The Ins and Outs of Selling Houses

L Rachel Ngai          Kevin D Sheedy

London School of Economics

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Findings for this presentation

- Document the cyclical properties of sales, new listings, time-to-sell, the number of houses for sale, and prices
- The variance decomposition shows that the inflow (listing) rate contributes around 98% while the outflow (sales) rate contributes around 2% to the volatility of sales volume
- Analyze housing market dynamics in a search and matching model with endogenous inflows and outflows – focuses on match quality (Ngai and Sheedy, "Moving House", 2015).
  - The model delivers a good fit to relative volatilities and correlations among key housing-market variables (even with only one shock to housing demand)
Data
Data — Housing-market variables Jan 1991 – Mar 2012

- FHFA — monthly repeated sales purchase-only house-price index for single-family homes
- NAR — monthly sales \((S_t)\) and inventories \((I_t)\) for single-family homes
- Construct new listings \((N_t)\), houses for sale \((U_t)\) and time-to-sell \(\left(\frac{U_t}{S_t}\right)\) from NAR data:

\[
N_t = I_{t+1} - I_t + S_t \quad , \quad U_t = I_t + \frac{N_t}{2} - \frac{S_t}{2}
\]

- Compute correlation matrix and construct autocorrelation graph for seasonally adjusted series (converted to quarterly series)
### Data — Autocorrelation graph and correlation matrix

<table>
<thead>
<tr>
<th>Sales</th>
<th>Price</th>
<th>New listings</th>
<th>Homes for sale</th>
<th>Time-to-sell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>1</td>
<td>0.671</td>
<td>1.289</td>
<td>1.012</td>
</tr>
</tbody>
</table>

**Relative standard deviations**

**Correlation coefficients**

| Sales       | 1     | 0.720        | 0.850          | 0.070        | -0.635       |
| Price       |       | 1            | 0.602          | 0.661        | -0.004       |
| New listings|       |              | 1              | 0.009        | -0.617       |
| Homes for sale |      |              |                | 1            | 0.689        |
| Time-to-sell | -0.635| -0.004       | -0.617         | 0.689        | 1            |

![Autocorrelation graph](image)
Data — Stylized facts

- Well-known facts: prices and sales are positively correlated, and both are negatively correlated with time-to-sell

- New facts
  - All variables are persistent
  - New listings are (1) more volatile than sales, (2) strongly positively correlated with sales and (3) negatively correlated with time-to-sell
  - Home for sale is (1) strongly positively correlated with price and time-to-sell, and (2) mildly positively correlated with sales and new listings
Data — Inflows versus outflows

- It is well-known that sales volume is extremely volatile (about 5 times more volatile than GDP, see Diaz-Jerez, 2013)
- What drives fluctuations in sales volume? Is it changes in the difficulty of selling houses (outflows) or changes in the number of houses put up for sale (inflows)?

\[
\begin{align*}
S_t &= (1 - e^{-s_t}) l_t + \int_0^1 \left( 1 - e^{-s_t(1-\tau)} \right) N_{t+\tau} d\tau \\
N_t &= (1 - e^{-n_t}) (K - l_t) + \int_0^1 \left( 1 - e^{-n_t(1-\tau)} \right) S_{t+\tau} d\tau
\end{align*}
\]

New listings

For sale \(\Leftrightarrow\) Not for sale

Inflows \((N_t)\) and outflows \((S_t)\) are
Both inflow \((n_t)\) and outflow \((s_t)\) rates are volatile, with coefficients of variation equal to 0.27 and 0.21 respectively.
Data — Variance Decomposition

- Given the inflow and outflow rates $n_t$ and $s_t$, the steady-state sales volume $S_t^*$ and houses for sale $u_t^*$ are:

  $$S_t^* = \frac{s_t n_t}{s_t + n_t}, \quad u_t^* = \frac{n_t}{s_t + n_t}$$

- The change in $S_t^*$ can be decomposed into two parts related to the change in $n_t$ and the change in $s_t$:

  $$\frac{\Delta S_t^*}{S_{t-1}^*} = (1 - u_t^*) \frac{\Delta n_t}{n_{t-1}} + u_t^* \frac{\Delta s_t}{s_{t-1}}$$

- $\beta_n$ and $\beta_s$ are respectively the covariances between $\Delta S_t^*/S_{t-1}^*$ and the terms in $\Delta n_t/n_{t-1}$ and $\Delta s_t/s_{t-1}$, divided by the variance of $\Delta S_t^*/S_{t-1}^*$

- The variance decomposition shows that the inflow rate contributes around 98% while the outflow rate contributes around 2% to the volatility of sales volume
Model
Model set-up

- Unit continuum of families; unit continuum of houses, each owned by one family
- Houses either occupied (yield utility to family, only for one house) or for sale:
  - Measure of buyers = $b_t$
  - Measure of sellers (‘unsatisfied owners’) = $u_t$
  - Under our assumptions, $b_t = u_t$
- Three decisionmakers
  1. Homeowners (value function = $H_t(\epsilon)$, $\epsilon =$ match quality)
  2. Buyers (value function = $B_t$)
  3. Sellers (‘unsatisfied owners’) (value function = $U_t$)
Two types of search frictions:

1. Difficult for buyers and sellers to meet each other:
   Total viewings occur at a continuous rate given by the constant returns to scale meeting function $V(u_t, b_t)$

2. Idiosyncratic match quality can only be revealed by a viewing:
   Match quality $\epsilon$ is drawn from a Pareto distribution:
   $$\epsilon \sim \text{Pareto}(1; \lambda)$$

Sales happens when $\epsilon$ exceeds a transaction threshold $y_t$; the house price is determined by Nash bargaining

Costs:
- Transaction cost = $C$
- (Flow) search cost = $F$
- (Flow) maintenance cost = $M$
Utility flow value from occupying house = $\epsilon \xi_t$

Aggregate housing demand $\xi_t$ follows an exogenous stochastic process:

$$\log \xi_t = \rho \log \xi_{t-\tau} + \eta_t, \quad \eta_t \sim i.i.d. \left(0, \varsigma^2\right)$$

Match quality $\epsilon$ is a persistent variable:

- $\epsilon$ remains constant unless an idiosyncratic shock is received
- Shocks arrive at rate $a$
- Following a shock, $\epsilon$ is degraded to $\epsilon' = \delta \epsilon$ (with $\delta < 1$)

Following the idiosyncratic shock, homeowners can decide whether to put their houses up for sale, which happens when $\epsilon$ is below a moving threshold $x_t$. 


The distribution of match quality across all homeowners varies endogenously for two reasons:

- the distribution of match quality for surviving matches changes over time because the moving threshold $x_t$ can fluctuate — moving decisions today have consequences for future distributions
- the transaction threshold $y_t$ changes over time

The fluctuations in the moving threshold generate a new mechanism that works through a ‘cleansing’ effect:

- a higher current threshold for not moving now implies that moving in the future becomes less likely (a greater degree of ‘cleansing’)
Model – Value functions (for sales and new listings)

Owner-occupier:

\[ H_t(\epsilon) = \tau \epsilon \xi_t + \beta \alpha E_t[H_{t+\tau}(\epsilon) - \tau M] + \beta(1-\alpha) E_t \max\{H_{t+\tau}(\delta \epsilon) - \tau M, W_{t+\tau}\} \]

The combined value of being a buyer and having a house for sale:

\[ W_t = -\tau(F + M) + \beta E_t W_{t+\tau} + \nu \pi_t \Sigma_t \]

The average surplus from viewings:

\[ \Sigma_t = \int_{\epsilon=y_t}^{\infty} \frac{\lambda_t}{y_t} \left( \frac{\epsilon}{y_t} \right)^{-(\lambda_t+1)} H_t(\epsilon) d\epsilon - \beta E_t W_{t+\tau} - C \]

The two endogenous thresholds \( x_t \) and \( y_t \) solve

\[ H_t(y_t) = \beta E_t W_{t+\tau} + C, \quad H_t(x_t) = W_t + \tau M \]

We derive the thresholds \((x_t, y_t)\) thus levels of sales and new listings, and using the law of motion for \( u_t \), the future \( u_{t+1} \)
Model – Value functions (for prices)

The surpluses of the buyer and the seller (‘unsatisfied owner’) are:

\[ \Sigma_{b,t}(\epsilon) = H_t(\epsilon) - \beta \mathbb{E}_t B_{t+\tau} - p_t(\epsilon) - (1 - \kappa)C \]
\[ \Sigma_{u,t}(\epsilon) = p_t(\epsilon) - \beta \mathbb{E}_t U_{t+\tau} - \kappa C \]

The value of being a buyer:

\[ B_t = -\tau F + \beta \mathbb{E}_t B_{t+\tau} + \nu \int_{\epsilon=y_t}^{\infty} \lambda_t e^{-(\lambda_t+1)\Sigma_{b,t}(\epsilon)} d\epsilon \]

and a seller (‘unsatisfied owner’):

\[ U_t = -\tau M + \beta \mathbb{E}_t U_{t+\tau} + \nu \int_{\epsilon=y_t}^{\infty} \lambda_t e^{-(\lambda_t+1)\Sigma_{u,t}(\epsilon)} d\epsilon \]

The transaction price for a house:

\[ p_t(\epsilon) = \omega H_t(\epsilon) + (\kappa - \omega)C + \beta \left( \frac{\tau}{1-\beta} \right) (\omega F - (1 - \omega)M) \]
Solution method

- **Steady state**: Model with no aggregate shocks ($\xi_t = 1$) — solve for $x$ from one non-linear equation, other variables can then be found analytically.

- **Dynamics**: Model with aggregate shocks $\xi_t$ is solved using a first-order perturbation method around the steady state.

- Pareto distribution assumption for match quality implies:
  - Decision thresholds can be determined by averages of the value functions (at the steady-state distribution of match quality).
  - State space of linearized model is small — laws of motion for aggregate variables do not require tracking the whole distribution of surviving match quality.
Solution method (differentiability at decision thresholds)

- Well-known problem of non-differentiability in models with endogenous ‘lumpy’ adjustments
- Avoided here by assuming idiosyncratic shocks are necessary for moving, and are large relative to aggregate shocks

\[
x_t - x_{t-1} - \epsilon
\]

Density

No idiosyncratic shock (‘kink’)

Range of \( x_t \) values due to aggregate shock

Large idiosyncratic shock (‘no kink’)

Range of \( x_t \) values due to aggregate shock
The model contains 12 parameters \( \{\tau, r, \omega, F, M, C, \kappa, a, \delta, \nu, \lambda, \rho\} \).

Calibrate the first 11 of them so that steady state of the model is consistent with observables:

- Directly set \( \{\tau, r, \omega\} \): time period to one week \( \tau = 1/52 \), discount rate \( r = 0.07 \), and bargaining power \( \omega = 0.5 \).
- The cost parameters \( \{F, M, C, \kappa\} \) match data on transaction costs, search costs, and maintenance costs.
- The remaining parameters \( \{a, \delta, \nu, \lambda\} \) match the expected duration of a new match, the average time home-owners have owned their homes, the number of viewings per sale, and the average time-to-sell.

The persistence parameter \( \rho \) for aggregate shock is calibrated to match the persistence of house prices (the model predicts that house prices have the same persistence as the demand shock), equivalent to an autoregressive parameter of 0.965 at the quarterly frequency.
## Calibration targets

<table>
<thead>
<tr>
<th>Target description</th>
<th>Notation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to sell (time to buy)</td>
<td>$T_s$</td>
<td>6.5/12</td>
</tr>
<tr>
<td>Viewings per sale (viewings per purchase)</td>
<td>$V_s$</td>
<td>10</td>
</tr>
<tr>
<td>Expected duration of ownership of a house</td>
<td>$T_d$</td>
<td>12.2</td>
</tr>
<tr>
<td>Average years since home-owners moved in</td>
<td>$T_a$</td>
<td>11</td>
</tr>
<tr>
<td>Ratio of transaction cost to average price</td>
<td>$c$</td>
<td>0.10</td>
</tr>
<tr>
<td>Ratio of flow search costs to average price</td>
<td>$f$</td>
<td>0.025</td>
</tr>
<tr>
<td>Ratio of flow maintenance costs to average price</td>
<td>$m$</td>
<td>0.045</td>
</tr>
</tbody>
</table>

- $T_a$ and $T_d$ are informative about the arrival rate $a$ and the size $\delta$ of idiosyncratic shocks, and their difference reveals information about the slope of the hazard function for moving house.
- $V_s$ reveals information about the meeting probability $v$ between buyers and sellers.
- $T_s$ is informative about the distribution parameter $\lambda$ for match quality.
Simulation results

- Report autocorrelation graph, impulse response function and correlation matrix for analyzing the joint dynamics of the flows, the stock of houses for sale, and prices.
- To highlight the roles of endogenous moving on generating persistence and relative volatilities observed in the data, we present results for:
  1. a special case of the model with exogenous moving ($\delta = 0$)
  2. the baseline model
  3. a version of the model with a lower persistence of housing demand
## Exogenous moving model

<table>
<thead>
<tr>
<th></th>
<th>Sales</th>
<th>Price</th>
<th>Listings</th>
<th>Houses for sale</th>
<th>Time to sell</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relative standard deviations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>1</td>
<td>4.734</td>
<td>0.176</td>
<td>3.453</td>
<td>3.761</td>
</tr>
</tbody>
</table>

### Correlation coefficients

<table>
<thead>
<tr>
<th></th>
<th>Sales</th>
<th>Price</th>
<th>Listings</th>
<th>Houses for sale</th>
<th>Time to sell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>1</td>
<td>0.429</td>
<td>0.176</td>
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<td></td>
</tr>
<tr>
<td>Price</td>
<td></td>
<td>1</td>
<td>0.964</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listings</td>
<td></td>
<td>0.176</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Houses for sale</td>
<td>-0.178</td>
<td>-0.965</td>
<td>-0.999</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Time to sell</td>
<td>-0.429</td>
<td>-1.000</td>
<td>-0.964</td>
<td>0.965</td>
<td>1</td>
</tr>
</tbody>
</table>

![Graph showing the trend of sales, price, listings, houses for sale, and time to sell over quarters.](attachment:image.png)
Exogenous moving model

Impulse response function to a housing demand shock

![Graph showing the impulse response function to a housing demand shock with various indicators such as sales, price, listings, houses for sale, and time to sell over a 20-quarter period.]
Unsurprisingly the volatility of listings is too low
- Listings can only vary as a reflection of changes in houses for sale, but by a much smaller amount
- Perfect negative correlation between listings and houses for sale
- Listings and houses for sale have same correlations (in absolute value) with other variables

But also, the relative volatility of sales volume is far too low, and this variable has very little persistence
- With no possibility of significant inflows, any change to the volume of sales is going to be short lived because the stock of houses for sale is quickly depleted by an increase in the sales rate

The correlation of sales and listings, and sales and prices are both too low
Allowing the inflow rate subject to exogenous time variation, i.e. by adding an aggregate shock to the moving rate:

- Improves predictions for volatility for inflows and its correlation with sales.
- Fails on relative volatility of other variables
- Predicts the wrong correlation signs for price with all other variables.
- We next show the endogenous moving model do a much better job of matching relative volatility and correlations between housing-market variables.
- It introduces some entry into the market orthogonal to variables matters for transaction decision
### Baseline model

<table>
<thead>
<tr>
<th>Sales</th>
<th>Price</th>
<th>Listings</th>
<th>Houses for sale</th>
<th>Time to sell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>1</td>
<td>1.822</td>
<td>0.880</td>
<td>1.363</td>
</tr>
</tbody>
</table>

**Relative standard deviations**

**Correlation coefficients**

<table>
<thead>
<tr>
<th></th>
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<th>Time to sell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>1</td>
<td>0.919</td>
<td>0.877</td>
<td>-0.764</td>
<td>-0.919</td>
</tr>
<tr>
<td>Price</td>
<td></td>
<td>1</td>
<td>0.927</td>
<td>-0.957</td>
<td>-1.000</td>
</tr>
<tr>
<td>Listings</td>
<td></td>
<td></td>
<td>1</td>
<td>-0.868</td>
<td>-0.927</td>
</tr>
<tr>
<td>Houses for sale</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>0.957</td>
</tr>
<tr>
<td>Time to sell</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

![Graph showing correlation coefficients over quarters](image)
Baseline model

Impluse response function to a housing demand shock
Summary of baseline model

- Volatility of listings is comparable to sales (close to data)
- Movements in sales are also much more persistent (again close to data)
- Correlation of sales and listings is strongly positive, and correlations of sales and price (and time-to-sell) are higher than before (closer to data)
  - Higher housing demand now leads to more houses coming on to the market
  - This allows higher sales volume to be maintained for a longer time
Less persistent demand shock ($\rho = 0.95$)

<table>
<thead>
<tr>
<th></th>
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<td><strong>Relative standard deviations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>1</td>
<td>1.511</td>
<td>0.724</td>
<td>2.099</td>
<td>2.721</td>
</tr>
<tr>
<td><strong>Correlation coefficients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>0.734</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listings</td>
<td>0.557</td>
<td>0.707</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Houses for sale</td>
<td>-0.475</td>
<td>-0.946</td>
<td>-0.651</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Time to sell</td>
<td>-0.734</td>
<td>-1.000</td>
<td>-0.707</td>
<td>0.946</td>
<td>1</td>
</tr>
</tbody>
</table>
Less persistent demand shock ($\rho = 0.95$)

*Impluse response function to a housing demand shock*

- Listings do not rise on impact
- And can fall for demand shocks with even lower persistence
- Need shocks with sufficient persistence to exercise option of moving (given frictions in the market)
Summary of this presentation

- Using data from FHFA and NAR
  - perform a two-state variance decomposition to show inflow rate contributes around 98% while the outflow (sales) rate contributes around 2% to the volatility of sales volume
  - compute autocorrelation graph and correlation matrix to show both flows are persistent, volatile and highly correlated with other housing-market variables
- Use a search-and-matching model where both inflows and outflows are endogenous to show
  - quantitatively, endogenous inflows are crucial in understanding persistence, relative volatility and comovement for housing market variables