Why are required to discuss on urban forms?

- Human activity is strongly affected by urban form
- Close relationship between human activity and transport network
- Travel is a derived demand of activities
- Limitation of single transportation policies
- Change of life cycle stage affects on travel patterns
Environmental Sustainability in Urban Transportation

- Less road construction
- Fewer car trips/shortened vehicle miles traveled
- ...

Transportation strategies
- Transportation demand management
- Transportation control measures
- Vehicle/fuel technologies

Land use strategies
- Transit Oriented Development (TOD)
- Compact city

Transportation and Land Use Strategies

- Vehicle/Fuel Technology
- Transportation Systems Management
- Travel Demand Management

- Transit Oriented Development
- Compact City

- Trip patterns (mode, length, time of day etc.)
- Vehicle activity (vehicle-trips, vehicle miles of travel etc.)

- Traffic Flow (speed, acceleration)

- Air Quality

Outcomes
Relationship between LCS and residential & travel mode choices

Younger single
Frequently
Public transit

Younger couple
Frequently
Car + transit

Couple with junior children
Occasionally
Car² + transit

Elder single
Occasionally
Public transit

Elder couple
Infrequently
Car + transit

Couple with senior children
Infrequently
Car² + transit

Transit Oriented Development

- “The practice of developing or intensifying residential land use near rail stations” (Boarnet and Crane 1998).
- “Development within a specified geographical area around a transit station with a variety of land uses and a multiplicity of landowners” (Salvensen 1996).
- “A mixed-use community that encourages people to live near transit services and to decrease their dependence on driving” (Still 2002).
- “A compact, mixed-use community, centered around a transit station that, by design, invites residents, workers, and shoppers to drive their cars less and ride mass transit more. The transit village extends roughly a quarter mile from a transit station, a distance that can be covered in about 5 minutes by foot. The centerpiece of the transit village is the transit station itself and the civic and public spaces that surround it. The transit station is what connects village residents to the rest of the region...The surrounding public space serves the important function of being a community gathering spot, a site for special events, and a place for celebrations—a modern-day version of the Greek agora” (Bernick and Cervero 1997, p. 5).

- **Mixed-use development**
- **Development that is close to and well-served by transit**
- **Development that is conducive to transit riding**
- **Compactness**
- **Pedestrian- and cycle-friendly environs**
- **Public and civic spaces near stations**
- **Stations as community hubs**
Transit Oriented Development
different elements of design

Compact City

- To limit distances between home and work and to aim for a better balance between living and working;
- To make the best possible use of existing facilities and infrastructure, and to improve the position of public transport;
- To use space as efficiently as possible by building connected properties in high densities;
- To maintain and create varied residential environments in and on the outskirts of the city;
- To fragment rural areas as little as possible and to reduce the environmental burden from road traffic.

- Minimum densities
- Multi functionality
- Concentration of development at nodes
- Transformation of urban mobility
- Congruence of spatial-functional structure and public transit system
- Station areas as catalysts for development.
Newly Developing Asian Cities
Basic Characteristics

- Development of economic activities at a world scale
- Spatial division of labor
- Division of function between core and periphery of the city
- Shift from single core to multiple cores
- Land use change in the urban center, agricultural land conversion on the periphery
- Development of large scale infrastructure
- Substantial increase in space production (by horizontal, vertical expansions and renewal of old land uses)
- High growth in commuters and increasing commuting time

(Firman, 1998)
JA(karta)BO(gor)TA(ngerang)BEK(asi)
metropolitan area

面積=6418km²

murakami et al. 2004
cyriwsky and ford, 2001

 Firman, 1998
Stated Preference Survey

- Household based survey
- Based on three hypothetical city forms
  - Transit oriented development
  - Compact city
  - Metropolitan suburban setting
- Household makes the decision
  - The place of residence
    - Transit oriented development
    - Compact city
    - Metropolitan suburban setting
  - Commute trip mode
    - Private car
    - Bus
    - Train
Sample Characteristics

- 303 Surveyed households
- 4 instances of choices on residence and commute mode
  - (data points 303x4=1212)
- Total number of individuals in households=1536
- Average household size=5.07 (s=1.93)
- Autumn, 2003
Sample Characteristics

Distance to markets

Distance to restaurants

Distance to parks

Distance to department stores

Simultaneous Residence and Commute
Mode Choice-survey design

Transit Oriented City

Suburban in a Metropolitan Area

Compact City
Simultaneous Residence and Commute Mode Choice-survey design

Responses (uncontrolled)

TOD= Transit Oriented Development; CC= Compact City; MS= Metropolitan Suburban
Responses (controlled by super districts-pooled)

Initial definition of DC models

- **Models** describe individual behaviour choosing a best option among discrete alternatives.
• Decision maker
  – an individual person/a group of persons
• Alternatives
  – car, bus and railway
• Attributes
  – =attractiveness: travel cost, time
• Decision rule
  – dominance, lexicographic, utility

• Dependent variable: unobserved probability between 0 and 1
• Observation: individual choices which are either 0 or 1
  – Depart/arrive at a given time or not
  – Visit on a given destination or not
  – Use a given travel mode or not
  – Choose a given route or not
DC models = disaggregate models

- Individual behaviour theory
- 11 samples of individual travelers
- Common parameters over homogenous groups of individuals

Individual models

- Individual behaviour theory
- 5 samples from repetitive observations of travelers
- 11 parameters for 11 persons
Advantages

• calibrated by maximum likelihood estimation (MLE) rather than standard curve fitting (least squares)
• more stable (transferable) in time and space
• more efficient in data collection
• avoid ‘ecological correlation’
• more flexible representation of policy variables

Random utility theory

• Individuals belong to a homogeneous population
• Individuals act rationally and possess perfect information
  i.e. They always select the option which maximizes their net personal utility subject to legal, social, physical and constraints.
• Individual’s choice set is predetermined
utility function

$$\text{utility} = \text{systematic} + \text{error}$$

systematic
- observable variables
  - eg. Individual SE characteristics
  - LOSs of alternatives
  - constraint (omitted variables)

error
- unobservable variables
  - eg. Individual idiosyncrasies, taste, attitude, habit, principle
  - measurement errors of observable variables

Advanced Econometric Model

- **Mixed (Random coefficients) Logit Model**
  - Earlier applications by Boyd and Mellman (1980), Cardell and Dunbar (1980) on automobile demand,
  - Customer-level data, such as Train *et al.* (1987) and Ben-Akiva *et al.* (1993),
  - A very general introduction by Train (1999),
  - Does not show IIA property 😊
  - (but) Requires simulation 😞
Why Mixed Logit Model?

1. Mixed logit is a highly flexible model that can approximate any random utility model (McFadden and Train, 2000),
2. Mixed Logit model accounts for Independence from Irrelevant Alternatives (IIA) shortcoming of the traditional (multinomial) Logit model,
3. Mixed Logit Model accounts for individual heterogeneity (allows controlling random taste variation),
4. (Once simulation techniques are taken for granted!) simple extension to panel data estimation (allows correlation in unobserved factors over Time).

Mathematical Specification

\[ U_{ni} = V_{ni} + \varepsilon_{ni} \]
Utility is comprised of observed and unobserved components (individual n and alternative i)

\[ L_{nit}(\beta_n) = \frac{e^{B'x_{nit}}}{\sum_j e^{B'x_{njt}}} \]
The unobserved component, i.e., distributed as IID Gumbel lead us to Logit model (individual n, alternative i and time t)

\[ R_n(\beta_n) = \prod_{t=1}^{T} L_{nit}(\beta_n) \]
Similar choices made on multiple time points are multiplied with each other. (individual n)

\[ P_n(\theta^*) = \int R_n(\beta_n) f(\beta_n|\theta^*) d\beta_n \]
The parameters \( \beta \) are assumed to be distributed IID based on parameter vector \( \Theta \). [We choose:

\[ \ell(\theta) = \sum_n \ln(P_n(\theta)) \]
The loglikelihood function.
Estimation

Assume

\[ \beta_{nk} \sim N(\mu_k, \sigma_k^2) \]
\[ \beta_{nk} = \mu_k + \sigma_k s_{nk} \]

\[ U_{ni} = \alpha_i + \sum_{k=1}^{K} \beta_{nk} x_{nik} + \epsilon_{ni} = \alpha_i + \sum_{k=1}^{K} \mu_k x_{nik} + \sum_{k=1}^{K} \sigma_k s_{nk} x_{nik} + \epsilon_{ni} \]

\[ \frac{V_{ni}}{\text{deterministic}} + \sum_{k=1}^{K} \sigma_k s_{nk} x_{nik} + \epsilon_{ni} \]
\[ \frac{V_{ni}}{\text{random}} + \sum_{k=1}^{K} \sigma_k s_{nk} x_{nik} + \epsilon_{ni} \]

\[ L_{nij} = \frac{e^{\alpha_i + \sum_{k=1}^{K} \mu_k x_{nik} + \sum_{k=1}^{K} \sigma_k s_{nk} x_{nik}}}{\sum_{j} e^{\alpha_j + \sum_{k=1}^{K} \mu_k x_{njk} + \sum_{k=1}^{K} \sigma_k s_{nk} x_{njk}}} \]

\[ R_n = \prod_{t} \frac{e^{V_{nit} + \sum_{k=1}^{K} \sigma_k s_{ntk} x_{ntkt}}}{\sum_{j} e^{V_{njt} + \sum_{k=1}^{K} \sigma_k s_{ntk} x_{ntkt}}} \]

\[ \log(\text{likelihood}) \]

\[ \log(L) = \sum_{n} \log \left( \int_{s_{n1}}^{\infty} \int_{s_{n2}}^{\infty} \cdots \int_{s_{nk}}^{\infty} \prod_{t} e^{V_{nit} + \sum_{k=1}^{K} \sigma_k s_{ntk} x_{ntkt}} d\Phi(s_{n1}) d\Phi(s_{n2}) \cdots d\Phi(s_{nk}) \right) \]

Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant (with respect to Transit Oriented Development and Car)</td>
<td>-0.07(0.01)</td>
<td>-0.07(0.01)</td>
</tr>
<tr>
<td>Travel Cost by mode (with respect to car)</td>
<td>-0.04(0.01)</td>
<td>0.05(0.02)</td>
</tr>
<tr>
<td>Travel Time by mode (with respect to car)</td>
<td>0.02(0.01)</td>
<td>0.08(0.02)</td>
</tr>
<tr>
<td>Dummy Variable Transfers for Bus (relevant for Transit Oriented Development)</td>
<td>-0.00(0.00)</td>
<td>0.02(0.06)</td>
</tr>
<tr>
<td>Distance to CBD (relative to Transit Oriented Development)</td>
<td>-0.02(0.009)</td>
<td>0.05(0.02)</td>
</tr>
<tr>
<td>Distance to Park, Recreation etc. activities (relevant for Transit Oriented Development)</td>
<td>-0.01(0.007)</td>
<td>0.04(0.02)</td>
</tr>
<tr>
<td>Distance to Restaurants and Shops (relevant for Transit Oriented Development and Compact City Development)</td>
<td>-0.02(0.01)</td>
<td>0.06(0.01)</td>
</tr>
<tr>
<td>Distance to Supermarkets (relevant for Transit Oriented Development and Compact City Development)</td>
<td>-0.02(0.007)</td>
<td>0.04(0.02)</td>
</tr>
<tr>
<td>Distance to Rail Station (relevant for Transit Oriented Development)</td>
<td>-0.02(0.01)</td>
<td>0.09(0.02)</td>
</tr>
<tr>
<td>Income (relative to transit oriented development, car option, i.e., the coefficient of this alternative is fixed to 0)</td>
<td>-0.01(0.01)</td>
<td>0.01(0.02)</td>
</tr>
<tr>
<td>Number of Four Wheeled Vehicles (relative to transit oriented development, car option i.e., the coefficient of this alternative is fixed to 0)</td>
<td>-0.03(0.01)</td>
<td>0.02(0.07)</td>
</tr>
<tr>
<td># of Household Members (relative to transit oriented development, car option i.e., the coefficient of this alternative is fixed to 0)</td>
<td>-0.02(0.002)</td>
<td>0.008(0.05)</td>
</tr>
</tbody>
</table>

Log Likelihood with only constant term=-2622.71
Log Likelihood at convergence full model=-2577.45
With respect to Log-likelihood Ratio Test (with 22 degrees of freedom), the model is significant at a value lower than 0.005.
Sample Size=303
Conclusions

- Increase of distance from relevant land uses affect residential choice such that if residential location is far away from relevant land uses individuals prefer to live in suburban setting. But if they are not far away, then the use of the public transit and its combination with accessibility to different land uses make household choose TOD and compact city environments.

- Travel cost when increased with respect to private car costs, household turn to private cars as their commuting mode of travel.

- But surprisingly travel time increase make people use transit option, which can only be explained by other psychological factors that are not captured by the current model, e.g., the frustration that might be caused by staying behind the steering wheel and wait in the midst of the congested roads. This is supportive for an argument that automobile is the best option for a moderate ranges in time (also take this in distance)...

Further Research

- In this study we have used simulation based on the normality of the parameter values; further research is needed on distributional assumptions of the parameters.

- The estimation is solely based on the stated intentions, the parameter values have to be weighted by the inclusion of the revealed preferences of the individuals. This requires the inclusion of the residential area properties of the households along with their actual living environments. The spatial separation of the sample is required with careful examination of the urban amenities.