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Model Behaviour: The Evolution of Strategic Transport Models?

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Introduction

Offices in Brisbane, Melbourne, and Sydney. Core services:

EMPLOYEES

Analytics and forecasting (~20 people)

DEN

- Economics, planning, and policy (~15 people)
- Transport futures (~10 people)



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ADVISED ON

A\$100bn+

OF TRANSPORT

INFRASTRUCTURE

PROJECTS

A LEADER AND

FOUNDED IN

1986

JALA MARCA

11155

Introduction

Transport models inform (1) high level policy / strategy and (2) project planning and business cases.

Questions:

- What sorts of behavioural responses are modelled?
- Do these responses align with key areas of policy?
- How might strategic models evolve?

NB: Our research in this area is ongoing; the views herein are presented for "discussion purposes" only.





Strategic transport models

Model inputs, e.g. household composition, land use, and VOL

Transport model:

- Trip generation
- Trip-distribution
- Mode choice
- Route choice

Transport outputs, e.g. generalized cost skims





Behavioural Responses

Conventional strategic transport models typically include three main behavioural responses, specifically:

- 1. Route choice
- 2. Transport mode choice
- 3. Destination choice (sometimes)
- **Q. What responses are missing?**





Behavioural Responses

Strategic transport models typically do not include:

- 1. Trip scheduling
- 2. Location choice
- 3. Vehicle ownership choices
- 4. Travel substitution
- 5. Supply-chains

Q. Are these important?



Travel substitution

Without online shopping



With increased online shopping











Behavioural Responses

Industry response to modelling issues takes two broad forms:

- Improve existing strategic models, or
- Develop new activity-based models (ABM).

Q. What strategy should we pursue?

Let's consider the evolution of strategic models first, focusing on *location choice* and *vehicle ownership choice*.





Location choice





Our approach

Model calibrated for all four transport modes: car, PT, walk, and cycle.

Statistically and economically significant effects for all modes.

Stable results found across models and for six Australian cities.





COMMERCIAL IN CONFIDENCE









Glenfield Primary School

Glenfield Pool and Leisure Centre

Glenfield Library

Camrose Kids

imary School

nton

Kaipatiki Creek Reserve Powrie Res

Oruamo Domain

Sydney: "Moving to accessibility"

- In Sydney, we use our location choice model to predict land use outcomes in the future (2031) base
- Allowing for location choice resulted in:
 - "Moving to accessibility", notably City Centre, Paramatta, and northern areas (with major PT improvements)
 - A ~10% increase in demand for non-car modes (PT, walk, cycle) compared to the future base without location choice

Economically meaningful effects.





Sydney: "Moving to Accessibility"





Vehicle ownership choice?





Vehicle ownership choice?

- Vehicle ownership levels (VOL) form part of demographic inputs into strategic transport models. Usually constant over time.
- Evidence suggests VOL change in response to land use (e.g. density) and transport (e.g. accessibility), e.g.
 - Academic literature, e.g. Giuliano and Dargay (2006)
 - NZTA-RR 513 (pg. 26) uses a panel regression model
 - VLC's own regression analysis in Australia ...
- Currently developing a vehicle fleet model for our strategic transport models, where VOL varies over space and time





Three main modelling components

Vehicle ownership Number of vehicle per households at SA2/SA3 level

Econometric model based on aggregate variable at SA2/3 level



Model type and detail depend on data availability

EV uptake Sales and stock by fuel type at SA2/SA3 level

Behavioural model based on TCO optimisation for different customer segments





Vehicle Ownership Levels

Vehicle ownership Number of vehicle per households at SA2/SA3 level

Econometric model based on aggregate variable at SA2/3 level



Model type and detail depend on data availability

EV uptake Sales and stock by fuel type at SA2/SA3 level

Behavioural model based on TCO optimisation for different customer segments





Mostly Simple Econometrics

.

Aggregate demographic and geographic characteristics

- Household size
- Occupation
- Income
- Density
- PT accessibility
- Centrality

Policy levers

- Parking availability and price
- Density?
- Road density?

Variable	Estimate 1-vehic l e		Estimate 2-vehicle or more	
Intercept	0.97	0.31	0.75	0.31
Income	1.31	0.37	2.52	0.36
Density	-0.03	0.02	-0.10	0.03
Job access	-3.87	0.74	-7.01	0.73

Logistic multivariate

regression

Share of households by number of cars

0.1 or more than 2



South-East Queensland

Model captures a large portion of the spatial variation in SEQ.

Discrepancies around Brisbane City Centre. Possible improvements:

- Demographics
- Accessibility, e.g. schools



Cumulated prediction error



From ownership to sales ...

Vehicle ownership Number of vehicle per households at SA2/SA3 level

Econometric model based on aggregate variable at SA2/3 level



Model type and detail depend on data availability

EV uptake Sales and stock by fuel type at SA2/SA3 level

Behavioural model based on TCO optimisation for different customer segments





Vehicle type model

Again explain spatial variability, with the exception of the Brisbane CBD.

NB: Cars registered to addresses in the CBD do not always live there (company cars, car rentals...)

Luxury cars and UTE respond very well to the model but wagons are hard to predict (need for more categories or explanatory variables).



Hatchback as reference	Luxury	Sedan	Wagon	UTE
Intercept	-2.1	0.58	0.37	0.55
	0.06	0.03	0.03	0.03
Income	0.31	-0.67	-0.05	-0.53
	0.05	0.02	0.02	0.03
Job access	-0.99	-0.33	-0.98	-2.28
	0.11	0.05	0.05	0.06
Dummy for low density	-0.30	0.03	-0.06	-0.21
	0.04	0.02	0.02	0.02



Q. EV uptake? A. Segmented model!

Customer segmentation

Households have different mobility needs and value cost components differently

We will build a number of customer segments based on:

- Type of vehicle
- Number of vehicles in the household owning this vehicle
- Mileage (daily and annual)
- Geography

Behaviour based on Total Cost of Ownership

Car buyers evaluate the total cost of ownership of different fuel options to make their decisions

For each customer segment and fuel type (if available), we will evaluate the TCO:

TCO = Purchase cost – Residual value $+\sum$ usage costs





TCOs drives arbitrage

Powertrain arbitration

The arbitration function is a logistic curve comparing the TCOs of the different fuel options

 $MS_i = f(TCO_i, TCO_k)$



Due to change inertia, the share of EV is less than 50% at break-even point. This is reflected in a coefficient of the logistics curve.







- Averages often not enough to infer vehicle purchasing decisions.
- Customer segments take the distribution of travel (annual and daily) into account.
- Strategic model gives access to the geographical distribution of daily

47500

50000



Activity based models



Premise: Current trip / tour based models (like ours) cannot cope with complex and rapidly changing relationships between activities, travel demands, and technology





Activity Based Models

- Simulate individuals and their households
- Explicitly acknowledges:
 - Transport is a derived demand associated with activities
 - Undertaking activities has benefits and costs to individuals
 - Individuals face inter-related scheduling constraints
 - Households make inter-related decisions
- Greater demographic and socio-economic segmentation
 → more closely approximates individual travel decisions
- More temporal and spatial resolution than existing models





Behavioural responses

Response Type	Activity	Tour	Trip
Reduce or increase number of trips e.g. increased working from home	✓	×	×
Start work earlier or latere.gleave later to avoid charges	g. 🗸	×	×
Change trip sequence e.g. go to gym before work instead of after	✓	√	×
Trip frequency e.g. small daily shop instead weekly	of 🗸	×	×
Household interactionse.g. escort trips for children/ elderly	✓	\checkmark	×
Public transport/ vehicle fleet requirements e.g. fleet size for DRT/ MaaS applications	s √	\checkmark	\checkmark





Example: Road user charging



Activity based models used extensively







What can be analysed with ABMs?

- All the things currently with a trip/tour-based model
 - Road and PT project assessment
 - Impacts of congestion/crowding
 - Deficiency assessment
 - Fixed / distance based tolling
 PLUS
 - PLUS
- Autonomous vehicles
 - Shared mobility
- Travel demand management
 - Dynamic pricing strategies
 - Transit pricing
 - Telecommuting
- Supply chain analysis
 - Last mile





Issues identified

- 1. Cost and timeframe
- 2. Risk
 - "Big bang" could be just that!
 - Client and reviewer acceptance
- 3. Two sources of truth
 - "Horses for courses" but inevitably people will want to compare model results and assumptions
- 4. Model calibration and validation
 - Data availability need an expanded HTS, not a stripped back one
- 5. Model convergence and uniqueness
 - A major issue for cost benefit analysis
- 6. Complexity
 - User skills
 - Runtimes





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- Typically link to strategic models; sacrifice some aspects to gain details that are most relevant to PT:
 - Detailed "zones" (individual stops) and pedestrian / cycle access network
 - Actual PT demands (from smartcard data) and PT schedules (from GTFS data)
 - Small time-steps (e.g. half hourly)



