Estimating dynamic workplace capacities using public transport smart card data and a household travel Survey

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Motivation and requirements

Problem
- Activity based transport simulation requires detailed data on activity locations
- Detailed data on e.g. work locations is often not available and hard to obtain
- Traditional surveys are expensive and tedious

Solution
Modeling of work location based on merge of number of data sources:
- Record of public transport journeys
- Travel diary
- Land-use information

Challenges
- How to identify working activities between public transport journeys?
- How to assign number of work places to each building?
HITS Singapore

One day travel diary for ~ 1% of Singapore's population

~10’500 Households (~ 38’000 people)
~ 40’000 activities (incl. home)
~15’500 PT consistent activities
~ 7600 home
~ 6100 work
~ 1800 other
Work trips detection (previous work)

<table>
<thead>
<tr>
<th>Model</th>
<th>Parameters</th>
<th>Choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rule based model (work, non-work)</td>
<td>• Activity duration</td>
<td>• Work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Other</td>
</tr>
</tbody>
</table>
| 2. Discrete choice MNL model (home, work, other) | • Activity duration  
• Activity start time  
• Land-use information | • Work           |
|                                            |                                        | • Home           |
|                                            |                                        | • Other          |

Results

<table>
<thead>
<tr>
<th>Probability for correct choice</th>
<th>Rule-based model</th>
<th>Model with land-use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.867</td>
<td>0.893</td>
</tr>
<tr>
<td>Test sample</td>
<td>100%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Distribution problem

Number of **detected work trips** that finish at each stop of Singapore
Distribution problem

The time when the work activity starts and the duration

- 8:01-17:32
- 9:44-18:15
- 7:54-16:03
...

Many work schedules!

Idea:
Define categories
Work schedule information

Duration (h)

Start time (h)
Distribution problem

Count how many people at each category

- 8:00-17:30: 50
- 9:00-18:00: 75
- 18:00-03:00: 2
...

Just a few number of work schedules
Distribution problem

Which buildings or parcels do the people who alight at a certain stop go to?
Last mile travel times
Maximum capacities

Each building has a size. Then there is a maximum number of workers that fit in the building.

<table>
<thead>
<tr>
<th>Type</th>
<th>Work space (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>1.00E+05</td>
</tr>
<tr>
<td>Commer. &amp; resident.</td>
<td>250</td>
</tr>
<tr>
<td>Commercial</td>
<td>18</td>
</tr>
<tr>
<td>Hotel</td>
<td>500</td>
</tr>
<tr>
<td>Utility</td>
<td>60</td>
</tr>
<tr>
<td>Business Park</td>
<td>10</td>
</tr>
<tr>
<td>Business 1</td>
<td>12</td>
</tr>
</tbody>
</table>
Distribution problem

How many people go to each building at each work schedule?

Stop
\[ \sum q = 200 \]

Parcel
\[ \sum x \leq 75 \]
Distribution to land use parcels.

Minimize last-mile travel time

$$\min \sum_{s \in S} \sum_{p \in P} \sum_{w \in W} x_{spw} t_{sp} \quad 0 \leq x_{spw}$$

People at each bus stops and at each work schedule can not disappear

$$\sum_{p \in P} x_{spw} = q_{sw} \quad s \in S, \ w \in W$$

People in a parcel can’t exceed the maximum

$$\sum_{s \in S} \sum_{w \in W} x_{spw} \leq m_p \quad p \in P$$
What about car commuters?

Two necessary procedures

- Deflation of the maximum number of workers
- Inflation of the resulting quantities

Idea:
Use travel diary survey (HITS) for observed mode shares for work trips
Mode share zones (162 zones)
Mode share inflation (proportional)

Quantities of different zones must be inflated with different proportions.

<table>
<thead>
<tr>
<th>20</th>
<th>60</th>
<th>30</th>
<th>...</th>
<th>...</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>90</td>
<td>45</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

66%

<table>
<thead>
<tr>
<th>44</th>
<th>12</th>
<th>15</th>
<th>...</th>
<th>...</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>88</td>
<td>24</td>
<td>30</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

50%
1. The number of public transport (pt) users workers is aggregated for each mode share zone.
2. The number of non-pt commuters of the zone is estimated.
3. The number of non-pt commuters is distributed to the master plan area.

Mode share inflation (pt accessibility-based)
Distribution to single buildings
Work schedules and individual buildings
Limitations and Outlook

Assumptions
- Constant mode share over different work schedules
- No spatial variation of work space requirements
- Minimization of last-mile travel time only

Outlook – potential projects
- Calculation of walking times with pedestrian network
- Sensitivity analysis
- Application with newer CEPAS dataset