An Agent-based Simulation of the Rental Housing Market: Information and Search

John Mc Breen, Florence Goffette-Nagot and Pablo Jensen

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Institut des Systèmes Complexes
Complex Systems Institute
Rhône-Alpes
IXXI

Motivation

- Housing markets
  - Many heterogeneous interacting agents
  - Heterogeneous, spatially distributed goods
  - Out of equilibrium
- Agent-based simulations
  - Complex dynamic systems
  - Heterogeneities
  - Interactions
  - Freed from analytic constraints
- Potential of Agent-based simulations in search markets?

Some Empirics of Housing Market

- Stylised facts reproduced
  - Vacancies (Blanck & Winnock 1953)
  - Price dispersion (Lueng et al. 2006)
  - Asking Rents / Time-on-the-Market (Allen et al. 2009)
- Potential extensions
  - Correlations in liquidity, prices and volumes (Fisher et al. 2003); (Clayton et al. 2008)
    - Information effects
  - Natural vacancy rate (Rosen & Smith 1983)

Existing search models of the housing market

- Rent bargaining models (Wheaton 1990; Desgranges & Wasmer 2000)
- Rent posting models (Read 1993; Read 1997; van der Vlist et al. 2002)
  - Search frictions
  - Landlords post rents
  - Perfect Information
  - Trade-off between match quality & search costs (times)
- Agent Simulations (Bradburd et al. 2005 & 2006)
- Search on the labour market (Rogerson et al. 2005)

Our contribution

- Imperfect information for all agents
  - More realistic
  - Importance of information for rent-setting landlords
  - Landlords with different levels of information
- Dynamic behaviour sought
  - *"It will be of interest to examine how the behavior of the market differs when it is either growing or contracting, or when it is subject to anticipated or unanticipated shocks and policy changes."* (Arnott, 1989, p. 23)
- Advantages of a multi-agent model
  - Heterogeneities
  - Dynamics results

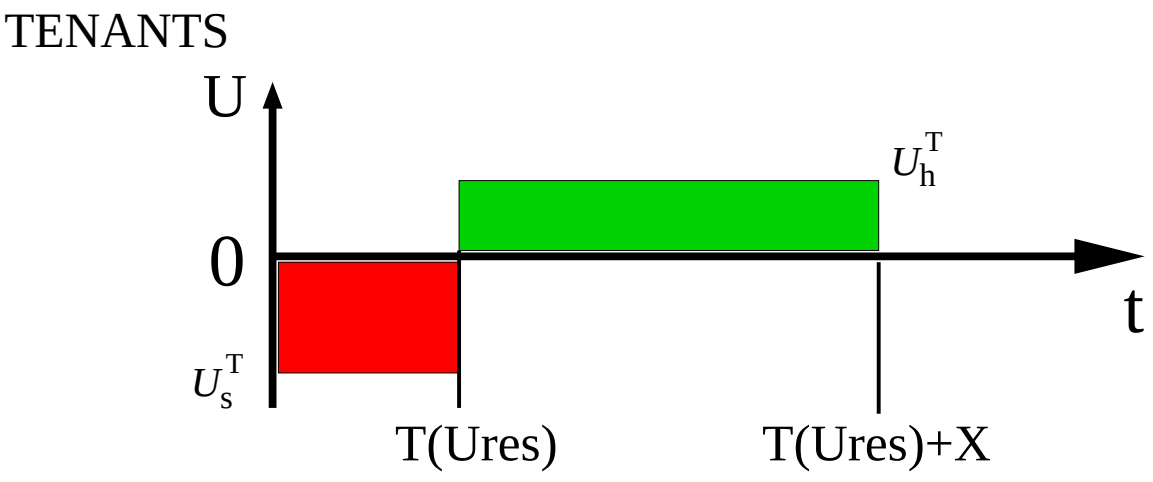
Model Assumptions

- Closed Town (10,000 landlords & tenants)
- Homogeneous residences
- Tenants search every iteration
- Time discounting agents
- Max. allowed rent level (10% highest seen)

Simulation Procedure

- Searchers visit a randomly chosen apartment
  - accept or reject
- Landlords:
  - Vacant
    - Review their rent or withdraw from the market
  - Off-the-market
    - Return? at what rent?
- A exogenous fraction of tenants, randomly chosen, leave
- Landlords of newly empty apartments choose their posted rents
- Five iterations corresponds to 1 month

Tenants' Decision



- Decision variable: U_{res}
  - Expected search time: $T(U_{res})$
  - Expected utility from housing: U_h^T
- Heterogeneous in income
- Idiosyncratic preferences (% Income)

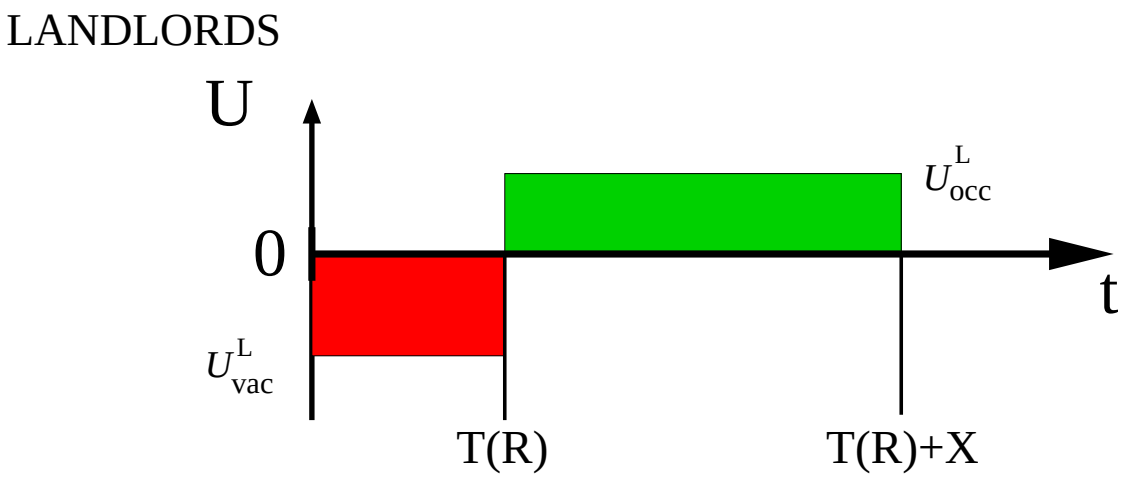
Tenants' Utilities

- Utility Searching:
  - $U_s^T = Y - C_T$
    - Y: Housing budget
    - C_T: Cost of searching
- Utility Housed
  - $U_h^T = Y - R + \eta(Y)$
    - R: Rent
    - $\eta(Y)$: Idiosyncratic preference
    - η: Gaussian distribution of variance σ
    - σ is a % of housing budget
- Benefit calculated per unit time

Tenants' Characteristics

- Heterogeneous in income
- Time discounting (default 3%)
- Decision variable: U_{res}
- Undirected search
  - Partially informed of the distribution of offers
  - Visit one random apartment each iteration
  - Discover idiosyncratic preference
  - Accept or reject visited apartment
- Constant probability to leave once housed

Landlords' Decision



- Decision variable: R
  - Expected Time-on-The-Market (TOM): $T(R)$
  - Rent obtained: R
- Homogeneous landlords
- Withdraw from market if expected benefit negative

Landlords' Utilities

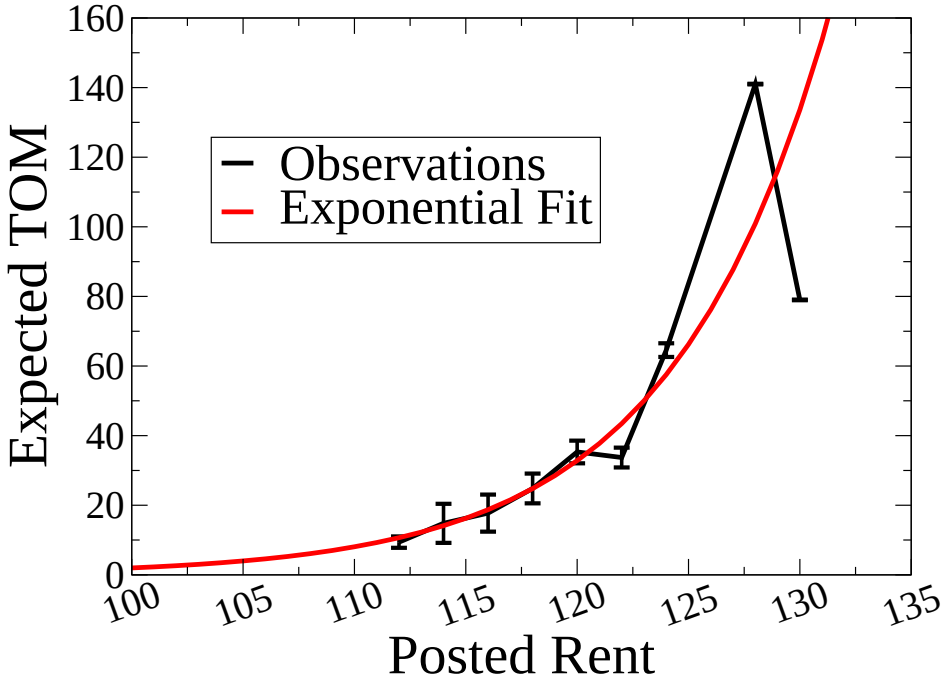
- Utility vacant:
  - $U_{vac} = -C_L$
    - C_L: Cost of maintenance
- Utility Housed
  - $U_{occ} = R - C_L$
    - R: Rent
- Choose R that maximises benefit
- R determines
  - $E[T(R)]$: TOM in expectation
- Benefit calculated per unit time

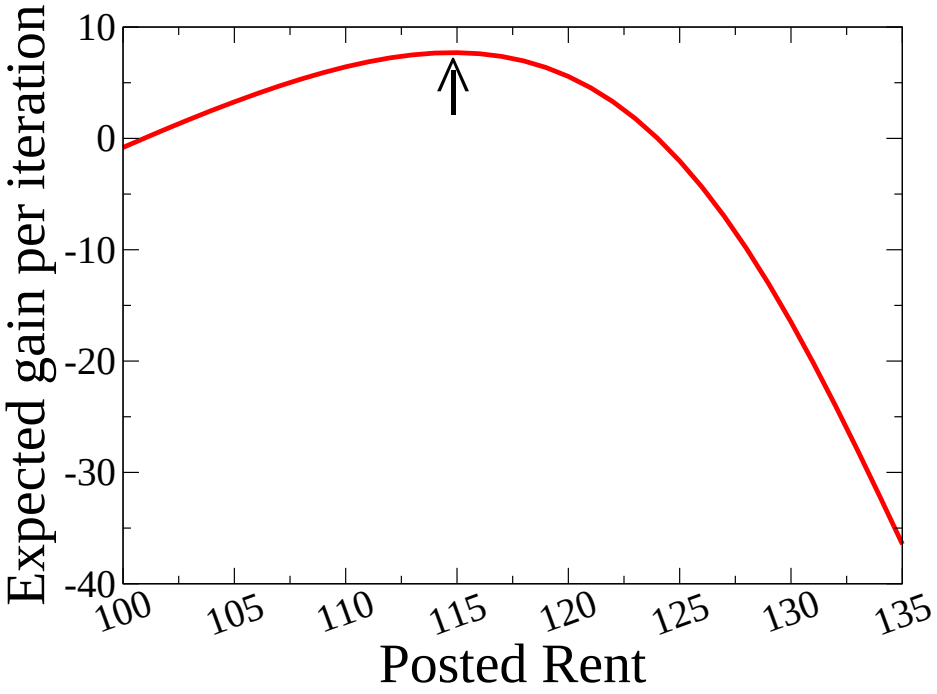
Landlords' Characteristics

- Time discounting (default 3%)
- Decision variable: Posted rent R
- Review posted rent on average each F iterations if vacant
- Withdraw from market if expected benefit negative
- Trade-off TOM with Rent obtained
- Stochastic partial information
- Within each rent interval over last F iterations
  - Number of accepted rents
  - Total TOM

TOM/Rent Relation

- Exponential fit to Rent/TOM relationship

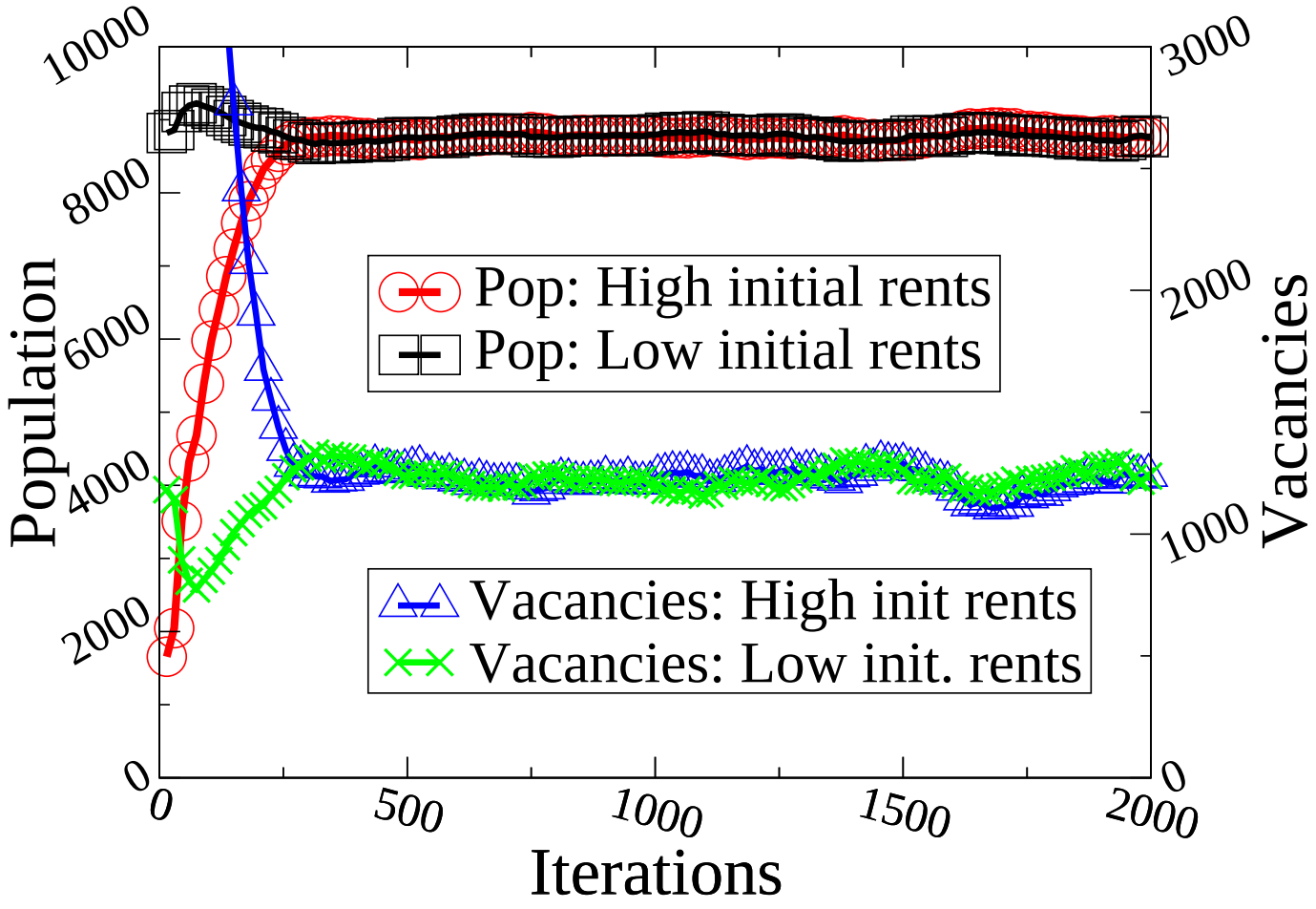




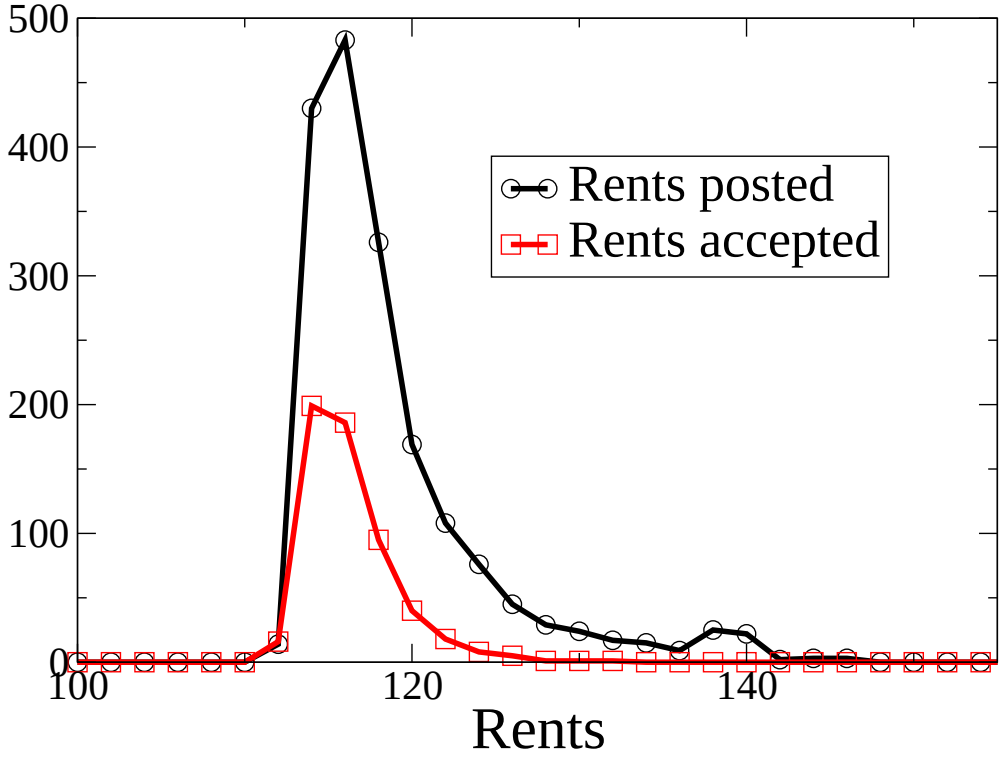
Results

- Basic Results
  - Convergence to steady-state
  - Rent dispersion, vacancies, positive search times
- Information results
  - Homogeneous landlords
    - Low information moves market to higher rents
  - Heterogeneous landlords
    - Better informed landlords better off
- Dynamic variation in discount rate

Convergence to Steady-state

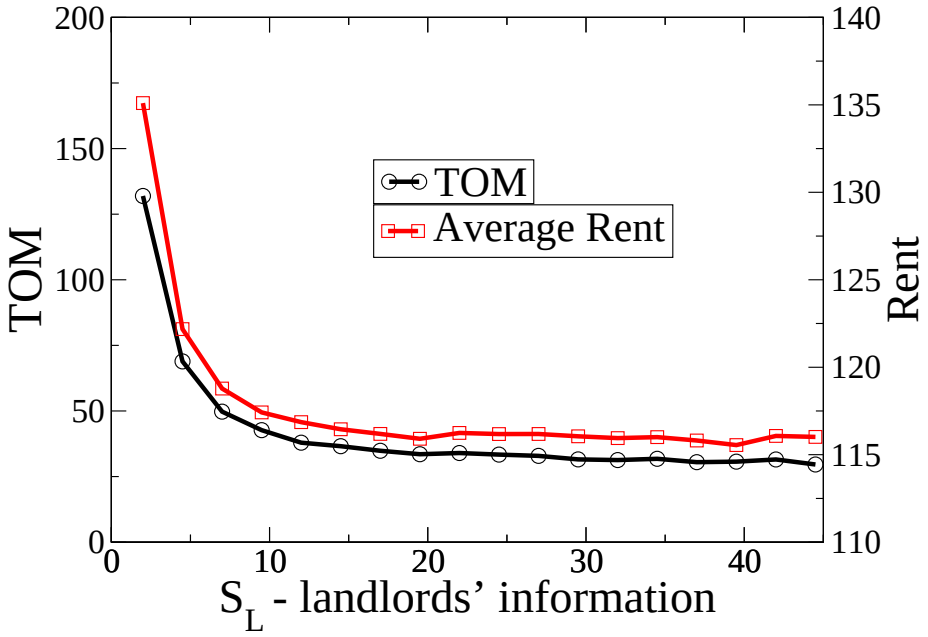


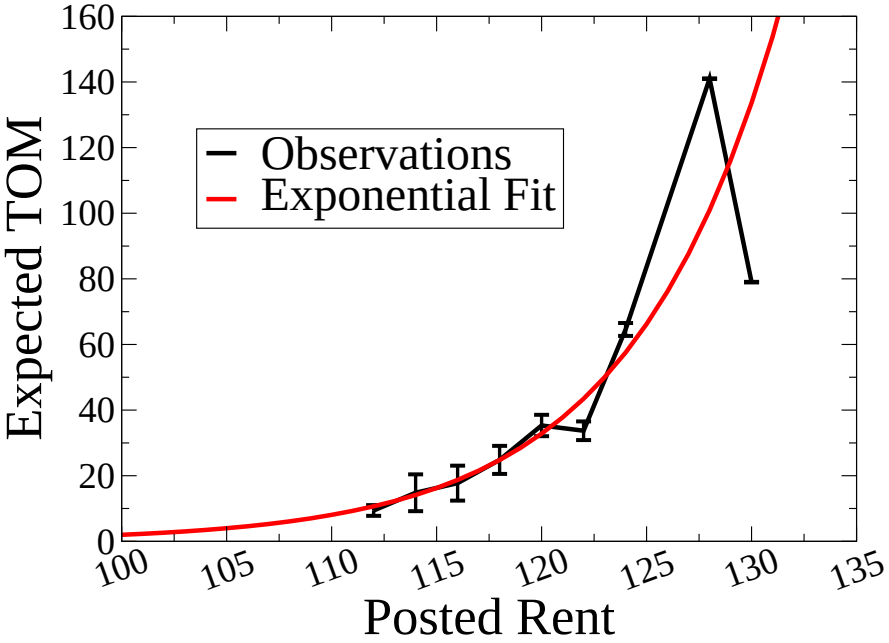
Rent Dispersion



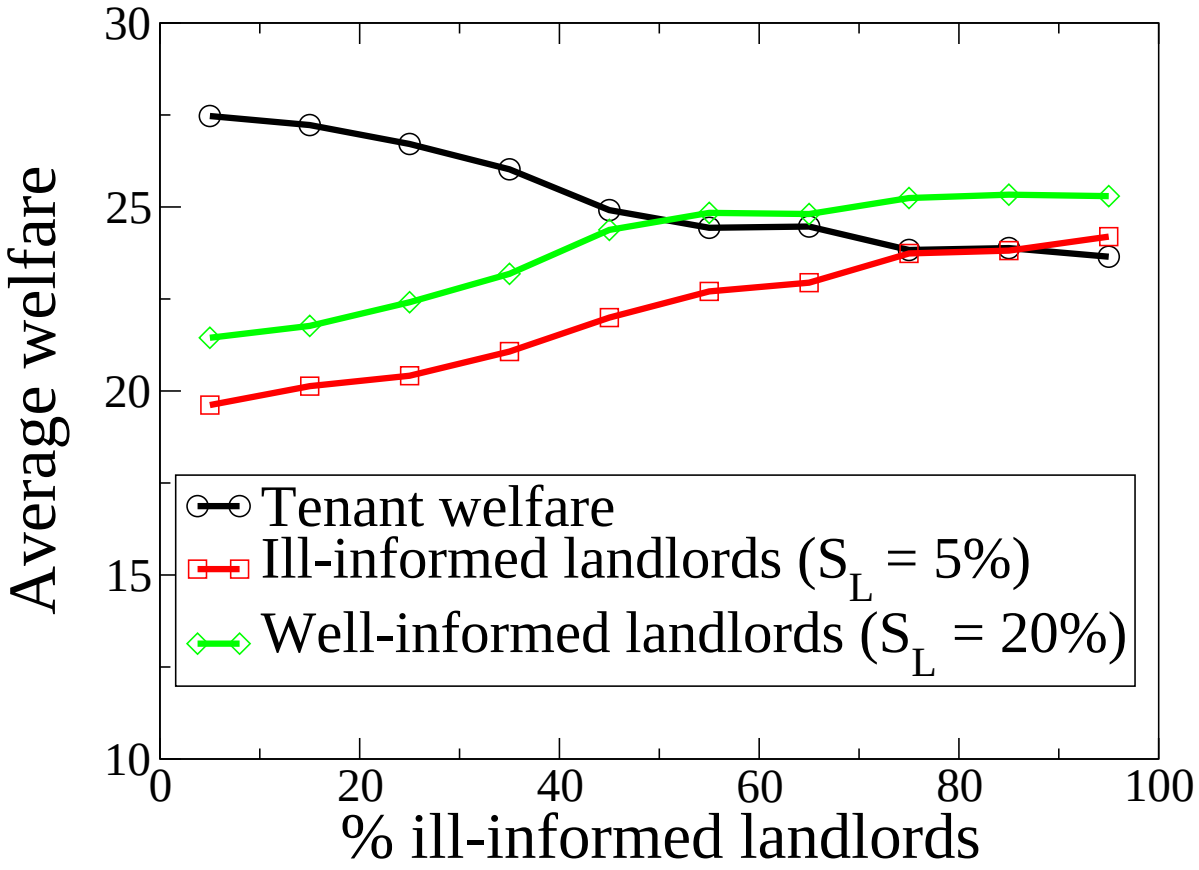
- Dispersion
  - Heterogeneous tenants; Stochasticity: Information, offers, idiosyncratic preferences

Homogeneous landlords - Rent

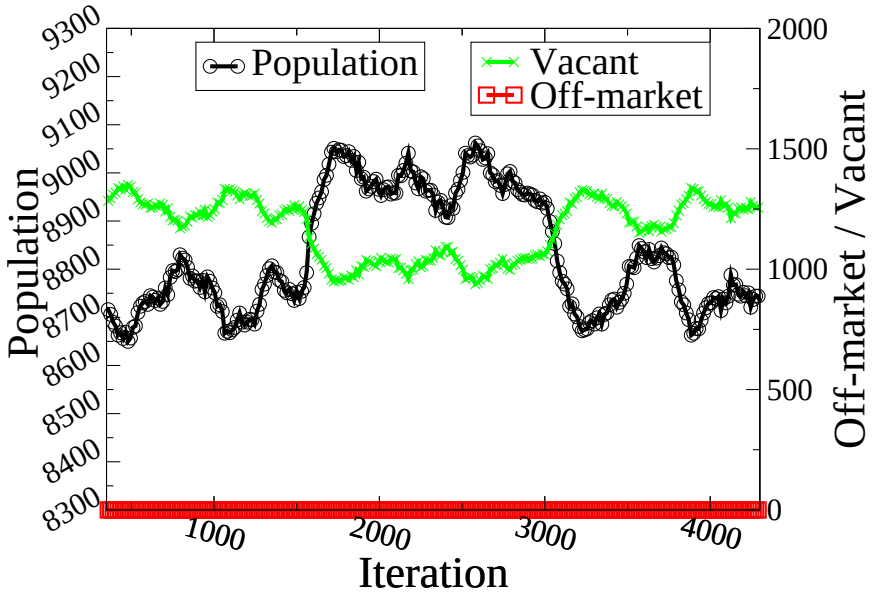


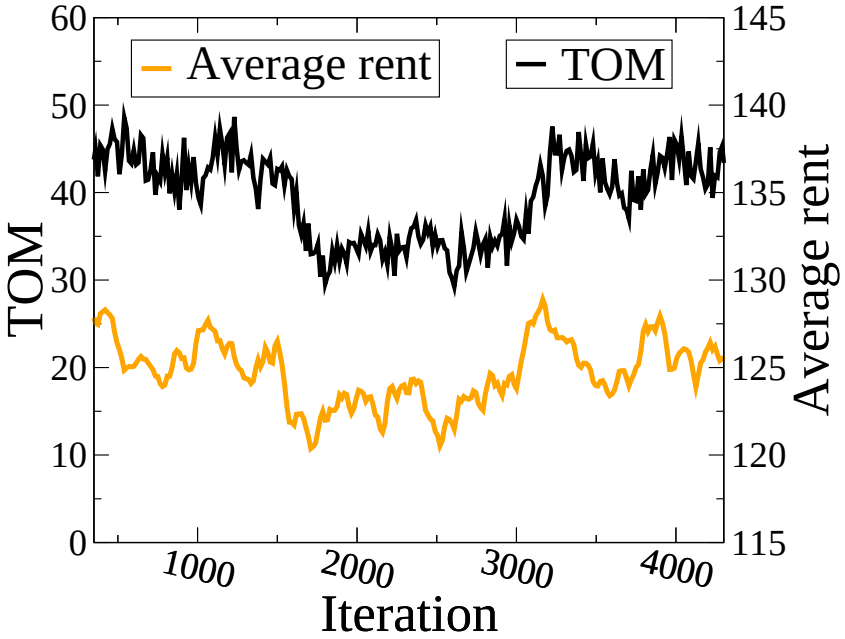


Heterogeneous Information



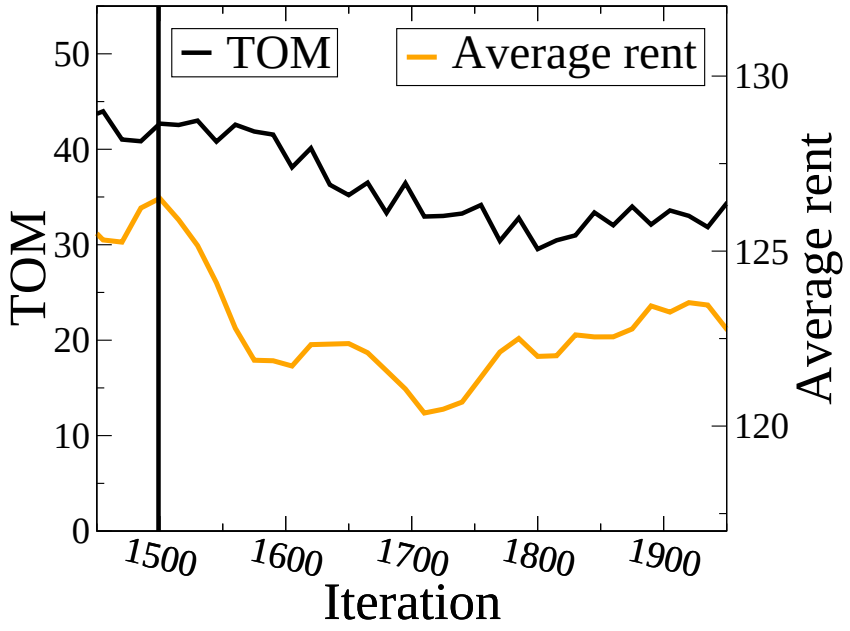
Dynamic Variation of Discount Rate 1

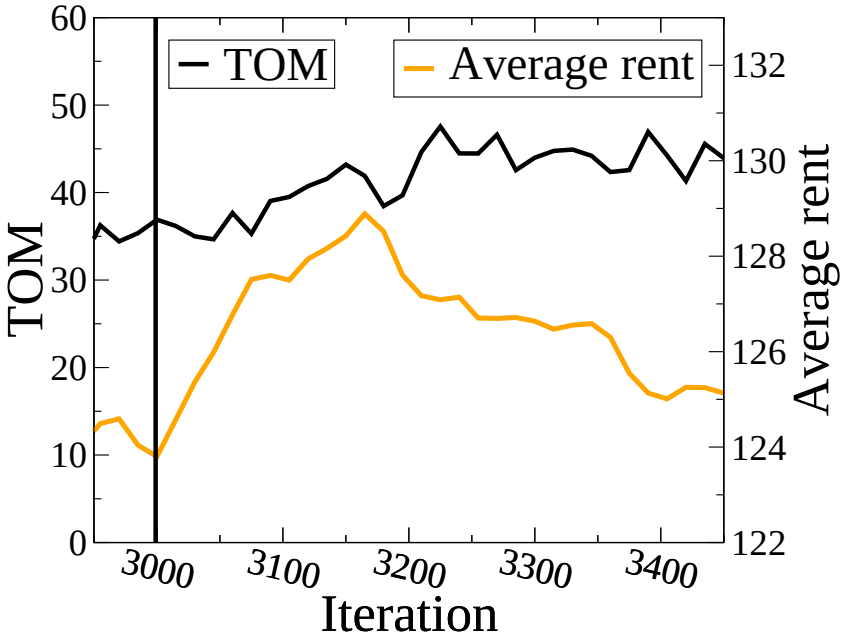




- At 1500 iterations 2% to 10% and at 3000 iterations 10% to 2%

Dynamic Variation of Discount Rate 2

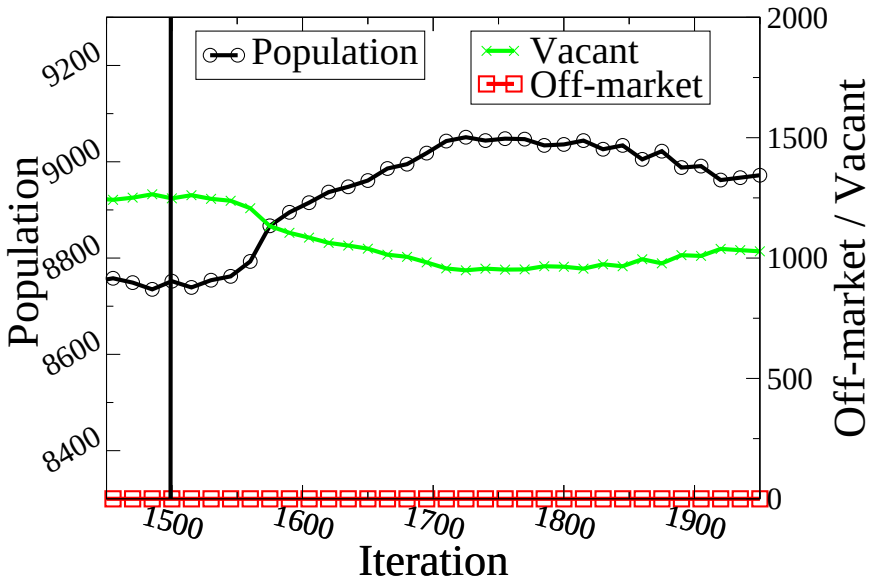


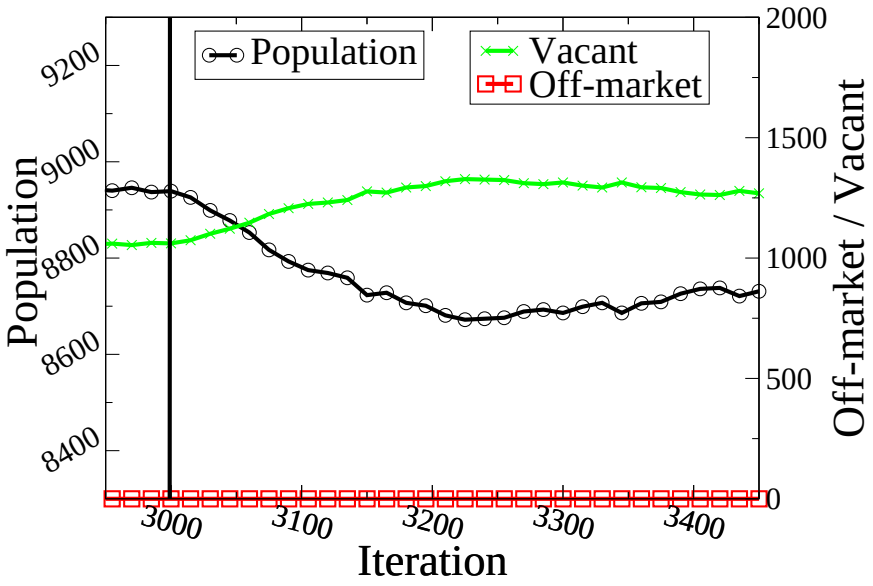


- At 1500 iterations 2% to 10%

At 3000 iterations 10% to 2%

Dynamic Variation of Discount Rate 3





- At 1500 iterations 2% to 10% At 3000 iterations 10% to 2%

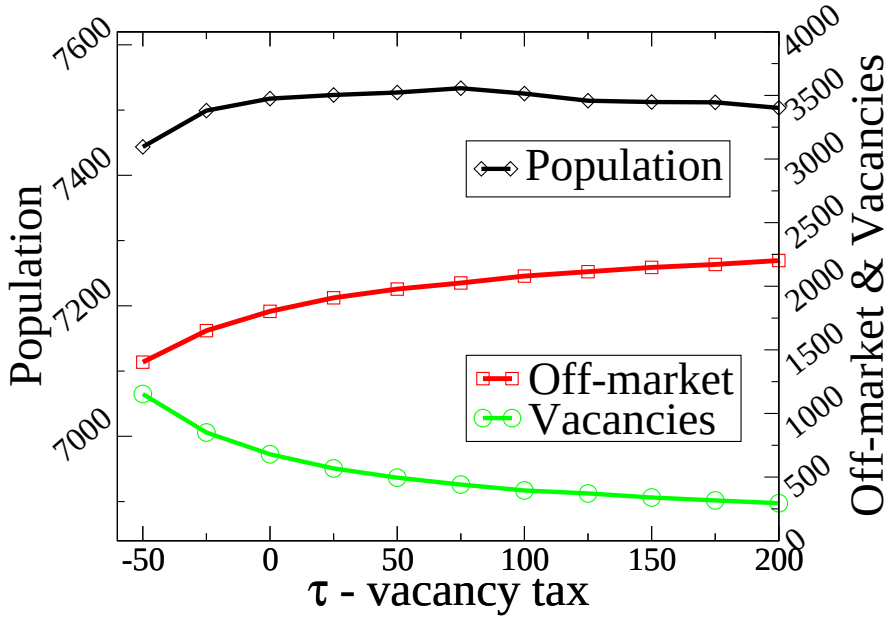
Extensions

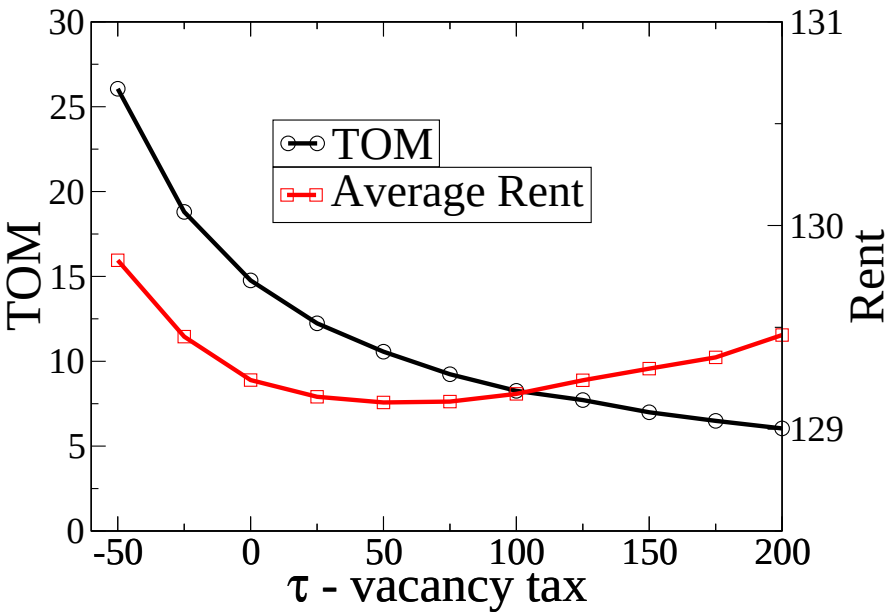
- Directed search
- Rent controls
- Owner-occupier market
  - Downpayment effects (Stein 1995)
  - Inelastic supply and demand (Novy-Marx 2008)
  - Correlations TOM/Prices/Volume
- Other real-estate (and labour) markets

Conclusions

- Agent-based simulations
  - Appropriate for search markets
  - Many heterogeneous interacting agents
  - Imperfect information
    - Quality/quantity depends on market state
- Heterogeneities bring greater stability
- Considerable scope for extensions

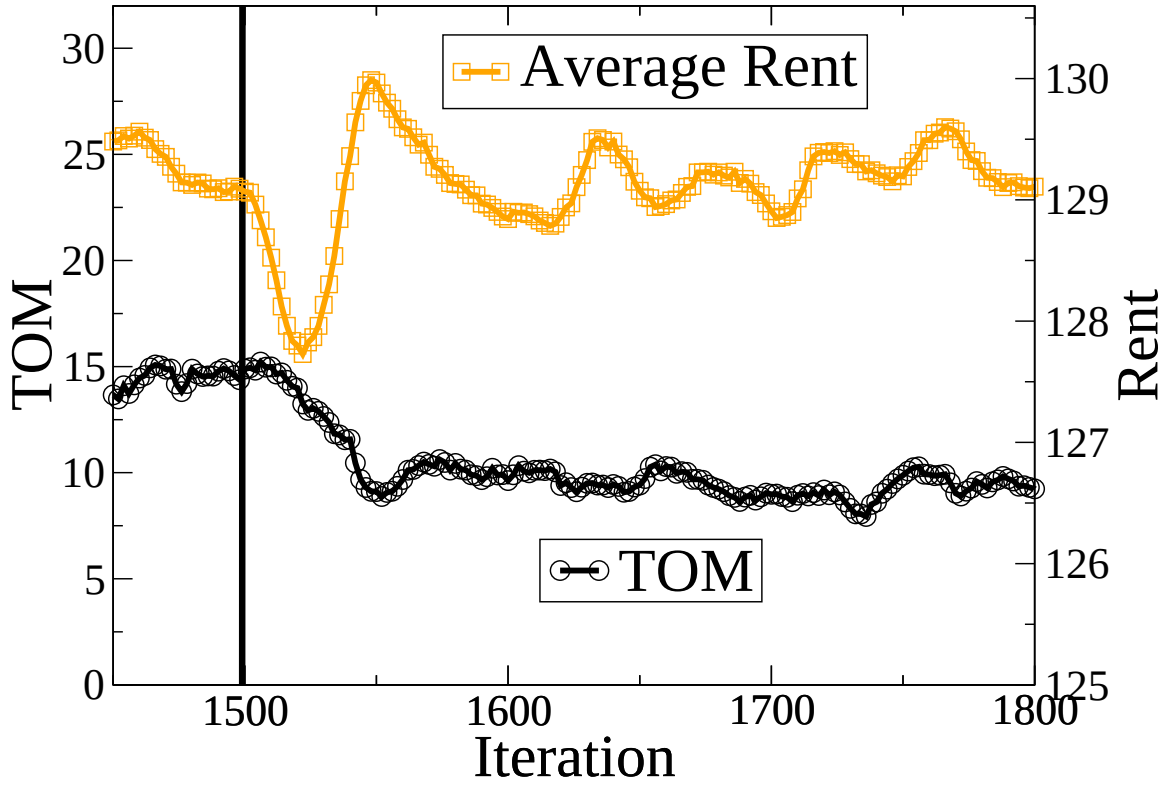
Vacancy Tax





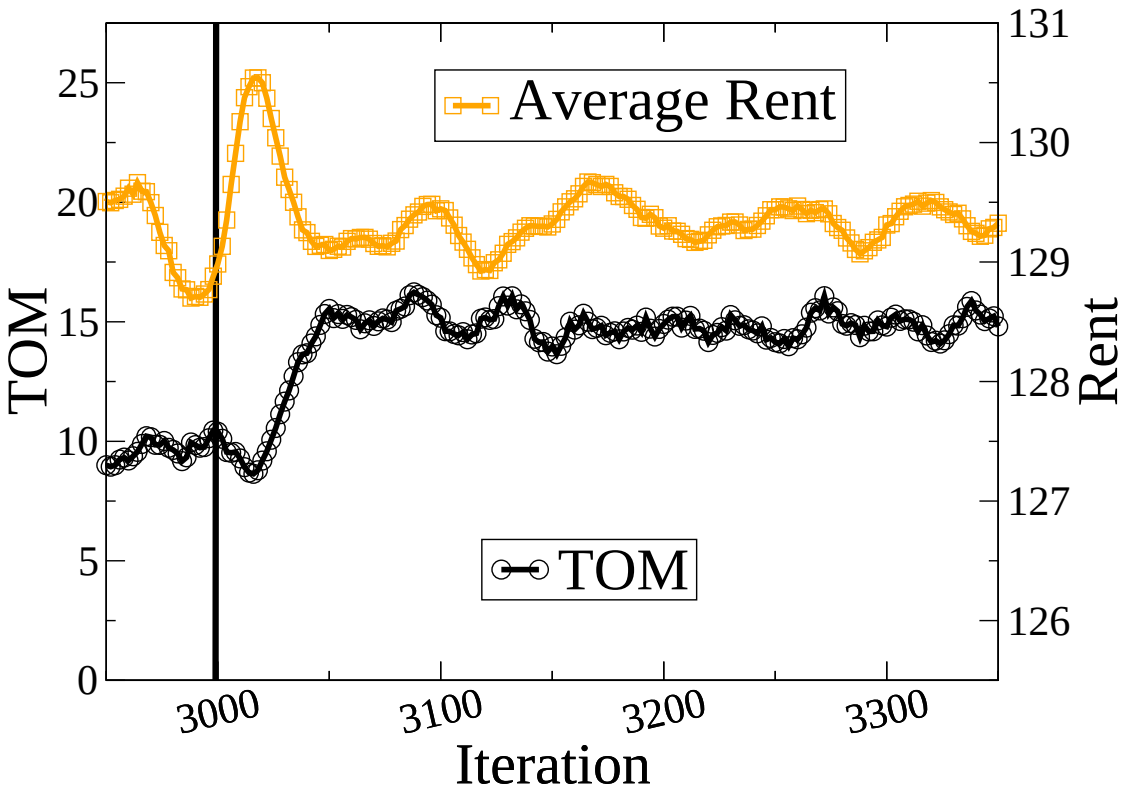
- Heterogeneous landlords [100,129]
- Optimal tax rate?

Introduction of Vacancy Tax



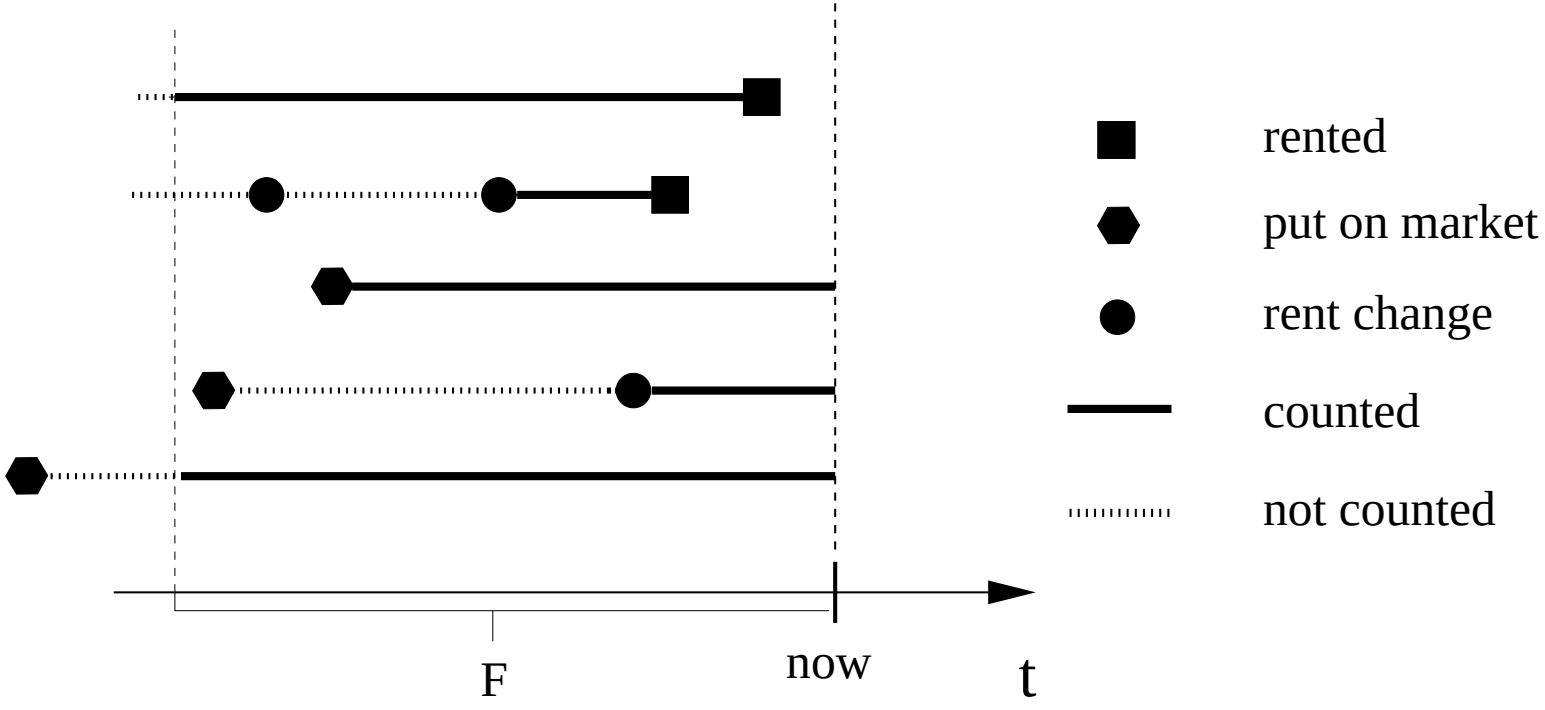
- Tax from 0 to 50 at 1500 iterations

Abolition of Vacancy Tax



- Tax from 50 to 0 at 3000 iterations

Landlords' Information



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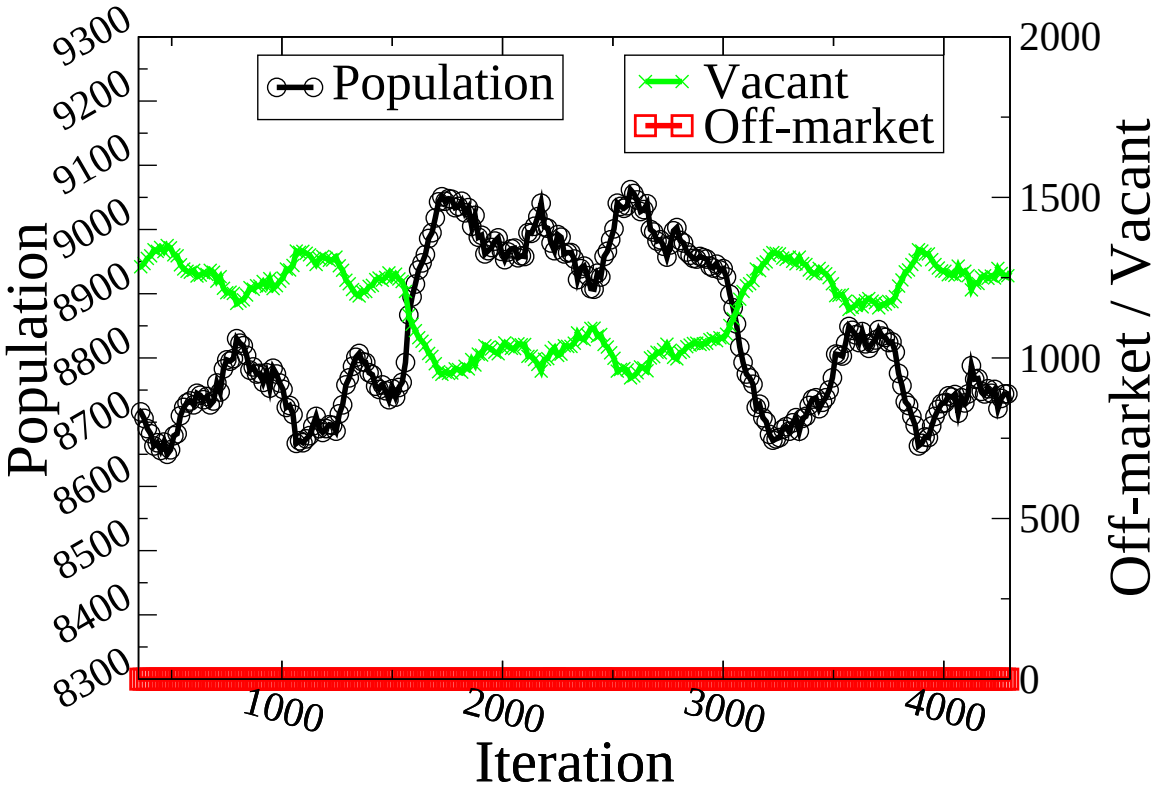

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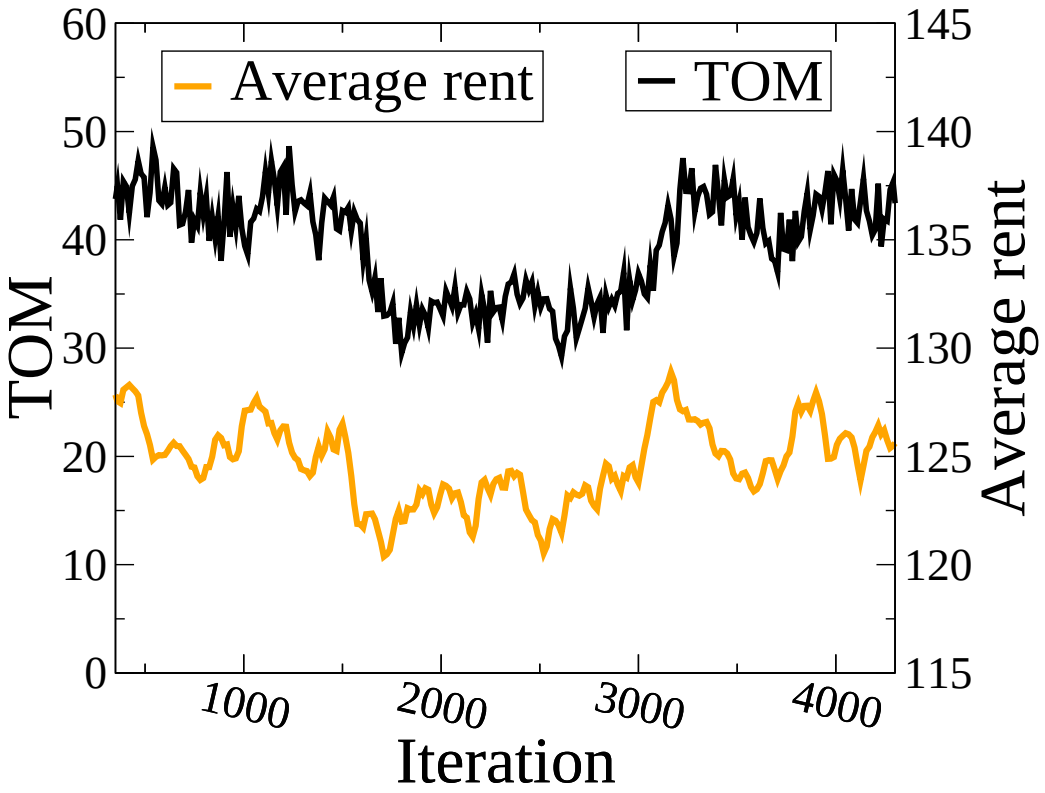

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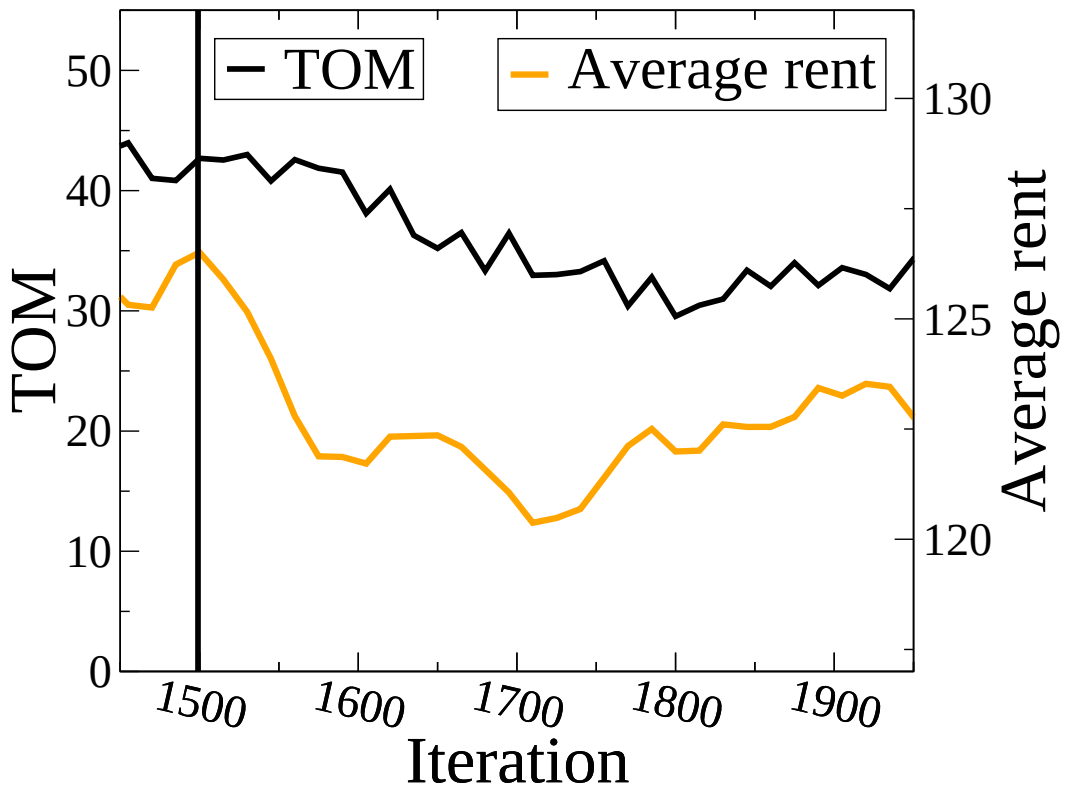
Increase in Discount Rate



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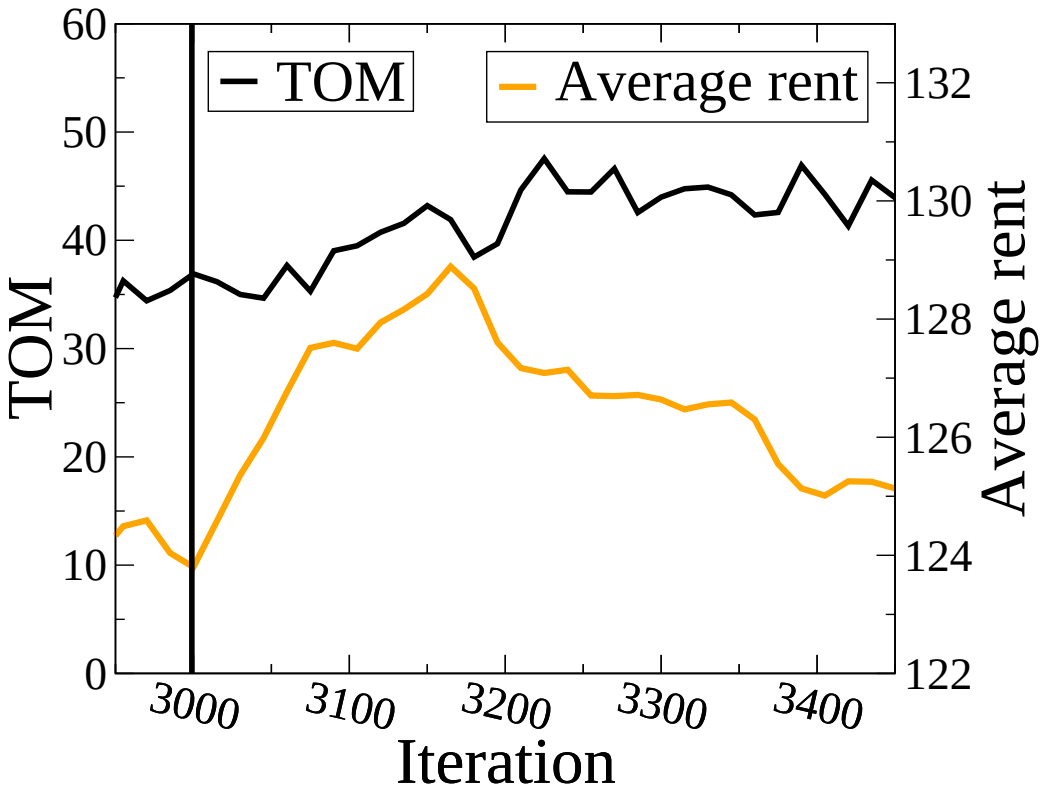
Reduction in Discount Rate



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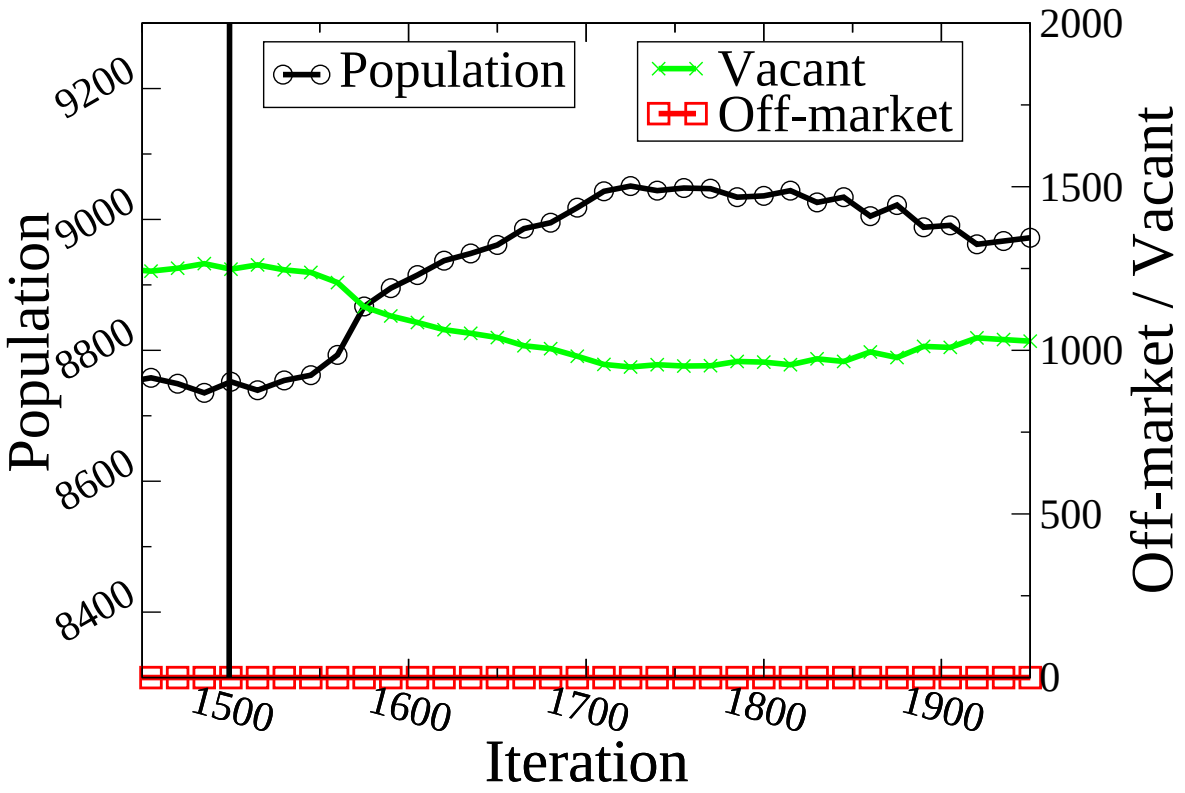
Increase in Discount Rate



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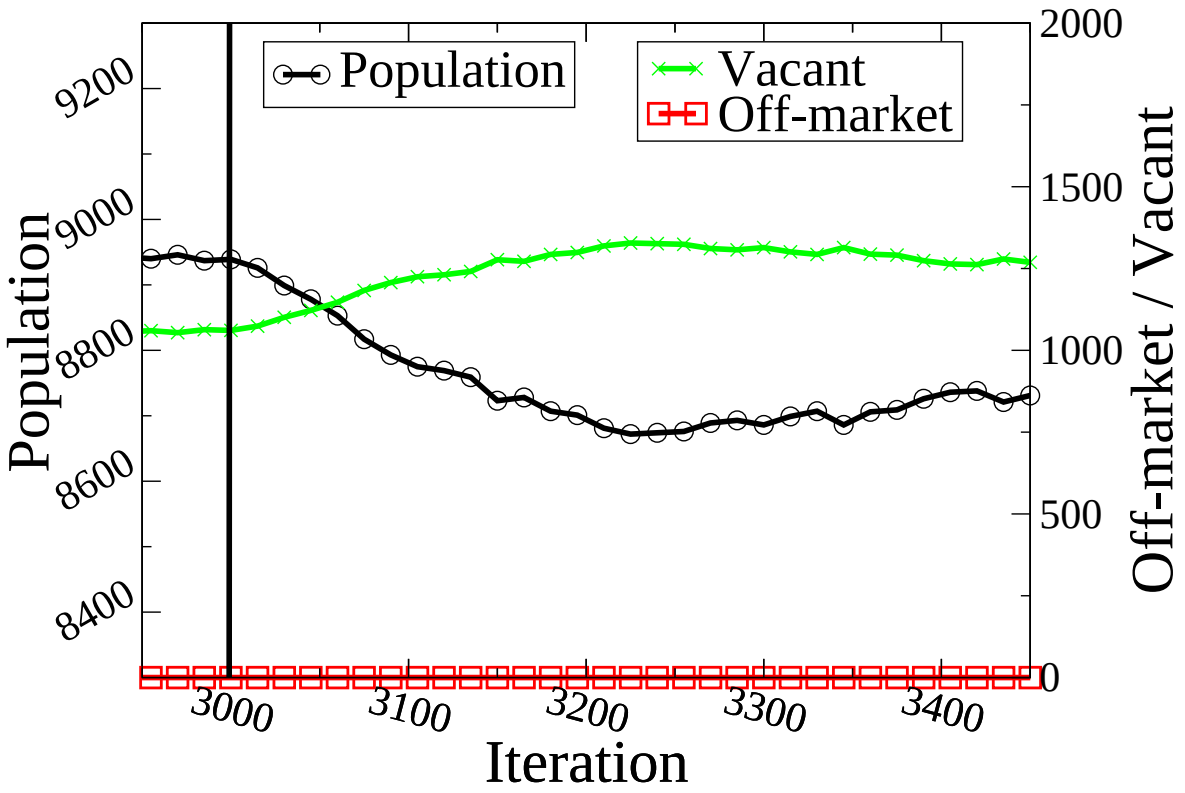
Reduction in Discount Rate

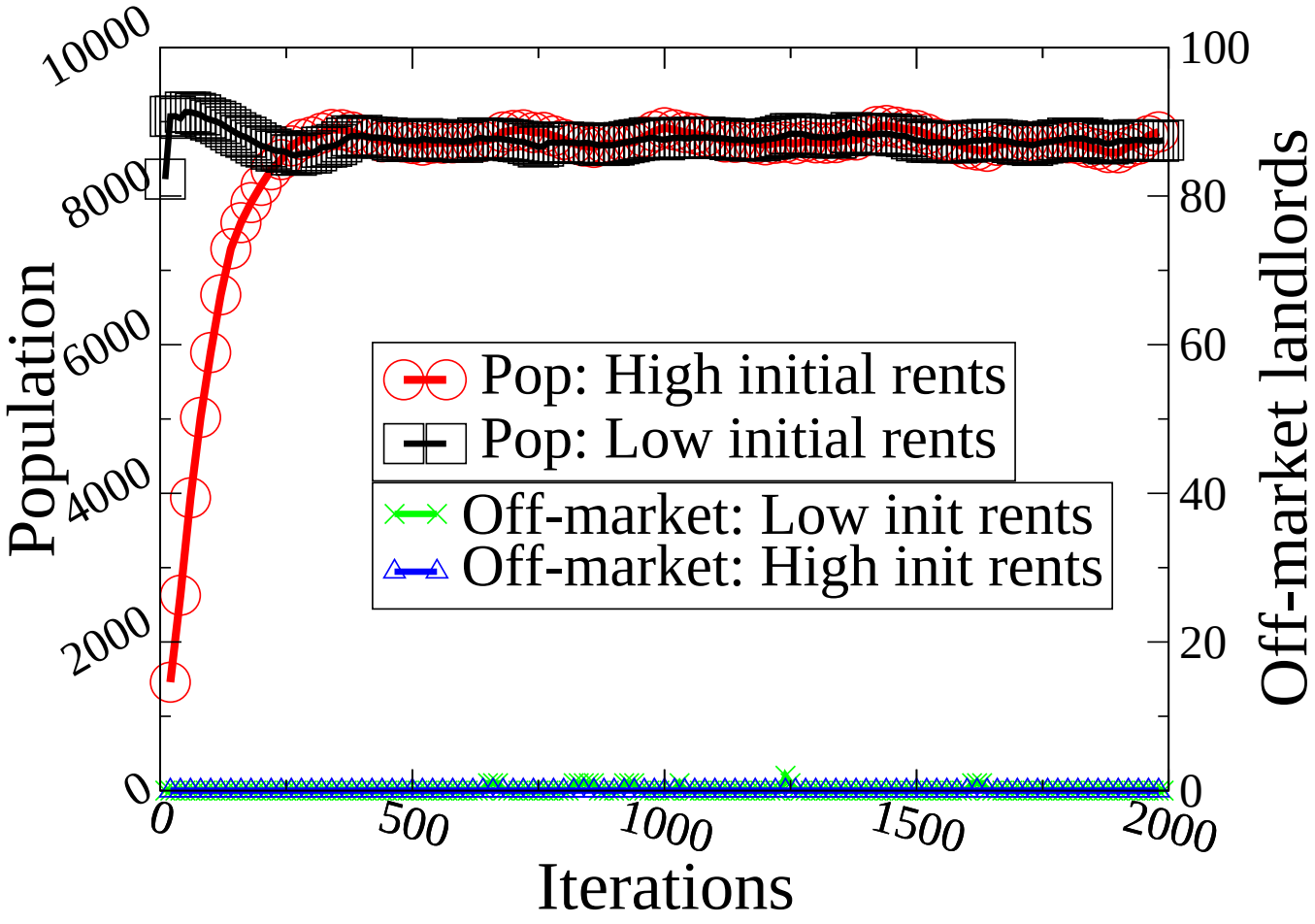


- At 3000 iterations 10% to 2%

Other Model Parameters

Symbol	Meaning	Default Value of Parameters
	Landlords' parameters	
S_L	% of sales seen	20%
F	Timescale rent changes (and memory)	15
I_{max}	Maximum rent increase	10%
C_L	Maintenance costs	100
	Tenants' parameters	
X	Expected length of residence	240
σ	Idiosyncrasy of tenants preferences	5 (% Y)
S_T	Percentage of offers seen	5%
C_T	Search costs	200

Convergence to Steady-state



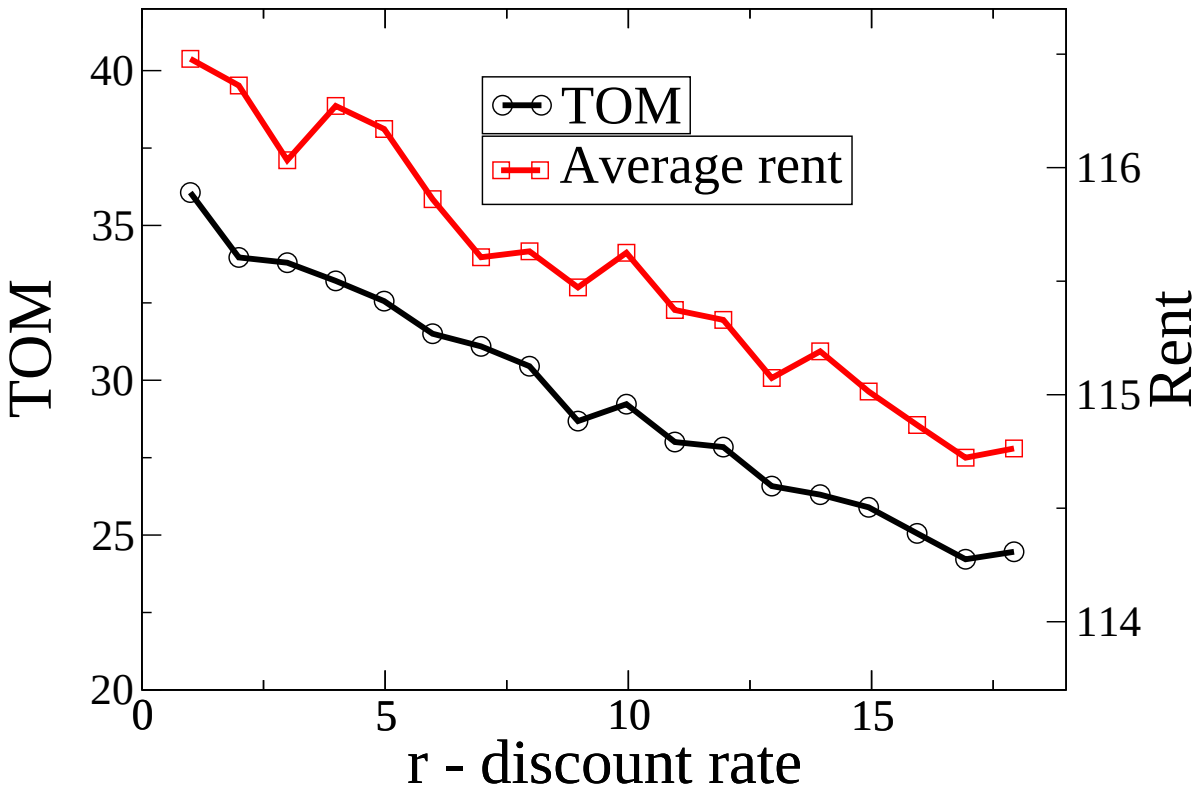
Tenants' equation

$$B_T\left(U_{res}\right) = \frac{D_s}{X+T(U_{res})}\int_0^{T(U_{res})}\exp(rt)\mathrm{d}t + \frac{\mathrm{E}[U_h]}{X+T(U_{res})}\int_{T(U_{res})}^{T(U_{res})+X}\exp(rt)\mathrm{d}t$$

Landlords' equation

$$B_L(R) = \frac{-C_L}{X+T(R)} \int_0^{T(R)} e^{-rt} \mathrm{d}t + \frac{R-C_L}{X+T(R)} \int_{T(R)}^{X+T(R)} e^{-rt} \mathrm{d}t$$

Discount Rate



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