Effects of information provision on going home behavior and traffic congestion at large-scale disaster: case study of Nagoya Metropolitan area

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Japan has experienced many earthquakes, typhoons and floods.

Big earthquakes periodically hit Nagoya metropolitan area

- M7.9 in 1605
- M8.6 in 1707
- M8.4 in 1854
- M7.9 in 1944

Next one is anticipated in 30 years with 88% probability
1. Background

The Great East Japan Earthquake occurred on March 11, 2011.

In Tokyo Metropolitan area,

- Over 5 million peoples were unable to get home
- More than 80% started going home
- 24% drove home
2. Objectives

Size of refugees unable to get home and traffic congestion are estimated, and the effects of information services are evaluated for the next earthquake at Nagoya Met.

– Current situation, family safety

Key points:
• Car demand resulting from higher share in daily trips
• Confusion between going home and evacuation from anticipated Tsunami
Information services

- Ordinal telephone network became busy and unreliable at the disaster

- Reliable information service at the disaster
  - Specially designed for emergency period to leave and retrieve a message to/from family member at the designated phone number
3. Research flow

Mode choice analysis at the Great East Japan Earthquake
- Development of mode choice model considering the effects of information services
- Demand for going home trips is estimated at Nagoya metropolitan area

Meso-scopic traffic simulation of going home trips
- Stochastic/deterministic route choice behavior with/without real-time traffic information
- Degraded road network and evacuation from Tsunami are considered
Mode choice analysis at the Great East Japan Earthquake
4. Internet survey on the Great East Japan Earthquake

- Investigators: Univ. of Tokyo, Toyo Univ. and Survey Research Center
- Survey period: 2011/03/25 to 03/28
- Survey area: Tokyo Metropolitan (Tokyo, Kanagawa, Saitama & Chiba)
- Respondents: 20+ yrs. old who were away from home at the Quake
- Method: internet survey with panels
- Sample size: 1,915 out of 2,026 responses
- Questionnaires: Going home behavior & information access at the Quake

Age distribution by gender

Daily commute mode

- Car 20%
- Train 60%
- Bicycle 11%
- Walk 7%
- Bus 2%
5. Survey results

**Going home behavior**

- Returned home: 81%
- Stayed at office: 12%
- Stayed at others: 5%
- Gave up on the way home: 2%

**Going home behavior by info. access**

- Current situation:
  - Accessed: 80% at home, 20% not obtained
  - Not obtained: 0% at home, 100% not obtained

**Going home behavior by daily commute mode**

- Train: Car, Car from home, Walk, Bicycle, Stayed
- Bus: Car, Car from home, Walk, Bicycle, Stayed
- Walk: Car, Car from home, Walk, Bicycle, Stayed
- Bicycle: Car, Car from home, Walk, Bicycle, Stayed
- Car: Car, Car from home, Walk, Bicycle, Stayed
6. Mode choice model of going home

- Car and bicycle availability is considered for commuters, but no information for non-commuters
- Train and bus are excluded from the alternatives

### Choice set

<table>
<thead>
<tr>
<th></th>
<th>Car</th>
<th>Car from home</th>
<th>Bicycle</th>
<th>Walk</th>
<th>Stayed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car commuter</td>
<td>○</td>
<td>○</td>
<td>×</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Bicycle commuter</td>
<td>×</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Other commuter</td>
<td>×</td>
<td>○</td>
<td>×</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Non-commuter*</td>
<td>×</td>
<td>○</td>
<td>×</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

*Non-commuter visiting by car or bicycle is assumed as captive*
# 7. Estimation results of mode choice model

## MNL for commuters

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Coef</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Car</td>
<td>7.18**</td>
</tr>
<tr>
<td>Constant From home</td>
<td>7.66**</td>
</tr>
<tr>
<td>Constant Bicycle</td>
<td>7.88**</td>
</tr>
<tr>
<td>Constant Walk</td>
<td>6.26**</td>
</tr>
<tr>
<td>Male From home</td>
<td>-0.742**</td>
</tr>
<tr>
<td>Full-time worker From home</td>
<td>-0.536**</td>
</tr>
<tr>
<td>Ln(Distance to home) Walk</td>
<td>-0.909**</td>
</tr>
<tr>
<td>Ln(Distance to home) Stayed</td>
<td>1.31**</td>
</tr>
<tr>
<td>Train commuter Walk</td>
<td>1.46**</td>
</tr>
<tr>
<td>Ln(Age) From home</td>
<td>-0.787**</td>
</tr>
<tr>
<td>Access to current situation Stayed</td>
<td>1.14**</td>
</tr>
<tr>
<td>Access to family safety Stayed</td>
<td>0.917*</td>
</tr>
</tbody>
</table>

- Sample size: 1318
- Adjusted rho-squared: 0.407

## MNL for non-commuters

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Coef</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant From home</td>
<td>10.19**</td>
</tr>
<tr>
<td>Constant Walk</td>
<td>4.69**</td>
</tr>
<tr>
<td>Male Stayed</td>
<td>-1.39</td>
</tr>
<tr>
<td>Ln(Distance to home) From home</td>
<td>-0.864**</td>
</tr>
<tr>
<td>Ln(Distance to home) Stayed</td>
<td>1.20**</td>
</tr>
<tr>
<td>Ln(Age) From home</td>
<td>-2.14**</td>
</tr>
<tr>
<td>Access to current situation Stayed</td>
<td>1.82*</td>
</tr>
</tbody>
</table>

- Sample size: 172
- Adjusted rho-squared: 0.488

Access to information encourages to stay (avoid going home)
8. Estimation of going home behavior at Nagoya met.

- 5.96M people away from home at noon in Nagoya metropolitan area
- Effects of information access are estimated

<table>
<thead>
<tr>
<th>Family safety</th>
<th>Current situation</th>
<th>Car</th>
<th>Car from home</th>
<th>Bicycle</th>
<th>Walk</th>
<th>Stayed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not obtained</td>
<td>Not obtained</td>
<td>2,973,000</td>
<td>855,000</td>
<td>598,000</td>
<td>1,436,000</td>
<td>252,000</td>
</tr>
<tr>
<td>Accessed</td>
<td>Not obtained</td>
<td>2,908,000</td>
<td>794,000</td>
<td>595,000</td>
<td>1,349,000</td>
<td>466,000</td>
</tr>
<tr>
<td>Not obtained</td>
<td>Accessed</td>
<td>2,883,000</td>
<td>768,000</td>
<td>594,000</td>
<td>1,298,000</td>
<td>569,000</td>
</tr>
<tr>
<td>Accessed</td>
<td>Accessed</td>
<td>2,723,000</td>
<td>678,000</td>
<td>587,000</td>
<td>1,169,000</td>
<td>955,000</td>
</tr>
</tbody>
</table>
Meso-scopic traffic simulation of going home trips
9. Traffic simulation of going home trips

- Assumed earthquake: Occurred at noon in weekday

- Timing of trip: Going home at once after the quake
  Evacuation from Tsunami at 5 min. after the quake

- Degraded road network: One lane closure for multiple lane roads
  Decreased capacity for one lane roads
  Unable to use expressways

- Traffic flow
10. Results of simulation

Waiting queues at base case

- **5 min. after**: Confusion between going home and evacuation.
- **30 min. after**: Persons in queue.
- **60 min. after**: Persons in queue, indicating confusion.

Persons in queue:
- 1,000 - 1,000
- 400 - 1,000
- 100 - 400
- 50 - 100
- 50 - 50

Tsunami risk area.
10. Results of simulation

- **Base case**
  - Stochastic route choice under current situation
  - No information access
- **Information access case**
  - Reduced trips by information access

<table>
<thead>
<tr>
<th></th>
<th>Base case</th>
<th>Info. access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Returned home in 4 hrs.</td>
<td>2,371,000 (74%)</td>
<td>2,230,000 (78%)</td>
</tr>
<tr>
<td>Unable to evacuate before Tsunami concentration</td>
<td>438,000</td>
<td>382,000</td>
</tr>
</tbody>
</table>
11. Conclusions

Findings

- 0.7M peoples can be reduced from going home trips by information services on current situation and family safety
- Reduced demand by information services increases the number of people able to evacuate before Tsunami concentration by 50,000

Future research topics

- Consideration of buildings height for realistic evacuation scenario
- Congestion of pedestrian traffic
- Psychological aspects of behavior: dependency to others and group behavior