AUM2020: Applied Urban Modeling 2020 - Modeling the New Urban World
Session 7 (Nov. 9, 2020) - Urban mobility: now and future

Linking substantial accessibility improvements to housing market dynamics

Prof. Joseph Ferreira, Jr.

Department of Urban Studies and Planning
Massachusetts Institute of Technology

Outline

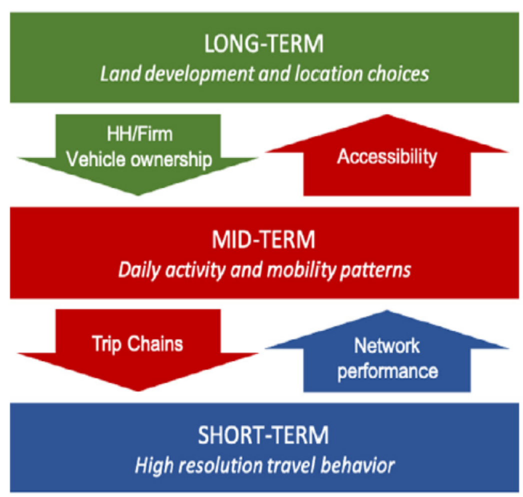
- Introduction to research setting
- SimMobility microsimulation platform
- Developing 'car-lite' neighborhoods
- Modeling housing dynamics
- Singapore example
- Implications and conclusions

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



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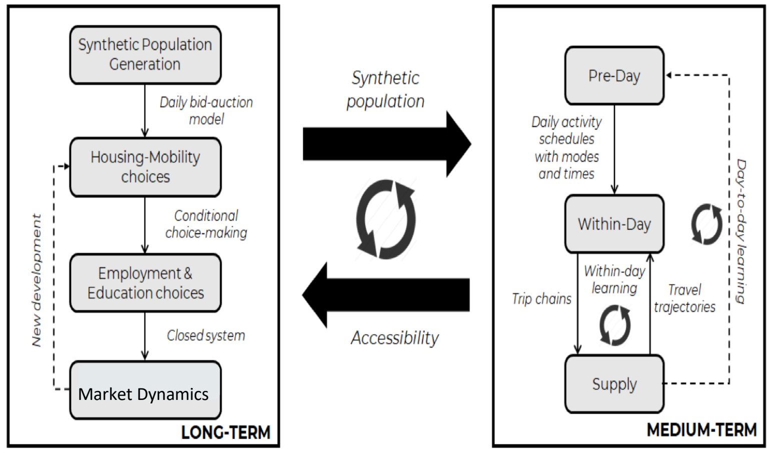
SimMobility: Long-Term (LT)

- 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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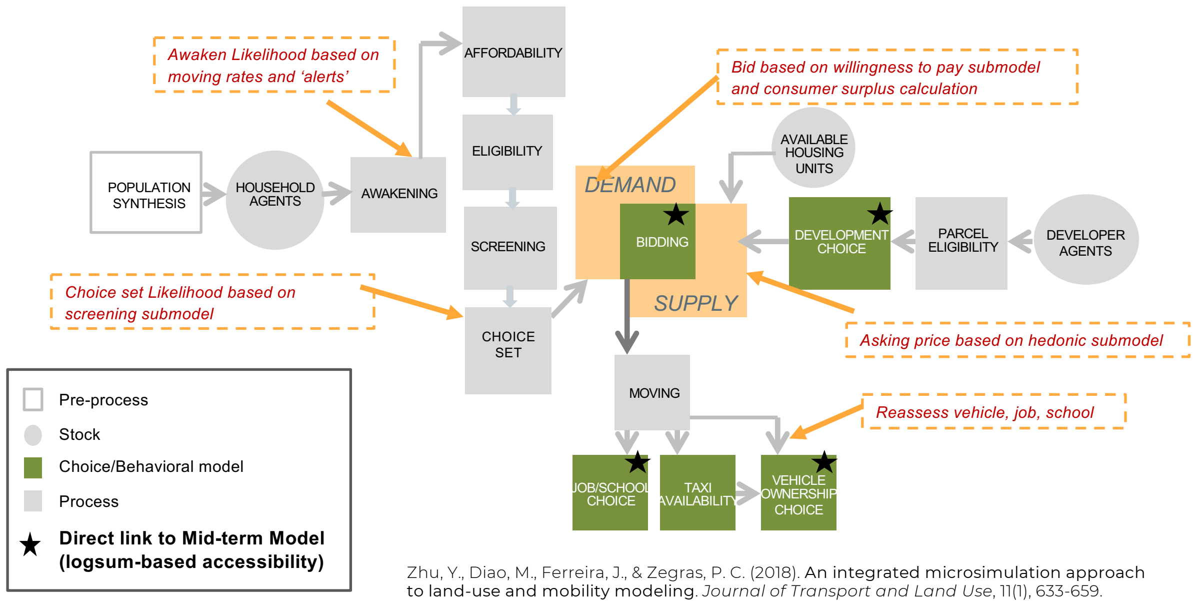
Modeling Daily Housing Market Dynamics in SimMobility-LT



Zhu, Y., Diao, M., Ferreira, J., & Zegras, P. C. (2018). An integrated microsimulation approach to land-use and mobility modeling. *Journal of Transport and Land Use*, 11(1), 633-659.

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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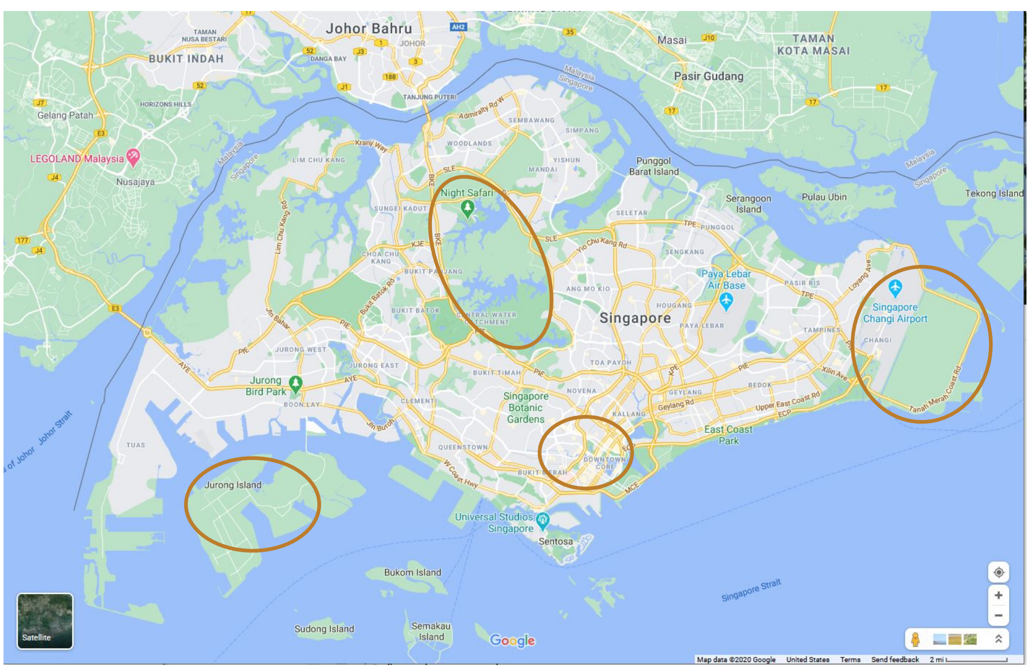
Singapore

with major highways
& landmarks
(maps.google.com)

725 sq.km
5.7 m. persons

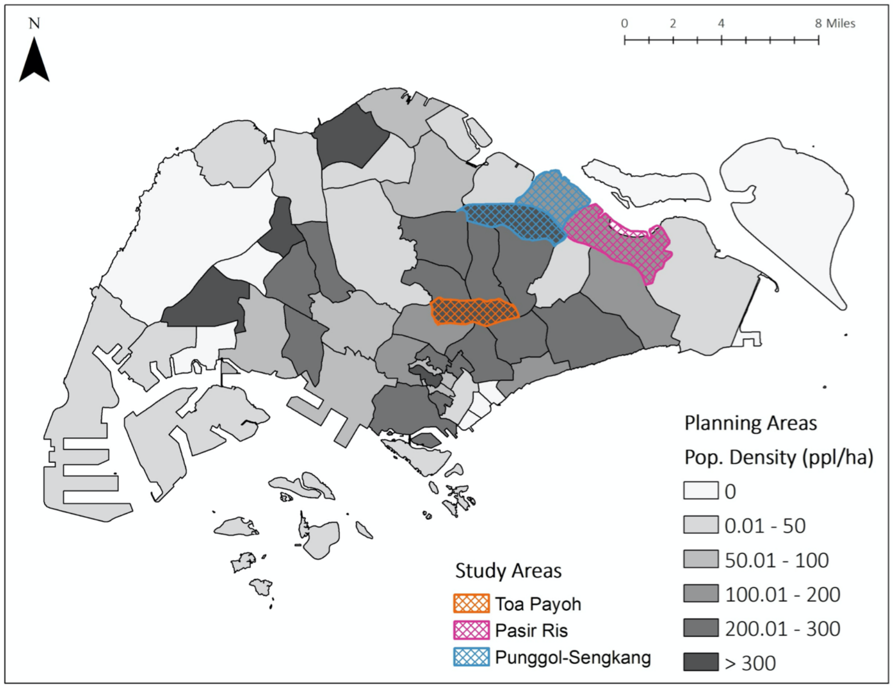
- Central Area
- Changi Airport
- Central Reserve
- Jurong Island



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, ...)
- Built environment (SLA 2008, 2012, 2016; URA)
- 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

Area	Count
Planning Regions	6
Planning Areas	55
Traffic Analysis Zones	1,169
Postcodes	116,624

Workstation performance

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

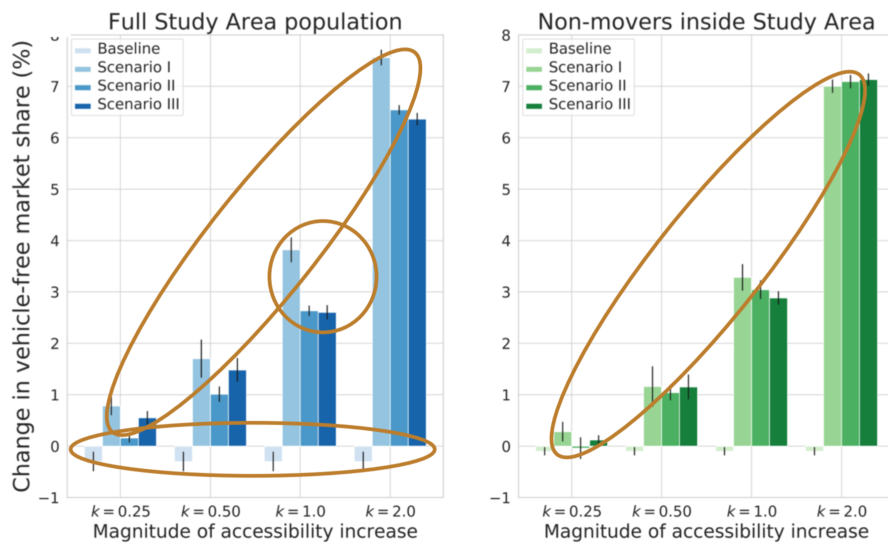
‘Car-lite’ Scenario Assumptions

- 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

Car-free response to accessibility improvement*

Change in car-free percent
by
Scenario
and
Δ 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?



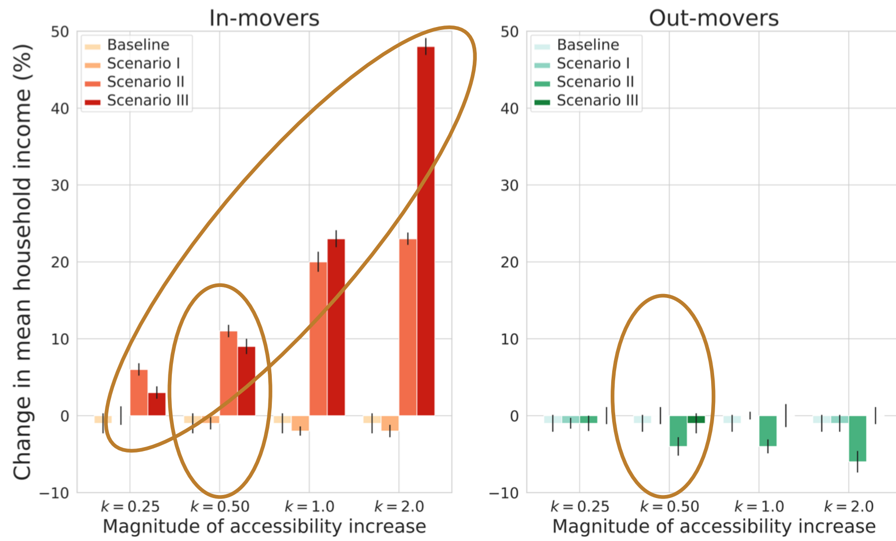
* Basu, R., & Ferreira, J. (2020). A LUTI microsimulation framework to evaluate long-term impacts of automated mobility on the choice of housing-mobility bundles. *Environment and Planning B: Urban Analytics and City Science*, 2399808320925278.

Gentrification Effect

Percent change in Household income
by
Scenario
and
Δ 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 Δ



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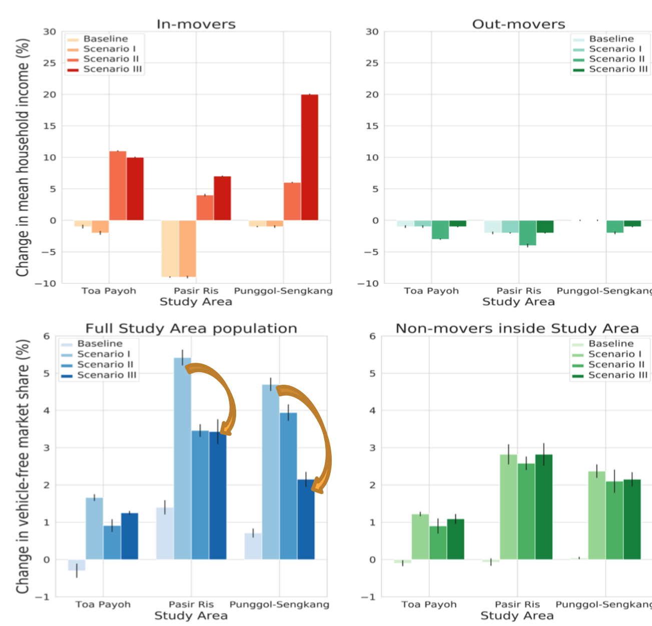
Which neighborhood characteristics matter & how much?*

'Car-Lite' Study Areas

Planning Area	HHs	Housing Units	Vacancy rate (%)	Car-free (%)
Toa Payoh	43,789	45,715	3.71	66.6
Pasir Ris	38,116	41,103	7.27	49.1
Punggol & Sengkang	68,694	78,817	10.87	51.6
Singapore*	1,148,070	1,235,837	6.56	54.3

*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
    - Basu, R., & Ferreira, J. (2020). Planning car-lite neighborhoods: Examining long-term impacts of accessibility boosts on vehicle ownership. *Transportation Research part D: transport and environment*, 86, 102394.
- 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, unreproducable, 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
    - Basu, R., Lopez, R.P., & Ferreira, J. (2020). A framework to generate virtual cities as sandboxes for LUTI models. *Journal of Transport and Land Use*. In proof.

Questions?

Joseph Ferreira and Rounaq Basu
< jf@mit.edu > < rounaq@mit.edu >

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Collaborative research with

- Primary MIT PhD researcher: Rounaq Basu < rounaq@mit.edu >
- Co-PIs of "Future Urban Mobility": Professors Chris Zegras & Moshe Ben-Akiva
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