

The Margins of Response to Road Use Prices

Leslie Martin and Sam Thornton

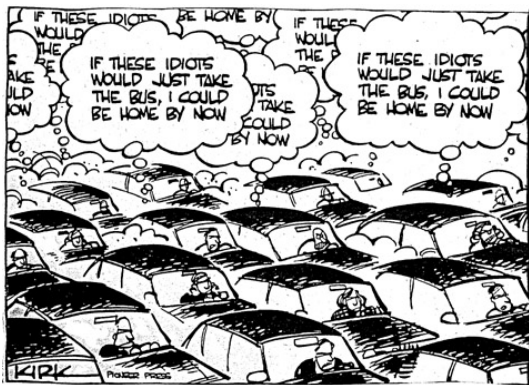
25 June 2018

1 IN 5 UK DRIVERS WILL SPEND OVER A YEAR OF THEIR LIVES SITTING IN TRAFFIC



EXTERNALITY:

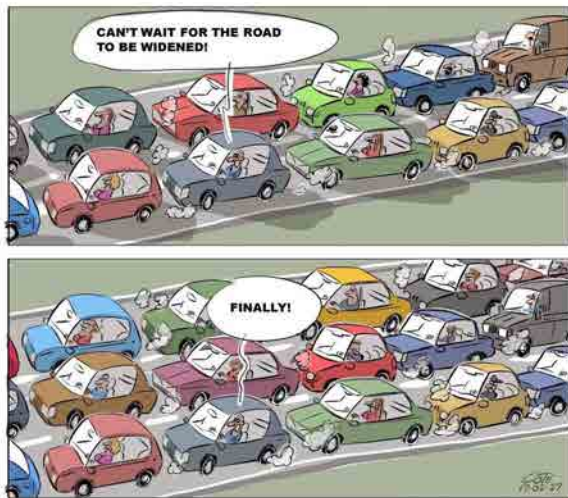
DRIVERS DON'T TAKE INTO ACCOUNT THAT THEIR PRESENCE MAY INCREASE DRIVE TIMES FOR OTHERS



- ▶ Largest cost: time wasted by households and businesses

SUPPLY SIDE SOLUTIONS FAIL: INDUCED DEMAND

DURANTON & TURNER 2011



PRICES: CHARGE FOR ROAD USE / CONGESTION

How we currently pay for roads: registration fees, petrol taxes

Alternatives: per kilometer, for entering zone, for traveling at peak times, fees that adjust to guarantee free-flow



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“Under mobility pricing, some struggling mom or dad with kids of modest income living in the Fraser Valley, because that’s the only place they can barely afford to buy a home, would be hit with high tolls of one kind or another while a single lawyer or other professional with a high income and **wealthy enough to live in Vancouver near their work** would pay almost nothing.” – Gordon Clark, The Province Op-Ed, Vancouver, February 2018

ROAD USE / CONGESTION CHARGES

Proposed: per kilometer, for entering zone, for traveling at peak times, that adjust dynamically to guarantee free-flow

- ▶ Technology is almost ready
- ▶ Is the public?

“I’ve never been in favor of those proposals because I haven’t seen one that I thought was fair, particularly to folks in the outer boroughs.” New York Mayor Bill de Blasio, August 2017

ROAD USE/ CONGESTION CHARGES

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- ▶ Technology is almost ready
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“another penalty for being poor in London”

– Ed Wiseman, The Telegraph Op-Ed, London, October 2017

OUR RESEARCH

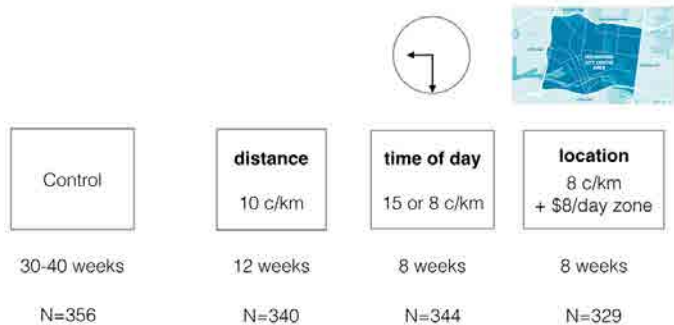
- ▶ Who contributes the most to the externality?
- ▶ Who wins/loses in how we currently pay for roads
- ▶ Identify margins of adjustment if we price differently:
who, on what trips

Frontier: large field experiment with real drivers and high-frequency data

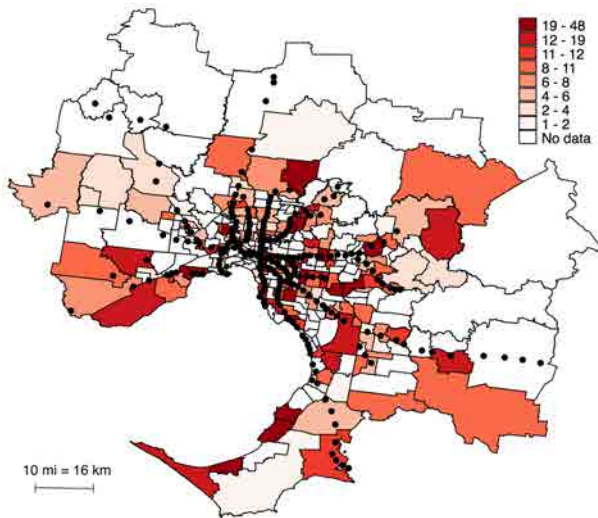
EXPERIMENT

- ▶ Independent govt advisory agency Infrastructure Victoria asked us to analyze raw data from 2015-2016 experiment implemented by Transurban (road & toll company)
- ▶ GPS in 1400 cars for 8-10 months
- ▶ Control group and several treatment arms facing road use charges
- ▶ Real money in credit accounts

TREATMENTS



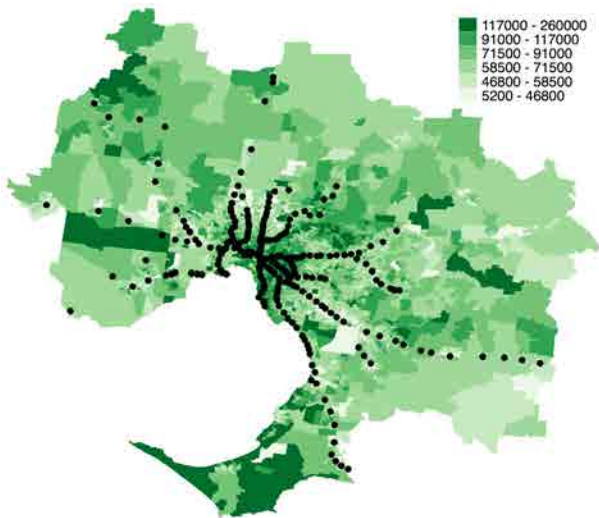
REPRESENTATIVE SAMPLE OF MELBOURNE DRIVERS



46% live within walking distance train/tram (1km)

22% within 10 minutes (500m)

INCOME \neq ACCESS TO PUBLIC TRANSPORT



DATA

- ▶ GPS
 - ▶ 43 million location coordinates and time stamps
 - ▶ Map to road network, railway stations, tram stops, schools, zoning codes
 - ▶ Google Places to identify nearby shops
- ▶ HH surveys
 - ▶ Income, age, employed, children, vehicle
- ▶ Fuel economy: Green Vehicle Guide
- ▶ Petrol prices: AAA

HYPOTHESES TO TEST

1. Under un-targeted road charges (fuel taxes), drivers reduce trips that are not contributing much to congestion
2. Low income, particularly low income living far from public transport, will be most hurt by congestion charges
3. Congestion charges could lead to increased social isolation amongst elderly

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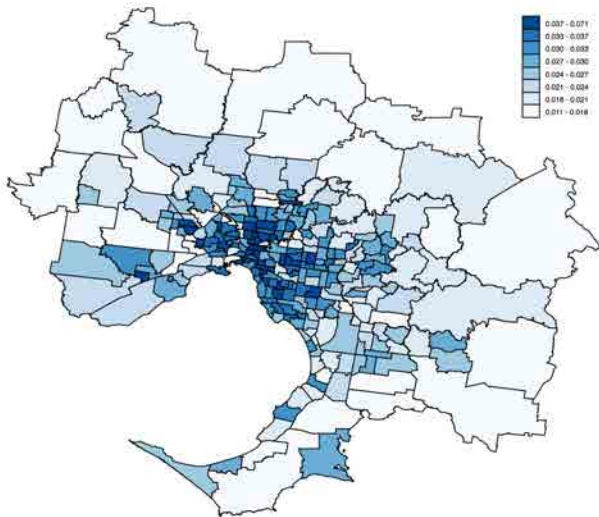
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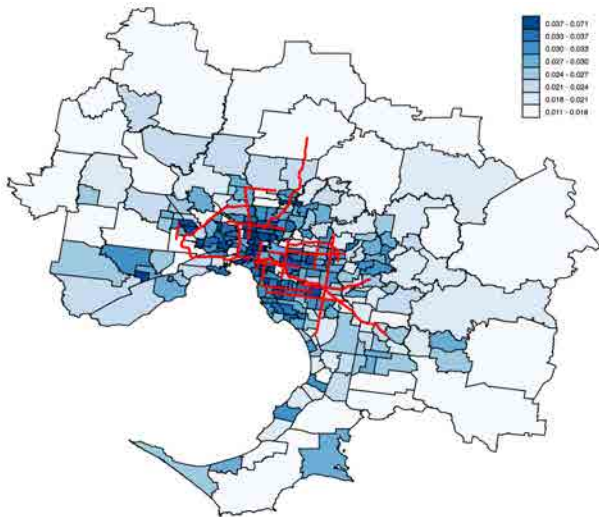
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CONGESTION NOT JUST IN CENTER OF CITY

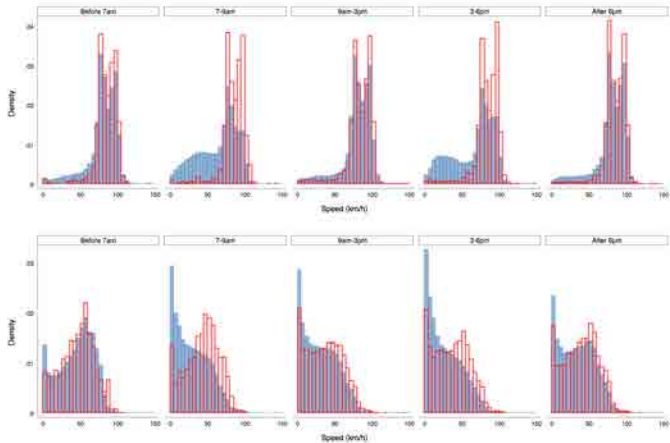


TOP 25 MOST CONGESTED ROADS (AUSROADS 2016)



FREEWAY CONGESTED AT PEAK TIMES

CONGESTION ON ARTERIALS DIFFICULT TO PREDICT



blue = Monday-Friday, red=public holiday

LOWER INCOME HH CONTRIBUTE LEAST TO CONGESTION

Lower income: 40% (21%) of HH in sample (not senior)

- ▶ 3% (2%) of km in CBD
- ▶ 14% (10%) of km on congested arterials
- ▶ 19% (14%) of km on congested expressways

Seniors drive much less, especially at peak and into CBD

Households far PT: 53% (24%) of HH (also low income)

- ▶ 6% (1%) of km in CBD
- ▶ 24% (9%) of km on congested arterials
- ▶ 54% (14%) of km on congested expressways

Congested inner city: 50% trips by < 5% of drivers

LOW INCOME HOUSEHOLDS BETTER OFF UNDER MORE CONGESTION-TARGETED REVENUE SCHEMES

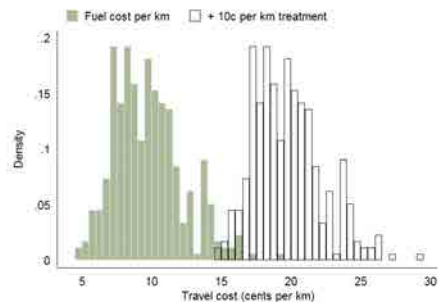
Δ weekly travel expenditures under VMT charge

Income	Distance to public transit			
	0 to 500m	500m - 1km	1 - 2.5km	More 2.5 km
Less than \$20,800	-6.66	-5.01	-3.31	-1.10
\$20,800 to 41,600	-6.20	-4.03	-2.10	-1.77
\$41,600 to 65,000	-4.59	-1.10	2.01	1.66
\$65,000 to 104,000	-2.51	0.97	2.11	4.90
\$104,000 to 156,000	0.80	-1.33	2.29	7.75
Greater \$156,000	-1.79	0.40	-0.21	5.89

ELASTICITY: % Δ KM FROM 1% Δ PRICE

$$\text{price elasticity} = \frac{\partial \ln q}{\partial \ln p} = \frac{\Delta Q/Q}{\Delta P/P}$$

Let base MC travel = cost of fuel
10 c/km doubles cost of driving:



UNIFORM DISTANCE-TRAVELED CHARGE

10c/km reduces distance traveled -8%, time on road -6%
Price elasticity: 10-12% reduction in km traveled for 100% increase in cost per km

Most driving and reductions:

- ▶ off-peak times
- ▶ far from city center
- ▶ not on most congested roads
- ▶ time spent at speeds representing uncongested road conditions

CHARGES BETTER TARGETING CONGESTION?

Time of day -based charge reduces peak driving

- ▶ But peak response small relative to increase in price
- ▶ Most reductions from peak driving on uncongested roads
- ▶ Limited evidence of time-shifting to off-peak

Location-based charge reduces driving in CBD, on weekends

- ▶ Technically not priced then
- ▶ No evidence of increased driving around CBD
- ▶ Of three options modelled, largest reduction in time spent at speeds representing congested road conditions

Conclusion: targeting helps, above plans not targeted enough

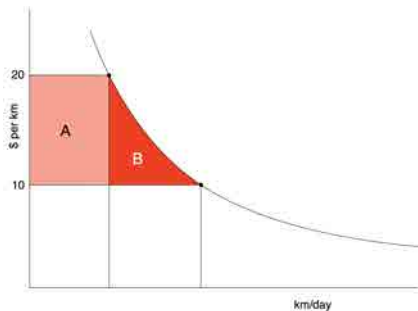
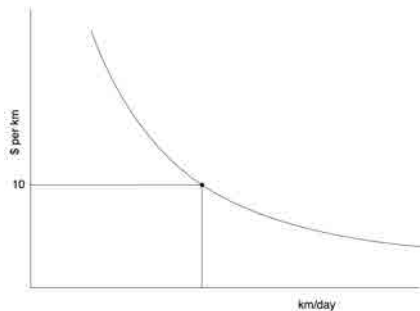
WHO WINS/LOSES UNDER ROAD USE CHARGES?

1. Estimate treatment effects and elasticities
 - ▶ by income and proximity to public transport
2. Fit demand curve, estimate change in CS from road use charges
 - ▶ assuming no price response
 - ▶ using estimated price elasticities
3. Revenue-neutral: reduce gasoline taxes and, as needed, registration fees

ESTIMATING Δ CONSUMER SURPLUS FROM Δ PRICES

Under constant elasticity of demand, $q = \alpha p^\eta$:

$$\Delta CS = \int_{p_1}^{p_0} p(x) dx = \frac{\alpha}{1 + \eta} \left(p_0^{1+\eta} - p_1^{1+\eta} \right)$$



We estimate household-level α_i and income group level η_j using experimental variation in price

LOW INCOME HH RESPOND MORE SO SAVE MORE

Distance-based charge

Annual income	Households	Elasticity	% Δ CS		Elasticity	% Δ CS	
			(1)	(2)		(1)	(2)
Less than 20,800	83	-0.13	-12.44	2.74	-0.60	-10.34	3.90
20,800 to 41,600	162	-0.13	-13.81	1.93	-0.19	-13.47	2.18
41,600 to 65,000	185	-0.13	-16.53	-0.26	-0.18	-16.21	-0.02
65,000 to 104,000	260	-0.13	-17.26	-1.10	0.10	-18.97	-1.85
104,000 to 156,000	203	-0.13	-18.19	-1.84	-0.22	-17.55	-1.43
Greater than 156,000	167	-0.13	-16.24	-0.37	0.05	-17.46	-0.89

Even more so under time-of-day

IN SUMMARY

- ▶ Uniform VMT charges (and petrol taxes) are likely to reduce driving under uncongested conditions
- ▶ More targeted charges could make moderate improvements at right times/speeds/places
- ▶ Low income contribute least to congestion externality, respond most to uniform charges: target!
- ▶ Low income households could benefit from a revenue-neutral shift to road use charges