Inattention and Inertia in Household Finance: Evidence from the Danish Mortgage Market

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Inertia in Household Finance

- Households respond slowly to changed circumstances.

- An important example: Mortgage refinancing.
  - Inertia (“woodheads”) in prepayment models and MBS pricing (Stanton 1995, Deng, Quigley, and Van Order 2000, Gabaix, Krishnamurthy, and Vigneron 2007).
  - Cross-subsidies from sluggish to prompt refinancers (Miles 2004, Campbell 2006, Gabaix and Laibson 2006).
Mortgage Refinancing Inertia: Questions

- Do prompt refinancers look different from sluggish refinancers?
  - US HMDA tracks borrowers at origination, so we don’t observe non-refinancers.
  - American Housing Survey and other survey data are very noisy (Schwartz 2006).

- Does the opposite of inertia (too-hasty refinancing) also exist?
  - Optimal refinancing solves a difficult real options problem (Agarwal, Driscoll, and Laibson 2013).
  - Errors of “commission” and “omission” when only refinancers are observed (Agarwal, Rosen, and Yao 2012).

- Can household constraints explain sluggish refinancing?
Mortgage Data from Denmark

- We use high-quality administrative data from Denmark to surmount many of these obstacles.

- Denmark has predominantly FRMs, like the US, but with important special features:
  - Funding with covered bonds, fixed-rate maturity-matched bonds with integer coupons.
  - Refinancing does not require positive home equity or a credit check provided there is no cash-out.
  - Refinancing involves buying back the underlying mortgage bond, either at market value or face value.
  - When buying back at face value, the refinancing incentive is the bond’s coupon rate less the current mortgage yield.
Administrative Data from Denmark

- All mortgages from 5 largest mortgage banks (out of 7) with a 94% market share.
- Demographic information from Civil Registration System.
- Income and wealth from the Customs and Tax Administration.
- Education from the Ministry of Education.
- Medical treatments from the National Board of Health.
- Start with 2.7 million households.
  - Match education and income: 2.5 million.
  - 953,000 households have mortgages in 2009 and 703,000 have a single mortgage.
  - 282,000 households have a fixed-rate mortgage in 2009 and 272,000 have one in 2010.
  - 60,000 households refinance in 2009 and 23,000 refinance in 2010.
# Summary Statistics (Table 1)

## Panel A: 2010

<table>
<thead>
<tr>
<th></th>
<th>3% Coupon</th>
<th>4% Coupon</th>
<th>5% Coupon</th>
<th>6% Coupon</th>
<th>&gt;6% Coupon</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial # of observations</td>
<td>8,054</td>
<td>79,929</td>
<td>141,610</td>
<td>44,590</td>
<td>7,515</td>
<td>281,698</td>
</tr>
<tr>
<td>Fraction refinancing</td>
<td>0.039</td>
<td>0.050</td>
<td>0.203</td>
<td>0.556</td>
<td>0.437</td>
<td>0.217</td>
</tr>
<tr>
<td>Fraction refinancing to ARM</td>
<td>0.013</td>
<td>0.024</td>
<td>0.108</td>
<td>0.218</td>
<td>0.153</td>
<td>0.100</td>
</tr>
<tr>
<td>Fraction refinancing to FRM</td>
<td>0.026</td>
<td>0.026</td>
<td>0.095</td>
<td>0.338</td>
<td>0.284</td>
<td>0.117</td>
</tr>
<tr>
<td>Principal remaining (Million DKK)</td>
<td>0.394</td>
<td>0.888</td>
<td>0.947</td>
<td>0.946</td>
<td>0.598</td>
<td>0.905</td>
</tr>
<tr>
<td>Loan-to-value (LTV) ratio</td>
<td>0.242</td>
<td>0.506</td>
<td>0.595</td>
<td>0.640</td>
<td>0.462</td>
<td>0.563</td>
</tr>
</tbody>
</table>

## Panel B: 2011

<table>
<thead>
<tr>
<th></th>
<th>3% Coupon</th>
<th>4% Coupon</th>
<th>5% Coupon</th>
<th>6% Coupon</th>
<th>&gt;6% Coupon</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial # of observations</td>
<td>10,168</td>
<td>110,709</td>
<td>125,369</td>
<td>21,205</td>
<td>4,442</td>
<td>271,893</td>
</tr>
<tr>
<td>Fraction refinancing</td>
<td>0.031</td>
<td>0.041</td>
<td>0.114</td>
<td>0.159</td>
<td>0.117</td>
<td>0.085</td>
</tr>
<tr>
<td>Fraction refinancing to ARM</td>
<td>0.012</td>
<td>0.019</td>
<td>0.060</td>
<td>0.062</td>
<td>0.045</td>
<td>0.037</td>
</tr>
<tr>
<td>Fraction refinancing to FRM</td>
<td>0.018</td>
<td>0.021</td>
<td>0.053</td>
<td>0.097</td>
<td>0.095</td>
<td>0.048</td>
</tr>
<tr>
<td>Principal remaining (Million DKK)</td>
<td>0.479</td>
<td>0.978</td>
<td>0.883</td>
<td>0.591</td>
<td>0.321</td>
<td>0.875</td>
</tr>
<tr>
<td>Years remaining on mortgage</td>
<td>8.662</td>
<td>22.342</td>
<td>23.686</td>
<td>21.785</td>
<td>17.389</td>
<td>22.407</td>
</tr>
<tr>
<td>Loan-to-value (LTV) ratio</td>
<td>0.290</td>
<td>0.557</td>
<td>0.564</td>
<td>0.486</td>
<td>0.299</td>
<td>0.541</td>
</tr>
</tbody>
</table>
Refinancing by Coupon (Figure 4)

Andersen et al (2015)
## Refinancers and Non-Refinancers (Table 3)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Average</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single male household</td>
<td>0.128</td>
<td>-0.041***</td>
</tr>
<tr>
<td>Single female household</td>
<td>0.124</td>
<td>-0.029***</td>
</tr>
<tr>
<td>Married household</td>
<td>0.638</td>
<td>0.024***</td>
</tr>
<tr>
<td>Children in family</td>
<td>0.406</td>
<td>0.102***</td>
</tr>
<tr>
<td>Immigrant</td>
<td>0.072</td>
<td>-0.001***</td>
</tr>
<tr>
<td>No educational information</td>
<td>0.006</td>
<td>-0.003***</td>
</tr>
<tr>
<td>Financially literate</td>
<td>0.046</td>
<td>0.006***</td>
</tr>
<tr>
<td>Family financially literate</td>
<td>0.129</td>
<td>0.016***</td>
</tr>
<tr>
<td>Getting married</td>
<td>0.010</td>
<td>0.009***</td>
</tr>
<tr>
<td>Change to health</td>
<td>0.036</td>
<td>-0.004***</td>
</tr>
<tr>
<td>Having children</td>
<td>0.042</td>
<td>0.032***</td>
</tr>
<tr>
<td>Rank of age</td>
<td>0.015</td>
<td>-0.087***</td>
</tr>
<tr>
<td>Rank of education</td>
<td>0.004</td>
<td>0.027***</td>
</tr>
<tr>
<td>Rank of income</td>
<td>0.008</td>
<td>0.056***</td>
</tr>
<tr>
<td>Rank of financial wealth</td>
<td>0.009</td>
<td>-0.094***</td>
</tr>
<tr>
<td>Rank of housing value</td>
<td>0.010</td>
<td>0.029***</td>
</tr>
<tr>
<td>Region North Jutland</td>
<td>0.124</td>
<td>0.000***</td>
</tr>
<tr>
<td>Region Middle Jutland</td>
<td>0.241</td>
<td>0.023***</td>
</tr>
<tr>
<td>Region Southern Denmark</td>
<td>0.228</td>
<td>0.002***</td>
</tr>
<tr>
<td>Region Zealand</td>
<td>0.187</td>
<td>-0.015***</td>
</tr>
<tr>
<td>Region Copenhagen</td>
<td>0.220</td>
<td>-0.011***</td>
</tr>
</tbody>
</table>

# of observations: 2,146,395
Refinancing Types

\[ p_{i,t}^h(y_{i,t} = 1|\nu_h, \beta_h, \sigma_e) = p_{i,t}^h(\nu_h + e^{\beta_h I_h(z_{i,t})} + \epsilon_{i,t} > 0). \]

- Household \( i \) has type \( h \), refinancing is event \( y_{i,t} = 1 \).
- Parameter \( \nu_h \) governs base refinancing rate, \( \beta_h \) governs response to incentive \( I_h(z_{i,t}) \), \( z_{i,t} \) contains mortgage characteristics.
- Stochastic choice error \( \epsilon_{i,t} \) is logistic (as in standard logit model).
- Woodheads: refinance at fixed rate \( \nu_W \), ignore incentives so \( I_W(z_{i,t}) = 0 \) and \( \beta_W = 0 \).
- Levelheads: respond rationally to incentives with some \( \beta_L > 0 \), but \( \nu_L = 0 \).
A Mixture Model

- Household $i$ has mixing weight $\delta_i^h$ on type $h$, where $0 < \delta_i^h < 1$ and $\sum_h \delta_i^h = 1$.
- We model
  \[
  \delta_i^h = e^{\zeta_i^h} / \sum e^{\zeta_i^h},
  \]
  where $\zeta_i^h$ can be a function of household characteristics.
- We can capture dynamic effects using issuing quarter and current quarter dummies (interactions of these dummies have almost no explanatory power).
  - Pure time effects (e.g. from media coverage of refinancing opportunities).
  - Age effects (burn-in and burn-out).
  - Currently working on modeling the persistence of type assignments.
A Basic Mixture Model (Figure 1)

Andersen et al (2015)
The Refinancing Incentive

\[ I(z_{it}) = C_{it}^{old} - Y_{it}^{new} - O(z_{it}). \]

- Interest saving is old bond coupon less new mortgage bond yield.
- Use Agarwal, Driscoll, and Laibson (2013) approximate closed-form solution for threshold:

\[ O(z_{it}) \approx \sqrt{\frac{\sigma \kappa_{it}}{m_{it}(1 - \tau)}} \sqrt{2(\rho + \lambda_{it})}. \]

- \( \sigma \) interest rate volatility, \( \tau \) mortgage interest tax deduction, \( \rho \) discount rate, \( \kappa_{it} \) fixed plus variable refinancing cost, \( m_{i,t} \) size of mortgage, \( \lambda_{it} \) base rate of principal reduction, which includes termination probability.
  - We estimate termination probability: median 8.4%, mean 11.0%, standard deviation 8.7% (ADL suggest 10%).
Summary of the Evidence

- Danish mortgage rates have fallen substantially since their peak in 2008.
- About 23% of household-quarters have positive refinancing incentives.
- Almost 90% of these do not refinance (errors of omission).
- About 2% of the households with negative incentives do refinance, but about half of these cash out or extend maturity so only 1% appear to be mistakes (errors of commission).
- Most demographic characteristics shift refinancing up or down and therefore move these errors in opposite directions.
Incentives and Refinancing (Figure 6)

Andersen et al (2015)
Errors of Omission and Commission (Table 5 Panel A)

<table>
<thead>
<tr>
<th>Level of Cutoff</th>
<th>0</th>
<th>0.25</th>
<th>0.5</th>
<th>0.75</th>
<th>1</th>
<th>1.5</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td># Observations (Incentives &lt; Cutoff)</td>
<td>1,688,215</td>
<td>1,475,545</td>
<td>1,278,737</td>
<td>751,439</td>
<td>362,251</td>
<td>137,457</td>
<td>137,457</td>
</tr>
<tr>
<td># Observations, refinancing</td>
<td>37,297</td>
<td>28,294</td>
<td>22,095</td>
<td>14,340</td>
<td>7,983</td>
<td>2,919</td>
<td>1,014</td>
</tr>
<tr>
<td># Observations, cash out or extend maturity</td>
<td>15,743</td>
<td>12,224</td>
<td>9,715</td>
<td>7,356</td>
<td>4,878</td>
<td>1,921</td>
<td>791</td>
</tr>
<tr>
<td># Observations, errors of commission</td>
<td>21,554</td>
<td>16,070</td>
<td>12,380</td>
<td>6,984</td>
<td>3,105</td>
<td>998</td>
<td>223</td>
</tr>
<tr>
<td>Fraction with error of commission</td>
<td><strong>0.013</strong></td>
<td><strong>0.011</strong></td>
<td><strong>0.010</strong></td>
<td><strong>0.009</strong></td>
<td><strong>0.009</strong></td>
<td><strong>0.007</strong></td>
<td><strong>0.002</strong></td>
</tr>
<tr>
<td># Observations (Incentives &gt; Cutoff)</td>
<td>458,180</td>
<td>252,336</td>
<td>152,097</td>
<td>100,844</td>
<td>61,309</td>
<td>17,434</td>
<td>6,287</td>
</tr>
<tr>
<td># Observations, errors of omission</td>
<td>411,015</td>
<td>220,084</td>
<td>130,389</td>
<td>83,668</td>
<td>49,456</td>
<td>15,749</td>
<td>5,746</td>
</tr>
<tr>
<td>Fraction with error of omission</td>
<td><strong>0.897</strong></td>
<td><strong>0.872</strong></td>
<td><strong>0.857</strong></td>
<td><strong>0.830</strong></td>
<td><strong>0.807</strong></td>
<td><strong>0.903</strong></td>
<td><strong>0.914</strong></td>
</tr>
</tbody>
</table>
Who Makes These Errors?

- Most household demographic characteristics have offsetting effects on the two types of errors (Table 5 Panel B).
- Characteristics that are associated with increased refinancing in Table 3 increase errors of commission and reduce errors of omission.
- This suggests that a pure inattention model will not fit the data (since pure inattention would increase both types of error).
- Errors of omission are costly (Table 6): 1.9% of the outstanding mortgage balance for the average error-prone household, and about 0.25% of all outstanding mortgages (using 0.25 cutoff, across both years).
Mixture Model Results (1)

- Baseline model with no history dependence or demographic effects delivers sensible estimates (Figure 1):
  - 88% of household-quarters are woodheads who refinance with probability 0.8%.
  - 12% are levelheads who refinance with probability 10% when the incentive is -0.88%, 25% when the incentive is -0.43%, 50% when the incentive is zero, 75% when the incentive is 0.43%, and 90% when the incentive is 0.88%.

- History dependence and demographics greatly increase model’s explanatory power from initial pseudo $R^2 = 8.5\%$.

- Issuing quarter effects are intuitive (Figure 8):
  - Woodhead refinancing probability increases initially, then remains flat on average (as in the PSA model used in the US).
  - Levelhead probability declines in mortgage age, except for mortgages with few lifetime chances to be refinanced at attractive rates.
Mixture Model Fit (Figure 7)

Andersen et al (2015)

Inattention and Inertia

Mortgage Design 2015
Mixture Model Results (2)

- Full mixture model has pseudo $R^2 = 15.7\%$.
- Most demographic variables move levelhead proportion and woodhead refinancing probability, or equivalently inattention and inertia, in the same direction.
  - Inertia and inattention as fitted from demographics have a cross-sectional correlation of 0.67; we can reject perfect correlation.
- Age reduces attention while education and income increase it among younger, less educated, and poorer households.
- Financial wealth and housing wealth have opposite effects
  - Highest attention for households with large houses relative to their financial wealth.
Effects of Age (Figure 9A)
Effects of Education (Figure 10A)
Effects of Income (Figure 11A)

Andersen et al (2015)
Effects of Financial Wealth (Figure 12A)
Effects of Housing Wealth (Figure 13A)

![Graph showing the effects of housing wealth on change in probability]

Andersen et al (2015)
Refinancing in Household Finance

- We propose a mixture model of household types to capture heterogeneity in propensity to refinance.
  - Distinguish inattention (low levelhead probability) and inertia (low woodhead refinancing probability).
  - Household characteristics generally move inertia and inattention in the same direction.

- Demographic effects are intuitive.
  - Inertia and inattention increase with age, decrease with education and income.
  - Financial wealth (proxy for cost of time?) and housing wealth have opposite effects.
Next Steps

- Enriching the set of household types, looking for active behavioral patterns.
- For example, “roundheads” refinance when interest saving or coupon reduction reaches a round number.
  - We find some evidence for a “new bond available with 2% lower coupon” effect.
  - But the improvement in the overall model fit is modest, because few households reach this point.
  - Demographic patterns discussed above are robust to this change in model specification.
- Also working on a better model of type persistence. Ultimate goal is a richer dynamic characterization of multiple household types.
Some Thoughts on Mortgage Policy

- The Danish mortgage system is impressively well designed.
- But it still places the burden of the refinancing decision on households.
  - Many people, particularly poorer and less educated people, get this wrong.
  - Errors of omission can be expensive for these people.
- Errors of omission increase the value of mortgage bonds, lowering yields in equilibrium.
  - Thus, sophisticated borrowers gain at the expense of the less sophisticated.
  - A troublesome phenomenon in an age of inequality.
- This cross-subsidy makes it harder for individual mortgage lenders to introduce new products (Gabaix and Laibson 2006).
  - An automatically refinancing “ratchet” bond would help the unsophisticated but hurt the sophisticated, who would otherwise be the natural early adopters.
  - In this situation there is a case for public policy to force the issue.