Public Housing Market Design

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August 18, 2022

Outline

Place-Based Affordable Housing

- Housing is a basic need, and a large expense
  - Low-income households spend highest shares of income on rent
  - Concerns about high rent burdens, homelessness, low housing quality
- Interactions with many important markets
  - Access to schools; jobs; health care
  - Neighborhood environment, crime, social network
- Many countries provide subsidized housing to lower-income households
  - "Public housing" or "social housing": subsidy tied to a specific unit
  - Waitlists ration overdemanded slots

Goals for this Talk

- Study public housing allocation as a market design problem
  - How to ration a heterogeneous in-kind transfer
  - Planner may value redistribution as well as efficiency

- Agenda for today:
  1. Dynamic assignment mechanisms
     - Design trade-offs depend crucially on empirical quantities
  2. Public housing institutions
     - U.S. program and design problem; comparison to other countries
  3. Revealed preference analysis of waitlist mechanisms
     - Preferences over both final assignments, and waiting times
     - Not covered: estimating treatment effects (Van Dijk '19)
  4. Empirical application to Cambridge, MA

Outline

Departure from Static Framework

- Thus far: all agents on both sides of the market are present at the same time
    - Preferences can be elicited before any matches formed
    - Strong theoretical results: stability, strategy-proofness, Pareto efficiency
    - Strategic incentives determined by distributions of final assignments
- Now: timing is an essential aspect of the allocation problem
    - Public housing, organs, child adoption, medical care, hunting licenses
- Key features:
    1. Stochastic arrivals on both sides of the market
    2. Time-sensitive allocation: one side must be allocated quickly
    3. Assignments are permanent – limited future trading opportunities
    4. Extreme scarcity. Not all agents can be matched

  Some agents on one side of the market have to wait $\Longrightarrow$ **waiting lists**

Dynamic Assignment Model

- **Arrivals:** objects j and agents i, Poisson rates λ, μ, with $\lambda < \mu$
  - Objects: public housing units vacated by previous tenants
  - Agents: households apply for benefits
  - Objects must be allocated immediately; agents can wait
- **Departures:** waiting agents depart exogenously at Poisson rate δ
  - Public housing applicants become unresponsive
  - Plays "market clearing" role
- **Agent values** $v_{ij} \sim F_{ij}(.)$. Private information
  - Common discount rate ρ: future assignments valued at $e^{-\rho t} v_{ij}$
  - No direct waiting cost
  - Objects do not have preferences

Design Considerations

Design Considerations

- Utilitarian welfare criterion

$$W(\mu) = E_\mu[v_{ij} \mid \text{j allocated to i}]$$

  where $v_{ij} \equiv 0$ if object unassigned
  - Planner wants to find highest-value agent for each object
  - Waiting times do not enter SWF (why?)

- Less focus on axiomatic properties in one-sided dynamic assignment
  - Stability less of a concern. Strategy-proofness unlikely to be satisfied

- **Dynamic incentives** for agents on the side of the market that can wait
  - Reports to mechanism determine not only what you get, but when

- **Stochastic arrivals** of agents and objects
  - Time-sensitivity limits planner's ability to hold out for a good match

Mechanisms

- Examples of **priority rules** for offering an object when it arrives
  - **First Come, First Served (FCFS):** earliest arrival first
  - **Last Come, First Served (LCFS):** most recent arrival first
  - **Service in Random Order (SIRO):** randomly generated order
  - Order applicants by observed characteristics (e.g. veterans, homeless)

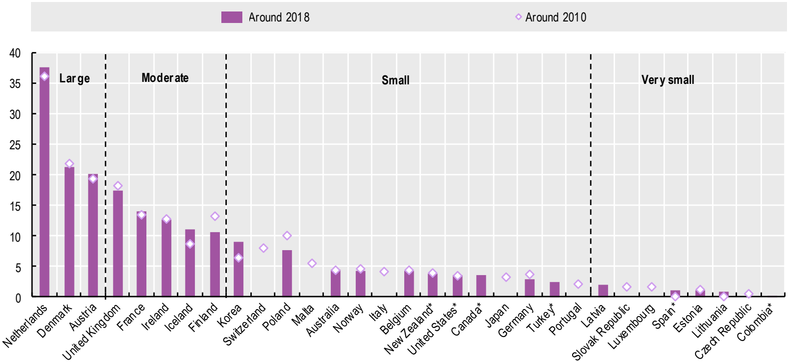
- Examples of **choice rules** for agents
  - **Sequential Offers:** May decline offered items without penalty
    - May wait for a more preferred item
  - **Ex-Ante Choice:** Removed from waitlist after declining an item
    - **Choose One:** only receive offers from chosen development
    - **No Choice:** offered whichever unit is available
    - Generally: a subset of developments from which to receive offers

Design Trade-Offs and Role of Empirics

- The relative performance of mechanisms depends on agent preferences
- **Horizontal:** $v_{ij} \overset{iid}{\sim} F(.)$
  - FCFS w/o rejection penalty preferred by all agents (Bloch & Cantala '17)
  - Encourages agents to only accept offers with high match values
- **Persistent Agent Heterogeneity:** $v_{ij} = \eta_i + \epsilon_{ij}$, $\epsilon_{ij} \overset{iid}{\sim} F(.)$, $\eta_i \sim G(.)$
  - Trade-off between finding good matches and matching high-need agents
  - LCFS or rejection penalties may "screen out" low-need agents
  - Depends on shape and support of $F(.)$, $G(.)$ (Arnosti & Shi '20)
- Limited guidance from theory on optimal waitlist design for general preference distributions

Outline

Common Features of Public Housing Systems



- 6% of OECD housing stock (28 million units)
- Place-based assistance: rent subsidy tied to living in a specific unit
- National programs, local administration and allocation rules
- Demand from eligible households exceeds supply

U.S. Public Housing Program

- Federal government spends ≈\$50 billion/year on affordable housing
  - \$10 billion goes to public housing, serving 1.1 million households
  - Half of tenants elderly/disabled. Average income \$15,000/year
  - Federally funded but administered by local housing authorities (PHAs)
  - Estimated 1.6 million households on public housing waitlists in 2013
- Reasons for scarcity (hence rationing):
  1. Broad eligibility: below 80% Area Median Income (AMI)
  2. Generous benefits: tenants pay 30% pre-tax income toward rent
     - Entitled to continued assistance only once admitted
  3. Fixed supply: new public housing not built
     - Vouchers, section 8, and LIHTC also rationed due to limited funding
- Local public housing authorities (PHAs) do not control these rules

Application Process

- Application process (applicant's perspective)
  - Submit household information to housing authority
    - Determines priority, eligible units (# bedrooms, developments)
  - Choices usually made at initial application
    - Subset of (unranked) developments from which to receive offers
  - Wait. Lists ordered by priority group, FCFS tiebreaking
  - Screening: eligibility and priority verified near top of waitlist
  - Unit offer: rejections penalized
  - Limited ability to transfer after accepting an offer

$\Longrightarrow$ Static, forward-looking decisions

- Contrast with sequential offer mechanisms used elsewhere
  - NYC LIHTC; Amsterdam public housing; UK council housing

$\Longrightarrow$ Dynamic discrete choice problem

Examples of Mechanisms

- Major differences along two dimensions
  - Choice: whether applicants can select which units to be offered
  - Priority: economic vulnerability, SES

- Seattle Housing Authority
  - **Choice:** List up to 3 developments ex-ante. Must accept first offer
  - **Priority:** Homeless and below 30% AMI

- Los Angeles Housing Authority
  - **Choice:** Must accept first or second offer from any development
  - **Priority:** Working/studying or economically "self-sufficient" households

- Boston Housing Authority
  - **Choice:** May wait for any subset of developments
  - **Priority:** Detailed scoring rule

Trade-Off Between Efficiency and Redistribution

- Scarcity motivates directing public housing to those most in "need"
- Compare two choice systems common in U.S. cities
  - **Choose One**: applicants choose one development to wait for
    - New York City, Seattle, New Haven, Cambridge
    - Good match quality: can wait for preferred option
  - **No Choice**: applicants offered first apartment. Rejection penalty
    - Los Angeles, Miami, Minneapolis
    - Lower match quality: applicants accept mismatched offers
    - Better targeting: applicants with good outside options reject
- Related idea in public economics: ordeals can improve targeting (Nichols & Zeckhauser, '82)
  - Heterogeneity + rationing creates analogous trade-off

Outline

Model of Public Housing Preferences

- Approach: model of *flow payoffs* from public housing developments
  - Applicant i could be housed in developments $j = 1, ..., J$
  - v_{ij} - indirect flow utility from living in development j
  - v_{i0} - indirect flow utility from not living in public housing
  - ρ - continuous discount factor
- If housed in development j in t years, net present value is

$$\int_0^t e^{-\rho x} v_{i0} dx + \int_t^\infty e^{-\rho x} v_{ij} dx$$
$$= e^{-\rho t} \frac{1}{\rho}(v_{ij} - v_{i0}) + \frac{1}{\rho} v_{i0}$$

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$$= \underbrace{\frac{1}{\rho} e^{-\rho t}(v_{ij} - v_{i0})}_{\text{Decision-relevant}} + \frac{1}{\rho} v_{i0}$$

Model of Ex-Ante Development Choice

- Let's begin with one-stage choice mechanisms and removal after a rejection
  - A choice rule can be formalized as a set of subsets of developments:

$$\mathcal{C} \subseteq 2^{\{1,\ldots,J\}}$$

$$\begin{aligned} \text{Choose One:} \quad & \mathcal{C} = \{\{1\}, \{2\}, ..., \{J\}\} \\ \text{No Choice:} \quad & \mathcal{C} = \{\{1, ..., J\}\} \\ \text{Any Subset:} \quad & \mathcal{C} = 2^{\{1,\ldots,J\}} \end{aligned}$$

- Applicant i solves

$$\max_{C \in \mathcal{C}} \mathbb{E}\left[e^{-\rho t}(v_{ij} - v_{i0}) \mid C, \mathcal{I}\right] ,$$

where the expectation is over (j, t) given i's information $\mathcal{I}$.

  - Similar to choice over lotteries in Agarwal-Somaini '18
  - Now relevant distribution is over assignments and waiting times

- Note: optimal to reject an offer if $v_{ij} < v_{i0}$
  - Substitute $\tilde{v}_{ij} \equiv \max\{v_{ij}, v_{i0}\}$ for v_{ij} in objective function

Empirical Predictions

- Preference model of Arnosti & Shi:

$$v_{ij} - v_{i0} = \eta_i + \epsilon_{ij} \qquad \epsilon_{ij} \overset{iid}{\sim} F(\cdot)$$

- Choose one, deterministic wait times T_j:

$$\max_j e^{-\rho T_j}(\eta_i + \epsilon_{ij})$$

- A household with higher η_i is more likely to
  - Submit an application. Occurs if $\max_j(v_{ij} - v_{i0}) > 0 \implies \max_j \epsilon_{ij} > -\eta_i$

$$Pr(\text{apply} \mid \eta_i) = 1 - F(-\eta_i)^J$$

  - Choose a development with a shorter waiting time ($T_j < T_k$):

$$e^{-\rho T_j}(\eta_i + \epsilon_{ij}) > e^{-\rho T_k}(\eta_i + \epsilon_{ik}) \quad \implies \quad e^{-\rho(T_j - T_k)} > \frac{\eta_i + \epsilon_{ik}}{\eta_i + \epsilon_{ij}}$$

  - Also more likely to accept a random offer under No Choice:

$$Pr(\text{accept} \mid \eta_i) = 1 - F(-\eta_i)$$

Outline

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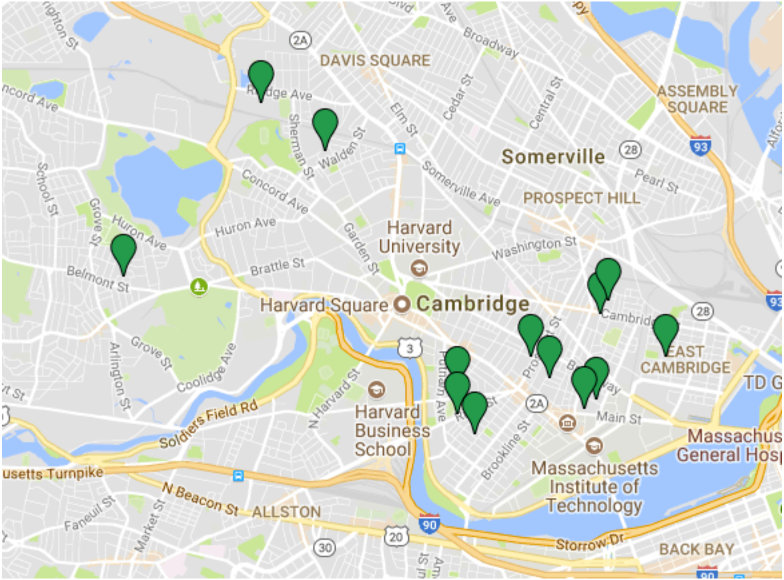
The Cambridge Housing Authority (CHA)

- Manages public housing and voucher programs in Cambridge, MA
  - Analysis focuses on "Family" public housing
  - Voucher waitlist closed during study period
- **Data:** CHA waiting lists between 2010 and 2014
  - **Applicant Choices:** initial and final choices, timing of events
  - **Applicant Characteristics:** income, demographics, city + zip code

  2010-2014 ACS microdata used to estimate eligible population

Family Public Housing Developments in Cambridge



The Cambridge Mechanism

- Two stages of development choice
  1. **Initial Choice** of up to 3 developments
     - Forms choice set in the next stage
  2. **Final Choice** of one development in initial set
     - New information: position on each list
- Rejection penalty: removed from list, cannot reapply for one year
- Equal priority for applicants living/working in Cambridge
  - Other applicants have no chance to be housed

Key Descriptive Facts

- Developments differ in waiting time, size, and location
  - 20-300 apartments per development
  - Avg. waiting times 2-4 years
- **Who Applies**
  - 6,800 eligible households, 1,726 applicants
  - Lower-income, non-white households apply at higher rates
- **Initial Choices**
  - Cambridge residents prefer to remain in their neighborhoods
  - Higher-income applicants more selective
- **Final Choice**
  - Responsiveness to new waiting time information

Response to Waiting Time Information

- Applicants receive new waiting time information at the final choice stage
  - A letter with their position on each list
  - Just a number - no waiting time prediction
- Applicants with same *choice set* told different positions
  - Randomness in apartment vacancies, choices of earlier applicants

	No Controls		Development Controls		Choice Set Controls	
	(1)	(2)	(3)	(4)	(5)	(6)
Position on Waiting List	-0.0186		-0.0206		-0.0299	
	(0.0032)		(0.0037)		(0.0065)	
Expected Waiting Time (Years)		-0.265		-4.031		-5.411
		(0.289)		(0.755)		(1.335)
Development FE's			X	X		
Development - Choice Set FE's					X	X
Implied Own-Price Elasticity	-0.707	-0.121	-0.817	-3.270	-1.332	-4.136
	(0.149)	(0.145)	(0.182)	(0.637)	(6.486)	(1.946)
Observations	573	573	573	573	343	343

Outline

Two-Stage Choice Model

- Decisions: whether to apply, initial and final choices
  - Estimate preferences given model of strategic behavior
- Rational choice: applicants strategize correctly given beliefs
  - Rational expectations benchmark
  - Robustness to alternative beliefs, choice heuristics
- Portfolio choice problem (Chade & Smith '06)
  - Limited information in first stage, new info in second stage
  - First-stage decision affects second-stage timing and information

Decision Problem

- **Final Choice** - given choice set C, list positions $p \equiv \{p_j\}_{j \in C}$:

$$V_{i,C}^{\text{final}}(p) = \max_{j \in C} \quad E\left[e^{-\rho T_j} \mid p\right] \frac{1}{\rho}(v_{ij} - v_{i0})$$

- **Initial Choice** - maximize expected discounted value of final choice

$$C^* \equiv \arg \max_{C:|C|<3} E_C\left[e^{-\rho S} V_{i,C}^{\text{final}}(P)\right]$$

Outer expectation over final choice **date** (S) and **information** (P)

- **Decision to Apply** - apply if $\max_j v_{ij} > v_{i0}$
  - No application cost
  - Changing the mechanism doesn't affect who applies

Microfoundation and Interpersonal Comparisons

- In discrete choice models, only differences in payoffs are identified
  - Choices reveal distribution of $v_{ij} - v_{i0}$
  - Sufficient to predict counterfactual behavior, not for normative analysis
- Paper provides a microfoundation of utility to
  1. Interpret distributional consequences of allocation policy: recover v_{i0}
  2. Provide a basis for interpersonal comparisons based on willingness-to-pay
- Private Market: household solves

$$\max_{c,h} \quad u_1(c) + u_2(h) \;\; s.t. \;\; c + h \leq y_i + \eta_i$$

$$\implies v_{i0} = v_0(y_i + \eta_i)$$

- Public Housing: pays $\tau \cdot y_i$ in rent, enjoys housing quality d_{ij}:

$$v_{ij} = u_1((1-\tau)y_i) + u_2(d_{ij})$$

Model Implications

- The difference in values is given by

$$v_{ij} - v_{i0} = \underbrace{u_1((1-\tau)y_i) - \overbrace{v_0(y_i + \eta_i)}^{\text{outside option}}}_{\text{value of assistance}} + \underbrace{u_2(d_{ij})}_{\text{match value}}$$

  - Applicants with higher values of assistance have higher marginal utilities of income, conditional on observables
  - Upper bound on targeting gains from choice restrictions

- Utility gains from assignments converted to equivalent variation

$$v_{iA} - v_{i0} = v_0(y_i + \eta_i + EV) - v_0(y_i + \eta_i)$$

Parameterization of Values

- Standard parameterization of flow payoffs:

$$v_{ij} - v_{i0} =$$

$$\delta_j + \underbrace{g(Z_i) + \phi_1 \log y_i - \phi_2 \overbrace{\log(y_i + \eta_i)}^{\text{outside option}}}_{\text{value of assistance}} + \underbrace{\sum_k X_{ijk}\beta_k^o + \sum_m X_{jm}\nu_{im}\beta_m^u + \epsilon_{ij}}_{\text{match value}}$$

$$\eta_i \overset{iid}{\sim} \begin{cases} TN(0, \sigma_\eta^2, c - y_i, \infty) & w.p. \;\; 1 - \Phi\left(\frac{c-y_i}{\sigma_\eta}\right) \\ c - y_i & w.p. \;\; \Phi\left(\frac{c-y_i}{\sigma_\eta}\right) \end{cases}$$

$$\nu_i \overset{iid}{\sim} N(0, I) \qquad \epsilon_{ij} \overset{iid}{\sim} N(0,1)$$

- Microfounded by Cobb-Douglas preferences: $u(c,h) = \gamma \log c + (1-\gamma)\log h$
- Model parameters: $\{\rho, \delta, \beta, g(.), \phi, \sigma_\eta\}$

Estimation Approach

- Given competitors' strategies, each agent solves a single-agent problem
  - Competitors affect an applicant's payoffs through waiting times
  - Applicants play against distributions generated by equilibrium behavior
  - FCFS queue $\Longrightarrow$ limited scope for strategic interactions
  - Many applicants with limited information about choices of competitors
- Estimation steps
  1. Construct "rational expectations" beliefs via simulation
  2. Estimate preferences using the method of simulated moments
     - Moments based on optimal initial and final choices
     - Avoids solving for equilibrium of the game
     - Consistency between beliefs and preferences only imposed in counterfactuals

Constructing Beliefs

- Beliefs are high-dimensional objects:
  - $\{G_C(S, \mathbf{P})\}_{C \in \mathcal{C}}$: how initial choice affects final choice date and info
  - $\{\{F_{j,C}(T_j \mid \mathbf{p})\}_{j,\mathbf{p}}\}_{C \in \mathcal{C}}$: continued waiting time given positions
  - Choice structure $\longrightarrow$ correlated waiting times across lists
  - "Small" lists $\longrightarrow$ uncertainty in waiting times and assignments
- Sparse data on waiting times: ≈325 applicants housed during sample period
- Approach: approximate beliefs via simulation
  - Beliefs governed by mechanism's stationary distribution
    - Queue lengths only observed at final choice
  - Determinants of stationary distribution are lower-dimensional
    - Rates of applicant arrival μ; vacancy λ; and exogenous departures δ
    - Choice probabilities at initial and final choices
  - Simulate Cambridge Mechanism given these estimates
  - Belief distributions constructed from simulation outputs

Method of Simulated Moments

- Challenges of a likelihood-based approach:
  - Complex regions of v for which each choice is optimal
    - Numerical integration or Bayesian approaches (MCMC) intractable
  - Many possible choices; concerns of bias from simulated MLE

- MSM procedure:
  1. Take simulation draws of preference components and final choice states
  2. For a candidate parameter value θ
     2.1 Calculate indirect utilities given (fixed) simulation draws
     2.2 Solve for optimal sequence of choices
     2.3 Calculate simulated moments from choices: $\hat{m}_i(\boldsymbol{\theta}) \equiv \hat{E}[m_i^{(q)} \mid \mathbf{Z}_i, \boldsymbol{\theta}]$
  3. Minimize objective function with respect to θ:

$$\min_{\boldsymbol{\theta}} \; \hat{\mathbf{g}}(\boldsymbol{\theta})' \, \mathbf{A} \, \hat{\mathbf{g}}(\boldsymbol{\theta}) \qquad \hat{g}^{(q)}(\boldsymbol{\theta}) = \frac{1}{N} \sum_{i=1}^{N} \left(m_i^{(q)} - \hat{m}_i^{(q)}(\boldsymbol{\theta}) \right) Z_i^{(q)}$$

Intuition for Identification

- Match values
  - Portfolio choice is like having "second choice" data (Berry et al., 2004)
- Values of assistance
  - Observed: applying reveals some development preferred to outside option
  - Unobserved: initial and final choices
    - Differences in selectivity that cannot be explained by observables or match value heterogeneity
- Willingness to wait for preferred development
  - Governed by time preference and value distribution
  - Variation in waiting times at final choice separates discount rate from flow payoffs

Moments

- Decision to apply
  - Application rates by income, demographics
- Initial choices
  - Development shares
  - Covariances between applicant, development characteristics
  - Variances of development characteristics
  - Variances of chosen waiting times, by income
  - Number of developments chosen
- Final choices
  - Development shares
  - Responsiveness to waiting time information

Summary of Preference Estimates

- Applicants are patient: estimated annual discount factor of ≈ 0.97
- UH in value of assistance equivalent to $9,000 S.D. unobserved income
- UH in match values also substantial
- Moderate differences in developments' overall desirability
- Qualitative features robust to specific alternative assumptions about beliefs, applicant sophistication, assumed utility function

	All Applicants		African American Household Head		Household Income Below $15,000	
Panel A: Value of Assignment to Preferred Development						
	Median ($)	Mean ($)	Median ($)	Mean ($)	Median ($)	Mean ($)
1st Choice Instead of 2nd	891	2,028	1,136	2,465	526	1,082
1st Choice Instead of 3rd	1,894	3,344	2,493	4,111	1,047	1,807
Panel B: Number of Acceptable Developments						
	% of Applicants	Outside Option ($)	% of Applicants	Outside Option ($)	% of Applicants	Outside Option ($)
1-3 Acceptable	16.2	30,547	12.0	45,150	4.9	21,091
4-10 Acceptable	23.2	24,888	22.1	34,431	11.9	17,525
11-12 Acceptable	36.5	13,327	35.8	18,825	42.8	11,001
13 Acceptable	24.1	4,710	30.1	5,230	40.4	4,510

Outline

Choice of Counterfactuals

- Trade-off between efficiency and redistribution in waitlist design
  - Efficiency: maximize equivalent variation of those housed
  - Redistribution: house applicants with worst outside options
- Combinations of choice and priority systems:
  - **Choice: Choose One** or **No Choice**
    - Paper considers intermediate systems (e.g. Any Subset)
  - **Priority: Low**- or **High-Income** applicants ($15,000/year cutoff)
    - Compared to **Equal Priority** – CHA system during study period
- Choice of mechanisms motivated by
  - Practice: systems used by PHAs
  - Theory: "extremes" of match quality and targeting
  - Convenience: one stage of choice is computationally tractable

Equilibrium Computation

- Stationary equilibrium concept, similar to one used for estimation
  - Applicants form beliefs based on stationary equilibrium of mechanism
  - No information about current state of queue when making decision
  - Applicants need only track joint distr. of waiting times, assignments

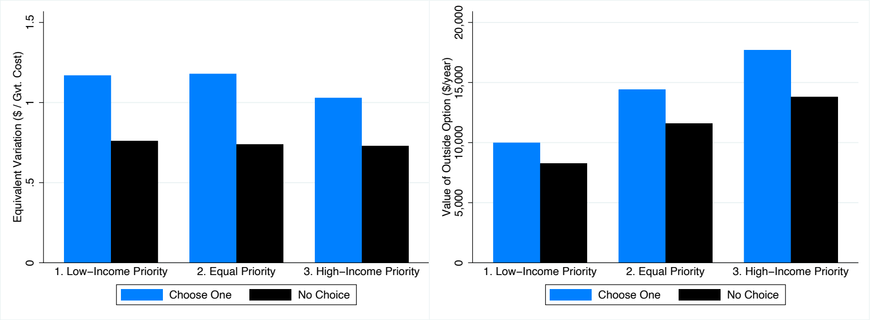
- Choice problem can be written as

$$\max_{C \in \mathcal{C}} \sum_{j \in C} w_j(C)(v_{ij} - v_{i0})$$

$$w_j(C) = \frac{1}{\rho}\mathbb{E}\left[e^{-\rho T_j} \mid T_j = \min_{k \in C} T_k\right] Pr\left[T_j = \min_{k \in C} T_k\right]$$

- Equilibrium computation finds a fixed point between choices and beliefs
  - Long simulation of the queue. Iterate between
    1. Optimal decisions C^* given beliefs $\{w(C)\}_{C \in \mathcal{C}}$
    2. Update weights $\{w(C)\}_{C \in \mathcal{C}}$ implied by decisions

Efficiency vs Redistribution



- Removing choice reduces efficiency by 33 percent; targets applicants with 16 percent worse outside options
- Income-based priorities mostly affect redistribution

Normative Analysis

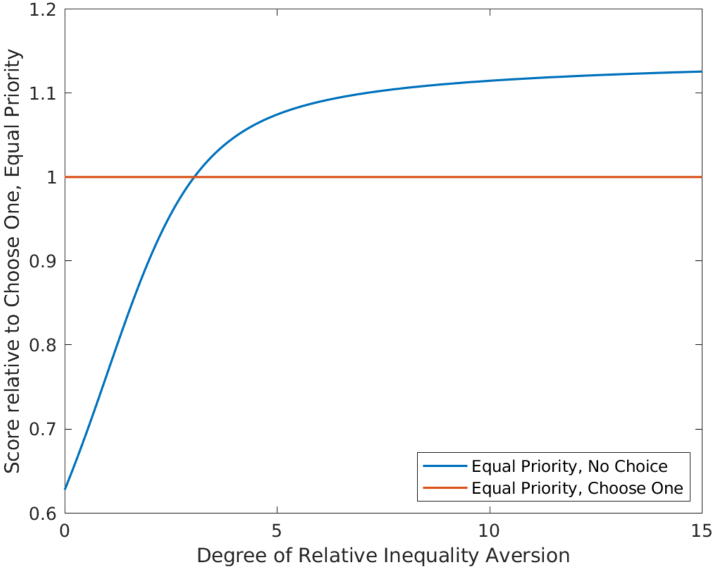
- Need a framework for balancing efficiency and distributional objectives
- Assignments $\longrightarrow$ utility gains $\longrightarrow$ equivalent cash transfers (EV)
  - Aggregate EV using a social welfare function that places greater value on transfers to households with worse outside options
- *Constant Relative Inequality-Aversion* (Atkinson, 1970):

$$f(\tilde{y}_i, EV; \lambda) = \frac{1}{1-\lambda}\left[(\tilde{y}_i + EV)^{1-\lambda} - \tilde{y}_i^{1-\lambda}\right]$$

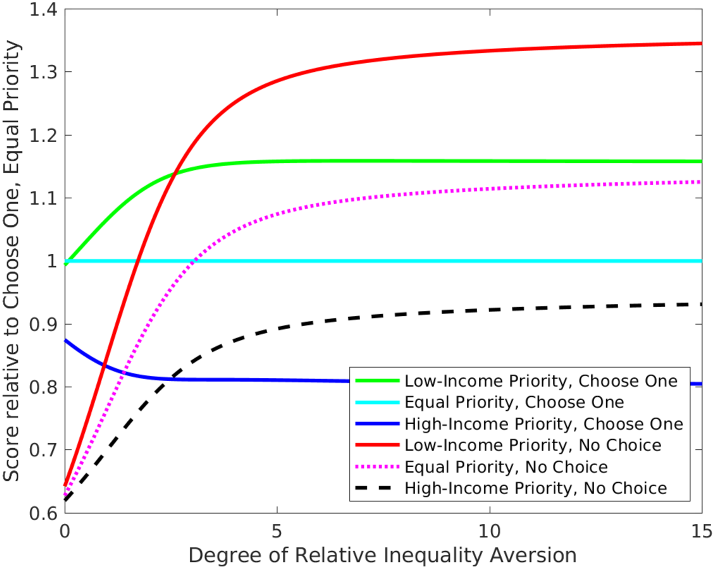
- Social marginal utility of income is λ% greater for a 1% lower-income household
  - $\lambda = 0$: no value of redistribution. $\lambda = \infty$: Rawlsian

Calculation

Preferred Choice System under Equal Priority



Preferred Combinations of Choice and Priority



Future Directions

- Many questions remain in public housing waitlist design
  - Applicant information and sophistication
  - Endogenous responses to priorities
  - “Frontier” mechanisms
  - Interactions with other markets
  - Choices and outcomes (Van Dijk ’19)
- What about re-designing the public housing program itself?
  - Rematching within public housing
  - Type and quality of housing provided
  - Public provision vs private market subsidy (vouchers, tax credits)
  - Why subsidize housing at all?