WATCH
+
SAKURA

＝花見
(Party under cherry blossom)
Inter-Temporal and Inter-Regional Analysis of Household Car and Motorcycle Ownership Behaviours in Asian Big Cities

SAKURA Project
July 2004

Nagoya University
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Toshiyuki Yamamoto, and Takayuki Morikawa
INTRODUCTION

Economic Growth

Income Increase

Vehicle Ownership Increase
CASE STUDY CITIES


Bangkok, Thailand (1995/96)

Manila, Philippines (1996)

Kuala Lumpur, Malaysia (1997)
Car Ownership in Case Study Cities
(1960 ~ 1995)
Car Ownership Forecast around the World

Increasing Trend in Developing Courtiers

OECD
U.S.A.
Others
Total

Number of Cars Owned (0 mln units)

2000 2020 2040 2060 2080 2100

2000 2020 2040 2060 2080 2100 (Yr)
INTRODUCTION

Vehicle Ownership Increase

→ can cause traffic congestions and environmental problems

Some Countermeasures Considered

• Investment in road infrastructure and public transit systems
• Regulations against vehicle ownership and usage
• Technical innovation in vehicle performance

However, understanding vehicle ownership behaviours is the key and prerequisite.
OBJECTIVES

- Modelling and comparing vehicle ownership behaviours in the case study cities (Nagoya, Bangkok, Kuala Lumpur and Manila)
- Obtaining insights into the effects of accessibility on vehicle ownership behaviours
- Evaluating temporal and spatial transferability of vehicle ownership models
MODELLING FRAMEWORK

**Mode Choice Model**  
Multinomial Logit Model  
(Trip Level)

**Vehicle Ownership Model**  
Bivariate Ordered Probit Model  
(Household Level)

**Accessibility Measures**

- Trip makers’ SE
- LOS
- Household members’ SE
MODELLING FRAMEWORK

Comparing Vehicle Ownership Models and Evaluating their Transferability

- NGO81
- NGO91
- NGO01
- BKK95
- KL97
- MNL96

Inter-temporal comparison and temporal transferability

Inter-regional comparison and spatial transferability
CASE STUDY CITIES AND THE DATA

- Bangkok, Thailand (1995/96)
- Manila, Philippines (1996)
- Kuala Lumpur, Malaysia (1997)
Chukyo Metropolitan Area (Nagoya and Surrounding Areas)

Area: 5656, 5173, 6696km²
Population: 7.8, 8.1, 9.0 million
Nagoya
Bangkok Metropolitan Region (BMR)

Area: 7758 km²
Population: 13 million

Kuala Lumpur Metropolitan (KLMP)

Area: 500 km²
Population: 4.1 million

(JICA: Japan International Cooperation Agency)
Kuala Lumpur
Area: 636 km²
Population: 14.4 million

Data source: JICA survey in 1996.
Vehicle Ownership Characteristics in Case Study Cities

In NGO, household without car (-) and with 2+ cars (+)
LOS DATA

Survey area is divided into zones

Travel time: Average travel time reported by respondents (if no trip is made, larger zones are considered)

Cost: Not available in all case study cities, thus not included in the model

SOCI O-ECONOMIC DATA

Driving license holding: Difficult to forecast and highly endogenous, thus not included in the model
MODELING FRAMEWORK

Mode Choice Model
Multinomial Logit Model (Trip Level)

Accessibility Measures

Vehicle Ownership Model
Bivariate Ordered Probit Model (Household Level)

Trip makers’ SE
LOS
Household members’ SE
### Estimation Results (Summary statistics)

<table>
<thead>
<tr>
<th></th>
<th>NGO81</th>
<th>NGO91</th>
<th>NGO01</th>
<th>BKK</th>
<th>KL</th>
<th>MNL</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>15,000</td>
<td>15,000</td>
<td>15,000</td>
<td>13,882</td>
<td>12,667</td>
<td>15,000</td>
</tr>
<tr>
<td>(L(\beta))</td>
<td>-10,834.2</td>
<td>-9,254.1</td>
<td>-8,223.8</td>
<td>-9,433.7</td>
<td>-9,212.4</td>
<td>-9,513.2</td>
</tr>
<tr>
<td>(L(\theta))</td>
<td>-15,702.5</td>
<td>-15,140.8</td>
<td>-14,787.2</td>
<td>-12,249.1</td>
<td>-13,434.0</td>
<td>-12,948.8</td>
</tr>
<tr>
<td>(\rho^2)</td>
<td>0.309</td>
<td>0.388</td>
<td>0.443</td>
<td>0.229</td>
<td>0.313</td>
<td>0.265</td>
</tr>
</tbody>
</table>

- 15,000 samples are drawn randomly in NGO and MNL
- Goodness of fit indexes are satisfactory
## Estimation Results (alternative-specific constants and LOS)

<table>
<thead>
<tr>
<th>Variable</th>
<th>NGO81</th>
<th>NGO91</th>
<th>NGO01</th>
<th>BKK</th>
<th>KL</th>
<th>MNL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant (R)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>Constant (B)</td>
<td>-1.30</td>
<td>-1.54</td>
<td>-1.69</td>
<td>0.04</td>
<td>0</td>
<td>1.03</td>
</tr>
<tr>
<td>Constant (C)</td>
<td>-1.95</td>
<td>-1.27</td>
<td>-0.66</td>
<td>-1.54</td>
<td>-0.72</td>
<td>-0.52</td>
</tr>
<tr>
<td>Constant (MC)</td>
<td>-4.46</td>
<td>-4.15</td>
<td>-3.90</td>
<td>-1.75</td>
<td>-1.62</td>
<td>-0.82</td>
</tr>
<tr>
<td>Time (60 min.)</td>
<td>-1.92</td>
<td>-1.95</td>
<td>-2.53</td>
<td>-0.17</td>
<td>-0.14*</td>
<td>-0.30</td>
</tr>
</tbody>
</table>

*Not significant at 5% level

- Four alternatives except for KL (Rail, Bus, Car, MotorCycle)
- Travel time is negatively estimated (not significant in KL)
### Estimation Results (SE: Socio-Economic variables)

<table>
<thead>
<tr>
<th>Variable</th>
<th>NGO81</th>
<th>NGO91</th>
<th>NGO01</th>
<th>BKK</th>
<th>KL</th>
<th>MNL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (C, MC)</td>
<td>1.74</td>
<td>1.49</td>
<td>1.02</td>
<td>0.72</td>
<td>0.95</td>
<td>0.40</td>
</tr>
<tr>
<td>Age ≥ 20 (C, MC)</td>
<td>1.36</td>
<td>1.23</td>
<td>1.02</td>
<td>1.17</td>
<td>4.30</td>
<td>0.79</td>
</tr>
<tr>
<td>In City (C)</td>
<td>-0.75</td>
<td>-0.81</td>
<td>-1.02</td>
<td>-0.01*</td>
<td>-0.27</td>
<td>-0.91</td>
</tr>
<tr>
<td>Age ≥ 65 (B)</td>
<td>1.78</td>
<td>1.83</td>
<td>1.29</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Female (R)</td>
<td>-0.75</td>
<td>-0.77</td>
<td>-0.54</td>
<td>-0.57</td>
<td>--</td>
<td>-0.43</td>
</tr>
<tr>
<td>Student (R)</td>
<td>0.64</td>
<td>0.97</td>
<td>1.04</td>
<td>-0.35</td>
<td>--</td>
<td>-0.64</td>
</tr>
</tbody>
</table>

*Not significant at 5% level

- Three SE variables have effects on car and motorcycle usage
  - Male and age ≥ 20 (+)
  - In City (−), not significant in BKK
- Three SE variables have effects on transit usage
  - Age ≥ 65 (+, bus)
  - Female (−, rail)
  - Student (+, in NGO; −, in BKK and MNL, rail)
MODELLING FRAMEWORK

**Mode Choice Model**
Multinomial Logit Model (Trip Level)

- Trip makers’ SE
- LOS

**Vehicle Ownership Model**
Bivariate Ordered Probit Model (Household Level)

- Household members’ SE

**Accessibility Measures**
For individual $n$ residing in zone $z_n$ ($z_n = 1, \ldots, Z$)

Systematic component of the utility when individual $n$ uses rail and bus from zone $z_n$ to zone $l$ respectively

\[
\ln(\exp(V_{R1n}) + \exp(V_{B1n}))
\]

\[
AT_{zn,n} = \sum_{z=1, z \neq z_n}^{Z} \ln(\exp(V_{Rzn}) + \exp(V_{Bzn}))
\]
ACCESSIBILITY

For individual $n$ residing in zone $z_n$ ($z_n = 1, \ldots, Z$)

$$\ln(\exp(V_{R1n}) + \exp(V_{B1n}) + \exp(V_{C1n}))$$

$$- \ln(\exp(V_{R1n}) + \exp(V_{B1n}))$$

$$\ln(\exp(V_{R1n}) + \exp(V_{B1n}) + \exp(V_{MC1n}))$$

$$- \ln(\exp(V_{R1n}) + \exp(V_{B1n}))$$

Additional Accessibility of Car and Motorcycle Availability

(Convenience of car and motorcycle if the individual can use these alternatives in addition to transit which is usually available to all citizens)

$$AAC_{z_n} = \sum_{z=1, z \neq z_n}^{Z} \left[ \ln(\exp(V_{Rzn}) + \exp(V_{Bzn}) + \exp(V_{Czn})) - \ln(\exp(V_{Rzn}) + \exp(V_{Bzn})) \right]$$

$$AAMC_{z_n} = \sum_{z=1, z \neq z_n}^{Z} \left[ \ln(\exp(V_{Rzn}) + \exp(V_{Bzn}) + \exp(V_{MCzn})) - \ln(\exp(V_{Rzn}) + \exp(V_{Bzn})) \right]$$
A potential drawback of “accessibility to transit” and “Additional accessibility of car and motorcycle availability”

When the survey area is large, considering accessibility to all zones is questionable.

Weighted accessibility measures based on # of trips are considered.
ACCESSIBILITY

For individual $n$ residing in zone $z_n$ ($z_n = 1, \ldots, Z$)

\[ w_{RB1} \ln (\exp (V_{R1n}) + \exp (V_{B1n})) \]

\[ w_{RBz} = \left( Q_{Rz} + Q_{Bz} \right) / \sum_{z=1, z \neq z_n}^{Z} \left( Q_{Rz} + Q_{Bz} \right) \]

Traffic volume from zone $z_n$ to zone $z$ by rail and bus respectively

: importance of zone $z$ for those reside in zone $z_n$

Weighted Accessibility to Transit

\[ WAT_{zn} = \sum_{z=1, z \neq z_n}^{Z} w_{RBz} \ln (\exp (V_{Rzn}) + \exp (V_{Bzn})) \]
ACCESSIBILITY

For individual \( n \) residing in zone \( z_n \) \((z_n = 1, \ldots, Z)\)

\[
\begin{align*}
\text{Zone 1: } & w_{RBC} \ln(\exp(V_{R1n}) + \exp(V_{B1n}) + \exp(V_{C1n})) \\
& - w_{RB1} \ln(\exp(V_{R1n}) + \exp(V_{B1n}))
\end{align*}
\]

\[
\begin{align*}
\text{Zone Z: } & w_{RBC} \ln(\exp(V_{R1n}) + \exp(V_{B1n}) + \exp(V_{MC1n})) \\
& - w_{RB1} \ln(\exp(V_{R1n}) + \exp(V_{B1n}))
\end{align*}
\]

\[
w_{RBCz} = \left( Q_{Rz} + Q_{Bz} + Q_{Cz} \right) / \sum_{z=1, z \neq z_n}^Z \left( Q_{Rz} + Q_{Bz} + Q_{Cz} \right)
\]

\[
w_{RBMCz} = \left( Q_{Rz} + Q_{Bz} + Q_{MCz} \right) / \sum_{z=1, z \neq z_n}^Z \left( Q_{Rz} + Q_{Bz} + Q_{MCz} \right)
\]

**Weighted Additional Accessibility of Car and Motorcycle Availability**

\[
W_{AAC} = \sum_{z=1, z \neq z_n}^Z \left[ w_{RBCz} \ln(\exp(V_{Rzn}) + \exp(V_{Bzn}) + \exp(V_{Czn})) - w_{RBz} \ln(\exp(V_{Rzn}) + \exp(V_{Bzn})) \right]
\]

\[
W_{AMC} = \sum_{z=1, z \neq z_n}^Z \left[ w_{RBMCz} \ln(\exp(V_{Rzn}) + \exp(V_{Bzn}) + \exp(V_{MCzn})) - w_{RBz} \ln(\exp(V_{Rzn}) + \exp(V_{Bzn})) \right]
\]
A potential drawback of weighted accessibility

If people may travel to close and convenient zones only, then inconvenient but attractive zones may be excluded from the evaluation.

Anyway, we expect that the lower accessibility to transit and higher additional accessibility lead to car and motorcycle ownership intentions.

Accessibility measures considered

<table>
<thead>
<tr>
<th>Without weights</th>
<th>NGO81</th>
<th>NGO91</th>
<th>NGO01</th>
<th>BKK</th>
<th>KL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Addition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With weights</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Addition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Not available due to the lack of zoning information)
Manila is excluded since the model has not been estimated successfully.
MODELLING FRAMEWORK

**Mode Choice Model**
Multinomial Logit Model (Trip Level)

**Vehicle Ownership Model**
Bivariate Ordered Probit Model (Household Level)

**Accessibility Measures**

- **Trip makers’ SE**
- **LOS**
- **Household members’ SE**
VEHICLE OWNERSHIP MODEL

Propensity for Car Ownership

\[ y_{i,\text{CAR}}^* = \gamma x_{i,\text{CAR}} + \epsilon_{i,\text{CAR}} \]

Propensity for Motorcycle Ownership

\[ y_{i,\text{MC}}^* = \beta x_{i,\text{MC}} + \epsilon_{i,\text{MC}} \]

Relationships these propensity functions with observations

\[ y_{i,\text{CAR}} = 0 \text{ if } y_{i,\text{CAR}}^* \leq 0, \]
\[ 1 \text{ if } 0 < y_{i,\text{CAR}}^* \leq \mu_{1,\text{CAR}}, \]
\[ \ldots \text{ if } \mu_{J-1,\text{CAR}} < y_{i,\text{CAR}}^* \]
\[ \mu_{2,\text{CAR}} \]

\[ y_{i,\text{MC}} = 0 \text{ if } y_{i,\text{MC}}^* \leq 0, \]
\[ 1 \text{ if } 0 < y_{i,\text{MC}}^* \leq \mu_{1,\text{MC}}, \]
\[ \ldots \text{ if } \mu_{K-1,\text{MC}} < y_{i,\text{MC}}^* \]
\[ \mu_{2,\text{MC}} \]

\[ y_{i,\text{CAR}}, y_{i,\text{MC}} \text{: observed \# of car and motorcycle owned by household } i \]
\[ \beta, \gamma, \mu \text{: unknown parameter and threshold vectors to be estimated} \]
\[ \epsilon_{i,\text{CAR}}, \epsilon_{i,\text{MC}} \text{: error components standard bivariate normally distributed with correlation } \rho \text{ to be estimated} \]
VEHICLE OWNERSHIP MODEL

Cars: 0, 1, 2 and 3+
MC’s: 0, 1 and 2+

Cars : 0, 1, 2 and 3+
MC’s : 0, 1 and 2+
EXPLANATORY VARIABLES USED

<table>
<thead>
<tr>
<th>Car Ownership</th>
<th>Motorcycle Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility</td>
<td>Accessibility</td>
</tr>
<tr>
<td># of males aged 20–65</td>
<td># of males aged 20–29</td>
</tr>
<tr>
<td># of males aged –19, 66–</td>
<td># of males aged –19, 30–</td>
</tr>
<tr>
<td># of females aged 20–65</td>
<td># of females aged 20–29</td>
</tr>
<tr>
<td># of females aged –19, 66–</td>
<td># of females aged –19, 30–</td>
</tr>
<tr>
<td># of workers</td>
<td># of workers</td>
</tr>
<tr>
<td># of motorcycles owned</td>
<td></td>
</tr>
</tbody>
</table>

License info. is not used: difficult to forecast in developing countries
## Introduction

We have confirmed that generally:

- Including error correlation significantly improves model fits
- Including interaction terms does not significantly improve model fits

Models with error correlation (not interaction) are presented hereafter

### Chi-square Test

- Without weights
  - Transit: \( \chi^2 \approx 3.84 \)
  - Addition: \( \chi^2 \approx 3.84 \)

- With weights
  - Transit: \( \chi^2 \approx 3.84 \)
  - Addition: \( \chi^2 \approx 3.84 \)

<table>
<thead>
<tr>
<th></th>
<th>NGO81</th>
<th>NGO91</th>
<th>NGO01</th>
<th>BKK</th>
<th>KL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without weights</td>
<td>Transit</td>
<td>11.24</td>
<td>2.90</td>
<td>3.88</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addition</td>
<td>12.18</td>
<td>4.06</td>
<td>4.88</td>
<td></td>
</tr>
<tr>
<td>With weights</td>
<td>Transit</td>
<td>26.72</td>
<td>2.84</td>
<td>0.56</td>
<td>24.32</td>
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<tr>
<td></td>
<td>Addition</td>
<td>0.58</td>
<td>2.88</td>
<td>0.58</td>
<td>16.66</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>NGO81</th>
<th>NGO91</th>
<th>NGO01</th>
<th>BKK</th>
<th>KL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without weights</td>
<td>Transit</td>
<td>0.46</td>
<td>0.02</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addition</td>
<td>0.46</td>
<td>0.12</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>With weights</td>
<td>Transit</td>
<td>1.42</td>
<td>0.26</td>
<td>0.48</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>Addition</td>
<td>0.56</td>
<td>0.5</td>
<td>0.68</td>
<td>0.8</td>
</tr>
</tbody>
</table>

We have confirmed that generally:

- Including error correlation significantly improves model fits
- Including interaction terms does not significantly improve model fits

Models with error correlation (not interaction) are presented hereafter
### ESTIMATION RESULTS

#### Accessibility measures considered

( $\bar{\rho}^2$ based on $L(0)$ and $L(c)$ is reported)

<table>
<thead>
<tr>
<th></th>
<th>NGO81</th>
<th>NGO91</th>
<th>NGO01</th>
<th>BKK</th>
<th>KL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Without weights</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transit</td>
<td>0.0857</td>
<td>0.1697</td>
<td>0.1744</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Addition</td>
<td>0.0848</td>
<td>0.1626</td>
<td>0.1744</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>With weights</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transit</td>
<td>0.0909</td>
<td>0.1888</td>
<td>0.1513</td>
<td>0.0478</td>
<td>0.0487</td>
</tr>
<tr>
<td>Addition</td>
<td>0.0945</td>
<td>0.1950</td>
<td>0.1568</td>
<td>0.0535</td>
<td>0.0487</td>
</tr>
</tbody>
</table>

As an example, the results using weighted additional accessibility of car and motorcycle availability are presented (the best fit to the data except for NGO 01).
### Estimation Results (summary statistics)

<table>
<thead>
<tr>
<th></th>
<th>NGO81</th>
<th>NGO91</th>
<th>NGO01</th>
<th>BKK</th>
<th>KL</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>L(β)</td>
<td>-1,600.6</td>
<td>-1,584.3</td>
<td>-1,419.7</td>
<td>-1,531.0</td>
<td>-1,896.4</td>
</tr>
<tr>
<td>L(c)</td>
<td>-1,782.0</td>
<td>-1,984.3</td>
<td>-1,699.1</td>
<td>-1,631.3</td>
<td>-2,007.1</td>
</tr>
<tr>
<td>(\overline{\rho}^2)</td>
<td>0.0945</td>
<td>0.1950</td>
<td>0.1568</td>
<td>0.0535</td>
<td>0.0487</td>
</tr>
</tbody>
</table>

- 1,000 samples are drawn randomly


### Estimation Results (car ownership)

<table>
<thead>
<tr>
<th>Variable</th>
<th>NGO81 Coef.</th>
<th>NGO81 t-stat.</th>
<th>NGO91 Coef.</th>
<th>NGO91 t-stat.</th>
<th>NGO01 Coef.</th>
<th>NGO01 t-stat.</th>
<th>BKK Coef.</th>
<th>BKK t-stat.</th>
<th>KL Coef.</th>
<th>KL t-stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>M20-65</td>
<td>0.38</td>
<td>6.0</td>
<td>0.64</td>
<td>8.8</td>
<td>0.57</td>
<td>7.4</td>
<td>0.29</td>
<td>14.6</td>
<td>0.20</td>
<td>3.5</td>
</tr>
<tr>
<td>M-19,66-</td>
<td>0.06</td>
<td>1.6</td>
<td>0.29</td>
<td>6.2</td>
<td>0.41</td>
<td>4.4</td>
<td>0.10</td>
<td>1.8</td>
<td>0.09</td>
<td>1.7</td>
</tr>
<tr>
<td>F20-65</td>
<td>0.03</td>
<td>0.6</td>
<td>0.50</td>
<td>7.6</td>
<td>0.66</td>
<td>9.7</td>
<td>0.14</td>
<td>2.4</td>
<td>0.18</td>
<td>3.5</td>
</tr>
<tr>
<td>F-19,66-</td>
<td>0.11</td>
<td>2.5</td>
<td>0.32</td>
<td>6.0</td>
<td>0.54</td>
<td>5.9</td>
<td>0.23</td>
<td>4.4</td>
<td>-0.01</td>
<td>-0.1</td>
</tr>
<tr>
<td>Worker</td>
<td>0.21</td>
<td>4.0</td>
<td>0.40</td>
<td>7.7</td>
<td>0.34</td>
<td>4.9</td>
<td>0.10</td>
<td>1.9</td>
<td>0.11</td>
<td>2.2</td>
</tr>
</tbody>
</table>

- Generally, household with more members has more cars
- # of workers have significant positive effects except for BKK
- Males aged 20-65 have greater effects than females aged 20-65 in developing countries and used to have in NGO
- Aged between 20-65 have greater effects than aged -19,66- except for NGO81 females and BKK females
## Estimation Results (motorcycle ownership)

<table>
<thead>
<tr>
<th>Variable</th>
<th>NGO81 Coef.</th>
<th>NGO81 t-stat.</th>
<th>NGO91 Coef.</th>
<th>NGO91 t-stat.</th>
<th>NGO01 Coef.</th>
<th>NGO01 t-stat.</th>
<th>BKK Coef.</th>
<th>BKK t-stat.</th>
<th>KL Coef.</th>
<th>KL t-stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>M20-29</td>
<td>0.22</td>
<td>2.0</td>
<td>0.54</td>
<td>4.9</td>
<td>0.36</td>
<td>2.9</td>
<td>0.45</td>
<td>5.6</td>
<td>0.36</td>
<td>6.0</td>
</tr>
<tr>
<td>M-19,30-</td>
<td>0.06</td>
<td>1.1</td>
<td>0.29</td>
<td>5.5</td>
<td>0.25</td>
<td>2.4</td>
<td>0.22</td>
<td>4.1</td>
<td>0.16</td>
<td>3.4</td>
</tr>
<tr>
<td>F20-29</td>
<td>0.02</td>
<td>0.2</td>
<td>0.04</td>
<td>0.4</td>
<td>0.11</td>
<td>0.9</td>
<td>-0.12</td>
<td>-1.5</td>
<td>-0.17</td>
<td>-2.6</td>
</tr>
<tr>
<td>F-19,30-</td>
<td>0.03</td>
<td>0.6</td>
<td>0.07</td>
<td>1.2</td>
<td>0.18</td>
<td>2.2</td>
<td>-0.03</td>
<td>-0.6</td>
<td>-0.11</td>
<td>-2.7</td>
</tr>
<tr>
<td>Worker</td>
<td>0.20</td>
<td>3.4</td>
<td>0.15</td>
<td>2.6</td>
<td>0.03</td>
<td>0.3</td>
<td>0.11</td>
<td>2.2</td>
<td>0.14</td>
<td>3.2</td>
</tr>
</tbody>
</table>

- Household members’ characteristics estimated positively significantly or insignificantly except for females in KL
- More members, more motorcycles, generally
- # of workers have positive effects
- Males have greater effects
- Aged between 20-29 have greater effects than aged -19,30- except for females in NGO001 and females in KL
## Estimation Results (accessibility measures)

<table>
<thead>
<tr>
<th>Variable</th>
<th>NGO81 Coef.</th>
<th>NGO91 Coef.</th>
<th>NGO01 Coef.</th>
<th>BKK Coef.</th>
<th>KL Coef.</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAAC</td>
<td>0.44</td>
<td>0.59</td>
<td>0.48</td>
<td>0.54</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
<td>7.1</td>
<td>9.2</td>
<td>3.1</td>
<td>0.1</td>
</tr>
<tr>
<td>WAAMC</td>
<td>1.13</td>
<td>0.92</td>
<td>0.27</td>
<td>0.89</td>
<td>-0.30</td>
</tr>
<tr>
<td></td>
<td>2.7</td>
<td>2.0</td>
<td>0.6</td>
<td>3.3</td>
<td>-0.3</td>
</tr>
</tbody>
</table>

- WAAC estimated positively and significantly in NGO and BKK
- WAAMC estimated positively and significantly in BKK and used to be in NGO
- WAAC is estimated more significantly than WAAMC in NGO, suggesting that some own motorcycles for pleasure
Estimation Results (correlation)

<table>
<thead>
<tr>
<th>Variable</th>
<th>NGO81 Coef. t-stat.</th>
<th>NGO91 Coef. t-stat.</th>
<th>NGO01 Coef. t-stat.</th>
<th>BKK Coef. t-stat.</th>
<th>KL Coef. t-stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cor.</td>
<td>0.25 5.7</td>
<td>0.08 1.8</td>
<td>0.04 0.9</td>
<td>-0.21 -4.0</td>
<td>-0.25 -6.5</td>
</tr>
</tbody>
</table>

- Positively estimated in NGO
  - Positive unobserved interaction between car and motorcycle ownership
  - Those who intend to own cars intend to own motorcycles, and vice versa
  - Tend to become insignificant, that is, independent
- Negatively and significantly estimated in BKK and KL
  - Negative unobserved interaction between car and motorcycle ownership
  - Those who intend to own cars DO NOT intend to own motorcycles, and vice versa (substitution effect)
NGO01 vehicle ownership is predicted using NGO81 and NGO91 models
TEMPORAL TRANSFERABILITY

(Forecast value – Actual value) is presented

Without weights

Transit

Addition

With weights

Transit

Addition

NGO81(T)

NGO81(A)

NGO81(W-T)

NGO81(W-A)

NGO91(T)

NGO91(A)

NGO91(W-T)

NGO91(W-A)

\[ \sum_{c,mc} S_{c,mc}(C_{t2}) - S_{c,mc}(\theta_{t1}) \]

\[ \sum_{c,mc} \]

91, without weights, additional is the best
SPATIAL TRANSFERABILITY

BKK95 vehicle ownership is predicted using NGO81, NGO01 and KL97 models.
SPATIAL TRANSFERABILITY

(Forecast value – Actual value) is presented

Transit

NGO81(W-T) 99.0%

NGO01(W-T) 175.3%

KL(W-T) 50.1%

Addition

NGO81(W-A) 42.8%

NGO01(W-A) 148.3%

KL(W-A) 41.9%

NGO81 and KL additional are better
CONCLUSIONS

- This study analysed car and motorcycle ownership behaviours in Asian cities incorporating accessibility measures obtained through mode choice models.

- Findings from the bivariate ordered probit models
  - More members, more vehicles
  - More workers, more vehicles
  - Males generally have greater effects on vehicle ownership
  - Aged between 20-65 (car) and 20-29 (motorcycle) have greater effects on vehicle ownership
  - Accessibility generally has significant impacts on vehicle ownership and has greater effects on car ownership
  - Correlation is estimated positively in NGO and negatively in developing countries
CONCLUSIONS

- Findings from transferability analysis
  - Additional accessibility models have better transferability
  - Without weights accessibility models have better temporal transferability
  - Models estimated at the year closer to the target year have better temporal transferability
  - Models estimated at the area or time point that have similar characteristics to the target area have better spatial transferability
Merci de votre attention!