

16 March 2018

MoT – Knowledge Hub

Transport Outcomes & Location Choice

Linking Research to Policy

Outline

1. Background
2. My Research
3. Policy Implications
4. Next Steps and Q&A

Background

It is very difficult to say nowadays
where the suburbs of London
come to an end and where the
country begins. The railways,
instead of enabling Londoners to
live in the country have turned
the countryside into a city.

Anthony Trollope

Background: Thought Experiment

Consider the last time you made a decision about changing jobs and/or moving house.

Did you make your decision independently of how you would travel between home and work? Most people answer “no”; most transport models assume “yes”.

Research question: Is there evidence that location choice depends on transport outcomes?



Background: Motivation #1

Auckland's New Network: Developing a connected network of (relatively permanent?) frequent bus lines.



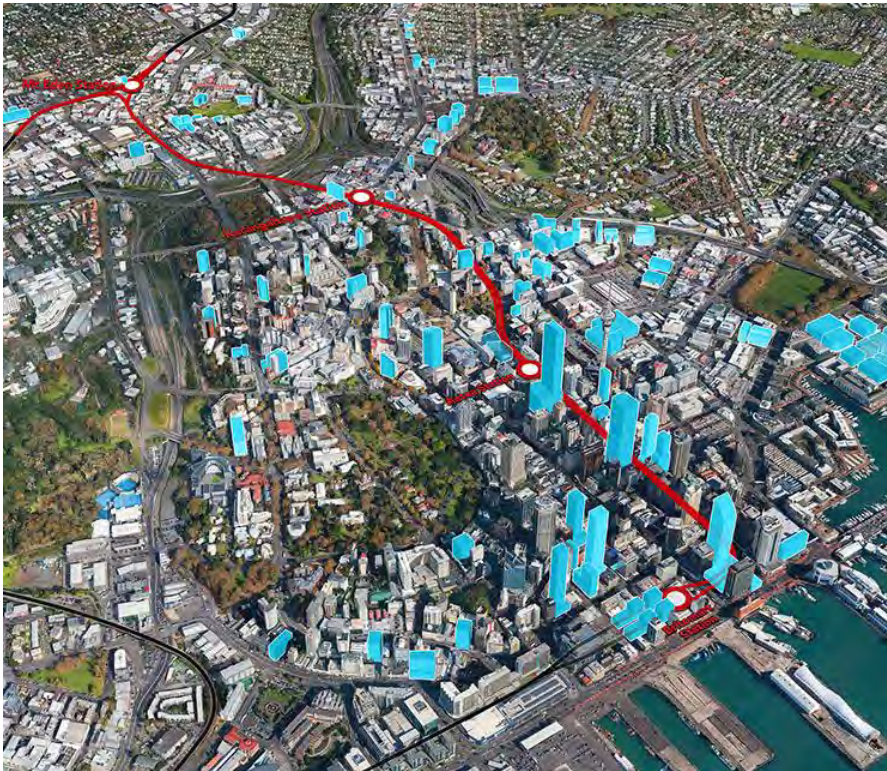
“Auckland’s New Network enables people who value frequent public transport to see where it is available, and make decisions about where they locate accordingly.”

Jarrett Walker

Source: Auckland Transport

Background: Motivation #2

Auckland's City Rail Link: Vastly increases PT accessibility in Auckland's city centre. To what end?



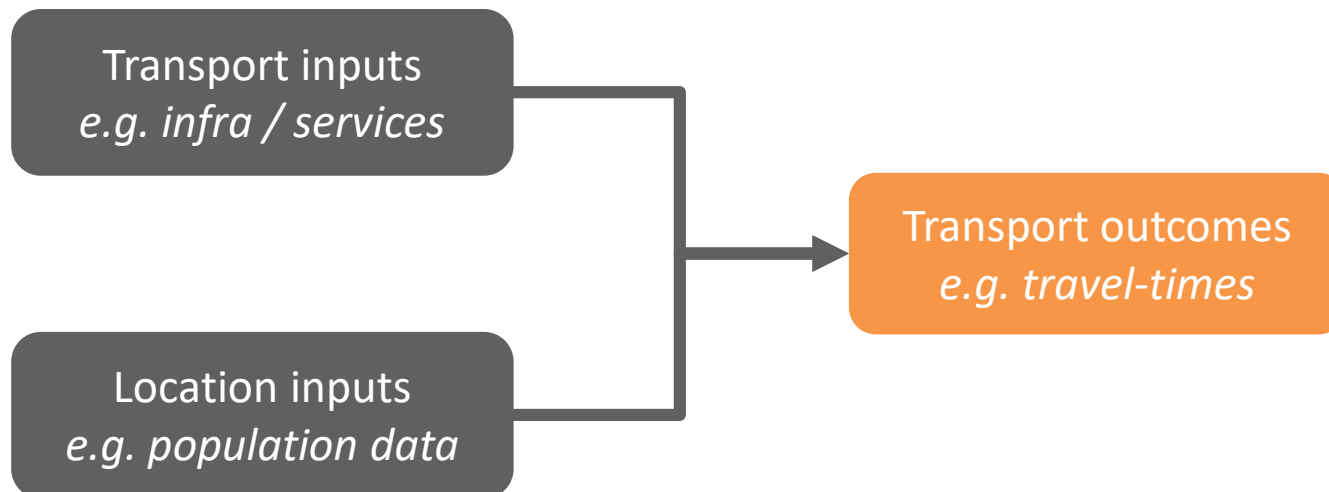
Estimates of the effects of the CRL on city centre employment varied from 50 to 10,000 extra jobs.

Differences of this magnitude have critical implications for transport business cases.

Source: Auckland Council

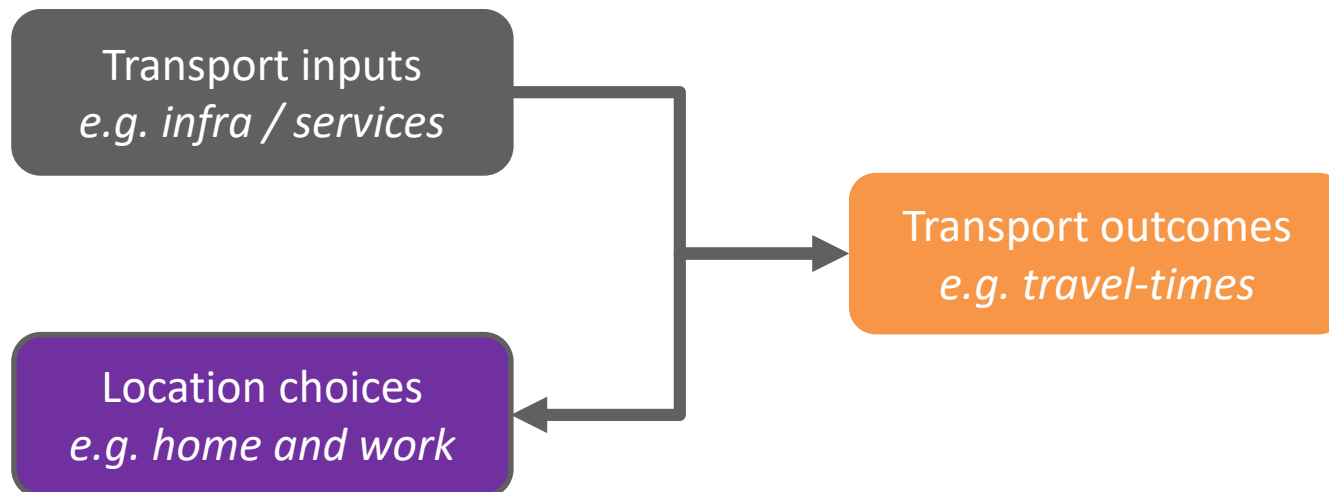
Background: Locations are Fixed?

- In most strategic transport models, people's home/work locations are treated as fixed inputs.



Background: Locations are Variable!

- **But** evidence suggests home/work locations respond to transport outcomes, that is, the two interact.



Background: Mode and Route?

Current framework: Tends to focus on (1) mode & (2) route choice.



People choose their mode and route to minimise (generalised) transport costs

In such a framework, the primary benefit of most transport policies is to **reduce transport costs**



Background: Transport costs?

But research finds transport cost reductions, e.g. travel-time savings, are not sustained.

Q. Why? Possible answers:

- Demand curve (“*induced demand*”)
- Road travel is under-priced (“*externalities*”)
- Wider economic effects (“*general equilibrium*”)
- Changes in behaviour (“*microeconomic channels*”):
 - *Travel patterns*, such as trip-chains; and
 - *Location responses*, such as “sprawl”.

Background: Hierarchy of Choices

Alternative framework: Location choices made in awareness of transport outcomes.



What is easier to change: Location or mode?

NZ / Australia have relatively high levels of residential mobility (flexible labour/housing markets).

Background: Further Reading

Economics research:

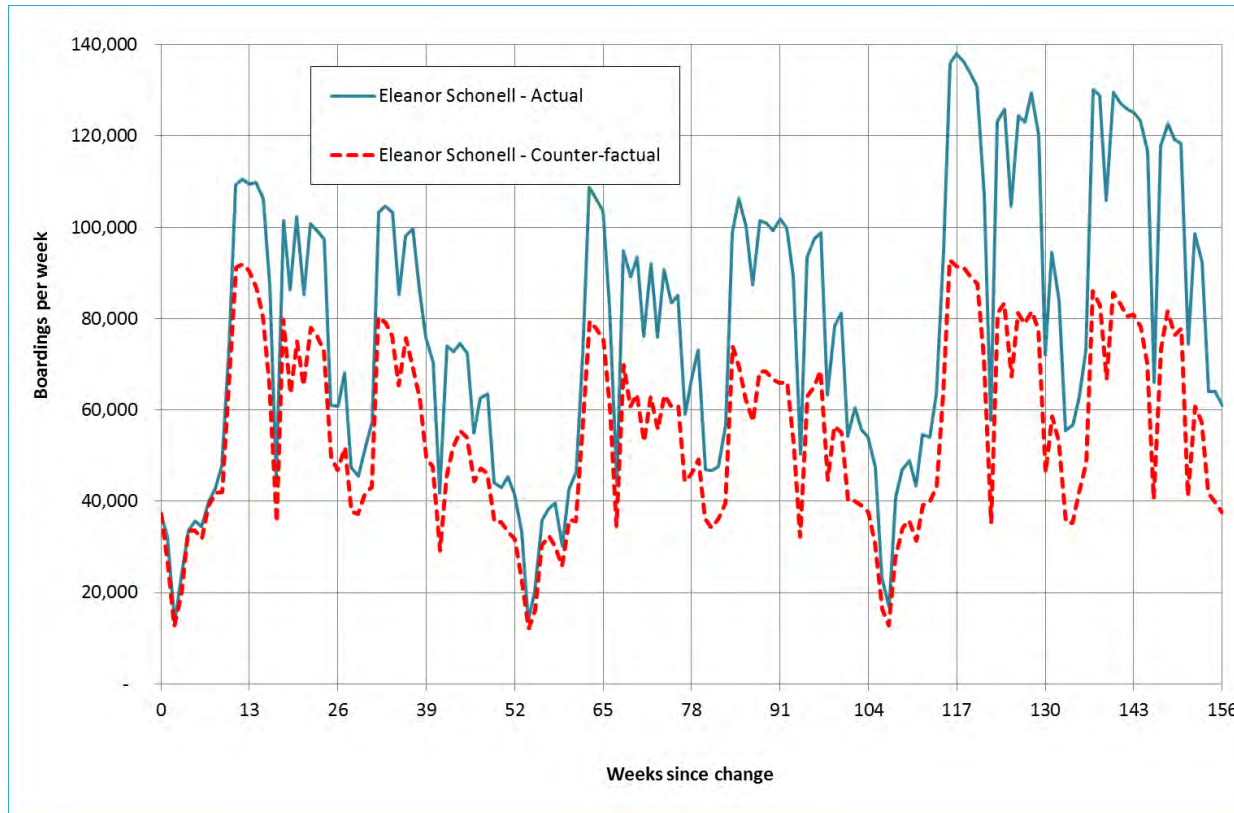
- *Baum-Snow (2007)*. Highways → suburbanization
- *Baum-Snow et al. (2012)*. Highways and railways → suburbanization in China.
- *Duranton and Turner (2011)*. Road supply → vehicle demand (“fundamental law of traffic congestion”).
- *Albouy and Lue (2015)*. Derive WTP for locations from data on rents, wages, and commuting costs.
- *Charles-Edwards et. Al (2015)*. New bridge changes locations of university staff and students.

Background: A Case Study



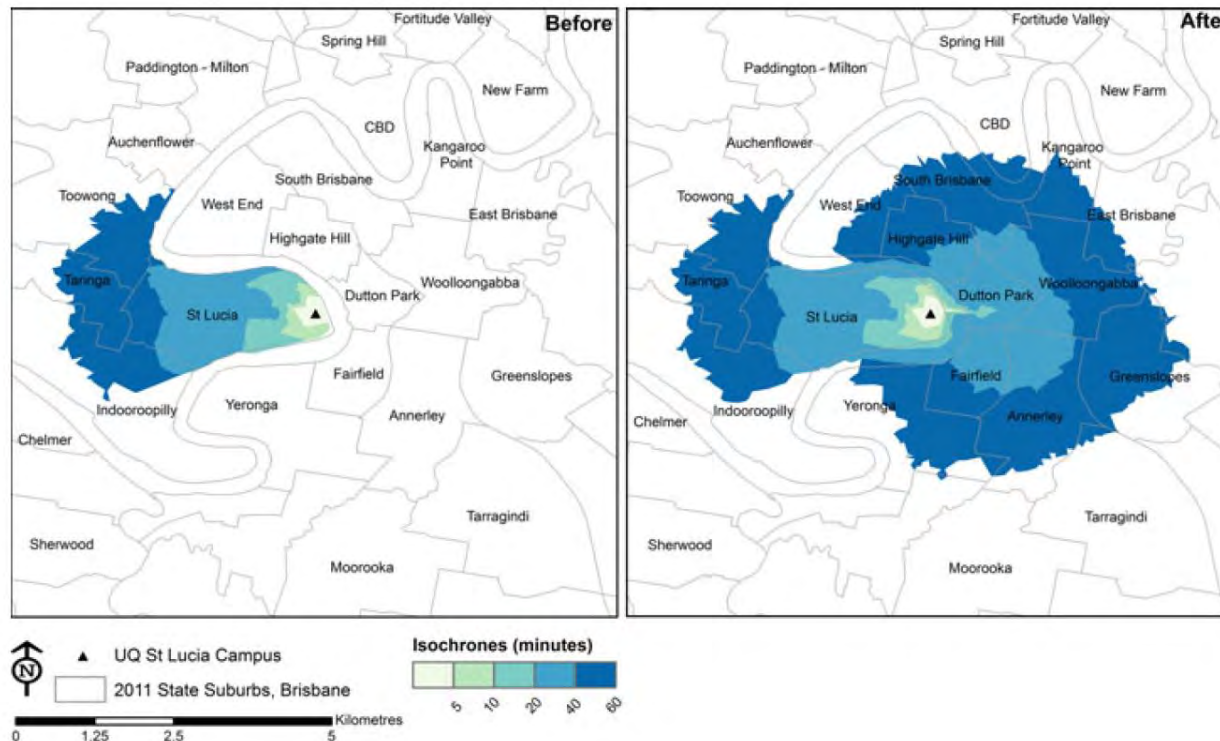
Eleanor Schonell Bridge opened in Brisbane in 2006. Cost ~\$70 million to construct. Connects South Brisbane to UQ. Accessible only by PT, walking, and cycling.

Background: A Case Study



PT: +2.3 million bus journeys p.a.

Background: A Case Study



Walk/cycle: Large increase in accessibility; +300% journeys.

Background: A Case Study

- Researchers at UQ compared the spatial distribution of the addresses for staff and students
- Find strong evidence of a shift in addresses towards areas affected by the ESB, esp. students

Background: Location vs land use?

- Location choice vis-à-vis land use:
 - Location choice relates to people, whereas
 - Land use relates to buildings.
- Transport outcomes can still affect location choice, even when land use remains constant.
- Of course, changes in location choice may catalyse a land use response, or vice versa.
- Location is linked to land use, but not equivalent.

My Research



My Research: The Context

- Focus on Brisbane. Why?
- Brisbane River carves a torturous path across the inner-city.
- Geographical barriers plus mode-specific transport infrastructure ...
- ... induces variation in travel-times between locations and modes.
- **Quasi experiment.**



My Research: Data and Identification

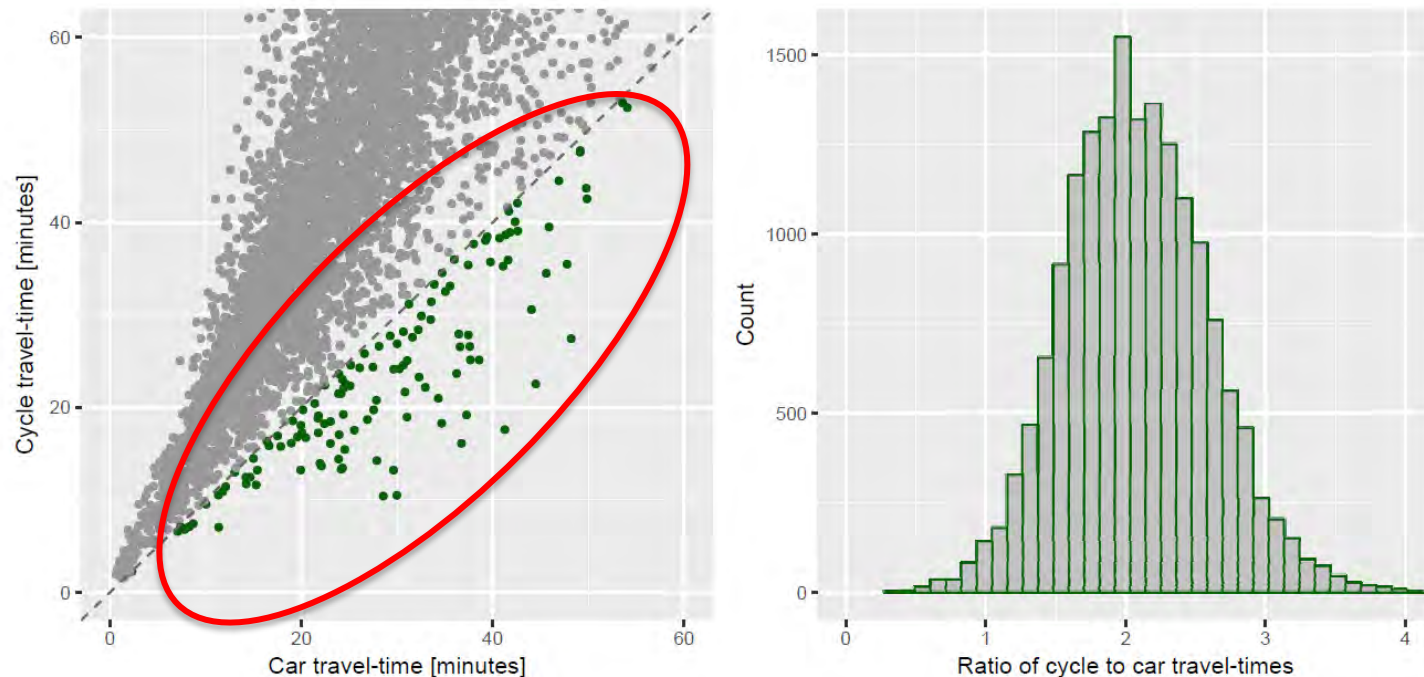


Figure 3: Left: Car versus cycle travel-time in Brisbane; right: ratio of cycle to car travel-times.

River introduces variation in travel-times between locations and modes.

My Research: Model Intuition (1 of 2)

Intuition: Commuting flows reveals information on people's preferences for home and work locations, as well as the costs of commuting between the two.

Behavioural model: People choose the home/work location that maximises their preferences. In equilibrium, people must be indifferent between alternative home/work locations.

Observation: Where people live/work can be influenced by:

- Common factors, such as prevailing prices/amenities, and
- Individual factors, such as proximity to friends/family.

My Research: Model Intuition (2 of 2)

Probabilistic model: The presence of unobserved individual (idiosyncratic) factors leads me to a model that predicts the *probability a given person lives in i and work in j .*

Deterministic ingredients:

- Home location fixed effect, δ_i (e.g. housing costs)
- Work location fixed effect, γ_j (e.g. wages)
- Transport costs between home and work, T_{ij}

Location F.E.: Capture everything good/bad about a place.

My Research: Data

- **Link commuting and transport data:**
 - *Commuting data* from the Census (home and work locations for ~300,000 people in Brisbane City)
 - *Transport data* from Google (17,000 SA2 origin-destination pairs x 3 modes).
- **Q. How to model transport costs T_{ij} ?** Sum distance and time variables for three transport modes.

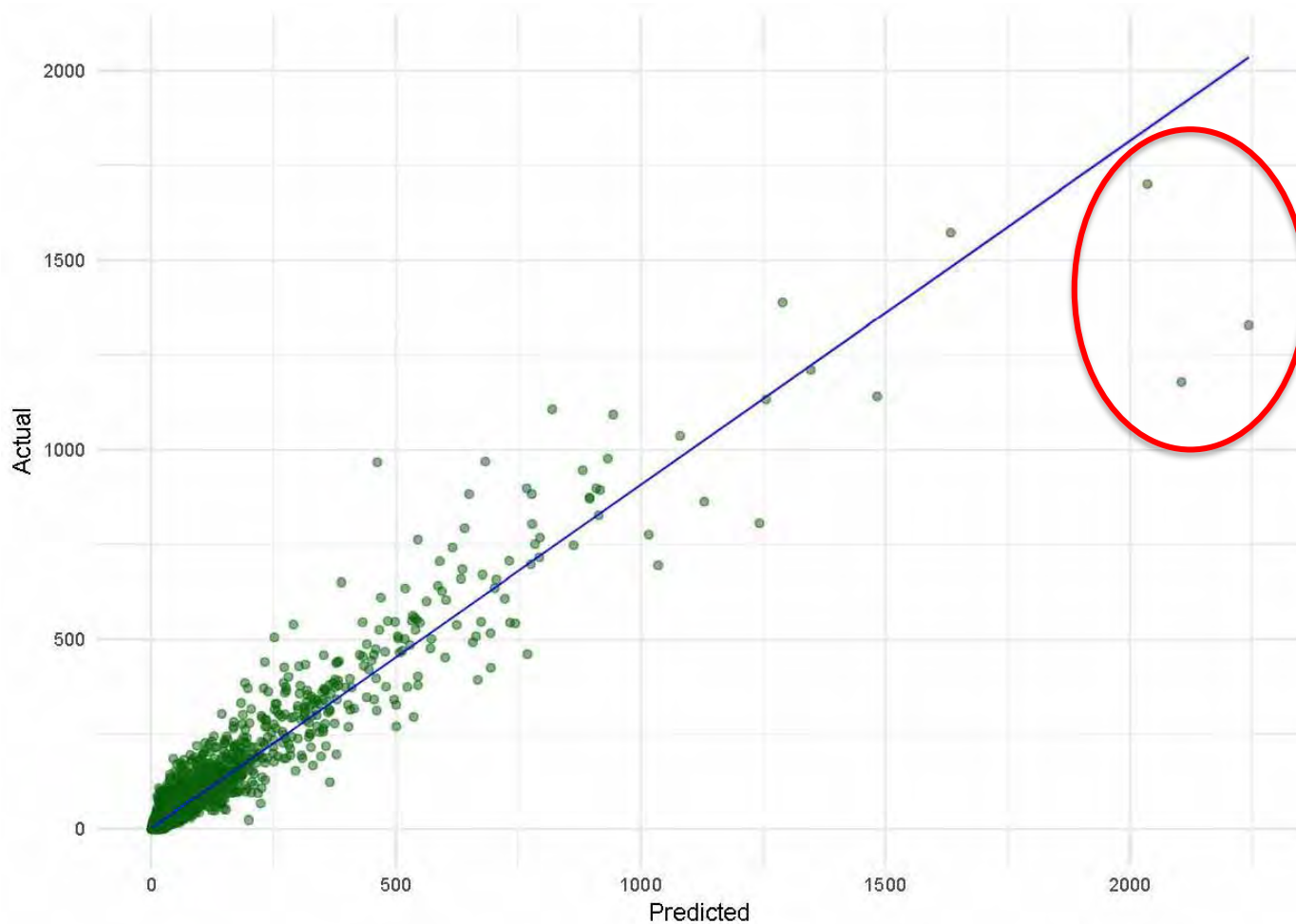
$$T_{ij} = (c_1 d_{ij}^{car} + c_2 t_{ij}^{car}) + (c_3 d_{ij}^{pt} + c_4 t_{ij}^{pt}) + c_5 \ln(t_{ij}^{cyc*})$$

c_1, c_2, c_3, c_4 , and c_5 are parameters that I estimate.

My Research: Main Findings

- **Results:** Transport outcomes have statistically and economically significant effects on commuting flows.
- **Magnitude:** A marginal (one minute) saving on:
 - Car commute → ~5% increase in commuting flows
 - Walk/cycle commute → ~5% increase in commuting flows (NB: The magnitude of this effect declines with distance)
 - Public transport → ~1% (NB: Not always statistically significant)
- **Explanatory power:** Most models have R-squared > 90%, i.e. explain most variation observed in the data.

My Research: Main Findings



My Research: Sensitivity Tests

Sensitivity tests:

- Influential observations (“outliers”, such as internal flows)
- Endogeneity (“instrumented variables / control function”)
- Zero flows (“zero-inflated models”)
- Assumptions on residuals (“IIA”)
- Extend to Perth and Adelaide

I find the effects of walk/cycle travel-time on location choice are extremely resilient to these sensitivity tests.

Next Steps: Careful Interpretation

- **Approximation of transport costs:**
 - Measure only between two points (centroids).
 - Do not explicitly model transport links/capacities.
 - Lump together effects of walk and cycle travel-time.
- **Assume elasticity holds city-wide:** I assume that the effect of transport outcomes on location choice is constant across the whole city. Realistic? Hmm ...

First to estimate what are effectively *elasticities of location choice with respect to transport outcomes?*

Next Steps: Explanation

- Q. Microeconomic channels?
- A. Mode shift explains ~50% of the response.
 - Reductions in travel-time induce people (including but not limited to commuters) to switch to walking/cycling; which
 - Frees up spare capacity in otherwise congested transport modes/networks for new commuters.
- Size of walk/cycle effect appears to increase with city-size: BNE > PTH > ADL.
- Perhaps location choice becomes more relevant as cities become larger and more congested?

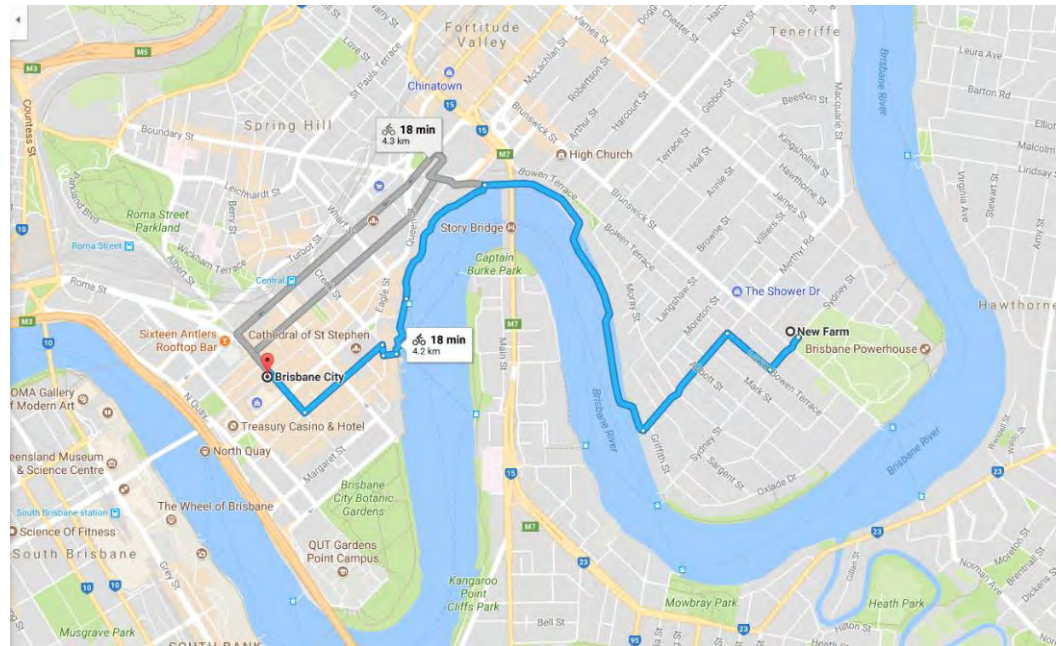
Policy Implications



Policy: Example

Saving one minute on walk/cycle journeys from New Farm to the City → +68 people choose to live and work in New Farm and the City, respectively.

One minute is not a large change: Signals?



Source: Google Maps

Policy: Transport Business Cases

- Q. What are the wider implications for business cases for major transport investments?
- A. Changes in location have implications for:
 - **Locational benefits:** providing access to locations people is an additional (potentially large) source of benefits from transport.
 - **Agglomeration benefits:** these models provide an opportunity to integrate models of location choice and transport outcomes and estimate resulting agglomeration economies.
 - **Road pricing:** Allows us to consider effects on location choice as part of scheme design.

Policy: Strategic Transport Models

- Q. How might we endogenise location choice within existing strategic transport models?
- A. One possible approach:
 1. Use (future year) pop/emp projections as a starting point;
 2. Use existing transport models to estimate future transport outcomes, such as travel-time, with / without investment;
 3. Compare transport outcomes with / without, and use elasticities of location choice to adjust pop/emp projections accordingly;
 4. Repeat from step 2 until pop/emp projections converge.

Policy: Location benefits

- Thought experiment: Imagine a totally flat city called “Dullsville” in which all locations are identical.
- What are the (ceteris paribus) benefits when people move home/work location in Dullsville? Always zero.
- The potential for transport policies to deliver location benefits reflects differences between locations.

Q. Sydney? Auckland? Wellington?

Policy: So much heterogeneity!



Source: Auckland Council

Policy: So much heterogeneity!



Source: Wellington City Council

Policy: Location Benefits

Q. How do we monetise preferences for locations?

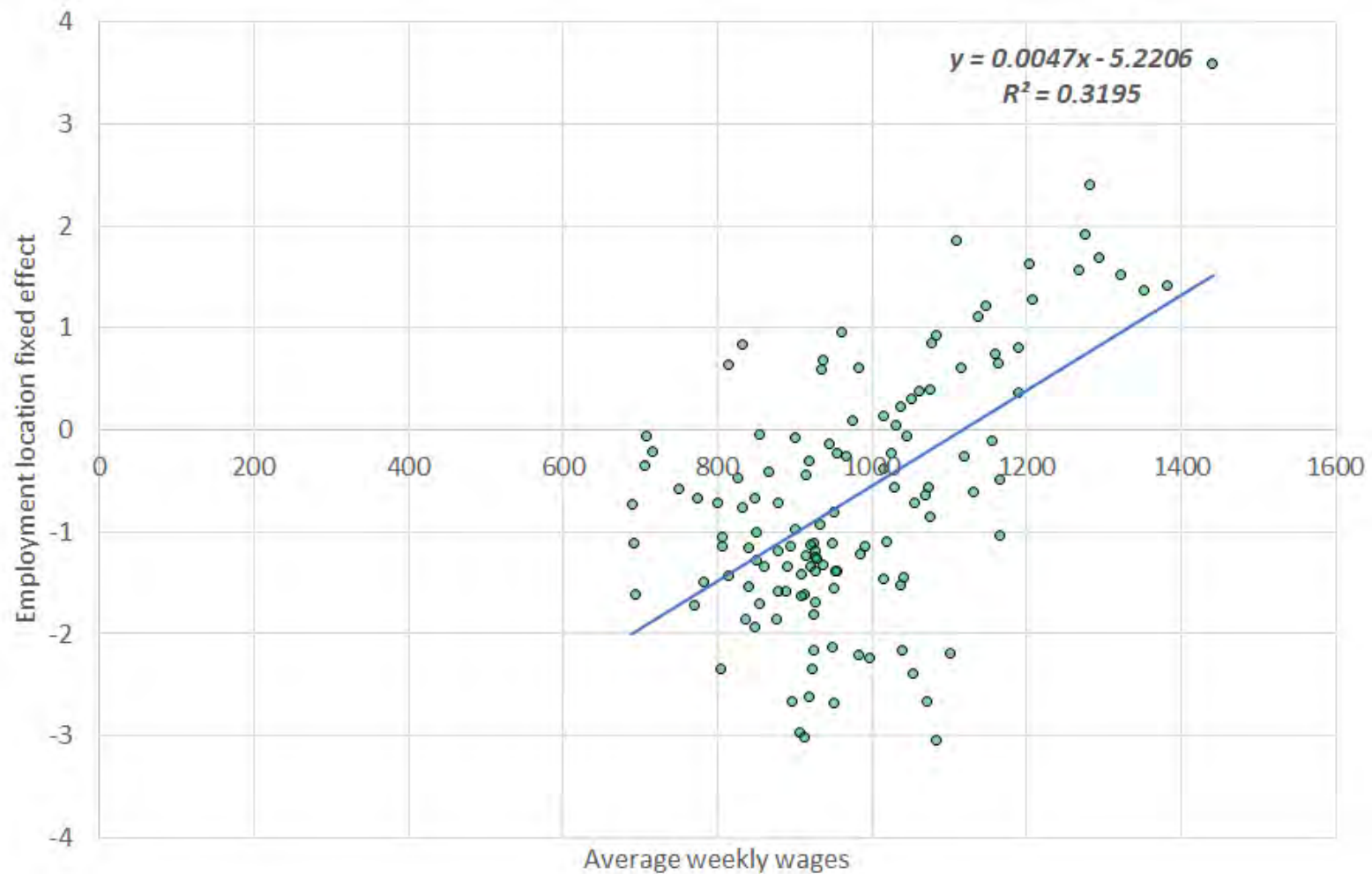
A. Relate the fixed effects to monetary indicators.

If I regress workplace F.E. versus wages, then this suggests Brisbane City Centre has a workplace premium of ~\$18k p.a. over South Brisbane (NB: Ongoing research).

Potentially large benefits from changes in work location?



Policy: Location Benefits



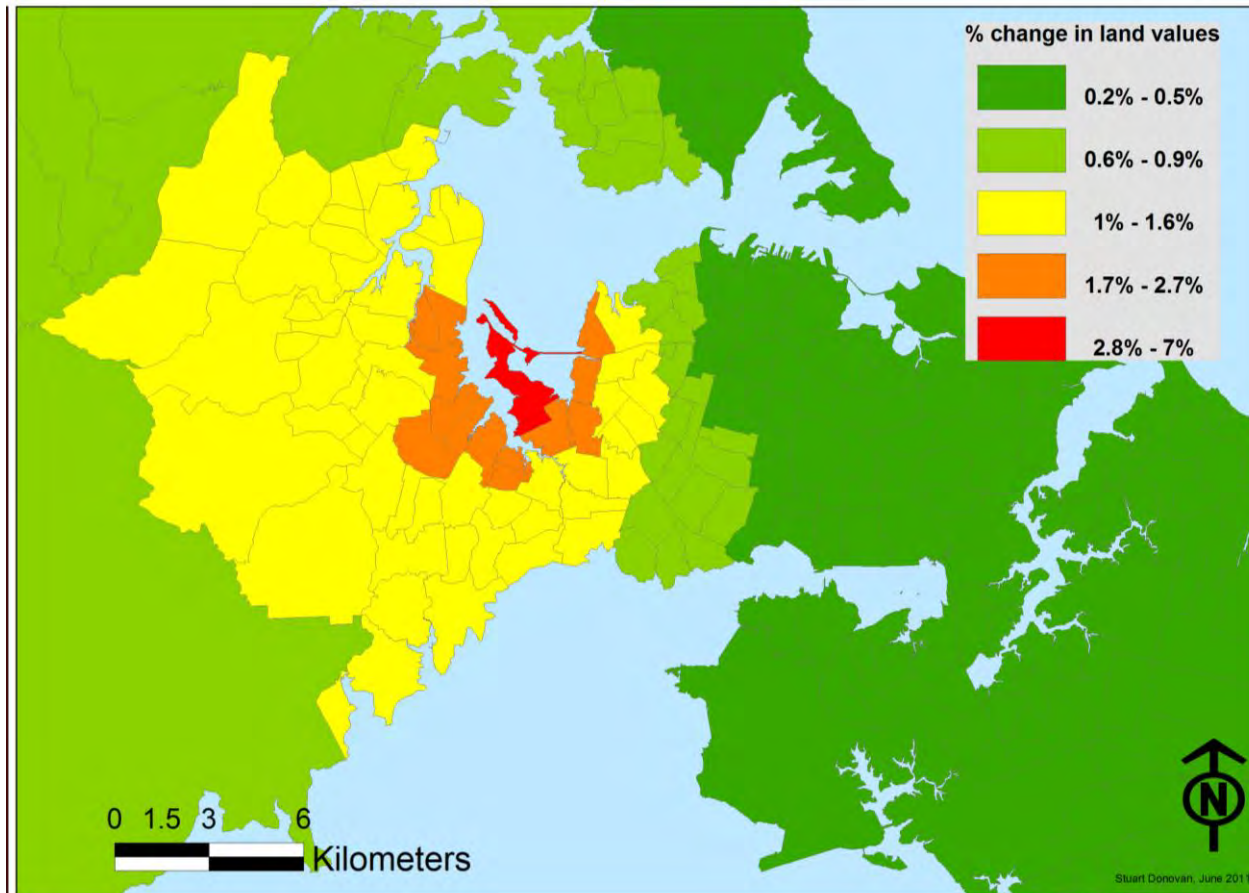
Policy: Location Benefits (Work)



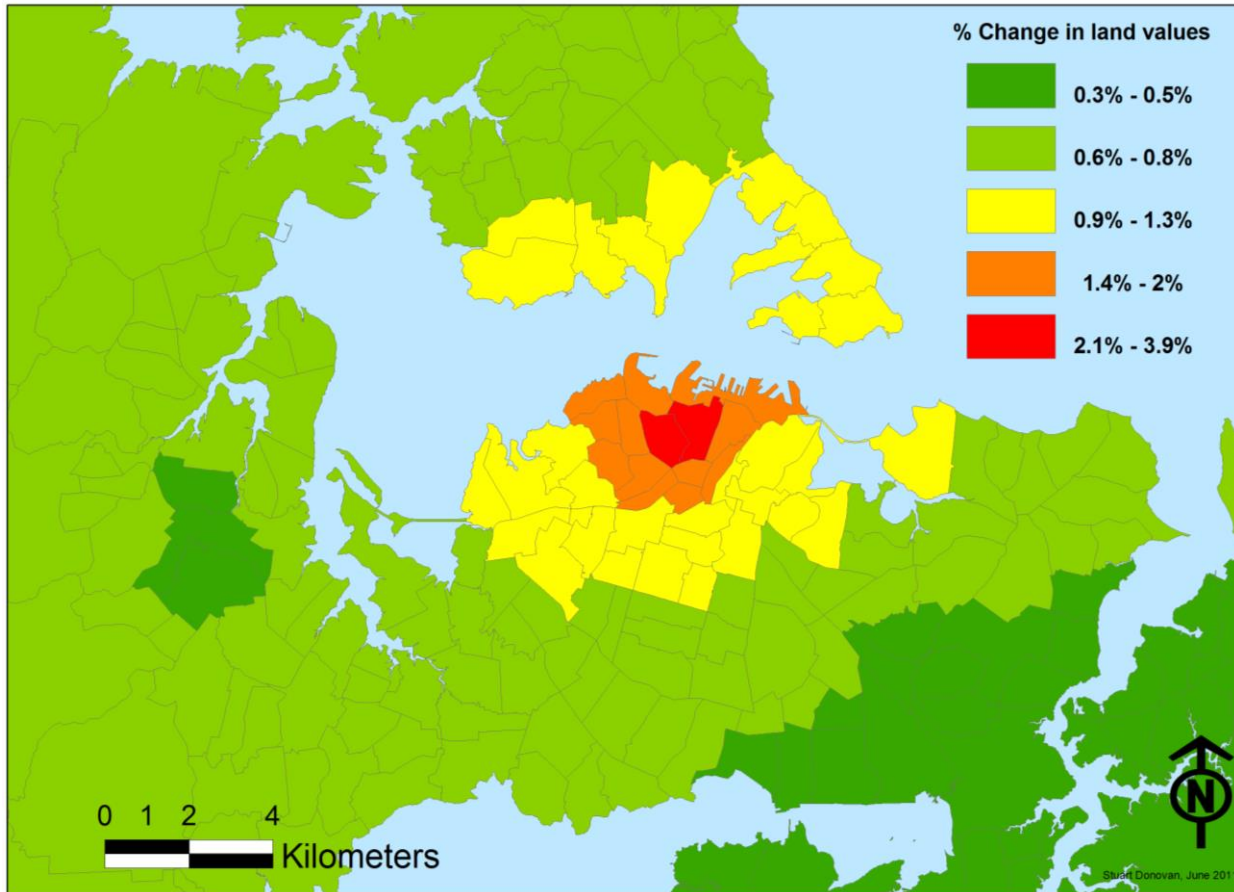
Policy: Agglomeration Economies

- Q. How do locational effects relate to agglomeration economies?
- A. Fairly intricate (but consistent?) chain of reasoning:
 1. Transport investment reduces transport costs between certain locations.
 2. Change in commuting flows → change in locations → change in agglomeration → change in wages
 3. Change in wages → change in employment F.E → change in commuting flows (higher to areas where wages increase).
 4. Iterate on steps 2 and 3 until commuting flows / wages have converged ...

Policy: Agglomeration Economies



Policy: Agglomeration Economies



Policy: Time-of-use Road Pricing

Q. Are locational choices relevant to road pricing?

A. Maybe? If I assume a \$2 toll, then this model predicts:

- VoT \$20 → 30% decrease in commuting
- VoT \$15 → 40% decrease in commuting
- VoT \$10 → 60% decrease in commuting

Effects seem plausible given (1) overseas experience of ~20% reduction in total vehicle volumes and (2) previous attempts to model of road pricing schemes in Auckland.

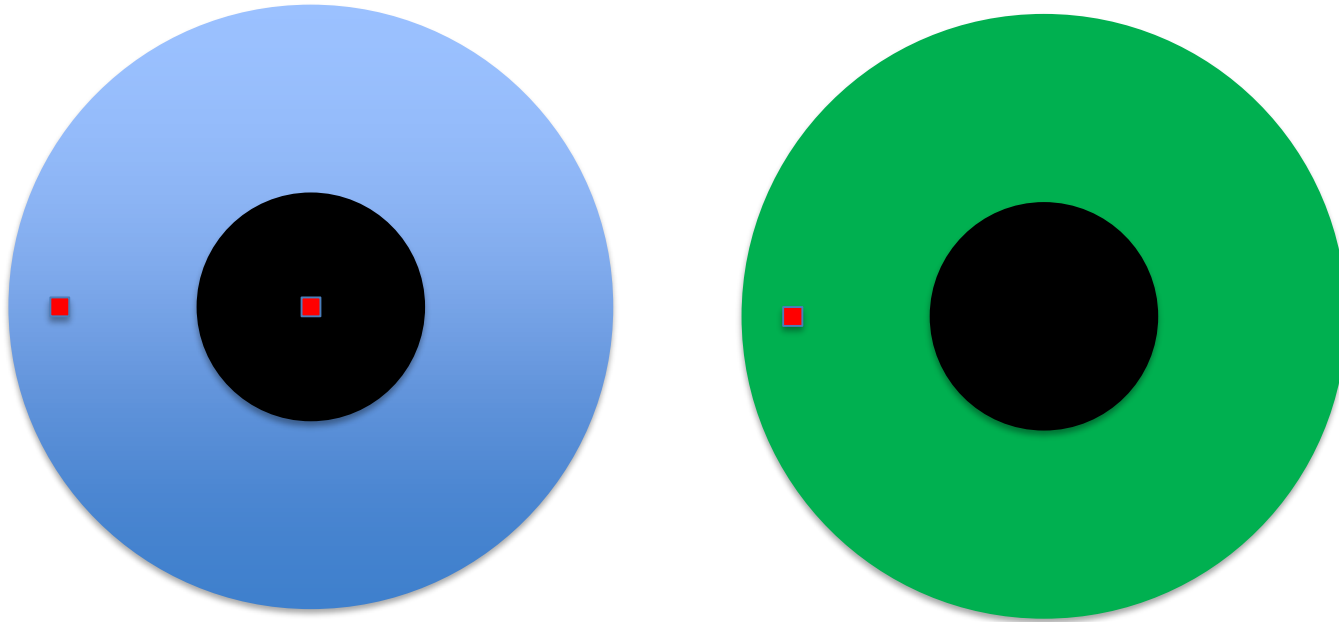
Policy: Time-of-use Road Pricing

- Overseas experience may not translate to NZ due to differences in housing/labour markets.
- These kinds of models can readily incorporate monetary costs / heterogeneous agents (useful for road pricing).
- The design of the scheme is likely to have implications for location effects, e.g. cordon vis-à-vis distance charge.
- Distance charging provides greater opportunities for people to change locations in response to road pricing.

Policy: Time-of-use Road Pricing

- Q. Why might a cordon be less “locationally efficient” than a distance-based road pricing scheme?
- A. Distance-based scheme expands the choice set of potential locations for people wanting to mitigate cost:
 - In a cordon scheme, only car commuters who enter the cordon are affected by the charge.
 - By extension, the only way for people to mitigate such a charge is to avoid entering the cordon by car.
 - In contrast, a distance-based scheme incentivizes people to reduce distances travelled by car → more alternative locations.

Policy: Time-of-use Road Pricing



Given the limited substitutability of employment locations, and wider agglomeration effects, price signals that relocate employment to the periphery may not be feasible/desirable?



Policy: Time-of-use Road Pricing

- Q. What about worker heterogeneity and road pricing?
- A. I find strong evidence the locations of low-income households are more sensitive to transport outcomes:
 - May reflect differences in housing/labour market structures
 - More likely to rent, rather than own, more likely to send children to public— rather than private— schools
 - Less security in employment? More temporary/contractor type work arrangements etc.
- Locational changes may be an area where low-income workers respond more quickly to road pricing?

Ongoing Research

- **Update data** – from 2011 to 2016
- **Extend coverage** – to more cities in Australia. Maybe New Zealand?
- **Transport cost functions** – need to test alternatives, such as generalized cost / nested logit models.
- **Travel demands** – capture transport effects on wider travel demands, e.g. via accessibility channels.
- **Panel models** – where I link Census data over-time to form a panel. Getting consistent historical data on transport costs is a challenge that I am working on.

Summing Up

- Strong economic evidence that transport outcomes affect location choice.
- I identify statistically / economically significant location responses in three Australian cities.
- Provide first (tentative) evidence that walking/cycling outcomes may also influence location choice?
- Effects of transport outcomes on location choice have major implications for transport policy, e.g. road pricing.
- **Lots of interesting directions for further research**

Thank you and Questions?

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Economic Model (1)

$$V_{ij} = \delta_i + \gamma_j - T_{ij} + \varepsilon_{ij}$$

Where:

- V_{ij} measures strength of people's preference for living and working in home i and location j .
- δ_i and γ_j denote preferences for home and work locations i and j , respectively.
- T_{ij} measures transport costs.
- ε_{ij} is individual preference component.

Economic Model (2)

Certain assumptions on the distribution of ε_{ij} leads to the (familiar?) multinomial logit (MNL) model:

$$\pi_{ij} = \frac{\exp(\delta_i + \gamma_j - T_{ij})}{\sum_i \sum_j \exp(\delta_i + \gamma_j - T_{ij})}$$

Problem! 300,000 commuters choosing from ~17,000 different (i, j) alternatives (home/work combinations) → Computer says no.

Econometric Model

Solution? In this setting the MNL is equivalent to the following Poisson model:

$$F_{ij} = \exp(\delta_i + \gamma_j - T_{ij})$$

Where F_{ij} denotes commuting flow from i to j . Poisson model is much more efficient to estimate than the MNL, and generates equivalent parameter estimates.

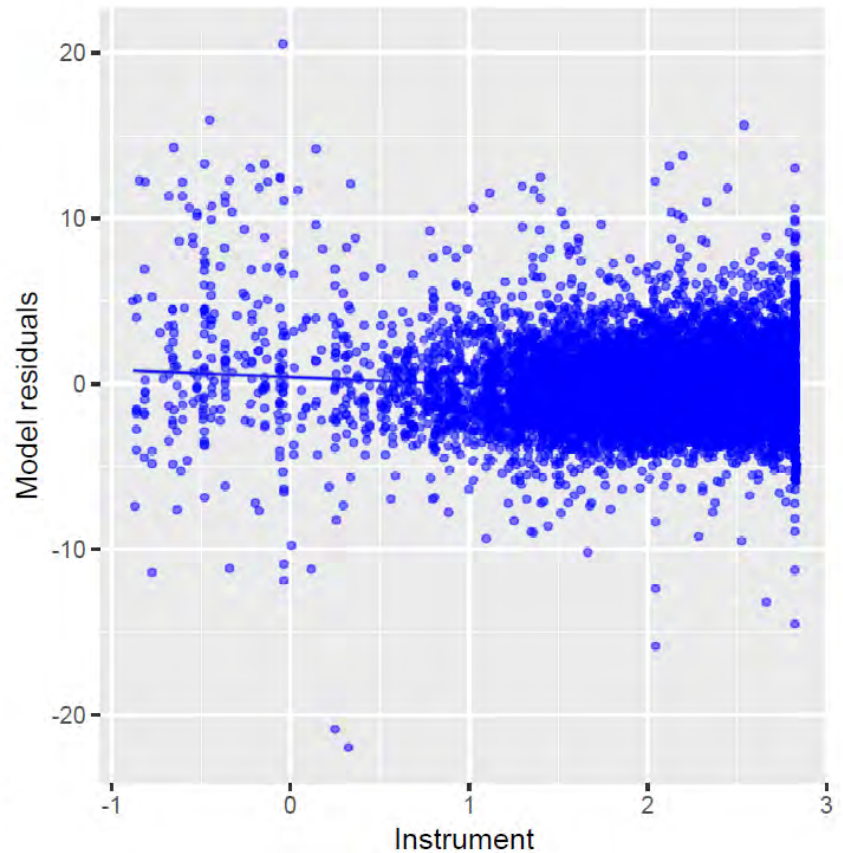
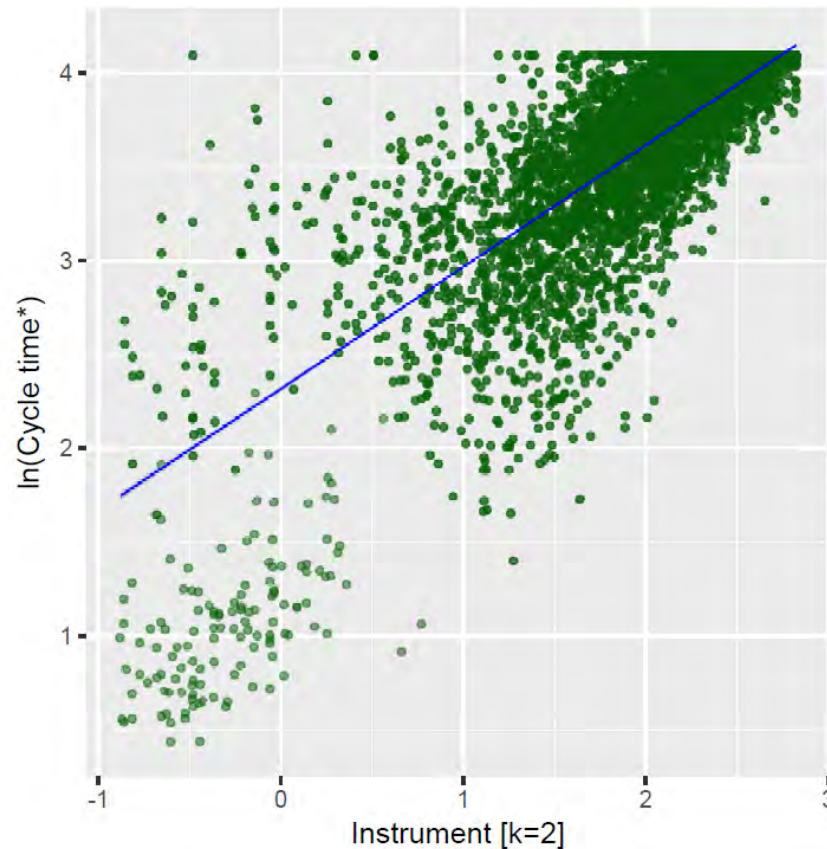
My Research: Endogeneity (1 of 4)

- “Endogeneity” = implied causation is wrong.
- Assuming causality runs from transport outcomes to commuting flows may be wrong if there exists:
 1. Omitted variables, and/or
 2. Reverse causality.
- Car travel-time is clearly endogenous:
 - Car travel-time has a causal effect on commuting flows; but
 - Car commuting flows have a causal effect on travel-time.
- Endogeneity is a common problem affecting transport research (and social sciences more generally).
- **Q. Solutions?**

Endogeneity (2 of 4)

- **Answer:** Instrumented variables.
- An instrument identifies exogenous variation in the endogenous explanatory variable.
- I instrument T_{ij} using Euclidean distance E_{pq} between two locations (p, q) proximate to (i, j)
- Identifying assumption: E_{pq} predicts T_{ij} but does not affect F_{ij} once other transport costs are controlled for.

Endogeneity (3 of 4)



Instrument needs to be relevant (lhs) and exogenous (rhs)

Endogeneity (4 of 4)

- E_{pq} is general, in the sense that it can be used in any spatial context and works for other transport modes.
- Instrument can also be applied in gravity models (which are commonly-used in transport models).

Suggestion: Next time you are presented (confronted?) with a transport model, ask whether endogeneity may be an issue and, if so, how it has been addressed, if at all.