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

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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: $U^T_h$
- 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
  - \( \eta \): Gaussian distribution of variance \( \sigma \)
  - \( \sigma \) 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:
  - $U_{\text{vac}} = -C_L$
    - $C_L$: Cost of maintenance
- Utility Housed
  - $U_{\text{occ}} = R - C_L$
    - $R$: 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

- **Population**
  - Pop: High initial rents
  - Pop: Low initial rents

- **Vacancies**
  - Vacancies: High init rents
  - Vacancies: Low init. rents

**Iterations**

- 0
- 500
- 1000
- 1500
- 2000
- 2500
- 3000

**Population**

- 0
- 2000
- 4000
- 6000
- 8000
- 10000

**Vacancies**

- 0
- 1000
- 2000
- 3000
- 4000
- 5000

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Rent Dispersion

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

![Graph showing TOM and Rent vs. landlords' information](image)

![Graph showing Expected TOM vs. Posted Rent](image)

Legend:
- TOM
- Average Rent
- Observations
- Exponential Fit

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Heterogeneous Information

![Graph showing average welfare vs. % ill-informed landlords]

- **Tenant welfare**
- **Ill-informed landlords ($S_L = 5\%$)**
- **Well-informed landlords ($S_L = 20\%$)**

The graph illustrates the relationship between the percentage of ill-informed landlords and the average welfare, with distinct lines for different information levels.
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

- **F**
- **now**
- **t**

- **•** rented
- **●** put on market
- **○** rent change
- **—** counted
- **—** not counted
Dynamic Variation of Discount Rate

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

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Dynamic Variation of Discount Rate

- At 1500 iterations 2% to 10%
- At 3000 iterations 10% to 2%
Increase in Discount Rate

- At 1500 iterations 2% to 10%
Reduction in Discount Rate

- At 3000 iterations 10% to 2%
Increase in Discount Rate

- At 1500 iterations 2% to 10%
Appendix

Reduction in Discount Rate

- At 3000 iterations 10% to 2%
### Other Model Parameters

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>Default Value of Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_L$</td>
<td>% of sales seen</td>
<td>20%</td>
</tr>
<tr>
<td>$F$</td>
<td>Timescale rent changes (and memory)</td>
<td>15</td>
</tr>
<tr>
<td>$I_{\text{max}}$</td>
<td>Maximum rent increase</td>
<td>10%</td>
</tr>
<tr>
<td>$C_L$</td>
<td>Maintenance costs</td>
<td>100</td>
</tr>
</tbody>
</table>

**Landlords’ parameters**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>Default Value of Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi$</td>
<td>Expected length of residence</td>
<td>240</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Idiosyncrasy of tenants preferences</td>
<td>5 (% $Y$)</td>
</tr>
<tr>
<td>$S_T$</td>
<td>Percentage of offers seen</td>
<td>5%</td>
</tr>
<tr>
<td>$C_T$</td>
<td>Search costs</td>
<td>200</td>
</tr>
</tbody>
</table>

**Tenants’ parameters**
Convergence to Steady-state

- Population
  - Pop: High initial rents
  - Pop: Low initial rents
- Off-market landlords
  - Off-market: Low init rents
  - Off-market: High init rents

Axes:
- Y-axis: Population
- X-axis: Iterations

Legend:
- Pop: High initial rents
- Pop: Low initial rents
- Off-market: Low init rents
- Off-market: High init rents
Tenants’ equation

\[
B_T(U_{res}) = \frac{D_s}{X + T(U_{res})} \int_0^T(U_{res}) \exp(rt) \, dt + \frac{E[U_h]}{X + T(U_{res})} \int_T^{T(U_{res}) + X} T(U_{res}) \exp(rt) \, dt
\]
Landlords’ equation

\[ B_L(R) = \frac{-C_L}{X + T(R)} \int_0^{T(R)} e^{-rt} \, dt + \frac{R-C_L}{X + T(R)} \int_{T(R)}^{X+T(R)} e^{-rt} \, dt \]
Discount Rate

![Graph showing the relationship between TOM and rent as a function of the discount rate. The graph includes two lines: one for TOM and another for average rent. As the discount rate increases, both TOM and the average rent decrease.](image-url)
Model Assumptions

- Closed Town (10,000 landlords & tenants)
- Homogeneous residences
- Tenants search every iteration
- Time discounting agents
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