Linking substantial accessibility improvements to housing market dynamics

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Outline

- Introduction to research setting
- SimMobility microsimulation platform
- Developing ‘car-lite’ neighborhoods
- Modeling housing dynamics
- Singapore example
- Implications and conclusions
Research setting

- MIT Department of Urban Studies and Planning
  - Urban analytics and urban information systems
  - New ‘urban science’ undergrad degree
- SMART Centre in Singapore
  - Singapore/MIT Alliance for Research and Technology
  - “Future Urban Mobility” interdisciplinary research group
- Collaborative research with
  - Primary MIT PhD researcher: Rounaq Basu
  - Co-PIs of “Future Urban Mobility”: Professors Chris Zegras & Moshe Ben-Akiva
  - SimMobility ‘long term’ research team, especially: MIT PhD’s Roberto Ponce Lopez, Shan Jiang, Yi Zhu, Postdocs Xiaohu Zhang, Meng Zhou, and NUS Professor Mi Diao

SimMobility microsimulation platform

- Three modules
  - Long-Term (LT): Days/months/years
  - Medium-Term (MT): Hours/day
  - Short-Term (ST): Seconds/minutes
- Activity-based LUTI model
- Integration of behavioral submodels with feedback

SimMobility: Long-Term (LT)

- Synthetic population generated for base year
- Long-term urban choices
  - Housing-mobility
  - Vehicle ownership
  - Employment, education
- MT integration through Logsum-based accessibilities

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Modeling mobility improvements

- **Traditional LUTI example**
  - Consider building new highway or transit line
  - Use LUTI model to simulate travel patterns, travel times, land use change for one or two decades

- **Our case: link rollout of mobility improvements to choices about housing relocation and vehicle ownership**
  - Focus on initial years of a new initiative
    - E.g., evaluate ‘car-lite’ neighborhood development
  - Compare neighborhood change +/- enhanced mobility services

Why focus on daily housing market dynamics?

- **CGE models show forces leading to long run equilibrium**
  - But they don’t simulate the possible paths along the way

- **LUTI models typically simulate multiple decades**
  - But many rules and practices can change along the way

- **New mobility technologies will first be tested in pilot projects**
  - Will ‘car-lite’ neighborhoods be effective, expensive, attractive...? To whom?
  - Household relocation needs attention
    - Housing market is reasonably open and can respond to changes much faster than (re)development and land use change
  - Initial experience will constrain implementation paths
    - E.g., roller coaster ride of dockless bikes and e-scooters
    - Adverse early experience could lead to constraining policy & regulation
Our Approach

- Modeling buyer / seller response to new mobilities
  - Convert mobility improvements into accessibility benefits
  - Focus on housing market at household / housing unit scale
  - Consider daily searching, pricing, and bidding behavior
    - Along with reconsideration of vehicle holdings
- Simulate pilot project rollout in a ‘study area’
  - Simulate daily housing market dynamics of buyer / seller interaction
  - Explore which study areas work best
    - Which neighborhood? what rules? what side-effects?
  - Start with plausible accessibility adjustments
    - Later on, simulate effects for specific places and mobility technologies

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Modeling Daily Housing Market Dynamics in SimMobility-LT

- Awaken Likelihood based on moving rates and ‘alerts’
- Bid based on willingness to pay submodel and consumer surplus calculation
- Asking price based on hedonic submodel
- Reassess vehicle, job, school

Simulating a ‘car-lite’ pilot project

- Measuring accessibility improvements
  - Begin with 2012 calibration of SimMobility for Singapore
  - Transport model (MT+ST) translates new mobility into accessibility measures
- Behavioral responses to accessibility improvements
  - Increased buyer awareness (choice set construction)
  - Increased buyer valuation (WTP model)
  - Increased seller asking price (hedonic market price model)
  - Increased buyer valuation of being vehicle-free (vehicle ownership model)
- Run market simulation for 365+ days
  - Does study area become more ‘vehicle-free’?
  - Who moves in/out of study area?
  - How sensitive are results to accessibility improvements?
  - How sensitive to characteristics of study area?
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Singapore
with major highways & landmarks (maps.google.com)

- Central Area
- Changi Airport
- Central Reserve
- Jurong Island

725 sq.km
5.7 m. persons
Singapore Population Density by Planning Area (people/ha)

Simulate 3 possible ‘Car-Lite’ Study Areas (with 4-7% of all housing in each study area)

Singapore SimMobility calibration

Data sources (2012 synthetic population & model calibration)
- Travel surveys (HITS 2008, 2012, 2016; LTA)
- Census (Singstat, MOM, …)
- Real estate transactions (REALIS & HDB 2000-2016)

Resolution and scale
- Households
  - 1.15m 'resident' households
  - 81.3% in public (HDB) housing
  - 4.1m of 5.1m individuals

Workstation performance
- 45 min/yr on 8 thread, 32 GB Windows-10 WSL2/Ubuntu
- 75 min/5-yr on 96 thread 64 GB Ubuntu

<table>
<thead>
<tr>
<th>Area</th>
<th>Count</th>
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<tbody>
<tr>
<td>Planning Regions</td>
<td>6</td>
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<tr>
<td>Planning Areas</td>
<td>55</td>
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<tr>
<td>Traffic Analysis Zones</td>
<td>1,169</td>
</tr>
<tr>
<td>Postcodes</td>
<td>116,624</td>
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</tbody>
</table>
‘Car-lite’ Scenario Assumptions

- Accessibility improvement
  - **For housing valuation:** assume logsum increase = fraction of the standard deviation across Singapore
  - **For vehicle ownership choice:** reduce car/no-car logsum gap by fraction of the average gap across Singapore

- Behavioral scenarios
  - **Scenario I:** Awareness only (increase in choice set likelihood)
  - **Scenario II:** Buyer valuation (willingness to pay, WTP, increases)
  - **Scenario III:** Buyer & Seller valuation (WTP and hedonic price increase)

- Vehicle ownership
  - All study area residents re-evaluate during simulated year
  - All movers re-evaluate vehicle holdings when they move

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Car-free response to accessibility improvement*

**Change in car-free percent by Scenario and ∆ Accessibility**
(Study area = Toa Payoh)
- Slight consistent drop for baseline
- Closing car-free gap motivates change
- But, market behavior diminishes net impact
  - When buyer / seller valuations respond (scenarios II and III), car-free effect drops
  - Why?

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Gentrification Effect

Percent change in Household income by Scenario and \( \Delta \) Accessibility (Study area = Toa Payoh)

for Scenarios II and III:

- In-movers have higher incomes than out-movers
- Higher income HHs much more likely to own a car
- Gap grows non-linearly with accessibility \( \Delta \)

Which neighborhood characteristics matter & how much?*

<table>
<thead>
<tr>
<th>Planning Area</th>
<th>HHs</th>
<th>Housing Units</th>
<th>Vacancy Rate (%)</th>
<th>Car-free (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toa Payoh</td>
<td>43,789</td>
<td>45,715</td>
<td>3.71</td>
<td>66.6</td>
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<tr>
<td>Pasir Ris</td>
<td>38,116</td>
<td>41,103</td>
<td>7.27</td>
<td>49.1</td>
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<tr>
<td>Punggol &amp; Sengkang</td>
<td>68,694</td>
<td>78,817</td>
<td>10.87</td>
<td>51.6</td>
</tr>
<tr>
<td>Singapore*</td>
<td>1,148,070</td>
<td>1,235,837</td>
<td>6.56</td>
<td>54.3</td>
</tr>
</tbody>
</table>

*Households with head as Singapore citizen or Permanent Resident

- Three study areas with varying vacancy and vehicle-free rates
- Market effects can reduce car-free gain by almost 50%
- ‘Mere’ mobility improvements aren’t enough
- Composition of housing inventory matters (!)

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What’s the “recipe” for ‘car-lite’ neighborhoods?

- Car-lite neighborhood design = Mobility + Housing policies (!)
  - Accessibility improvements can induce gentrification, which reduces car-lite gains
  - TRD paper compares paired combinations of vacancy / vehicle-free rates

- Simulating specific pilots with SimMobility LT-MT-ST integration
  - Other FM projects have explored specific Singapore projects using all three modules
  - E.g., adding fleets of AMOD vehicles with realistic size/price with/without private car restrictions
Ongoing Research

- Testing effectiveness of housing market interventions
  - Consider increasing housing supply within study area
  - Add housing that is attractive to HHs most likely to become vehicle-free
  - Provide a mix of affordable and market-rate housing units

- Preliminary results
  - Simply increasing supply moves further away from intended outcomes
    - Higher-income households still outbid for newly added housing
  - Providing targeted housing (with subsidies) could be effective

Policy Relevance of LUTI Modeling

- Takeaways regarding particular features
  - Realistic modeling of initial years of technology adoption
    - For some policies, early experience is crucial to acceptance
    - Especially important when behavior can change quickly long before land use change
  - Value of exploring real estate market dynamics at daily to yearly scale
    - Several types of behavioral changes are possible & trends are visible within a year
  - Agent-based LUTI modeling facilitates relevant programming
    - But, computational intensity is still considerable

- Need for synthetic population development / maintenance
  - Often overlooked, private, unreproducible, insufficiently heterogeneous

- Importance of open data, tools, sandboxes
  - With appropriate privacy protections and benchmark datasets
  - ‘Virtual City’ construction and use described in forthcoming JTLU paper
Questions?

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Collaborative research with
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• Co-PIs of “Future Urban Mobility”: Professors Chris Zegras & Moshe Ben-Akiva
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