Steven Laufer

Federal Reserve Board

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Federal Reserve Bank of Chicago
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Views expressed are those of the presenter and should not be attributed to the Board of Governors or others within the Federal Reserve System.
Motivation: Equity Extraction and LTV at Default

LTV ratios of defaulters who purchased their houses during 2000-2003

Steven Laufer (FRB)
Motivation: LTV at Default

Increase in cLTV at Default from Equity Extraction

Quarter of Purchase

Mean 10%
25% 50%
75% 90%

Increase in cLTV at Default from Equity Extraction

Quarter of Purchase

Mean 10%
25% 50%
75% 90%

Equity Extraction and Mortgage Default

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Why did these homeowners take out equity and then default?

1. **House prices**: Homeowners borrowed in response to rising prices. After prices fall, default because of negative equity. (Direct effect)

2. **Income shocks**: Homeowners with few liquid assets use equity extraction to smooth consumption. Liquidity constrained homeowners with negative equity default when hit by income shock. (Selection effect)
Why did these homeowners take out equity and then default?

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What would have been the effects of a policy that limited refinancing to 80% of the house value?
Approach

- Build model of equity extraction and default with large shocks in income process and boom/bust cycles of house prices.
- Use property-level mortgage data set where can observe equity extraction.
- Use other data sources for information on income, assets.
- Estimate parameters of model to match rates of equity extraction, sales, default.
- Run counterfactual policy experiment within estimated model.
Model

- Model of homeowners.
- Income shocks including large shocks that look like unemployment.
- House price shocks including persistent “boom” and “bust” periods.
- Household choices:
  1. Consumption and savings
  2. Mortgage balances and housing equity
  3. Sale, Default
Model

- Model of homeowners.
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- House price shocks including persistent “boom” and “bust” periods.
- Household choices:
  1. Consumption and savings
  2. Mortgage balances and housing equity
  3. Sale, Default
- Households withdraw equity to finance additional spending when they deplete savings.
- Households default when
  1. they can’t afford mortgage payments because of bad income realizations
  2. when they’re underwater and it’s optimal to do so (for a variety of reasons)
Data: Mortgages

Open Lien Search from CoreLogic

- Los Angeles County, California. Single Family Homes. 1.2-1.3M properties
- Quarterly observations 2000Q1-2009Q4
- Full property address
- Purchase information: date, value
- All open mortgages on property: origination date, original balance, interest rate, sub-prime lender, current balance
- Defaults: Filings of notice of default, notice of trustee sale
Data: Income

- Mortgage data does not have income.
- American Community Survey
  - Annual Survey by US Census starting 2000
  - Unemployment data by congressional district, age/race group: annual local unemployment rate
- Panel Study of Income Dynamics (PSID)
  - Annual observations of household income
  - Housing information: house value, mortgage balance, interest rates, move-in date
  - Distribution of income, assets among new homeowners
Data: House Prices

- Use observations from liens data to calculate repeat-sales house price index (HPI) for each zip-code.
- Estimate of house value using purchase price/date and zip-code HPI. Construct estimated LTV each quarter.
- Use prices of repeat sales to measure distribution of “true” house values around estimated values.
Estimate model parameters with method of simulated moments.

- Sample of 2002-2004 buyers
- Begin with observed LTV, income and assets to match distribution for new buyers from PSID
- Simulate income to match observed values of unemployment rate and median income growth, house prices to match observed regional house prices
- Find model parameters so that simulations match data: rates of default, moving, equity extraction, asset and income moments from PSID
What parameters values are needed for the model to match the data?

- Homeowners are very impatient, spend down savings quickly (quarterly discount factor $\beta = .94$)
- Homeowners act as if they face a harsh penalty for default (equivalent to sacrificing to 51% of future consumption)
Results: Aggregate Rates

![Graph of Fraction Extracting Equity](image)

![Graph of Fraction Selling](image)

![Graph of Fraction Defaulting](image)

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Equity Extraction and Mortgage Default  
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## Results: Equity Extraction and Default

<table>
<thead>
<tr>
<th>Purchase Year</th>
<th>Outcome</th>
<th>New Mortgages/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Data</td>
</tr>
<tr>
<td>2002</td>
<td>Stay</td>
<td>.25</td>
</tr>
<tr>
<td></td>
<td>Sell</td>
<td>.36</td>
</tr>
<tr>
<td></td>
<td>Default</td>
<td>.47</td>
</tr>
<tr>
<td>2003</td>
<td>Stay</td>
<td>.25</td>
</tr>
<tr>
<td></td>
<td>Sell</td>
<td>.36</td>
</tr>
<tr>
<td></td>
<td>Default</td>
<td>.47</td>
</tr>
<tr>
<td>2004</td>
<td>Stay</td>
<td>.21</td>
</tr>
<tr>
<td></td>
<td>Sell</td>
<td>.29</td>
</tr>
<tr>
<td></td>
<td>Default</td>
<td>.35</td>
</tr>
</tbody>
</table>
Model Discussion: Default

![Graph showing the probability of default](image)

- 0 < Prob( Default ) < 1

- Liquid Assets (A/P)
- LTV Ratio (M/H)
- Probability of Default

- Default
- No Default

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Equity Extraction and Mortgage Default

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Model Discussion: Causes of Equity Extraction and Default

Equity Extraction 2002-2005
- Without unemployment shocks, equity extraction is 2% lower.
- Without rising house prices, equity extraction is 92% lower.
- Without the *expectation* of rising house prices, equity extraction is 20% lower.

Default 2006-2009
- Liquidity constraints, income shocks account for 30% of defaults.
- Negative equity plus non-income shocks account for remaining 70%.
- Without unemployment shocks, 9% fewer defaults.
- Without falling house prices, 49% fewer defaults.
- Without the *expectation* of falling house prices, 34% fewer defaults.
Policy Experiment - 80% Refinancing Limit

Impose limit that total LTV of new loan cannot exceed 80%:
- Similar to a provision of the Texas A6 refinancing laws
- Prices adjust to clear the housing market: Everyone buys the same house as in the baseline
Policy Experiment - 80% Refinancing Limit

Solve and simulate model with 80% LTV limit on refinances.

- House prices are 14% lower because of lower value of housing as collateral.
- Equity extraction is 23% lower and defaults are 28% lower because of smaller house values and lower mortgage balances.
- At given LTV ratio, probability of default is actually higher.
- Overall, new homeowners are better off because of lower house prices. (Welfare gain equivalent to 3% of consumption)
## Distribution of outcomes in counter-factual for each outcome in baseline model

<table>
<thead>
<tr>
<th>Baseline Outcome</th>
<th>Stay</th>
<th>Sell</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay (62.7%)</td>
<td>93.8%</td>
<td>4.6%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Sell (26.7%)</td>
<td>0.9%</td>
<td>97.5%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Default (10.6%)</td>
<td>24.8%</td>
<td>16.4%</td>
<td>58.8%</td>
</tr>
<tr>
<td>Total</td>
<td>61.7%</td>
<td>30.7%</td>
<td>7.6%</td>
</tr>
</tbody>
</table>
Two new groups of defaulters:

1. Liquidity constrained with small amounts of positive equity
2. Negative equity, lower value of staying because of future equity extraction
Without any equity extraction, the default rate of homeowners who had purchased before 2004 would have been 80% lower.

This decrease represents 30% of total defaults.
Conclusion

- Equity extraction explains negative equity and 80% of default among earlier buyers, which is about 30% of total defaults.
- Equity extraction driven largely by high spending in response to rising house prices.
- In the model, post-2006 defaults caused mostly by high LTV ratios, 30% income shocks hitting liquidity-constrained households.
- Limiting refinances to 80% of house value would reduce house prices, equity extraction and default, result in welfare increase for new homeowners.
• Equity Extraction: Hurst and Stafford (2004), Greenspan and Kennedy (2007)
• Empirical studies of equity extraction and default
  • Holmes and LaCour-Little (2013): Study California foreclosures in 2006-2008. Half were underwater because of equity extraction rather than fall in prices.
Model Discussion: Expectations and Default

Probability of Default by Expected Price Growth

- Increasing Prices
- Decreasing Prices

Liquid Assets (A/P)
LTV Ratio (M/H)
Probability of Default by Expected Price Growth

- 0.0001
- 0.015
- 0.025

0.5 1 1.5 2 2.5 3 3.5 4
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6

Increasing Prices
Decreasing Prices
Findings

- Extract equity when liquidity constrained. Liquidity constraints bind because of high spending rather than income shocks. High spending because of house price growth.
- Rise in defaults driven by high loan-to-value ratios (LTV). Income shocks account for only 30% of defaults after crash.
- Limiting refinances to 80% of house value decreases prices, lowers defaults and increases the welfare for new homeowners.
- Without any equity extraction, 80% of defaulting homeowners who had purchased before 2004 (30% of total) would not have defaulted.
Regional Housing Prices: MLE of two-state Markov switching process on zip-code level house prices

- **Booms:**
  - Expected price growth is 15% per year.
  - Expected duration is 22 quarters.

- **Busts:**
  - Expected price decline is 7% per year.
  - Expected duration is 11 quarters.
House Price Expectations

Probability of High House Price Growth

Quarter
Mean 10%
25% 50%
75% 90%
Probability of High House Price Growth
Model: Income

- Permanent and transitory components
  \[ Y_t = P_t \varepsilon_t \]

- Permanent component
  \[ P_t = P_{t-1} \nu_t \quad \ln \nu_t \sim \mathcal{N}(\mu_\nu, \sigma^2_{\nu}) \]

- Transitory component
  \[ \varepsilon_t = e_t \cdot \varepsilon^0_t \]

- Unemployment shock
  \[ e_t \in \{\delta, 1\} \quad \text{Prob}(e_{1,t+1} = e' | e_t = e) = \Pi_{e',e}^{E} \]

- Continuous i.i.d. transitory shock
  \[ \ln \varepsilon^0_t \sim \mathcal{N}(\mu_\varepsilon, \sigma^2_\varepsilon) \quad E(\log \varepsilon_t) = 0 \]
Model: Housing

- House \( i \) in region \( j \) has price \( p_{ijt} \)

\[
\Delta \log p_{ijt} = \mu_{jt} + \eta_{jt} + \zeta_{it}.
\]

- Expected house price appreciation

\( \mu_{jt} \in \{\mu_1, \mu_2\}, \quad \text{Prob}(\mu_{j,t+1} = \mu' | \mu_{jt} = \mu) = \Pi_{\mu,\mu'}^{H} \)

- Regional house price shock

\( \eta_{jt} \sim \mathcal{N}(0, \sigma^2_\eta) \)

Observe regional house price growth \( \mu_{jt} + \eta_{jt} \). Don’t observe \( \mu_{jt} \) but observe history of prices in region \( j \) and filter price series to get distribution \( f_{jt}(\mu) \):

\[
f_{jt}(\mu_2) = \text{Prob}(\mu_{jt} = \mu_2).
\]

- Idiosyncratic shock

\( \zeta_{jt} \sim \mathcal{N}(0, \sigma^2_\zeta) \)

- Per-period maintenance cost \( \chi p_t h_t \).

- Selling cost \( \theta_0 P_t + \theta_1 p_t h_t \) if \( h_{t+1} \neq h_t \), dis-utility from moving \( \theta_u \)
Mortgage of size $M_t$ requires interest payments $r^m M_t$ but no principal payments.

All borrowers, mortgages have same constant interest rate.

Owners can take out new mortgage up to fraction $\phi(f_{jt}(\mu_2))$ of current house value.

No borrowing limits on existing mortgages. LTV ratio may rise above one if prices fall.

Limit on debt-to-income ratio: Mortgages must satisfy $r^m M_t < \psi_i P_t$. 

(i=Purchase or Refinance)

Mortgage costs

$$K(M_{t+1}) = k_0 P_t + (k_1 + k_2 \cdot 1(M_{t+1} > \bar{m} p_t h_t)) M_{t+1}$$
Defaulters permanently enter a frictionless rental market with housing services available at price $\rho p_t$.

Incentives to Default:

1. Defaulters do not pay mortgage/housing costs in period of default.
2. Lose value of house and obligation to repay mortgage. (Wealth increases by $M_t - p_t h_t$)

Default if can’t afford mortgage payment.

Default as an optimal decision even if can afford payments.
Model: Preference Shocks

- Every period with probability $\lambda$, the household receives a preference shock of strength $\omega_t$,

  $$
  \omega_t \sim \mathcal{N}(\mu_\omega, \sigma^2_\omega)
  $$

- If move (sell or default) in response to shock, get utility

  $$
  \Omega_t = \omega_t P_t^{1-\gamma} p_t^{(1-\alpha)(\gamma-1)}
  $$
Estimation: Income & Housing Prices

- Period is a quarter. All quantities are nominal.

- Discrete income shock: Match to unemployment

\[ \delta = 0.5 \quad \Pi_{e \rightarrow u}^E = 0.020 \quad \Pi_{u \rightarrow e}^E = 0.60 (u = 0.034) \]

- Continuous income shocks: Match moments of household income for homeowners from PSID

\[ \mu_v = 0.008 \quad \sigma_v = 0.096 \quad \sigma_\epsilon = 0.233 \]

- Regional Housing Prices: MLE of two-state Markov switching process on zip-code level HPI's

\[ \{\mu_1, \mu_2\} = \{-0.018, 0.038\}, \quad \Pi_{\mu_1,\mu_1} = 0.908 \quad \Pi_{\mu_2,\mu_2} = 0.954 \quad \sigma_\eta = 0.028 \]

- Idiosyncratic house price shock from variance of residuals of repeat sales observations

\[ \sigma_\zeta = 0.017 \]
Estimation: MSM

Estimate model with method of simulated moments.

- Sample of 2002-2004 buyers.
- Begin with observed LTV, income and assets to match distribution for new buyers from PSID.
- Simulate income to match observed values of unemployment rate, median income growth. Observed regional house prices plus idiosyncratic shock.
- Target 190 moments: rates of default, moving, equity extraction plus interactions with observed variables. Asset and income moments from Michigan Panel Study of Income Dynamics (PSID).
Model Discussion: Equity Extraction

Whether Extract Equity

- Increasing Prices
- Decreasing Prices
- Increasing or Decreasing Prices

Liquid Assets (A/P)
LTV Ratio (M/H)

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Policy Experiment - Recourse

Grant lenders full recourse. Convert un-paid balance of mortgages into un-collateralized debt upon default.

- Same interest rate $r_m = .017$.
- Can’t discharge debt through bankruptcy.

Will decrease default rate. Two effects:

1. Decrease in likelihood of default for given LTV.
2. Decrease in borrowing $\rightarrow$ lower LTV.
Policy Experiment - Recourse: Default

Liquid Assets (A/P)  
LTV Ratio (M/H)  
Probability of Default

1  1  1  0.0001  0.015  0.025
0.0001  0.015  0.025

1 2 3 4 5 6
0.6 0.8 1 1.2 1.4 1.6
Baseline
Recourse

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Distribution of outcomes in counter-factual for each outcome in baseline model.

<table>
<thead>
<tr>
<th>Baseline Outcome</th>
<th>Outcome with Recourse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay (62.7%)</td>
<td>94.9% 4.1% 1.0%</td>
</tr>
<tr>
<td>Sell (26.7%)</td>
<td>1.1% 97.7% 1.3%</td>
</tr>
<tr>
<td>Default (10.6%)</td>
<td>40.9% 13.1% 46.0%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>64.1% 30.1% 5.8%</td>
<td></td>
</tr>
</tbody>
</table>
Policy Experiment - Recourse

- House prices are 12% lower because of lower value of housing as collateral.
- Equity extraction is 18% lower and defaults are 45% lower because of smaller house values and restrictions on borrowing.
- Welfare gain for new homeowners equivalent to 2.7% of consumption because of lower house prices.
Data: Outcomes by Purchase Year

Outcomes by Purchase Year

Purchase Year

Sale Default

Outcomes by Purchase Year

Fraction of Outcomes


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## Data: Purchases

<table>
<thead>
<tr>
<th>Purchase Year</th>
<th>N (1000)</th>
<th>Mean cLTV</th>
<th>Median cLTV</th>
<th>Subprime</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>103</td>
<td>0.87</td>
<td>0.90</td>
<td>0.40</td>
<td>0.07</td>
</tr>
<tr>
<td>2001</td>
<td>88</td>
<td>0.87</td>
<td>0.90</td>
<td>0.14</td>
<td>0.08</td>
</tr>
<tr>
<td>2002</td>
<td>94</td>
<td>0.86</td>
<td>0.90</td>
<td>0.18</td>
<td>0.08</td>
</tr>
<tr>
<td>2003</td>
<td>94</td>
<td>0.86</td>
<td>0.90</td>
<td>0.25</td>
<td>0.11</td>
</tr>
<tr>
<td>2004</td>
<td>91</td>
<td>0.87</td>
<td>0.90</td>
<td>0.29</td>
<td>0.19</td>
</tr>
<tr>
<td>2005</td>
<td>88</td>
<td>0.88</td>
<td>0.91</td>
<td>0.28</td>
<td>0.32</td>
</tr>
<tr>
<td>2006</td>
<td>72</td>
<td>0.90</td>
<td>1.00</td>
<td>0.22</td>
<td>0.42</td>
</tr>
<tr>
<td>2007</td>
<td>53</td>
<td>0.85</td>
<td>0.90</td>
<td>0.05</td>
<td>0.19</td>
</tr>
</tbody>
</table>
Data: New Mortgages

New Mortgages

Quarter

Non–Cash–Out Refinacnes
New Junior Mortgages
Cash–Out Refinacnes

Number of New Mortgages (Thousands)

Data: Zip-code HPI’s
### Estimation: Parameter Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Estimate</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>discount factor</td>
<td>$\beta$</td>
<td>.942</td>
<td>.001</td>
</tr>
<tr>
<td>weight on non-housing consumption</td>
<td>$\alpha$</td>
<td>.636</td>
<td>.010</td>
</tr>
<tr>
<td>risk aversion</td>
<td>$\gamma$</td>
<td>1.89</td>
<td>.073</td>
</tr>
<tr>
<td>mortgage cost (fraction of income)</td>
<td>$k_0$</td>
<td>.116</td>
<td>.022</td>
</tr>
<tr>
<td>mortgage cost (fraction of mortgage balance)</td>
<td>$k_1$</td>
<td>.014</td>
<td>.001</td>
</tr>
<tr>
<td>mortgage cost (for LTV $&gt; .8$)</td>
<td>$k_2$</td>
<td>.080</td>
<td>.004</td>
</tr>
<tr>
<td>repayment cost</td>
<td>$\kappa$</td>
<td>4.17</td>
<td>.561</td>
</tr>
<tr>
<td>mortgage payment/income limit (purchase)</td>
<td>$\psi_p$</td>
<td>.372</td>
<td>.160</td>
</tr>
<tr>
<td>mortgage payment/income limit (refinance)</td>
<td>$\psi_r$</td>
<td>$&gt; 1$</td>
<td>( - )</td>
</tr>
<tr>
<td>moving cost (fraction of income)</td>
<td>$\theta_0$</td>
<td>2.86</td>
<td>.228</td>
</tr>
<tr>
<td>moving cost (fraction of house value)</td>
<td>$\theta_1$</td>
<td>.177</td>
<td>.011</td>
</tr>
<tr>
<td>moving cost (utility)</td>
<td>$\theta_u$</td>
<td>2.41</td>
<td>.276</td>
</tr>
<tr>
<td>default rent-price ratio</td>
<td>$\rho$</td>
<td>.177</td>
<td>.017</td>
</tr>
<tr>
<td>probability of preference shock</td>
<td>$\lambda$</td>
<td>.026</td>
<td>.001</td>
</tr>
<tr>
<td>mean of preference shock</td>
<td>$\mu_v$</td>
<td>10.62</td>
<td>.897</td>
</tr>
<tr>
<td>variance of preference shock</td>
<td>$\sigma_v$</td>
<td>.403</td>
<td>.235</td>
</tr>
<tr>
<td>job separation rate</td>
<td>$\Pi^E_{e \rightarrow u}$</td>
<td>.018</td>
<td>.002</td>
</tr>
</tbody>
</table>
Results: Defaults by LTV

<table>
<thead>
<tr>
<th>LTV Ratio</th>
<th>Default Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>1.25</td>
<td>1.5</td>
</tr>
<tr>
<td>0</td>
<td>0.005</td>
</tr>
<tr>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>0.015</td>
<td>0.015</td>
</tr>
<tr>
<td>0.02</td>
<td>0.02</td>
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<tr>
<td>0.025</td>
<td>0.025</td>
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<td>0.03</td>
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<td>0.035</td>
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<tr>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>0.045</td>
<td>0.045</td>
</tr>
</tbody>
</table>

The graph shows the relationship between LTV ratio and default rate, with data points indicating a positive correlation. The line labeled 'Data' shows the actual default rates observed, and the line labeled 'Model' represents the modeled default rates.
Data: LTV at Default

cltv of Defaulters v. Non–Defaulters

Quarter


10%–Def 90%–Def 50%–Def 90%–NoDef 50%–NoDef 10%–NoDef


10%–Def 90%–Def 50%–Def 90%–NoDef 50%–NoDef 10%–NoDef

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Data: LTV at Default

Increase in cLTV at Default from Equity Extraction

Quarter of Purchase

Mean 10%
25% 50%
75% 90%

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### Data: LTV at Default

![Chart: cLTV at Default, With and Without Equity Extraction](chart.png)

- **cLTV at Default, With and Without Equity Extraction**
- **LTV**
- **Quarter of Purchase**
- **cLTV 10%**
- **cLTV–no extract 10%**
- **cLTV 50%**
- **cLTV–no extract 50%**
- **cLTV 90%**
- **cLTV–no extract 90%**
Data: LTV at Default

Increase in cLTV of Defaulters v. Non–Defaulters

50%−Default  50%−Non−default
75%−Default  75%−Non−default
90%−Default  90%−Non−default
Purchase Policies

New Purchases: Low HPA

New Purchases: High HPA
Model Discussion: Spending

Total Spending by Expected Price Growth

Increasing Prices
Decreasing Prices

Liquid Assets (A/P)
LTV Ratio (M/H)
Total Spending by Expected Price Growth

5 10 15 20 25
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

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California Mortgages

Sample of homeowners is from Los Angeles County, California

- California is one of nine non-recourse states.
- Allows both judicial and non-judicial foreclosures (judicial foreclosures are rare)
- Laws on different types of loans
  - No deficiency judgements on purchase-money loans
  - Deficiency judgements on refinances (before 2013), second mortgages, cash-out, but only in judicial foreclosures.
Texas Refinancing Laws

Homestead Act of 1997, Article A, Section 6 permits cash-out refinance: Texas A6 Home Equity Loans

- Applies to any cash-out refinance or new loan on primary residence, or any refinance of existing A6 loan.
- Does not apply if cash is entirely for home-improvement or back taxes
- Borrower protections: 12-day review period, maximum 3% closing costs, no pre-payment penalties, judicial foreclosures.
- No refinancing within first 12 months.
- Total LTV when take out new A6 loan cannot exceed 80%.
Policy Experiment - Texas Refinancing

- **Fraction Extracting Equity**
  - 2002 to 2008
  - Baseline and Refinance LTV<.8 models

- **Fraction Selling**
  - 2002 to 2008

- **Fraction Defaulting**
  - 2002 to 2008
  - Baseline and Refinance LTV<.8 models

Steven Laufer (FRB)

Equity Extraction and Mortgage Default

FRB Chicago BSC, May 9 2014
## Data: Empirical Results

<table>
<thead>
<tr>
<th></th>
<th>Extract Equity</th>
<th>Sell</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subprime</td>
<td>.043***</td>
<td>-.015</td>
<td>.133***</td>
</tr>
<tr>
<td>Purchase LTV</td>
<td>.029***</td>
<td>.056***</td>
<td>-.047</td>
</tr>
<tr>
<td>Purchase cLTV</td>
<td>.142***</td>
<td>-.002</td>
<td>.191***</td>
</tr>
<tr>
<td>Purchase Rate</td>
<td>.061***</td>
<td>.071***</td>
<td>.106***</td>
</tr>
<tr>
<td>Current Rate</td>
<td>.089***</td>
<td>.061***</td>
<td>.759***</td>
</tr>
<tr>
<td>ΔHPI - 1yr</td>
<td>.395***</td>
<td>.261***</td>
<td>.095*</td>
</tr>
<tr>
<td>ΔHPI - last mort.</td>
<td>.035***</td>
<td>.127***</td>
<td>-.296***</td>
</tr>
<tr>
<td>cLTV &gt; 1</td>
<td>.169*</td>
<td>.062</td>
<td>.576***</td>
</tr>
<tr>
<td>cLTV × (cLTV &gt; 1)</td>
<td>-.190***</td>
<td>-.037</td>
<td>.185***</td>
</tr>
<tr>
<td>Δ med. inc.</td>
<td>.030***</td>
<td>-.002</td>
<td>-.023</td>
</tr>
<tr>
<td>Unemp.</td>
<td>.015**</td>
<td>-.007</td>
<td>.085**</td>
</tr>
<tr>
<td>(cLTV &gt; 1) × unemp</td>
<td>-.095**</td>
<td>.061</td>
<td>-.175***</td>
</tr>
<tr>
<td>(cLTV &gt; 1) × rate</td>
<td>-.107*</td>
<td>-.053</td>
<td>-.256***</td>
</tr>
<tr>
<td>2000 Unemp.</td>
<td>-.017**</td>
<td>.014</td>
<td>.023</td>
</tr>
<tr>
<td>2000 Frac Young</td>
<td>-.000</td>
<td>.120***</td>
<td>-.067*</td>
</tr>
<tr>
<td>2000 Frac. College</td>
<td>.064***</td>
<td>.168***</td>
<td>-.176***</td>
</tr>
</tbody>
</table>

* 5%, ** 1%, ***0.1%, Pseudo-$R^2=0.052$
Write problem recursively, solve for

\[ V(P, \tilde{a}, h, e, p, M, v, f) \]

\[ \tilde{a} = a + P\varepsilon \]

Each period, household has four options.

1. Continue to pay mortgage. \( (V^0) \)
2. Refinance into new mortgage \( (V^R) \)
3. Sell and buy a new house \( (V^S) \)
4. Default \( (V^D) \)

\[ V = \max(V^0, V^R, V^S, V^D) \]
Model: Household Problem

1. Continue to pay the mortgage.

\[ V^0(P, \tilde{a}, h, e, p, M, v, f) = \max_c u(c, h) + \beta \mathbb{E} V(P', \tilde{a}', h, e', p', M, v', f') \]

\[ a' = (1 + r_s) \cdot (\tilde{a} - \chi ph - r_m M - c), \quad a' \geq 0 \]

2. Refinance into a new mortgage of size \( M' \neq M \) with \( M' < \phi ph \)

\[ V^R(P, \tilde{a}, h, e, p, M, v, f) = \max_{c, M'} u(c, h) + \beta \mathbb{E} V(P', \tilde{a}', e', h, p', M', v', f') \]

\[ a' = (1 + r_s) \cdot (\tilde{a} + (M' - M) - r_m M - \chi ph - K(M') - c), \quad a' \geq 0 \]
Model: Household Problem (cont)

3 Move to a new house of size \( h' \neq h \) with a new mortgage \( M' < \phi p h' \).

\[
V^M(P, \tilde{a}, h, e, p, M, v, f) = \max_{c, h', M'} u(c, h) + \beta E V(vP', \tilde{a}', e', h', p', M', v', f')
\]

\[
a' = (1 + r^s) \cdot (\tilde{a} + (1 - \theta_1 - \chi)ph - \theta_0 P - (1 + r^m)M - ph' + M' -
\]
\[
\kappa((1 - \theta_1)ph - M) \cdot 1((1 - \theta_1)ph < M) - c), \quad a' \geq 0
\]

4 Default

\[
V^D(P, \tilde{a}, h, e, p, M, v, f) = \max_{c} u(c, h) + \beta E V^{rent}(vP, \tilde{a}', e')
\]

\[
a' = (1 + r^s) \cdot (\tilde{a} - c), \quad a' \geq 0
\]
Issues connecting equity extraction and default decisions

1. Extracting Equity increases LTV-ratio
   - Creates financial incentive to default if bank has no recourse beyond repossession of house: “Strategic Default.”
   - Makes it more difficult to pay off mortgage from value of house if want to move.

2. Extracting equity provides liquidity. May allow owner to keep up mortgage payments

3. Selection issue. Liquidity constraints can induce both equity withdrawal and default. High-risk borrowers have less access to credit.
Future Work

- Endogenous maintenance decisions
  - During the boom, extracted equity used for home improvements.
  - During the bust, debt overhang causes lower maintenance.

- Preference shocks as job offers that require relocation. Interaction between housing and labor markets.

- More flexible model of beliefs about house prices, fit to survey data on house price expectations.