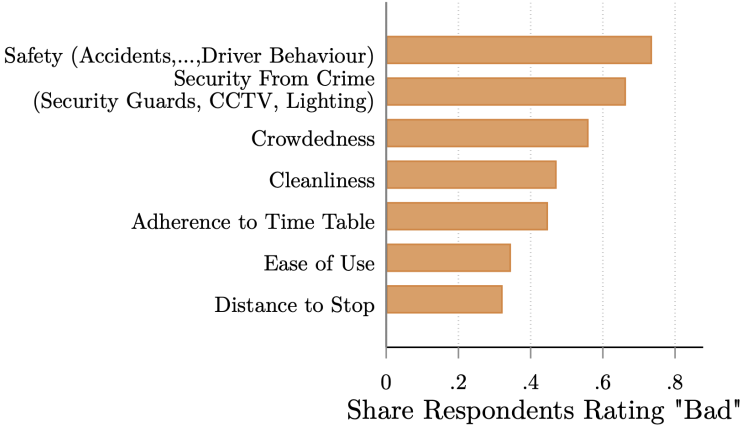


⇒ Counterfactual: optimal fares.

❷ Security = #2 Rider Complaint



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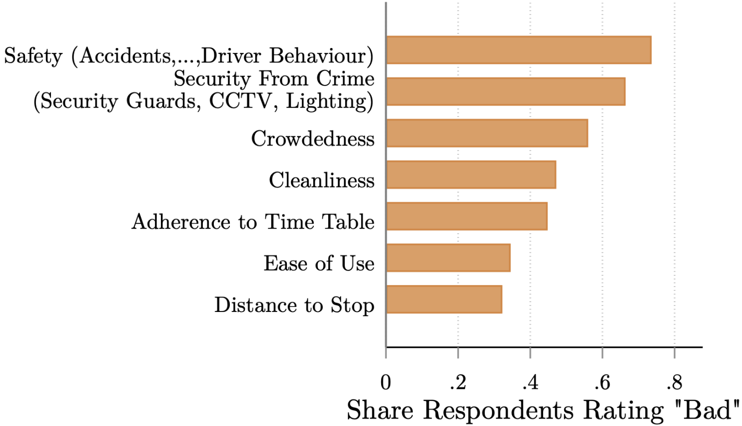

⇒ Counterfactual: station security guards.

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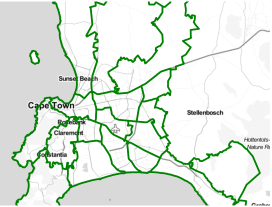
Model Overview

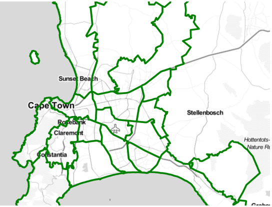


Environment

Time: continuous

Geography: I locations

Emissions costs
external, mode-specific



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Minibuses

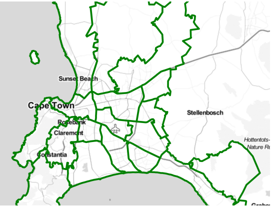
Entry: free [firm = bus]
∀ origin-destination

Fares: exogenous

Matching: frictional
with passengers

Trips: multiple

Model Overview



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▸ Market Structure

Minibuses

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$\forall$ origin-destination

Fares: exogenous

Matching: frictional
with passengers

Trips: multiple

Commuters

Skill: heterogeneous
$g \in \{\text{low}, \text{high}\}$

Choice:

1. Home i [amenity θ_i^g]
2. Work j [wage ω_j^g]
3. Mode $m \in$
   - minibus
   - formal transit
   - car

A Minibus Trip

1. Load passengers s.t. frictional matching process ▸ Why matching?

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3. **Collect** fares τ_{ijM} [calibrated to data] ▸ Data

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A Minibus Trip

1. **Load** passengers s.t. frictional matching process [Why matching?]

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3. **Collect** fares τ_{ijM} [calibrated to data] [Data]

4. **Travel** to j, operating cost χ per distance Δ_{ij}

5. **Arrive** at rate d_{ij} and end work "shift" with $\text{Pr} = g\overbrace{(\text{trip time})}^{(+)}$

[Profits]

Minibus-Passenger Matching

- **Matching function** for each route *ij*:

$$\mathscr{M}_{ij} \equiv \mu_{ij} p_{ij}^{\alpha} b_{ij}^{\beta} \quad \Big\} \begin{array}{l} \mu_{ij} = \text{matching efficiency} \\ p_{ij}, b_{ij} = \text{passengers, buses} \end{array}$$

$\Rightarrow$ Passenger **boarding** (λ_{ij}) and bus **loading** (ι_{ij}) rates

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- Expected **total passenger wait time** [$\mu_{ij} = 1$ and CRS]:

$$\underbrace{\frac{1}{\lambda_{ij}}}_{\text{off-bus}} + \underbrace{\frac{1}{2}\frac{\overline{\eta}}{\iota_{ij}}}_{\text{on-bus}} = \underbrace{\left(\frac{p_{ij}}{b_{ij}}\right)^{\beta}}_{\substack{\text{boarding} \\ \text{externality}}} + \underbrace{\frac{\overline{\eta}}{2}\left(\frac{b_{ij}}{p_{ij}}\right)^{1-\beta}}_{\substack{\text{filling} \\ \text{externality}}}$$

Commuters: Choose Home + Work + Mode

- **Example**: minibus choice utility for home i, work j ▸ Other Modes

$$\underbrace{\overline{U}^g_{ijM}}_{} = \underset{\text{amenity}}{\underset{\uparrow}{\theta^g_i}} + \underset{\text{wage}}{\underset{\uparrow}{\omega^g_j}} - \overset{\text{rate of time pref.}}{\overset{\downarrow}{r}}\,\omega^g_j \left(\underset{\substack{\text{off-bus}\\ \text{wait}}}{\underset{\uparrow}{\frac{1}{\lambda_{ij}}}} + \underset{\substack{\text{on-bus}\\ \text{wait}}}{\underset{\uparrow}{\frac{1}{2}\frac{\overline{\eta}}{\iota_{ij}}}} + \underset{\substack{\text{travel}\\ \text{time}}}{\underset{\uparrow}{\frac{1}{d_{ij}}}} \right) - \underset{\substack{\text{mode}\\ \text{utility}\\ \text{cost}}}{\underset{\uparrow}{\kappa^g_M}} - \underset{\text{fare}}{\underset{\uparrow}{\tau_{ijM}}}$$

Gumbel shock, shape $\nu \Rightarrow$ choice Pr. $\pi^g_{ijM} \equiv \exp\left(\frac{\overline{U}^g_{ijM}}{\nu}\right) / \sum_{i,j,m} \exp\left(\frac{\overline{U}^g_{ijm}}{\nu}\right)$.

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- **Policies**: $\kappa^g_M = f$(quality improvements) e.g. security ▸ Equilibrium

Social Planner Optimum Through Minibus Fares + Transfers

Social Planner Problem

$$\max_{\boldsymbol{b}_{ij},\boldsymbol{\pi}^g_{ijm},\boldsymbol{\tau}_{ijM},\boldsymbol{t}_{ijm}} \left\{ \sum_g \underset{\substack{\uparrow \\ \text{expected} \\ \text{commute utility}}}{N^g\Omega^g} \quad - \quad \underset{\substack{\uparrow \\ \text{operating} \\ \text{costs}}}{C} \quad - \quad \underset{\substack{\uparrow \\ \text{emissions} \\ \text{costs}}}{\varsigma E} \right\} \text{ s.t. } \begin{array}{c}\text{commuter choice} \\ \text{probabilities.}\end{array}$$

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Optimal Minibus Fare

Assume $\alpha + \beta = 1$, $\mu_{ij} = 1$, $\varsigma = 0$, and $\phi = 0$.

$$\tau^*_{ijM} \propto \underbrace{\chi\Delta_{ij}}_{\substack{\text{operating} \\ \text{costs}}} + \underbrace{\overline{\psi}g\left[\overline{\eta}^\beta\left(\frac{2\beta}{1-\beta}\right)^{1-\beta} + \frac{1}{d_{ij}}\right]}_{\text{net boarding} - \text{filling externality}}$$

Today's Talk

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Data Collection

1. Minibus **Station Counts**

- **Loading process** [M-F 6-10:00]
  - bus arrival/departure
  - waiting passengers
- **Sample**: $N = 44$ routes
  2-stage, stratified by bus entry

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2 Stated Preference Surveys

over commute modes

Q1.1	Option 1.1.1	Option 1.1.2
Cost	R18.00	R6.00
Travel Time	50 Minutes	50 Minutes
Security	Security at taxi rank	No security at taxi rank
Driver Behaviour	Adheres to speed limit	Exceeds speed limit
Bus Loading	Enough seats for all passengers	Overloaded: more passengers than seats

1. **New:** minibus options
   - 5 randomized **choice sets**
   - 2 minibus options/set
   - **Sample** ($N = 526$) ▸ vs. pop.
     at mall, minibus stations
2. **Existing:** other modes

Station Counts ⇒ Matching Function

- Estimate **bus loading rate** equation in logs ▸ Histograms
  across 44 routes (ij) × 48 5-min. periods (t)

$$\log \iota_{ijt} = \hat{\alpha} \log p_{ijt} + \left(\hat{\beta} - 1\right) \log b_{ijt} \underbrace{+ \overline{\mu}_{ij} + \overline{\mu}_{it} + \epsilon_{ijt}}_{\text{matching efficiency}}$$

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Parameter	OLS *route+origin-time FE*
α	0.645
	(0.0264)
β	0.435
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Note: Robust standard errors in parentheses, clustered at origin level.

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  ID Strategy: assume CRS ⇒ IV for **log** $\left(\frac{p_{ijt}}{b_{ijt}}\right)$ = commuters in i leaving at t

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Stated Preference Survey $\Rightarrow \kappa_m^g, r, \nu$

- Estimate multinomial logit [model-implied] ▸ Details

  ID Strategy: exogenously-varied attributes

Stated Preference Survey ⇒ κ_m^g, r, ν

- Estimate multinomial logit [model-implied] ▸ Details

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Parameter	Estimate
r	0.001
commuter rate of time pref.	(0.0004)
ν	4.76
Gumbel pref. shock shape	(1.26)

Note: Robust standard errors in parentheses

▸ Predictions ▸ Heterogeneity ▸ Sample vs. pop. ▸ Sample robustness ▸ All parameters ▸ Fit

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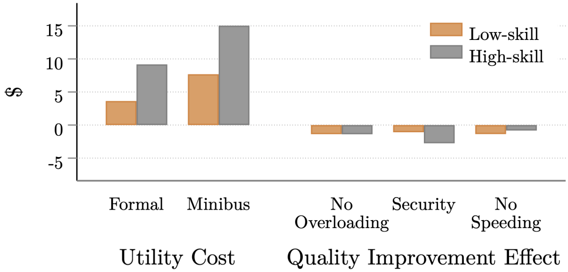

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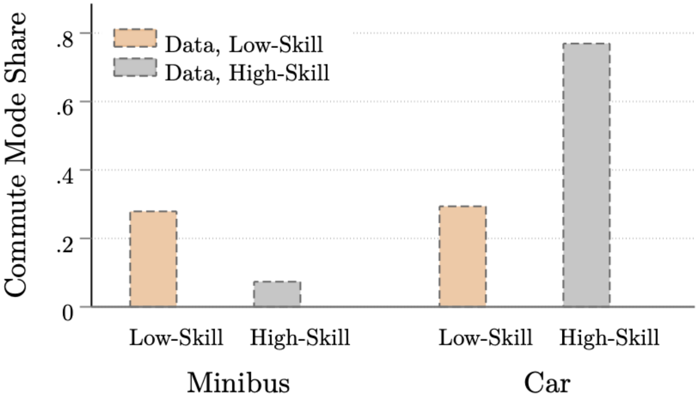
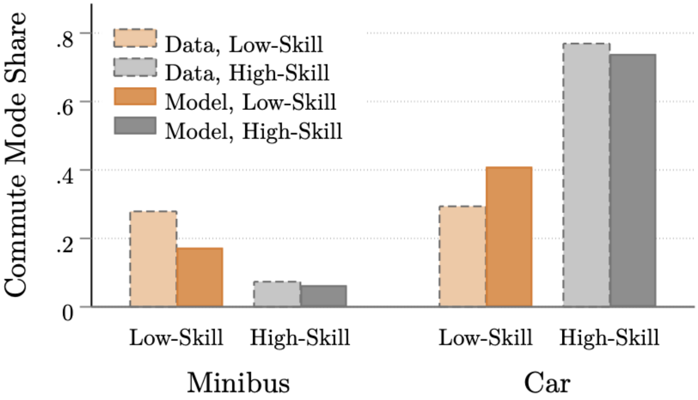


▸ Decomposition ▸ O-D mode choice pr. ▸ Network ▸ Matching

Only Low-Skill Use Minibuses ⇐ Due to Utility Costs

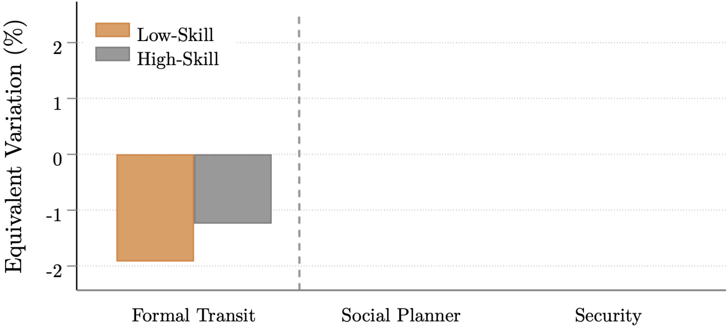


▸ Decomposition ▸ O-D mode choice pr. ▸ Network ▸ Matching

Today’s Talk

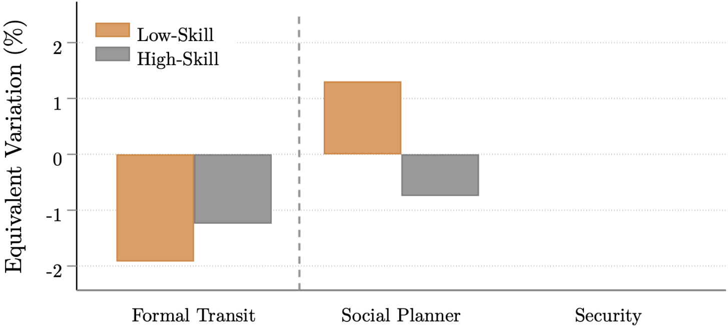
Comparing Policies [Net Welfare Gains]

1. *MyCiti* Formal Bus Rapid Transit [existing]
   Monetary costs: construction + operations, via lump-sum tax.



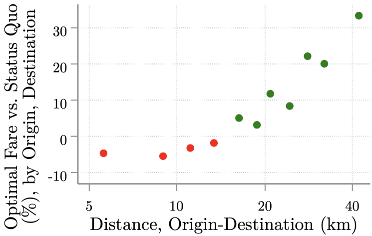
2 Social Planner

Optimal Minibus Fares + Mode-Specific Commuter Transfers

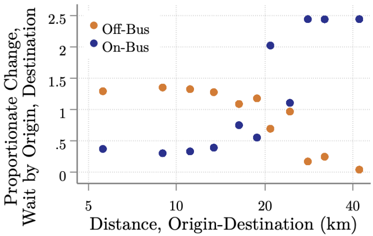


Higher fares on longer routes

[vs. status quo]

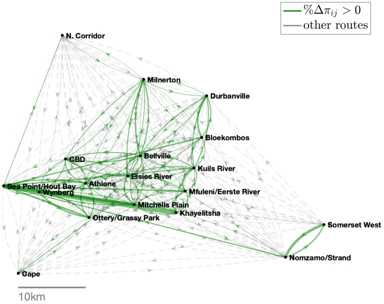


Long route off-bus waits ⇊



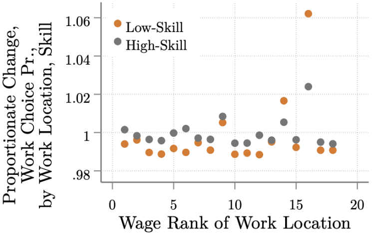
Suburb to Suburb Commutes

[Δ Home-Work Flow > 0]



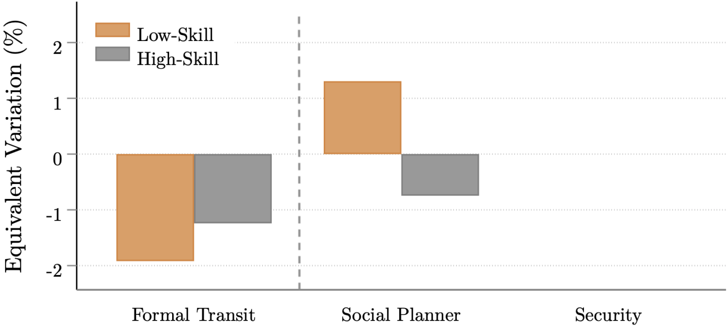
Higher Wages

[Δ Work Location Shares]



2 **Social Planner**

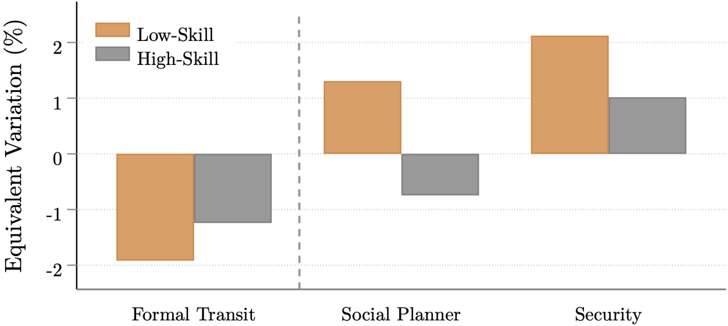
Optimal Minibus Fares + Mode-Specific Commuter Transfers



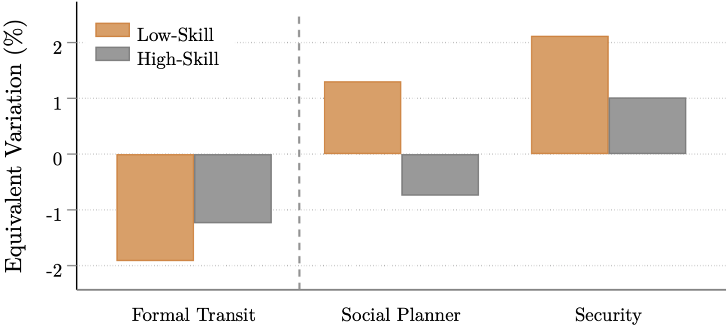
Comparing Policies [Net Welfare Gains]

3 **Minibus station security:** ↓ util. cost κ_M^g by stated pref. effect

Monetary costs: guard wages covered with lump-sum tax.



Comparing Policies [Net Welfare Gains]



Optimized minibuses = low-cost **solution** to long commutes?

Policies: Already Under Discussion

Government plans to subsidise taxis in South Africa – but there's a catch

Staff Writer 15 September 2021

02-14-18

This Uber-Like App Wants To Make African Minibus Taxis Better

What it's like using taxis in SA: 'Violent, aggressive and unsafe'

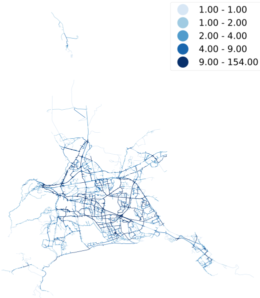
Priority infrastructure for minibus-taxis: An analytical model of potential benefits and impacts

L R De Beer, C Venter

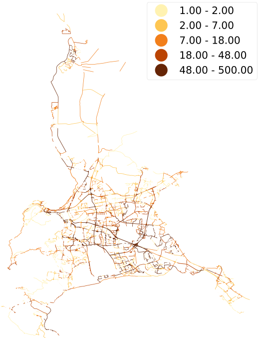
Back

Cape Town Transit Networks: # Routes

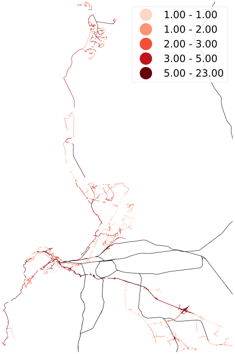
Minibus



Golden Arrow Bus



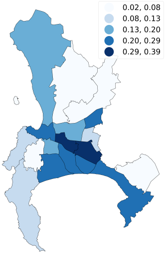
BRT + Metrorail



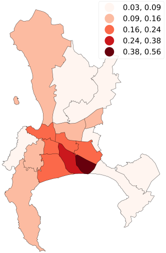
◂ Back

Mode Shares by Home Location

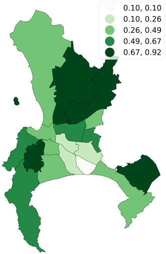
Minibus



Formal Transit

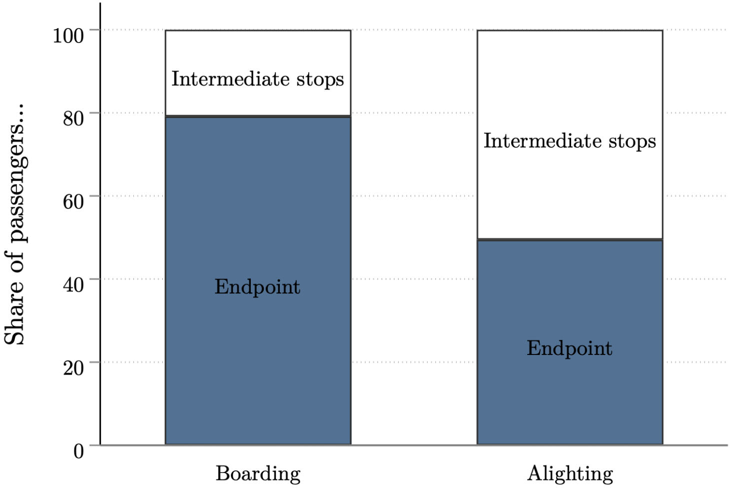


Car



Back to context

Most Boardings/Alightings at Endpoints



Back

Associations Entry Restrictions: No Consensus

Free entry at cost?

*Most associations are still taking on new members and going out on recruitment drives to **encourage new members to join**. These new members pay an exorbitant amount of money to join the association* - City of Cape Town Operating Licence Strategy (2014)

Cartel-like quantity controls?

*Taxi associations prevent entry by other operators through a number of different means, not all of which are used by every association. Firstly, some associations do not take on new members...**Entry deterrence and cartel price setting** make owning a taxi extremely lucrative on many routes.* - World Bank (2018)

◂ Back to context

Legal Restrictions on Minibus Size

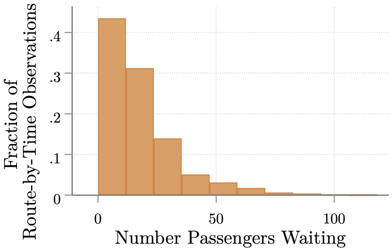
The [National Land Transport Act] specifies the vehicles…to be used for non-contracted PT purposes. - City of Cape Town Comprehensive Integrated Transport Plan (2018)

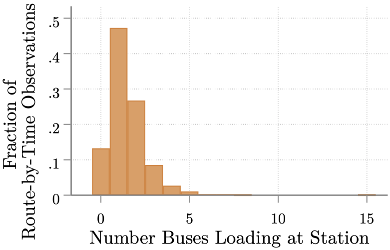
Table 6 2: Approved vehicle types, capacities and number of legal OLs issued

Type of Vehicle	Seating Capacities including the Driver	Current OLs per vehicle group
Sedan	5	205
Avanza (8 +1)	9	400
Minibuses (15+1)	16	9 500 to 10 100
Midi-buses (16<35)	35	negligible
Buses	35 +	**n/a**

◂ Back to context ◂ Back to fact

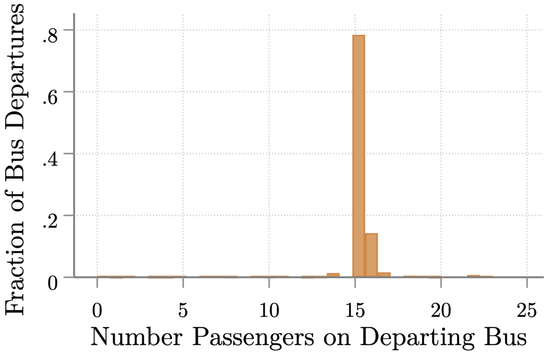
Long Passenger Lines + Multiple Buses Loading





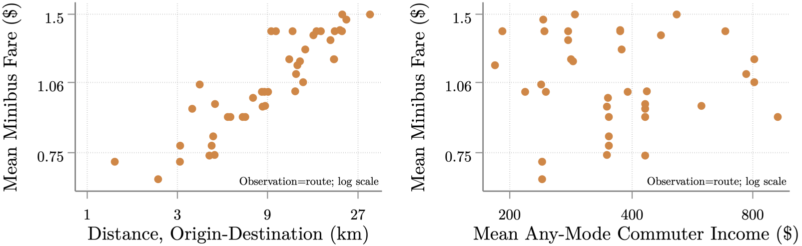
▸ On/offs ▸ Back

Minibuses: 15-Passenger + Depart When Full



▸ Restrictions ▸ Back

③ Fares ↑ with Distance, not Ability to Pay



Why? City considers "cost to the user" in route approvals

▸ Details ▸ Fares vs. entry ▸ Back to context ▸ Back to trip ▸ Back to market

City of Cape Town: New Route Approvals

Considerations and recommended procedure for new minibus-taxi routes

⋮

- *The potential for conflict with existing associations and members*
- *Existing travel patterns*
- *Existing public transport network coverage*

⋮

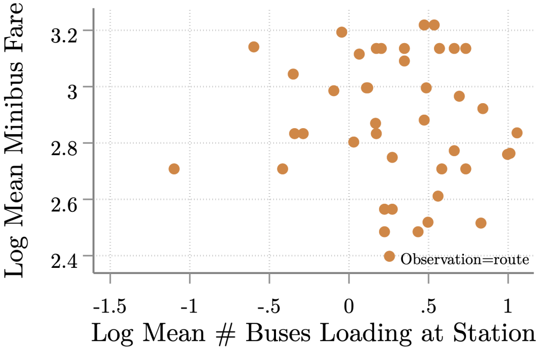
- ***Cost to the user (portion of monthly income spent on public transport)***

⋮

- City of Cape Town Operating Licence Strategy (2014)

◂ Back to context ◂ Back to fact ▸ Back to model

Route-Level Fares Versus Bus Entry



◂ Back to fact

Minibus Market Structure on each route ij

- **Entry cost**, increasing in mass of loading buses b_{ij}

$$\overline{\psi} b_{ij}^{\phi}$$

- **Multiple trips** during effectively finite “work shift”

- **Fares** exogenously calibrated ▸ Evidence

$$\tau_{ijM} \equiv h\Big(\underbrace{\overline{\Delta}_{ij}}_{\text{distance}}\Big)$$

▸ Back

Minibus Profits on route ij

$$\Pi_{ij} \equiv \underbrace{\left[\overline{\eta}\tau_{ijM} - \chi\Delta_{ij}\right]}_{\text{per-trip net revenue}} \underbrace{\frac{1 - g\left(\frac{\overline{\eta}}{\iota_{ij}} + \frac{1}{d_{ij}}\right)}{g\left(\frac{\overline{\eta}}{\iota_{ij}} + \frac{1}{d_{ij}}\right)}}_{E[\#\text{ trips}]} - \overline{\psi} b_{ij}^{\phi}$$

- Per-trip net revenue $\overline{\eta}\tau_{ijM} - \chi\Delta_{ij}$
- Expected total trip time $\frac{\overline{\eta}}{\iota_{ij}} + \frac{1}{d_{ij}}$
- Entry cost $\overline{\psi} b_{ij}^{\phi}$

▸ Back to trip

Commute Utility: Other Modes

- **Formal transit:** travel $\rightarrow$ arrive at rate d_{ijF}

$$\overline{U}^g_{ijF} = \underbrace{\theta^g_i}_{\uparrow\ \text{amenity}} + \underbrace{\omega^g_j}_{\uparrow\ \text{wage}} - r\omega^g_j \underbrace{\left(\frac{1}{d_{ijF}}\right)}_{\uparrow\ \text{travel time}} - \underbrace{\kappa^g_F}_{\uparrow\ \text{utility cost}} - \underbrace{\tau_{ijF}}_{\uparrow\ \text{fare}}$$

- **Car:** travel $\rightarrow$ arrive at rate d_{ij}

$$\overline{U}^g_{ijA} = \underbrace{\theta^g_i}_{\uparrow\ \text{amenity}} + \underbrace{\omega^g_j}_{\uparrow\ \text{wage}} - r\omega^g_j \underbrace{\left(\frac{1}{d_{ij}}\right)}_{\uparrow\ \text{travel time}} - \underbrace{\tau_A}_{\uparrow\ \text{car cost}}$$

Back

Equilibrium

Equilibrium

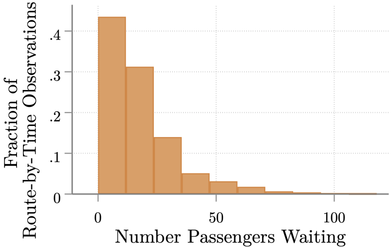
A vector $\{\boldsymbol{b}, \boldsymbol{\pi}, \boldsymbol{\lambda}, \boldsymbol{\iota}\}$ satisfying (i) free entry, (ii) 3 sets of choice probability equations, (iii) boarding as well as (iv) loading rate equations.

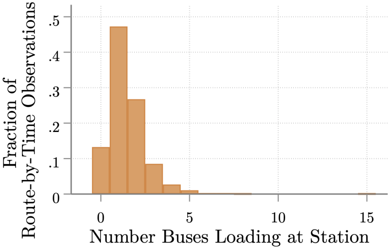
Welfare

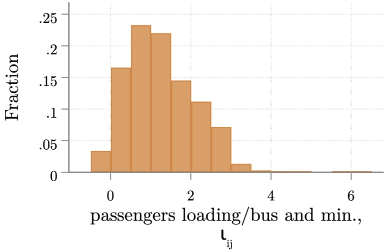
$$\overline{\Omega} \equiv \sum_g N^g \nu \log \Bigg[\sum_{i,j,m} \underbrace{\exp\left(\overline{U}^g_{ijm}\right)}_{\uparrow\ \text{commute utility}}{}^{1/\nu} \Bigg] + \underbrace{\Pi}_{\substack{\uparrow \\ \text{rebated} \\ \text{minibus} \\ \text{profits}}} + \underbrace{\Psi}_{\substack{\uparrow \\ \text{rebated} \\ \text{entry} \\ \text{costs}}} - \underbrace{\varsigma E}_{\substack{\uparrow \\ \text{emissions}}}$$

Back

Matching Estimation: Distributions of Variables







▸ Back

Estimated Parameters

Parameter	Description	Value
Externally Calibrated		
I	Number Locations	18
N^g	Number commuters	
ω_j^g	Wages	
θ_i^g	Amenities	
d_{ij}	Road-Based Destination Arrival Rate	
d_{ijF}	Formal Destination Arrival Rate	
τ_{ijF}	Formal Fare	
τ_A	Car Commute Cost	5.2
δ_0	Minibus Shift Length	240
δ_1	Minibus Inverse # Trips	0.01
χ	Per-km. Operating Cost	0.06
Δ_{ij}	Route Driving Distance	
$\overline{\Delta}_{ij}$	Straight-Line Distance	
Minibus Supply ▸ ϕ ▸ Γ_1		
α	Passenger Match. Elasticity	0.84
β	Bus Match. Elasticity	0.16
ϕ	Entry Cost Elasticity	0.0143
Γ_0	Fare Intercept	2.23
Γ_1	Fare Distance Slope	0.29

Parameter	Description	Value
Stated Preference		
r	Commuter Rate of Time Pref.	0.001
ν	Gumbel Shape	4.76
κ_M^l	Low-Skill Minibus Util. Cost	7.7
κ_M^h	High-Skill Minibus Util. Cost	15
κ_F^l	Low-Skill Formal Util. Cost	3.6
κ_F^h	High-Skill Formal Util. Cost	9.2
Emissions		
χ_M^e	Minibus CO2-equiv. per pass.-km.	0.06
χ_F^e	Formal CO2-equiv. per pass.-km.	0.04
χ_A^e	Car CO2-equiv. per pass.-km.	0.55
ς	Social cost of carbon	0.0485
Internally Calibrated ▸ $\overline{\psi}, \overline{\eta}, \mu$		
$\overline{\psi}$	Minibus Entry Cost Intercept	49.5
$\overline{\eta}$	Minibus Capacity	6.2
μ	Minibus Matching Efficiency	0.2

▸ Back

Entry Congestion Estimation

- **Station counts:** bus loading time $\overline{\eta}/\iota_{ijt}$ and loading buses b_{ijt} by route ij x time t
- **Estimate ϕ** using free entry: $\frac{\overline{\eta}}{\iota_{ijt}} = \zeta_0 - \frac{\phi}{\delta_1} \log b_{ijt} + \zeta_{ij} + \zeta_t + \varepsilon_{ijt}$

Variable	(1) mean bus loading time	
log loading buses, b_{ijt}	-1.434***	$\Rightarrow \hat{\phi} = .0143$
	(0.546)	
Constant	7.287***	
	(0.332)	
Route FE	✓	
Origin-Time FE	✓	
Observations	1,075	
R-Squared	0.654	

Robust standard errors in parentheses, clustered at origin level.
*** p<0.01, ** p<0.05, * p<0.1

▸ Back to parameter table

Fare Function Estimation: Γ_1

- **Onboard tracking data:** average fare $\overline{\tau}_{ijM}$ and straight-line distance $\overline{\Delta}_{ij}$ by route ij
- **Estimate Γ_1** using $\log \overline{\tau}_{ijM} = \tilde{\Gamma}_0 + \Gamma_1 \log \overline{\Delta}_{ij} + \epsilon_{ij}$

Parameter	(1) log mean fare
Γ_1	0.292***
	(0.0232)
Constant	2.231***
	(0.0591)
Observations	43
R-Squared	0.798

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Back to parameter table

Internal Calibration

Moment			Parameter		
Description	*Data*	*Model*	*Description*		*Value*
Median Loading Buses/ Waiting Passengers	0.09	0.09	$\overline{\psi}$	Entry Cost Intercept	49.5
Median Bus Loading Time	4	4	$\overline{\eta}$	Minibus Capacity	6.2
Median Off-Bus Passenger Wait Time	7.18	7.18	μ	Matching Efficiency	0.2

▸ Back to overview ▸ Back to parameter table

Multinomial Logit: Choice Probability

Pr. individual i in group g chooses alternative l in choice set c:

$$\pi_{icl}^{g} = \frac{\exp\left[\zeta_{m(c,l)}^{g} + \sum_{z} \beta_{z}^{g} q_{cl}(z) + \beta_{\text{time}}\omega_i \left(w_{cl} + t_{cl}\right) + \beta_{\text{fare}}\tau_{cl} + \beta_{\text{resid}} w_{cl}\tau_{cl}\right]}{\sum_{l'} \exp\left(\overline{U}_{icl'}^{g} / \nu\right)}.$$

- $\zeta_{m(c,l)}^{g}$ = group-mode fixed effect $\Rightarrow \kappa_m^g$
- $q_{cl}(z)$ = indicator: quality improvement z in set c, alternative l
- ω_i = personal income
- w_{cl} and t_{cl} = wait and travel time
- τ_{cl} = fare

▸ Back

Stated Preference Sample

	Stated Pref. Samples		*Data*
Variable	Own	City-Run	Cape Town
Share Auto Owners	0.448	0.581	0.561
Share Female	0.458	0.494	0.458
Share College-Educated	0.295	0.228	0.190
Median Monthly Personal Income [bin]	$182-$364	$182-$364	$182-$364
Median Age	35	39	39
Commute Mode Shares of...			
Minibus	59.56	22.56	23.55
Formal Transit	19.61	27.69	22.81
Auto	12.11	40	39.40
Share Using Minibuses > 1x/week	0.951	0.635	
N	413	407	

▸ Back to data ▸ Back to estimation

Stated Preference Robustness

Parameter	Skill	Baseline	Intermodal Sample Only	Commute Mode-Weighted
r		0.001	0.0014	0.0011
commuter rate of time pref.		(0.0004)	(0.0007)	(.0005)
ν		4.76	6.83	5.84
Gumbel pref. shock shape		(1.26)	(2.73)	(1.99)
κ_M	*Low*	7.68	10.61	9.25
minibus (baseline) utility cost		(1.56)	(3.54)	(2.55)
	High	15.03	21.16	18.3
		(3.55)	(7.82)	(5.67)
κ_F	*Low*	3.63	4.53	4.14
formal utility cost		(0.51)	(1.08)	(0.80)
	High	9.17	12.5	10.96
		(1.89)	(4.20)	(3.05)
N Respondents		820	546	820

Note: Robust standard errors in parentheses

▸ Back

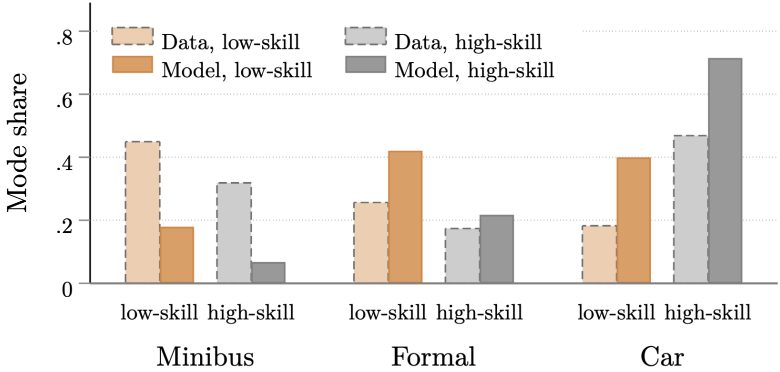
Stated Preference Robustness

Parameter	Skill	Baseline	Intermodal Sample Only	Commute Mode-Weighted
θ_{security}	*Low*	-1.09	-2.13	-1.55
effect of security on κ_M		(0.39)	(1.06)	(0.69)
	High	-2.75	-4.91	-5.1
		(0.84)	(2.29)	(1.86)
$\theta_{\text{no overloading}}$	*Low*	-1.38	-2.02	-1.26
effect of no overloading on κ_M		(0.437)	(1.01)	(0.596)
	High	-1.39	-1.25	-1.43
		(0.543)	(1.28)	(0.83)
$\theta_{\text{no speeding}}$	*Low*	-1.36	-3.03	-2.12
effect of no speeding on κ_M		(0.44)	(1.38)	(0.85)
	High	-0.825	-1.86	-0.582
		(0.465)	(1.39)	(0.73)
N Respondents		820	546	820

Note: Robust standard errors in parentheses

▸ Back

Stated Preference Respondents: Predicted Mode Shares



Back

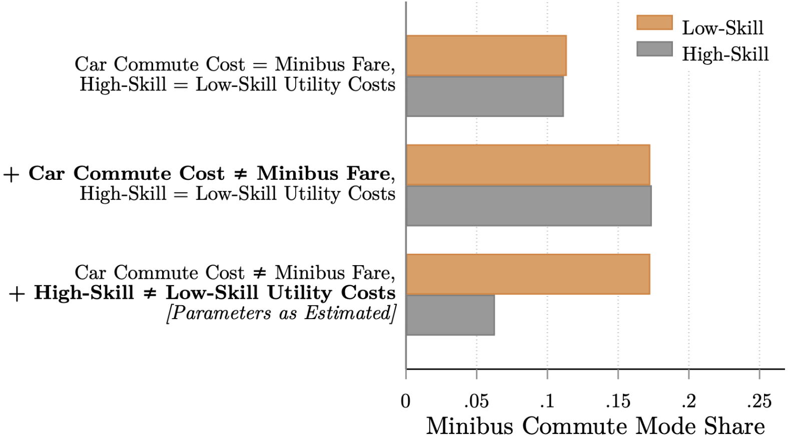
Stated Preference: Effect Heterogeneity

		Mode Utility Cost		Effects on Minibus Utility Cost		
Dimension	r *rate of time pref.*	κ_M *minibus*	κ_F *formal*	$\lvert\theta_{\text{overload}}\rvert$ *no overload.*	$\lvert\theta_{\text{security}}\rvert$ *security*	$\lvert\theta_{\text{speed}}\rvert$ *no speed.*
Female	+	-	-		-	
College	+	+	+		+	
Age>45	+		-		+	+

Note: (+) indicates larger effect magnitude, (-) smaller. Only effects significant at 5% level displayed.

▸ Back

Why Don't the Rich Use Minibuses?



Back

Validation: Mode Choice by Origin-Destination-Skill

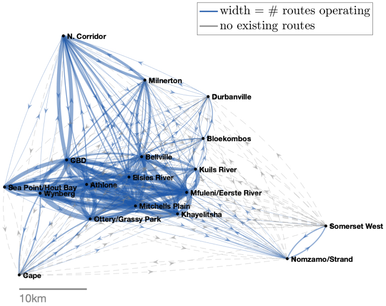
	Minibus	Car
Variables	Mode Share, Data	Mode Share, Data
Mode Share, Model	1.000***	1.110***
origin × destination × skill	(0.153)	(0.0660)
Constant	0.0281	-0.0407
	(0.0196)	(0.0413)
Observations	507	507
R-squared	0.083	0.307

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

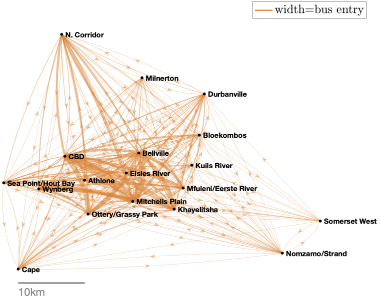
Back

Minibus Network

Data



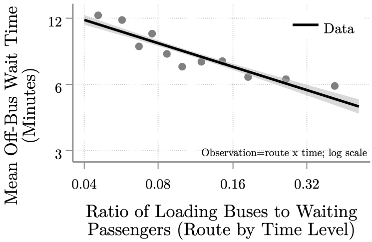
Model



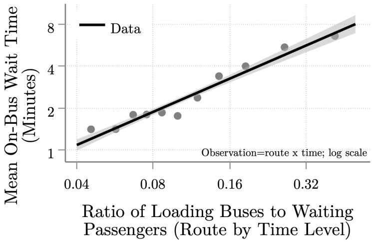
Back

Opposing Matching Externalities

Boarding



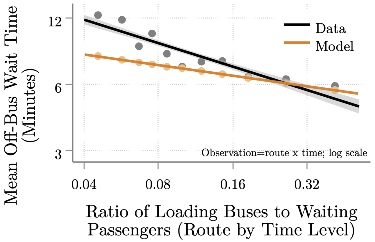
Filling



Back

Opposing Matching Externalities

Boarding



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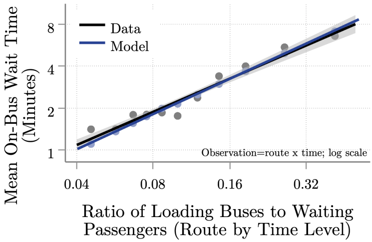

Back