California Center for Population Research

University of California - Los Angeles

Agent Models and

Demographic Research

Robert D. Mare

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**Agent Modeling vs. Business as Usual
in Demographic Research**

Agent models
are inherently more complex than standard multivariate models

relax the assumption of independent and identically distributed (random) observations

relax the assumption that specific demographic rates are independent of population composition

Interdependent Behaviors

Fertility, Mortality, Migration, Marriage, etc.

The rate at which you do it depends on how many and which other people are doing it.

(vs. classic approach in which the rate at which you do it depends only on your own characteristics.)

Examples of Population-Dependent Rates

1. Classic Macro Models of "Controlled" Populations
   (Lee, Easterlin, Samuelson, Malthus)
   (vs. stable models)

2. Residential Choice "Interactive" Markov Models
   (Conlisk, Bruch-Mare, others)
   (vs. Markov models, such as Leslie matrix)

3. Epidemics
   (Epstein, Morris, Moody, others)

Examples of Population-Dependent Rates

4. Diffusion of Demographic Innovations

European Fertility Decline (Coale et al.)

Language acquisition, maintenance, loss (Lieberson, Feldman & Cavalli-Sforza)

5. Endogenous Policies

- **Policing and crime**

- **Public health intervention and disease**

Examples of Population-Dependent Rates

6. Policy effects where migration may be induced: e.g., welfare-magnet effects; homeless policy effects, etc.

7. Incarceration, crime, wages, victimization, neighborhood poverty, socialization (elaborated prey-predator model) (Western)

8. Formation of social units

Marriages (assortative mating)

Neighborhoods (Schelling, Bruch-Mare, Macy)

Peer Groups

Networks (Moody, others)

Kin, "kin availability," social exchange
(jointness of social relationships and
spatial arrangements of kin)

Issues

    Theory, thought experiments, empirical work

    Agent models are inherently complex

    Give agents "real demography" (Lee, Axtell et. al.)
        Life cycles, aging, fertility, mortality,
        intergenerational transmission

    Time horizons
        Eons (Lee, Axtell et al.)
        "Timeless" problems (Bruch-Mare, Macy)
        What about finite periods (e.g., adolescence)?

    How do we know how agents ought to act? (Stated
     vs. revealed preferences vs. make it up)

	Hypothetical	Empirical
Simple	A	B
Complex	C	D

Issues (continued)

Importance of aggregate data for "calibration"
descriptive demography still matters

Multi-actor models
Buyers, sellers, and real estate agents
Men, women, matchmakers
Adult children, elderly parents
Multiple influencers (parents, teachers, peers)
Multiple deciders (parents, students, colleges)

How smart should agents be? Can they learn??

Issues (continued)

**Can we combine studies of "outcomes"
with studies of how social environments
are created?**

**neighborhood effects
family structure effects
school effects
family background effects**

Neighborhood Choice and Neighborhood Change

Elizabeth E. Bruch and Robert D. Mare

Broad Goals:

• Investigate how inequality is affected by spatial arrangement of population.

• Investigate neighborhood effects when residential location is endogenous.

• Explain and forecast residential segregation.

• Investigate the relationship between geographic and social mobility.

Two Approaches

1. Residential Mobility and Neighborhood Change in L.A.

    -Uses real data on actual mobility and residential demography

2. Artificial Neighborhoods and Computational Models

    - Investigates general principles about the effects of residential preferences and population composition on neighborhood change.

    -Extends Schelling's work on residential tipping to
    - multi-ethnic cities
    - larger cities
    - residential sorting based on race and income

Our Research

1. Develop a model of geographic mobility and neighborhood change

2. Link individuals' mobility decisions to their preferences for neighborhoods with varying race-ethnic makeup.

3. Link the changing race-ethnic makeup of neighborhoods to mobility flows.

4. Let the mobility decisions of each individual potentially alter the attractiveness of neighborhoods for all other individuals.

Empirical Approach

Los Angeles Survey of Families and Neighborhoods (residential mobility history)

- **Actual Mobility vs. Stated Preferences**

- **Mobility in a Plausible Local Residential Opportunity Structure**

- **Discrete Choice Model**

Neigh. Choice = F(Neigh. Char. x Indiv. Char.)

- **Use estimated choice function to predict movement between real neighborhoods (L.A. Census Tracts). (Interactive Markov Chain)**

Problems:

1. So much data, so many possible regressions….

2. What properties of choice function are particularly consequential for neighborhood change?

Schelling

- Simple threshold model
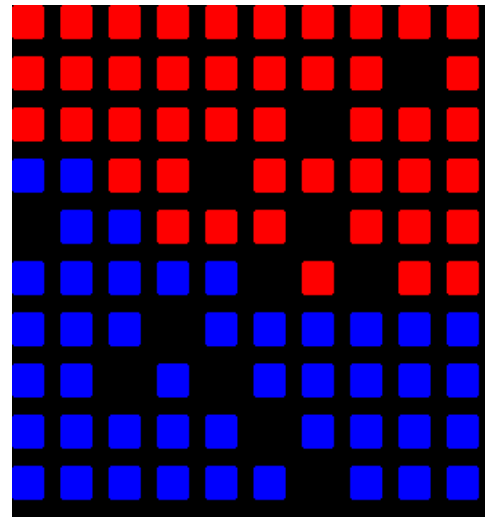- Even mild preferences for own race produce high segregation
- Residential tipping

                              But…

- Small world; 2 groups
- Hypothetical preference function; unrealistic assumptions about individual behavior

Schelling's Model
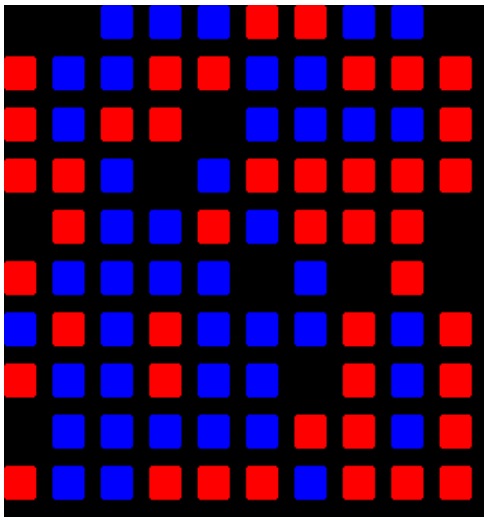
Start

End

Typical Problems with ABMs

- **Models are often assumed without (a) empirical validation and (b) investigation of how alternative assumptions about individual behavior affect macro-level outcomes**

Questions

1. What assumptions about individuals' race/ethnic preferences imply tipping?

2. Do data on preferences support these assumptions?

Choice Model

1) Random Utility (McFadden)

- $$U_{ijt} = F(Z_{jt}, X_{it}, \eta_{jt}, \varepsilon_{it})$$

- $$p_{ijt}(Z_{jt}, X_{it}, C_{(i)}) = \frac{\exp(\beta_i^* Z_{jt} + \delta Z_{jt} X_{it} + \eta_{jt})}{\sum_{k \in C_{(i)}} \exp(\beta_i^* Z_{kt} + \delta Z_{kt} X_{it} + \eta_{kt})}$$

Special Features of Residential Choice
 (a) "Inertia" (pref. for current residence)
 (b) Restricted Choice Sets
 (c) Preference Heterogeneity
 (d) Size Restrictions on Neighborhood
 (e) Endogenous Prices
 (f) Dynamic Effects of Neighborhoods
 (g) Dynamic Effects of Biography

Schelling Preference Function

$$\text{Pr(moving into the } j^{th} \text{ neighborhood at time t)} = \frac{X_{jt}}{\sum_{k=1}^{K} X_{kt}}$$

$$X_{jt} = 1 \bullet \{\text{neighborhood proportion own group } \geq 0.5\}$$

Continuous Function
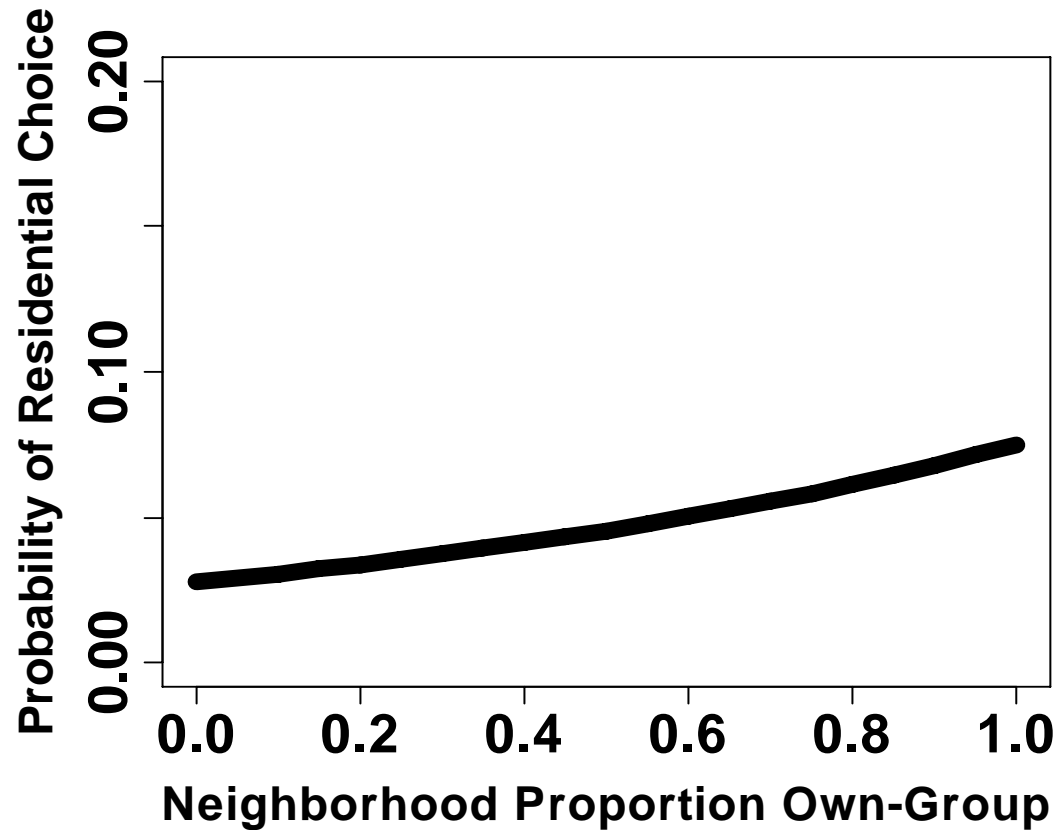
$$\text{Pr(moving into the } j^{th} \text{ neighborhood at time t)} = \frac{e^{q_{jt}}}{\sum_{k=1}^{K} e^{q_{kt}}}$$

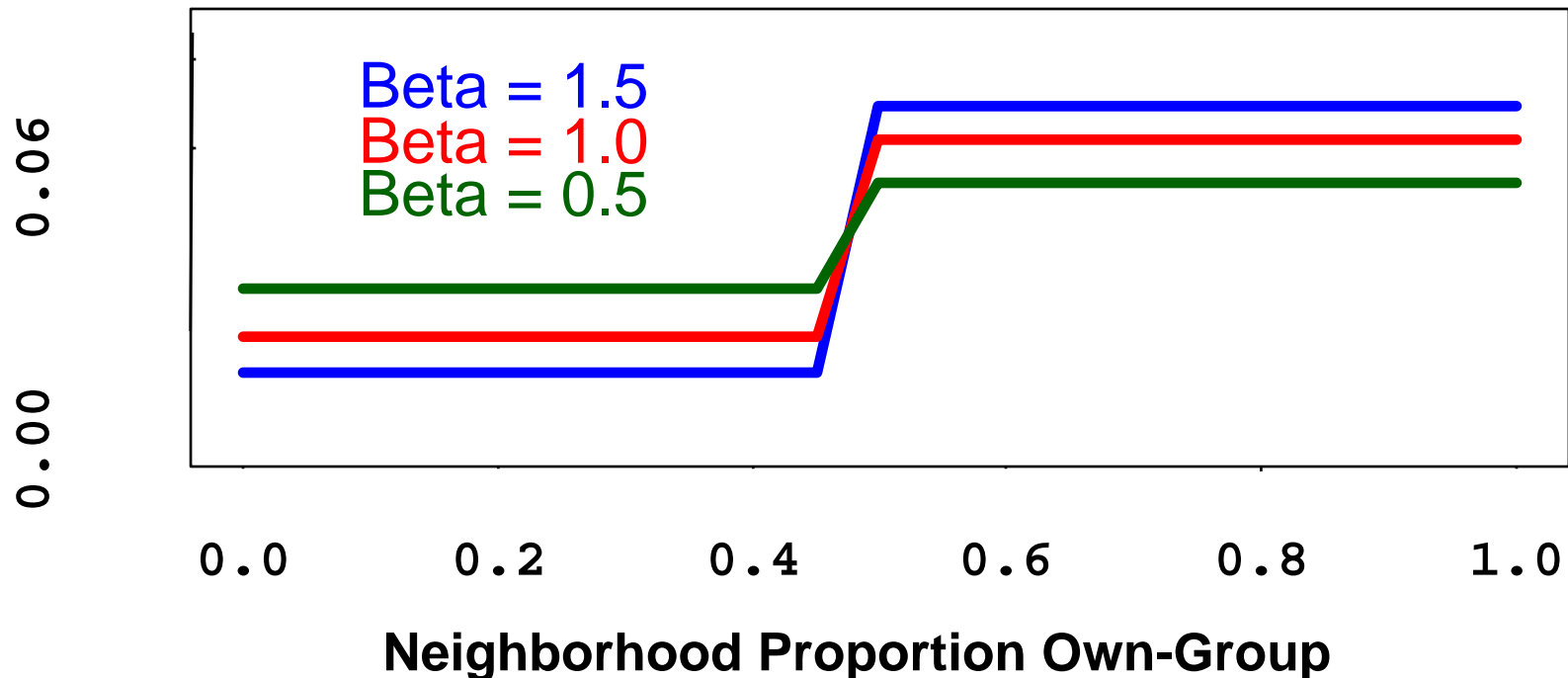q_{jt} = proportion own group in neighborhood j at time t

Individual Heterogeneity

$$\text{Pr}(i^{th} \text{ agent moves to the } j^{th} \text{ neighborhood at time t}) = \frac{e^{\beta_i * X_{ijt}}}{\sum_{k=1}^{K} e^{\beta_i * X_{ikt}}}$$

where $X_{ijt} = 1 \bullet \{\text{neighborhood j proportion own group} \geq 0.5\}$
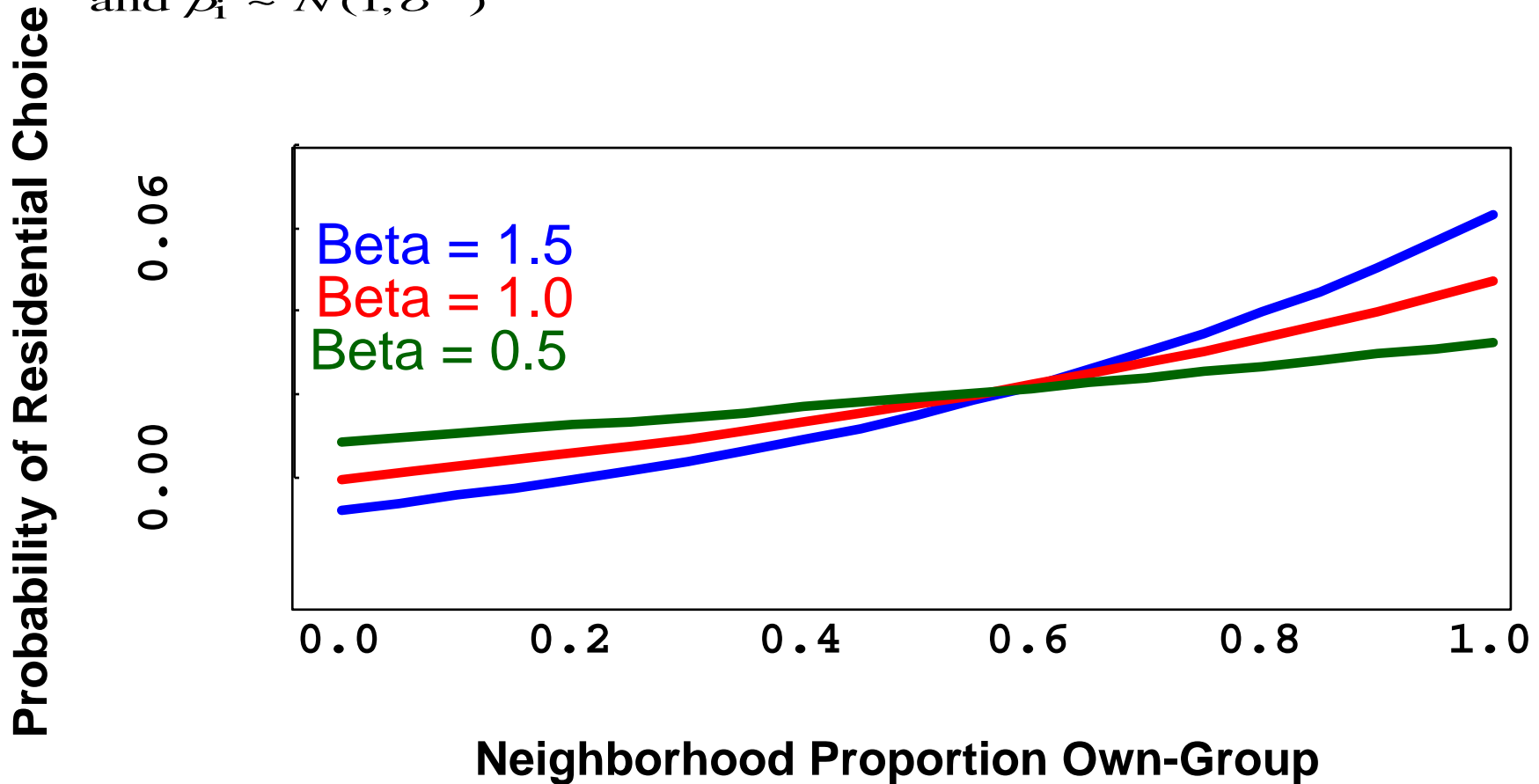
and $\beta_i \sim \mathcal{N}(1, \sigma^2)$

Continuous Function, Individual Heterogeneity

$$\Pr(i^{th} \text{ agent moves to the } j^{th} \text{ neighborhood at time t}) = \frac{e^{\beta_i * q_{ijt}}}{\sum_{k=1}^{K} e^{\beta_i * q_{ikt}}}$$
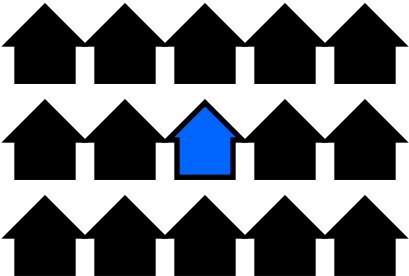
where q_{ijt} = proportion own group in j^{th} neighborhood at time t
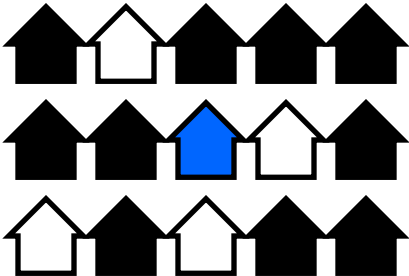
and $\beta_i \sim N(1, \sigma^2)$

Beta = 1.5
Beta = 1.0
Beta = 0.5

Probability of Residential Choice

0.06

0.00

0.0   0.2   0.4   0.6   0.8   1.0

Neighborhood Proportion Own-Group
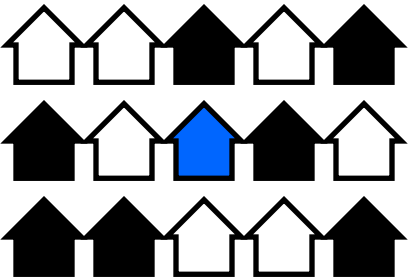
Segregation Measures, Modified Schelling Preference Function

Black-White Index of Dissimilarity
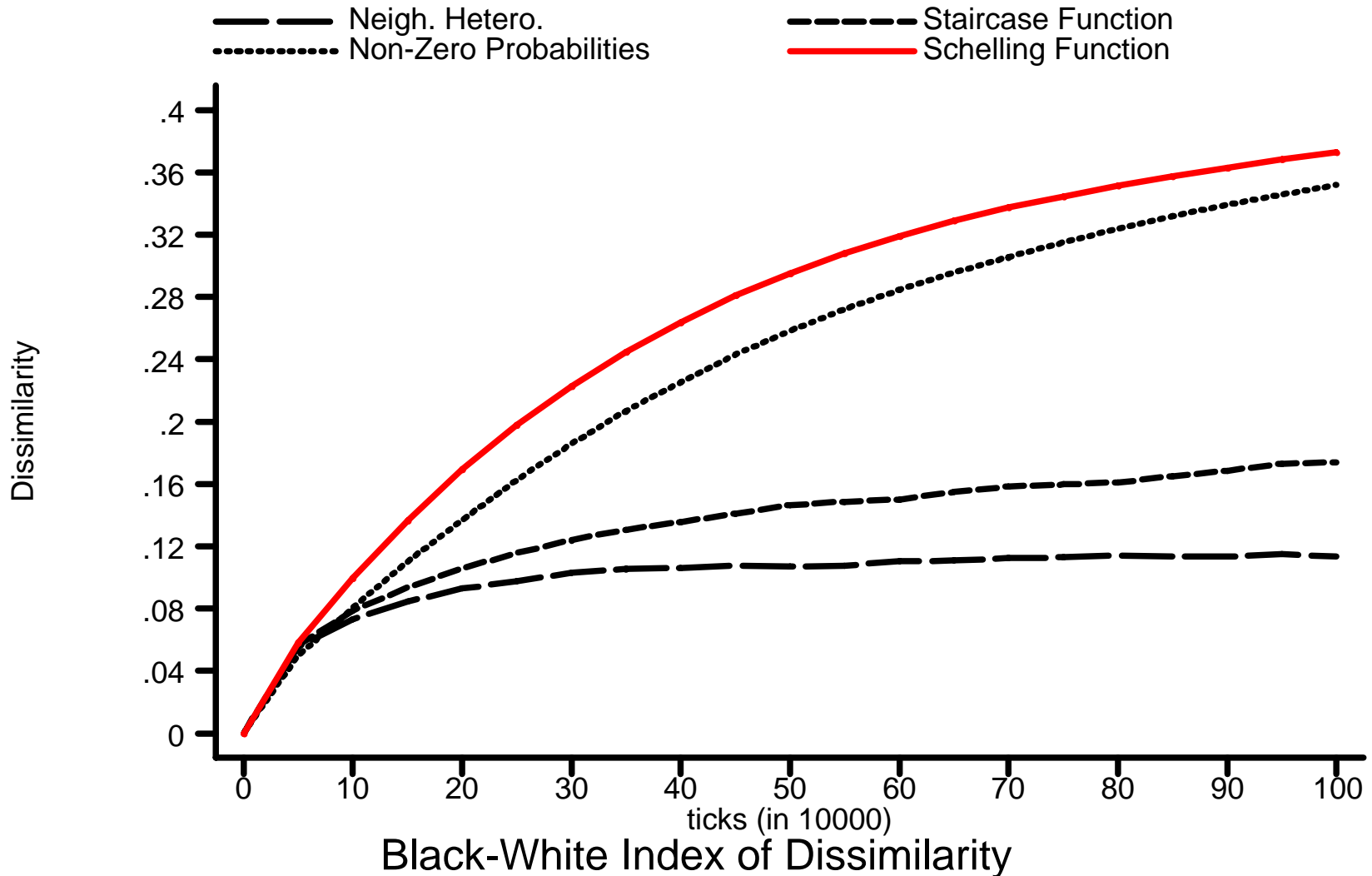
Vignette Data -- DAS, MCSUI
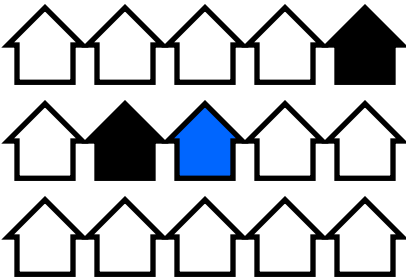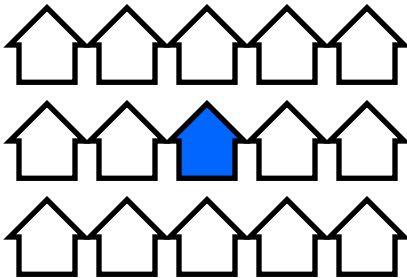
Empirical Functions, 1970s and 1990s
a) Utility Functions for Whites

- MCSUI 1990s
- DAS 1970s

Probability of Choice

Neighborhood Proportion White
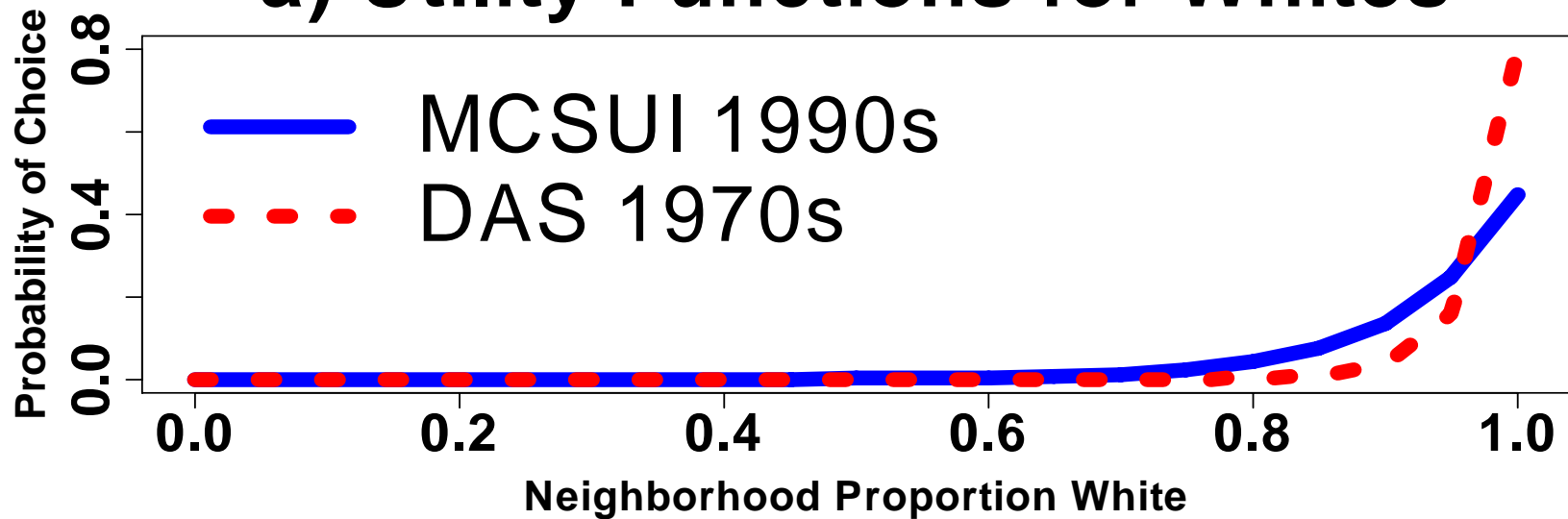
b) Utility Functions for Blacks

- MCSUI 1990s
- DAS 1970s

Probability of Choice

Neighborhood Proportion Black
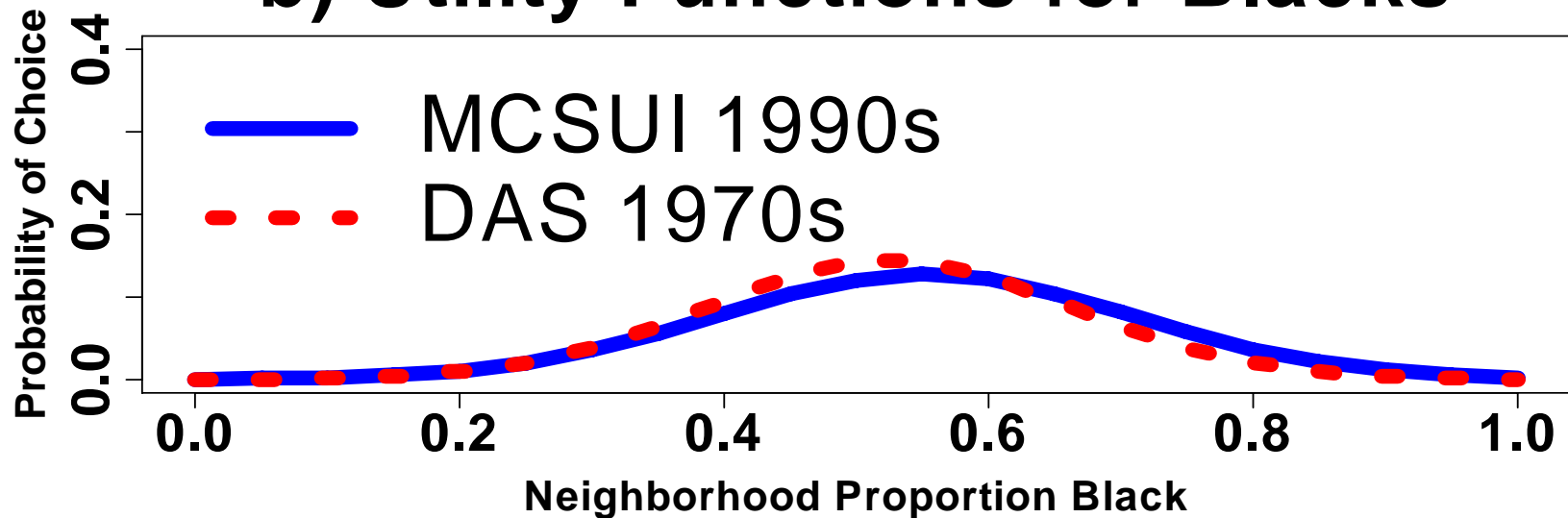
Continuous Functions May Result in Low Segregation

• Small inflows of whites to minority white area make neighborhood increasingly attractive to whites. Neighborhood whitens *until whites in other neighborhoods are too few to create a large flow.*

• Growing neighborhood attractiveness eventually offset by dwindling population at risk to entering neighborhood (and increasing population at risk to exiting).

Threshold Functions Maintain High Segregation

• With threshold models, small change in proportion own group may not be enough to increase neighborhood attractiveness.

• Neighborhoods stabilize at either zero or low proportion minority group.

Random Variability and Segregation

Whether Continuous Choice Functions for Individuals Lead to Low or High Segregation Depends on Degree of <u>Randomness</u> in Mobility Process

High randomness implies low segregation; Low randomness implies high segregation

Schelling's Model is (essentially) deterministic because neighborhoods with high own group proportion are an "absorbing state."

Next Steps

- Design an agent-based model that is grounded in real world data on residential mobility and neighborhood change, and use it to simulate patterns of neighborhood change in race and income composition

- Develop statistical methods to assess how well this model captures trends in patterns of segregation and neighborhood turnover

- See Bruch (in progress)

The Effects and Causes
of Mixed Income Housing
(R. D. Mare and SSRC-MacArthur Mixed Income Research Design Group)

Policies

- o **Redevelop Low Income to Mixed Income Housing (bring nonpoor to poor – but displace some poor)**

- o **Housing Assistance Via Vouchers (bring poor to nonpoor – but possible nonpoor "flight"?)**

Issues

- Effects vs. Causes
    - Does income mixing have beneficial effects?
    - Is income mixing inherently desirable?
    - Is income mixing possible?

- Mixed Income Housing vs. Mixed Income Neighborhoods

- Policy Effects vs. Baseline Patterns of Income Mixing/Segregation

Elements of Baseline Model:

o **Cross Section Patterns of Income Segregation**

o **Rates of Residential Mobility Among Neighborhoods (by poor and nonpoor)**

o **Rates of Socioeconomic (Income) Mobility**

o **Equilibrium Income Segregation Implied by Mobility Rates**

o **Residential Mobility = F(income, neighborhood income composition, life cycle factors, market factors)**

o **Income Mobility = G(life cycle factors, neighborhood factors)**

Complications

- Immigration

- New Construction

- (Endogenous and Exogenous Social Policies)

- Social Factors (Race, Discrimination, Incarceration)

Data Needs

o **Cross Section Observations on Spatial Distribution of Income**

o **Longitudinal Observations on residential choice/mobility and income mobility**

Elements of a rudimentary "Policy Model"

- 2 "treatments"
    - Mixed income redevelopments
    - Housing assistance vouchers

- 2 kinds of people
    - Low income
    - Middle/high income

- initial conditions (low income developments, no vouchers, "natural" income mixing/segregation)

Baseline Pattern of Income Segregation

L		**L**			

L		**L**			

M	M	M	M	M	M
M	M	M	M	M	M
M	M	M	M	M	M
M	M	M	M	M	M
M	M	M	M	M	M
M	M	M	M	M	M
M	M	M	M	M	M
M	M	M	M	M	M
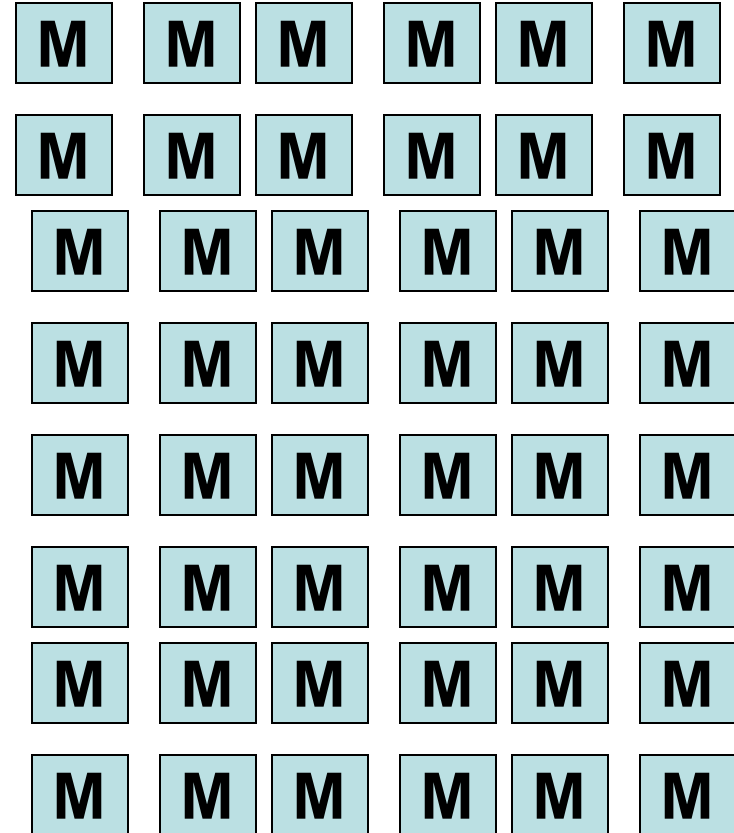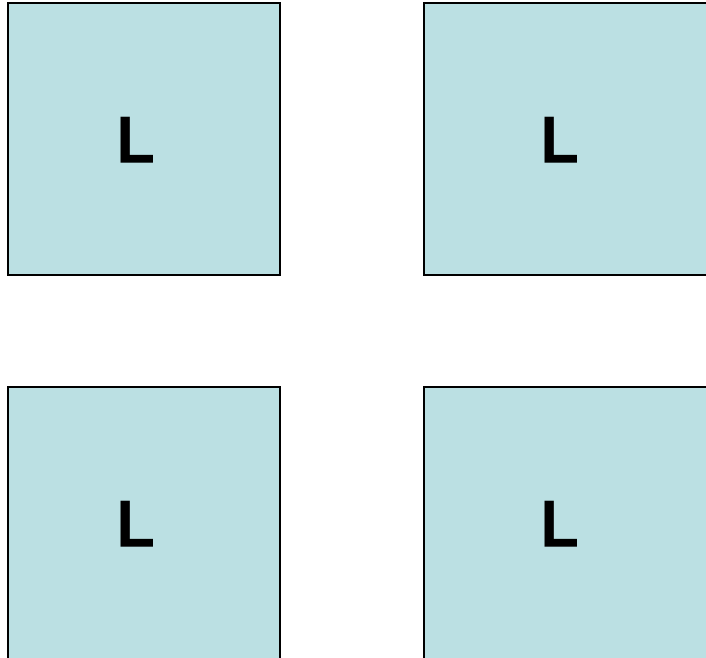
- mixed income redevelopments
  - displacement of (some) low income residents
  - attraction of middle income residents

- vouchers
  - mobility from low income developments to mixed income neighborhoods
  - "flight" by (some) middle income residents

Income Segregation with Mixed Income Redevelopment and Vouchers
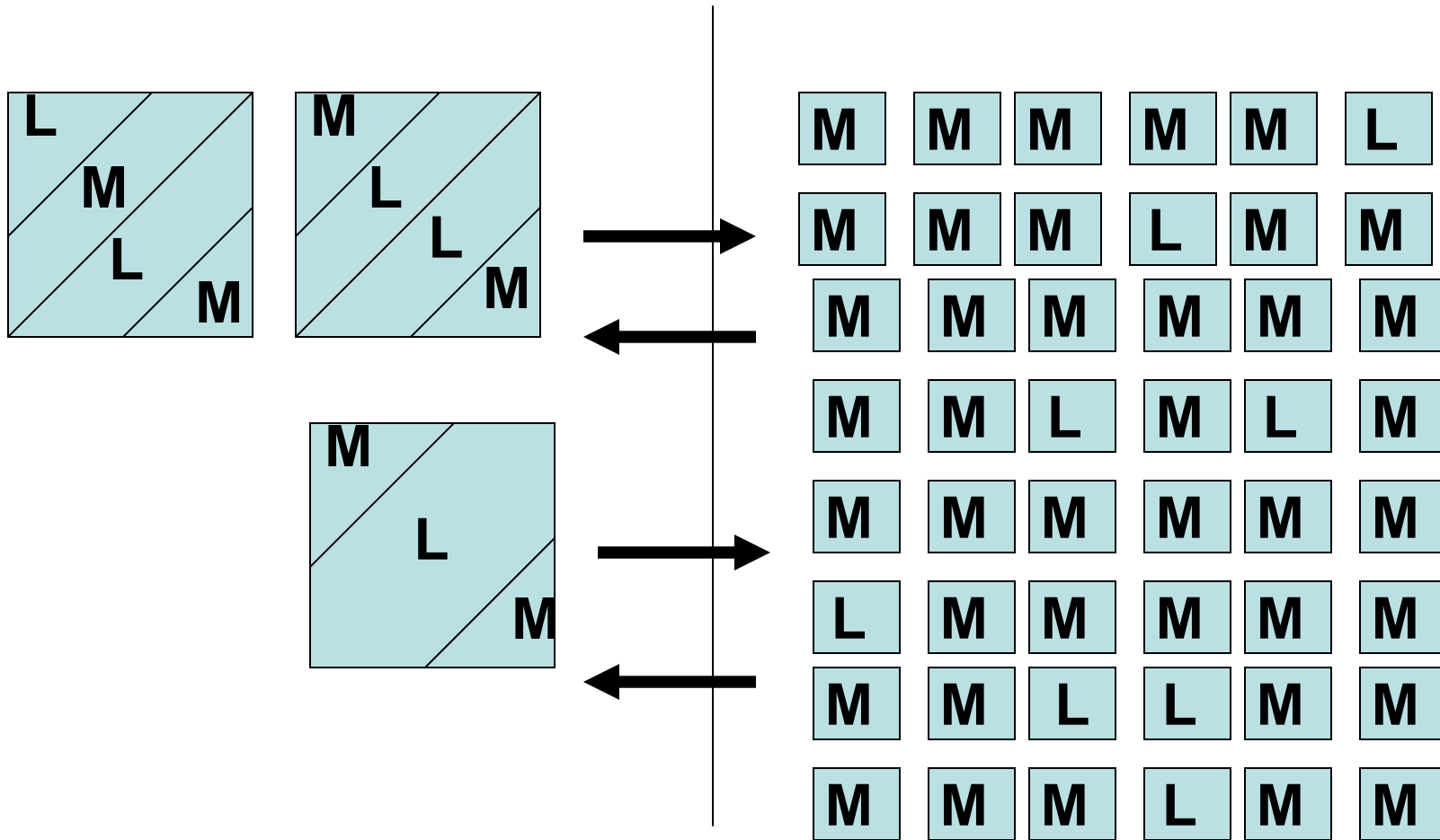
Income Segregation with Mixed Income Redevelopment, Vouchers, and Homelessness

(homeless??)