Sydney Strategic Travel Model

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Background

- STM originally developed in 1971
- Key output - determine infrastructure requirements
- Updated with more recent data
- Structure of model essentially unaltered until development program commenced
- Need to make enhancements
Redesigning the Model

• Undertaken by HCG/ITS consortium

• Design process
  • Review of model
  • Review of data
  • Review of current world practice
  • Stakeholder consultation
  • Model design
  • Implementation plan

• Staged implementation
Model Area
Model Geographic Scope

- Sydney Statistical Division
- 2001 population over 4,100,000
- Area of 12,100 sq kms (4,700 sq miles)
- Population growth over 1% per annum
Data for Model Estimation

- TDC face to face travel surveys
- Used 1991 and 1997 data for main models
- About 7,000 trip records for commuting
- Also Census of Housing and Population data
Census JTW Data

- 5 yearly complete enumeration
- Commuting modes used on census day
- Destination coded to zonal level
- Data available in cross-tabulations (not unit record)
- Some randomisation for confidentiality
- Source of data for base matrices for commuting
Stage 1 Estimation

- Mode/destination choice model - commuting
- Travel frequency model - commuting
- Licence holding model
- Car ownership models
- Other purposes estimated in Stage 2
Stage 2 Estimation

- Home based business
- Home based primary education
- Home based secondary education
- Home based tertiary education
- Home based shopping
- Home based other
- Work based business
- Business detours part of home based work
Mode Destination Choice (1)

- Seven alternatives
  - Car driver
  - Car passenger
  - Rail (possibly with bus access)
  - Bus only
  - Bicycle
  - Walk
  - Taxi

- Based on tours (round trip)
- Consistent with census JTW data
Model Structure

Individual (i)

- d1
- d2
- d3
- d(j)

- m1
- m2
- m3
- m(k)
Mode Destination Choice (2)

- Data used from both 1991 and 1997 surveys
- Different zoning systems
- Different network skims, costs, etc
- Sampling strategy during model estimation
- Scaling factor for different survey year data
- Final tree structure varies by purpose
Car Ownership / Availability

- 8 car ownership / availability segments (commuting)
  - No cars in household
  - No licence - household car
  - Competition for cars; 0, 1+ company cars
  - Free car use, one licence in hhld; 0, 1+ company cars
  - Free car use, several licences; 0, 1+ company cars

- Applied in different ways for car driver and car passenger

- Segments vary according to model purpose
Other Variables in Work Model

- Employment type
  - Manufacturing / other industry
  - Full time / part time employment
- Income categories (4)
- Age under 25
- Male travellers (car driver and bicycle)
- Reduced to 128 segments in implementation
Licence Holding Model

- Included because
  - Better model of mode choice
  - Part of increase in car ownership is from increase in licence holding

- Cohort approach
- Women’s holding is “catching up” with men
- Complicated by immigration
Car Ownership Models

- Two linked models
- Company cars in household
- Total household car ownership
- Include an accessibility term
Travel Frequency Models

- Two models
- 1st whether any tours are made
- 2nd extent of repeat tours
- Accessibility from mode /destination choice
- Applied across a number of employment categories (6) for work model
Stage 1 Model Validation

- Examination of validation tables (observed and predicted)
- Results compared with census JTW
- Running model system and extracting elasticities
Work Tour Length

Tour Distance (km)

- Observed
- Predicted
## Car ownership elasticities household income

<table>
<thead>
<tr>
<th>Workers</th>
<th>Base Model Company</th>
<th>Base Model HHold</th>
<th>Elasticity Company</th>
<th>Elasticity HHold</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0.76</td>
<td>n/a</td>
<td>0.22</td>
</tr>
<tr>
<td>1</td>
<td>0.18</td>
<td>1.31</td>
<td>0.73</td>
<td>0.16</td>
</tr>
<tr>
<td>2</td>
<td>0.33</td>
<td>1.80</td>
<td>0.68</td>
<td>0.13</td>
</tr>
<tr>
<td>3</td>
<td>0.38</td>
<td>2.54</td>
<td>0.69</td>
<td>0.11</td>
</tr>
<tr>
<td>4</td>
<td>0.45</td>
<td>2.98</td>
<td>0.70</td>
<td>0.05</td>
</tr>
<tr>
<td>Total</td>
<td>0.19</td>
<td>1.40</td>
<td>0.70</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Mean Cars per Household by Household Income

Household Income (1996 prices)

Mean Cars per Household

Household Income

<= $10,400
$15,600
$20,800
$26,000
$31,200
$36,400
$41,600
$52,000
$78,000
>= $78,000

cars/household

0
0.5
1
1.5
2
2.5
# Work Tour Elasticities

<table>
<thead>
<tr>
<th></th>
<th>Car cost</th>
<th>Car time</th>
<th>PT cost</th>
<th>PT time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car driver</td>
<td>-0.11</td>
<td>-0.23</td>
<td>+0.07</td>
<td>+0.14</td>
</tr>
<tr>
<td>Passenger/Taxi</td>
<td>+0.24</td>
<td>-0.36</td>
<td>+0.18</td>
<td>+0.28</td>
</tr>
<tr>
<td>Train etc</td>
<td>+0.24</td>
<td>+0.74</td>
<td>-0.32</td>
<td>-0.59</td>
</tr>
<tr>
<td>Bus</td>
<td>+0.18</td>
<td>+0.61</td>
<td>-0.35</td>
<td>-0.60</td>
</tr>
<tr>
<td>Non-motorised</td>
<td>+0.19</td>
<td>+0.59</td>
<td>+0.20</td>
<td>+0.27</td>
</tr>
</tbody>
</table>
## Work Kilometrage Elasticities

<table>
<thead>
<tr>
<th></th>
<th>Car cost</th>
<th>Car time</th>
<th>PT cost</th>
<th>PT time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car driver</td>
<td>-0.12</td>
<td>-0.93</td>
<td>+0.06</td>
<td>+0.14</td>
</tr>
<tr>
<td>Passenger/Taxi</td>
<td>+0.25</td>
<td>-0.85</td>
<td>+0.18</td>
<td>+0.28</td>
</tr>
<tr>
<td>Train etc</td>
<td>+0.21</td>
<td>+0.86</td>
<td>-0.33</td>
<td>-0.84</td>
</tr>
<tr>
<td>Bus</td>
<td>+0.21</td>
<td>+0.73</td>
<td>-0.36</td>
<td>-0.99</td>
</tr>
<tr>
<td>Non-motrised</td>
<td>+0.19</td>
<td>+0.58</td>
<td>+0.22</td>
<td>+0.29</td>
</tr>
</tbody>
</table>
Prototypical Sampling

- Objective: provide description of population
- Balance between detailed base year and future year sketch of characteristics
- Minimise differences using weighted sums of squares (quadratic function)
- Base year data from travel survey
Work Prototypical Targets

- Population age sex cohorts (4 by 2)
- Households (5)
- Workforce industry (2)
- Income (implementing as part of Stage 2)
Model Implementation

- Two separate components
  - Population model
  - Travel demand model
- Networks coded in Emme/2
- Population model not well suited to matrix operations
Population Model

Base sample \rightarrow PROTOSAM \rightarrow Licence/Car Models \rightarrow Zonal segments

Cohorts

Targets
Population Model

- Not influenced by networks
- Run infrequently
- Car ownership / licence initially region level
- Then allocated to travel zone
- Converted to Emme/2 matrices
Travel Demand Model

Networks

Accessibility

Car availability adjustments

Frequency

Mode-destination

JTW matrix

TOD/Factoring

Assignment

Zonal segments
Travel Demand Model

- Implemented inside Emme/2
- Accessibility for each car availability segment
- Car availability adjustment
- Demand models
- Expansion factoring and pivotting
Future Improvements

- Explicit modelling of other purposes - Stage 2
- Explicit modelling of car access to rail
- Construct better base year matrices
- Modelling of intermediate destinations
- Model allocation of tours to time periods rather than simple factoring
## Segmentation

<table>
<thead>
<tr>
<th>Mode</th>
<th>Destination</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>seg 1</td>
<td>freq 1</td>
<td></td>
</tr>
<tr>
<td>seg 2</td>
<td>freq 2</td>
<td></td>
</tr>
<tr>
<td>seg 3</td>
<td>freq 3</td>
<td></td>
</tr>
<tr>
<td>seg 4</td>
<td>.....</td>
<td></td>
</tr>
<tr>
<td>seg 5</td>
<td>freq F</td>
<td></td>
</tr>
<tr>
<td>seg 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.....</td>
<td></td>
<td></td>
</tr>
<tr>
<td>seg MD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Model Segments

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Mode - Destination</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>128</td>
<td>3 or 15</td>
</tr>
<tr>
<td>Business</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Primary</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Secondary</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Tertiary</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Shopping</td>
<td>36</td>
<td>27</td>
</tr>
<tr>
<td>Other</td>
<td>60</td>
<td>48</td>
</tr>
</tbody>
</table>
Protoypical Sample Matrices

- Values for each mode-destination and frequency segment for each origin zone
- Defined for 16 extended vehicle availability segments
- People (weights) can change between car availability categories depending on changes in accessibility (logsums)
- Data is created with separate suite of programs
- Need to be converted for input into Emme/2
Other Purpose Segments

- **5** Car availability by **2** Personal income by **6** Age / Fare = **60** Mode - Destination (MD) segments
- **3** Household income by **4** Number of Children by **4** Adult Status = **48** Frequency segments
- Enters Emme/2 with **16** extended car availability segments which is adjusted and collapsed to **5** car availability segments
- **2 * 6 * 16 * 48 = 9216** input weights for each origin zone for this model purpose
Vehicle Availability Adjustment

Input

Freq 1  
veh 1 .. 16

Freq 2  
veh 1 .. 16

Freq 3  
veh 1 .. 16

Adjusted

Freq 1  
veh 1 .. 5

Freq 2  
veh 1 .. 5

Freq 3  
veh 1 .. 5
Preparation of Other Matrices

- Separate file for each of the 12 income by age MD segments (all vehicle availability categories)
- File contains 768 matrices (12 * 768 = 9216)
- Data transformation implemented using SPSS
- File contains header comment records
  - c Data location ...
  - c Date created ...
- Precautionary deletion of matrices
  - d matrix=md101
  - a matrix=md101 name ....
Conversion of Other Matrices

- 768 input matrices (16 * 48)
- Adjusted for vehicle availability from 16 categories to 5
- Resultant 5 * 48 = 240 final weight matrices
- Also some intermediate calculation matrices
- Need to use both mo and md matrices to stay within 999 matrix limit
- Fewer matrices for other model purposes
Programming Style

- Use of matrix names not numbers for calculations
  \[ mf"vtn" + ms"tn\_ms" + md"vcommd" \]
- “Track” matrix usage via spreadsheet
- Single call to 3.21 within each macro
  
  ```
  3.21
  calculation 1
  calculation 2
  calculation 3
  q    / quit 3.21
  ```
Auditing of Calculations

• Results of all matrix calculations written to report files (correspond to macro names)
• Report files are deleted at start of macro

```plaintext
~#
~t2=%t1%cost_calcs.rep
~!if exist %t2% del %t2%
reports=%t2%
~#
```
Fast Macro

- Wrapper macro to speed up operation of Emme/2
- No need to include within each macro
- Can bypass this macro if errors and debugging
- Also include a count of errors
  - 016
  - 32768
  - 39
  - #
  - <\%t0\%
Other Tips

- Set bank to contain 999 ms matrices
- Separate macro file with transit skim factors
- Separate bank for each model run
- Can read in zonal population adjustment factors
- Caution using cumulative md matrices from mf matrices
- Fare calculations need a single path to simplify calculations
Use of Registers

- Registers used to control looping

```plaintext
~+;~x=1;~y=1;~z=1;~r1=0
~:demand_loop
~r1+1
~/ Work demand  x=%x%  y=%y%  z=%z%  mdseg=%r1%
~x+1
~?x=9
~+;~x=1;~y+1
~?y=5
~+;~y=1;~z+1
~+;~?r1<128;~$demand_loop
```
Some Problems With Registers

• Some calculations are difficult with registers
  - `a_out = recode(a, 1,2,3,3,3,4,4,4)`
  - `out_seg = 16 * (z-1) + 4 * (y-1) + a_out`

```c
~# ~+; r11=%z%; ~r11-1; ~r11*16
~+; ~r12=%y%; ~r12-1; ~r12*4
~r11+%r12%
~#
~+; ~?x=1; ~r11+1
~+; ~?x=2; ~r11+2 and etc for 8 %x% segments
```