# In Search of a Risk-free Asset:
## Search Costs and Sticky Deposit Rates

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# Motivation (1)

- What risk-free rate determines household consumption-savings decision?
- How do banks retain their monopoly power in a highly competitive market for certificates of deposit?
- What determines the pass-through of monetary policy rates to deposit rates?

- This paper: How much households shop for return on their savings

# Motivation (2)

- Certificates of deposit or time deposits are important savings instrument for households and a significant source of funding for banks
  - In 2006: $6 trillion deposits, $2.5 (1.2) trillion in time (small) deposits
- A certificate of deposit is a highly homogeneous financial product and in a highly competitive market
  - Nominally risk-free if held until maturity
  - Little financial innovation and simple contract structure
  - Large number of competitors: Over 6,000 FDIC insured banks
  - Large number of substitutes: Comparable to a Treasury bond or a government MMF
- Deposit insurance since 1934 has ruled out bank runs by small depositors, trade-off risk-taking and charter value (monopoly power)
  - 1990 certificates of deposits exempted from reserve requirements
  - By 1994 most restrictions on deposit competition were lifted: interest rate ceilings (1986) and interstate banking (1994)

# Motivation (3)

- Pricing of certificates of deposit
    - Large rate dispersion even within narrow geographic markets (MSA)
    - Deposit rates change rigidly and asymmetrically
        - Increase sluggishly following federal funds rate increases
        - Decrease rapidly following federal funds rate decreases
    - Duration and timing of rate adjustments are not synchronized
    - On average, deposits pay much less than matched maturity Treasuries
- Systematic violation of the law of one price leads to
    - Incomplete pass-through of changes in monetary policy rates
        - Large and pro-cyclical banks profits from deposits
    - Distortions in the savings behavior of households and potentially large welfare losses

## Overview

- Stylized facts on pricing of time deposits and deposit allocations
- Model of oligopolistic competition with heterogeneous search cost investors (Burdett-Judd 1983)
- Structural estimation of the model across markets (MSA) and time
  - Estimate of the IES that exceeds one
  - Distribution of search costs
  - Search intensities
- Document a large and non-declining share of high-search-cost (inactive) investors and a declining share of low-search-cost (active) investors
- Exit of low-search-cost (active) investors and steering of such investors into bank-affiliated MMFs
  - Bank MMFs earn higher monopoly markups (charge higher fees) than unaffiliated funds

# Stylized facts on deposit pricing

## Data

- Deposit rate data: RateWatch
  - Detailed weekly branch-level survey data: Close to 6,000 FDIC-insured commercial banks in over 80,000 branch offices located in over 10,000 cities covering all major metropolitan statistical areas (MSA), 1997-2016
- Branch-level information: Summary of deposits, FDIC
- Bank-level information: Regulatory filings (Call Reports and Y9C)
- Household level financial (deposit) asset allocations: Survey of Consumer Finances
- Money market funds: iMoneyNet

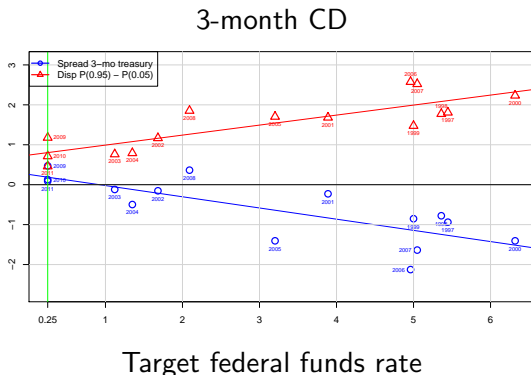# Pricing: Large cross-sectional rate dispersion

## 12-month
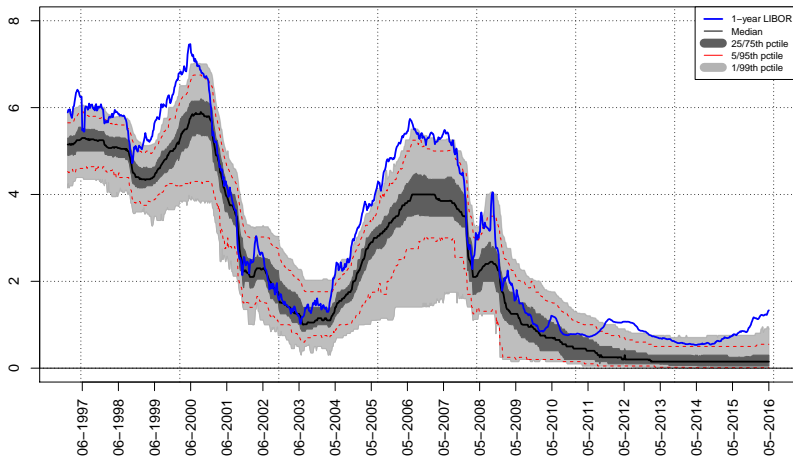


- Total variation is due to within-market and across-bank variation

# Pricing: Target federal funds rate, spreads, and dispersion



3-month CD

Target federal funds rate

- High level of market interest rates leads to high rate dispersion and negative spreads over Treasuries

# Pricing: Role of product differentiation

**Table 1.** Rate dispersion and bank fixed-effects

|  | Dependent variable: | | | |
|---|---|---|---|---|
|  | 12-month CD rate | | | |
|  | (1) | (2) | (3) | (4) |
| LIBOR 12-mo | $0.846^{***}$ | $0.846^{***}$ | $0.828^{***}$ | $0.822^{***}$ |
|  | (0.006) | (0.006) | (0.006) | (0.006) |
| $\frac{B_{j,m,t}-B_{m,t}}{B_{m,t}}$ |  | $-0.047^{***}$ | $-0.002^{**}$ | $-0.039^{***}$ |
|  |  | (0.003) | (0.001) | (0.007) |
| $\frac{A_{j,t}-A_{m,t}}{A_{m,t}}$ |  | $-0.013^{***}$ | $0.002^{***}$ | $0.016^{***}$ |
|  |  | (0.001) | (0.0003) | (0.002) |
| Constant | $-0.063^{***}$ | $-0.062^{***}$ |  |  |
|  | (0.021) | (0.021) |  |  |
| Bank FE |  |  | X | X |
| Bank FE $\times$ MSA FE |  |  |  | X |
| Observations | 9,413,628 | 9,413,628 | 9,413,628 | 9,413,628 |
| $R^2$ | 0.897 | 0.900 | 0.923 | 0.925 |
| Adjusted $R^2$ | 0.897 | 0.900 | 0.923 | 0.925 |
|  | Residual dispersion in 2006 | | | |
| Residual Std. Error | 0.73 | 0.72 | 0.59 | 0.58 |
| Residual $P(95) - P(5)$ | 2.37 | 2.37 | 1.92 | 1.89 |

$^*p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

# Pricing: Rank persistence

**Table 2.** Quartiles transition matrix: 12-month CD

|       | 1-month horizon | | | | 3-month horizon | | | |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|       | $q_1$ | $q_2$ | $q_3$ | $q_4$ | $q_1$ | $q_2$ | $q_3$ | $q_4$ |
| $q_1$ | **0.50** | 0.13 | 0.31 | 0.06 | **0.30** | 0.25 | 0.34 | 0.11 |
| $q_2$ | 0.06 | **0.64** | 0.13 | 0.17 | 0.12 | **0.47** | 0.23 | 0.18 |
| $q_3$ | 0.14 | 0.14 | **0.65** | 0.07 | 0.16 | 0.23 | **0.48** | 0.14 |
| $q_4$ | 0.05 | 0.30 | 0.16 | **0.49** | 0.09 | 0.33 | 0.27 | **0.31** |

- Despite rigid rate adjustments, there is active repositioning of bank offer rates
- Relatively low persistence in the extreme quartiles
- Relatively large rate readjustments $q_1 \rightarrow q_3$ and $q_4 \rightarrow q_2$
- More than 60 percent of rates adjust to a different quartile within 3-months

# Stylized facts on deposit allocations

# Demand for certificates of deposit

- Evidence from the Survey of Consumer Finances
  - Is there evidence that households shop for rates and respond to price dispersion?
  - Is there evidence that households maintain multiple CD contracts with different banks?
  - Is shopping for rates distinct from financial sophistication?

# SCF Evidence: Multiple deposit accounts
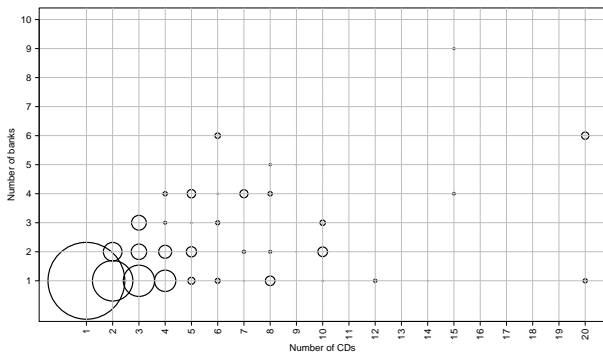


- 45 percent of CD accounts with a bank different from main checking account bank, 20 percent hold multiple bank accounts
- Determinants: Preference for shopping for return $(+)$, deposits above limited FDIC insurance $(+)$, financial sophistication $(+)$
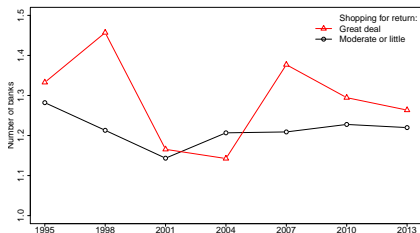
# Financial sophistication score

| | Financial Sophistication Score (2007) | | | | |
|---|---|---|---|---|---|
| | Q1 (low) | Q2-Q3 | Q4 (high) | Own CD | All |
| | (1) | (2) | (3) | (4) | (5) |
| Age | 50 | 50 | 54 | 60 | 50 |
| College education | 18 | 40 | 72 | 47 | 35 |
| Income | 38, 764 | 85, 777 | 278, 051 | 121, 404 | 88, 162 |
| —Share income from financial assets | 1 | 3 | 15 | 8 | 3 |
| Net worth (Assets–Debt) | 124, 349 | 476, 309 | 2, 830, 072 | 1, 047, 925 | 583, 351 |
| Own CD | 10 | 18 | 26 | 100 | 16 |
| —owned jointly [Own CD==1] | 43 | 60 | 60 | 57 | 57 |
| —above FDIC limit [Own CD==1] | 8 | 11 | 18 | 12 | 12 |
| Deposits above FDIC limit | 3 | 7 | 21 | 24 | 7 |
| Own money market mutual fund | 0 | 4 | 31 | 8 | 5 |
| Number of institutions | 2 | 4 | 6 | 4 | 4 |
| —Number of banks | 1 | 2 | 2 | 2 | 2 |
| Take above average financial risks | 5 | 25 | 50 | 20 | 21 |
| Budgeting horizon over 5 years | 13 | 50 | 72 | 47 | 40 |
| Great deal shopping for investment | 17 | 23 | 22 | 23 | 21 |
| Use Internet for investment decisions | 21 | 32 | 46 | 25 | 30 |
| Use professional investment advice | 24 | 46 | 54 | 50 | 40 |
| Excellent understanding of SCF | 36 | 52 | 71 | 53 | 48 |
| Financial Sophistication Index percentile | 0.1 | 0.5 | 0.9 | 0.5 | 0.5 |

- Preference for shopping for return independent of financial sophistication
- Use of Internet or professional advise by financial sophisticates higher than elderly households (CD holders)

# SCF Evidence: Multiple deposit accounts

## A. Low financial sophistication



## B. High financial sophistication
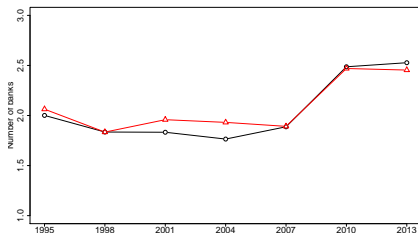


- Preference for shopping for return related to higher number of bank accounts in high dispersion years
- High-financial sophisticates have on average more bank accounts irrespective of rate dispersion

# Model of costly search

# Model of costly search

- Overview
    - Households
        - Heterogeneous in their search costs
        - Costly fixed-sample search for the best return
        - Consumption-savings decision given a rate of return
    - Banks
        - Competition in rates (no vertical or horizontal product differentiation)
        - Symmetric Nash equilibrium in mixed strategies

# Consumption-saving decision

- Consumptions-savings problem: $A_0$ liquid assets in a transaction account that support consumption today and $A_\tau$ illiquid time deposits available in $\tau$ periods
  - Marginal propensity to consume (save)

$$A_\tau = (1 - h_\tau^d(R))A_0, \text{ where } h_\tau^d(R) = \frac{1}{1 + \beta^{\tau\sigma} R^{\sigma-1}}$$

  - Marginal value of wealth

$$\nu_\tau(R, A_0) = \phi_\tau(R)A_0, \text{ where } \phi_\tau(R) = h_\tau^d(R)^{\frac{1}{1-\sigma}}$$

  - IES $\sigma > 1$ substitution effect dominates the income effect and a higher interest rate increases investments in time deposits
  - Marginal value of wealth increasing and concave in $R$

# Costly search

- Households are heterogeneous with respect to their search costs $\xi$ drawn from $F_\xi(x)$, first bank offer is free
- Optimal fixed-sample (nonsequential) search
  - Marginal value of information for a sample size $k$, decreasing in $k$

$$\Delta_k = \int_{R_{min}}^{R_{max}} \phi(R) \Big\{ (k+1)F_R(R)^k - k F_R(R)^{k-1} \Big\} f_R(R) dR.$$

- Optimal size of bank offers is $k$, if $\Delta_k \geq \xi > \Delta_{k-1}$
  - Total search costs $(k-1) \times \xi$
- Market segmentation based on search intensity $\{q_k\}_{k=1}^N$ where $q_k = F_\xi(\Delta_{k-1}) - F_\xi(\Delta_k)$
- The segment of high-search-cost investors $q_1 = 1 - F_\xi(\Delta_1)$ examines only one offer for free and does not shop for rates.

## Equilibrium

- Bank profits given common marginal cost $\tilde{R}$

$$\pi(R) = (\tilde{R} - R) \times \overbrace{(1 - h^d(R))}^{\text{Intensive}} \times \underbrace{\overbrace{\frac{1}{N} \sum_{k=1}^{N} k F_R(R)^{k-1} q_k}^{\text{Extensive}}}_{\text{Demand}}$$

- Mixed-strategies equilibrium of Burdett-Judd'83: $(F(R), [R_{min}, R_{max}])$

$$\pi(R) = \left\{ \begin{array}{ll} \pi^* & \text{if } R \in [R_{min}, R_{max}] \\ < \pi^* & \text{if } R \notin [R_{min}, R_{max}]. \end{array} \right.$$

where $R_{min}$ is the reservation rate.

# Equilibrium: Monopoly power and pass-through

- Monopoly power

$$\tilde{R} - R_{max} = \underbrace{\frac{q_1}{\sum_{k=1}^{N} kq_k}}_{\text{Extensive margin}} \times \underbrace{\frac{(1 - h^d(R_{min}))}{(1 - h^d(R_{max}))}}_{\text{Intensive margin}} \times (\tilde{R} - R_{min}). \qquad (1)$$

- Pass-through of changes in marginal costs

$$R_{max} \approx \tilde{R} - (\tilde{R} - R_{min}) \times \frac{q_1}{\sum_{k=1}^{N} kq_k} \qquad (2)$$

$$\frac{\partial R_{max}}{\partial \tilde{R}} \approx 1 - \frac{q_1}{\sum_{k=1}^{N} kq_k}.$$

- Rate rigidity: $R_t \in [R_{min,t}, R_{max,t}] \cap [R_{min,t+1}, R_{max,t+1}]$

## Equilibrium

- A change of variables $z = F_R(R)$ and $R(z) = F_R^{-1}(z)$

$$\Delta_k = \int_0^1 \phi(R(z))\Big((k+1)z - k\Big)z^{k-1}dz, \text{ for } k = 1, .., N-1. \quad (3)$$

With some abuse of notation, let us define $\Delta_N = \sup\{\xi : F_\xi(\xi) = 0\}$ and $\Delta_0 = \inf\{\xi : F_\xi(\xi) = 1\}$, then the percentiles of the offer distribution can be expressed as follows

$$R(z) = \psi^{-1}\Big(\psi(R_{min}, \tilde{R})\frac{1 - F_\xi(\Delta_1)}{\sum_{k=1}^N kz^{k-1}(F_\xi(\Delta_{k-1}) - F_\xi(\Delta_k))}, \tilde{R}\Big). \quad (4)$$

- Given set of primitives $(\tilde{R}, R_{min}, F_\xi(\cdot))$, the model generates $(R(z), \{\Delta_k\}_{k=1}^N, \{q_k\}_{k=1}^N)$

## Structural estimation

- Two-step procedure:
  - Estimation of the intertemporal elasticity of substitution using log-linearization of $A_\tau = (1 - h(R))A_0$, let $s_t = \frac{A_\tau}{A_0}$

  $$\Delta log(A_{t+1}) = \alpha_0 + (\sigma - 1)(1 - s_t) \times \Delta log(R_t) + \epsilon_t \qquad (5)$$

  - Estimation of the search costs and search intensities by maximum likelihood following Hong and Shum (2006) and Moraga-Gonzalez and Wildenbeest (2008) for each market and over time

  $$\sum_{k=1}^{N} k q_k F_R(R_j)^{k-1} = \frac{(\tilde{R} - R_{\min})(1 - h(R_{\min}))q_1}{(\tilde{R} - R_j)(1 - h(R_j))}, \text{ for } j = 1, .., N. \qquad (6)$$

    - Note that $\tilde{R}$ marginal costs vary by market

# Coefficient of intertemporal elasticity of substitution

|  | Dependent variable: Growth in time deposits | | | |
|  | OLS | | IV | |
|  | 6-month | 12-month | 6-month | 12-month |
|  | (1) | (2) | (3) | (4) |
| $\sigma$ | 1.190*** | 1.202*** | 1.311*** | 1.276*** |
|  | (0.033) | (0.035) | (0.101) | (0.092) |
| Constant | 0.012*** | 0.011*** | 0.017*** | 0.014*** |
|  | (0.004) | (0.004) | (0.004) | (0.004) |
| Observations | 73 | 73 | 72 | 72 |
| $R^2$ | 0.319 | 0.315 | 0.188 | 0.271 |
| Adjusted $R^2$ | 0.309 | 0.306 | 0.176 | 0.261 |
| Residual Std. Error | 0.028 (df = 71) | 0.028 (df = 71) | 0.031 (df = 70) | 0.029 (df = 70) |
|  |  |  | p-value | p-value |
| Weak instruments |  |  | 0.007*** | 0.007*** |
| Wu-Hausman |  |  | 0.163 | 0.325 |
| Sargan |  |  | 0.010** | 0.003*** |

*p<0.1; **p<0.05; ***p<0.01

# Structural estimates

# Structural estimates: Search cost distribution
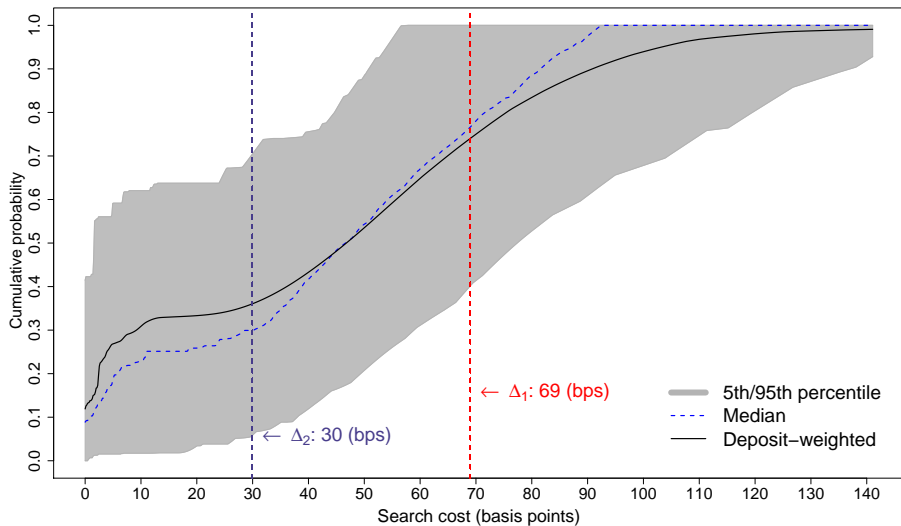
# Structural estimates: Search cost distribution
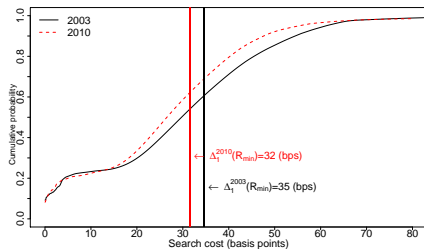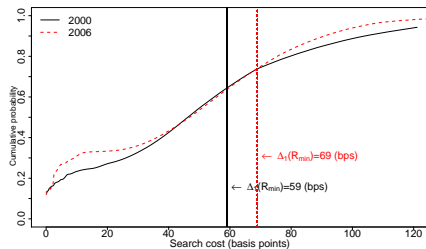


- Sample 1997-2016 includes a "pre-Internet era" and a "post-Internet era" periods
  - Some evidence that the level and dispersion in search costs have decreased over time but the effect is small
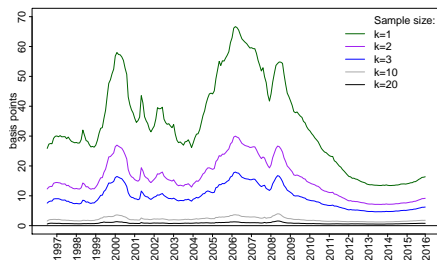
# Structural estimates: Search cost distribution

**Table 3.** Search cost distribution and market characteristics

|  | Dependent variable: MSA-level search cost estimates | | | |
|---|---|---|---|---|
|  | Median | Std. | P(25) | P(75) |
|  | (1) | (2) | (3) | (4) |
| Share population age 65+ | 0.072* | −0.123** | 0.583*** | 0.094 |
|  | (0.038) | (0.059) | (0.193) | (0.290) |
| log(Population) | 0.504 | 9.342*** | −2.236 | 7.274** |
|  | (0.379) | (0.595) | (1.999) | (3.030) |
| HHI | 0.478 | −0.745 | 0.245 | 1.357 |
|  | (2.146) | (3.697) | (2.082) | (3.152) |
| log(Population per bank) | 0.919** | −3.218*** | 0.177 | −4.616*** |
|  | (0.453) | (0.744) | (1.075) | (1.737) |
| log(Population per branch) | −1.135** | 3.698*** | 2.295* | 9.751*** |
|  | (0.514) | (0.869) | (1.326) | (2.129) |
| log(Income per capita) | 0.026 | −0.637 | −2.539 | −4.797 |
|  | (0.948) | (1.661) | (2.017) | (2.998) |
| Deposits/Income | 0.004* | −0.001 | −0.0003 | −0.002 |
|  | (0.003) | (0.004) | (0.003) | (0.004) |
| Time trend | −0.140*** | −0.308*** | −0.004 | −0.575** |
|  | (0.043) | (0.070) | (0.150) | (0.226) |
| Observations | 2,472 | 2,472 | 2,472 | 2,472 |
| $R^2$(between) | 0.035 | 0.038 | 0.006 | 0.014 |

*p<0.1; **p<0.05; ***p<0.01

# Structural estimates: Marginal value of information
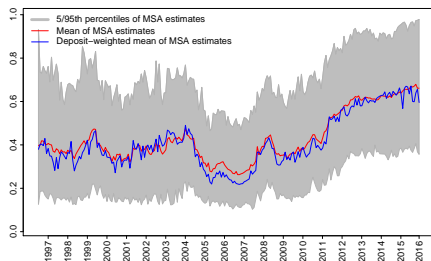
A. $\Delta_k$ variation over time

B. $\Delta_k$ variation over sample size
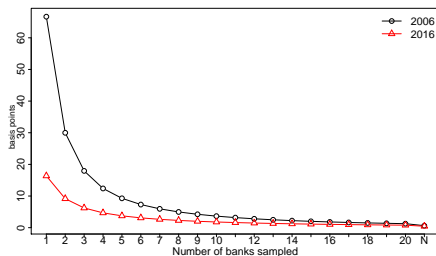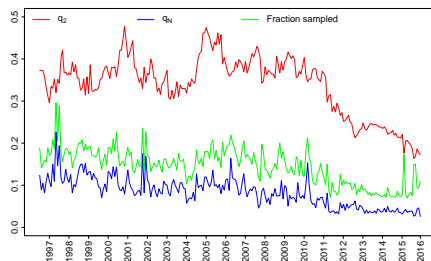


- Most variation in marginal value of information in $\Delta_1$
    - Most search decisions at the margin to "not shop" or "shop for two banks"
    - Low-search-cost depositors are always active regardless of rate dispersion

# Structural estimates: Search intensity

A. Inactive investors $q_1$



B. Active investors $q_k, k \geq 2$



- Large cross-sectional variation in search intensities
- Exit of "low-search-cost" (active) investors

# Structural estimates: Search intensity

**Table 4.** Search intensity and market characteristics

| | Dependent variable: Search intensity share $q_k$ | | | | | |
| | $q_1$ | | $q_2$ | | $q_N$ | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Share population age 65+ | $5.026^{***}$ | $1.573^{*}$ | $-2.398^{***}$ | $-0.252$ | $-1.742^{***}$ | $-0.729^{*}$ |
| | (0.531) | (0.885) | (0.736) | (0.641) | (0.612) | (0.388) |
| log(Population) | $-38.486^{***}$ | $-39.286^{***}$ | $16.153^{*}$ | $16.680^{*}$ | $-0.114$ | $0.212$ |
| | (6.459) | (9.410) | (8.703) | (8.576) | (8.558) | (3.874) |
| HHI | $0.081$ | $0.094$ | $0.001$ | $-0.002$ | $0.001$ | $-0.003$ |
| | (0.080) | (0.092) | (0.086) | (0.078) | (0.074) | (0.058) |
| log(Population per bank) | $15.055^{***}$ | $5.616$ | $-10.292^{**}$ | $-4.148$ | $2.585$ | $5.319$ |
| | (3.768) | (5.050) | (4.480) | (4.551) | (4.300) | (3.499) |
| log(Population per branch) | $14.241^{***}$ | $3.984$ | $-9.467$ | $-3.871$ | $-4.199$ | $-1.244$ |
| | (5.222) | (7.805) | (7.117) | (6.160) | (5.980) | (4.961) |
| log(Income per capita) | $-8.506^{***}$ | $4.934$ | $8.401^{**}$ | $-0.047$ | $-4.441$ | $-8.356^{***}$ |
| | (2.729) | (3.587) | (3.538) | (3.231) | (3.201) | (2.543) |
| Deposits/Income | $0.002$ | $-0.007$ | $-0.002$ | $0.003$ | $-0.008$ | $-0.006$ |
| | (0.010) | (0.010) | (0.009) | (0.009) | (0.008) | (0.009) |
| Range ($R_{max} - R_{min}$) | | $-7.404^{***}$ | | $4.638^{***}$ | | $2.148^{***}$ |
| | | (0.390) | | (0.380) | | (0.235) |
| Observations | 2,472 | 2,472 | 2,472 | 2,445 | 2,445 | 2,445 |
| $R^2$ (between) | 0.077 | 0.242 | 0.042 | 0.143 | 0.032 | 0.079 |

$^{*}$ p<0.1; $^{**}$ p<0.05; $^{***}$ p<0.01

## Exit of "low-search-cost" investors: Money Market Funds

- Banks steer some of their sophisticated depositors to affiliated MMFs
    - Bank-affiliated retail funds charge 10 bps higher fees than unaffiliated funds
    - No difference for institutional funds

| Distribution channel | Bank-affiliated | | | | | Other | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Funds count | AUM ($bn) | Expense (bps) mean | 5th | 95th | Funds count | AUM ($bn) | Expense (bps) mean | 5th | 95th |
| Bank Affiliated | 315 | 225 | 65 | 44 | 130 | 30 | 6 | 58 | 46 | 152 |
| Broker | 44 | 107 | 61 | 47 | 97 | 85 | 200 | 65 | 45 | 134 |
| Direct | 29 | 9 | 60 | 14 | 151 | 68 | 293 | 35 | 13 | 75 |
| Adviser | 11 | 2 | 73 | 45 | 181 | 164 | 61 | 76 | 44 | 156 |
| Other | 12 | 1 | 80 | 51 | 140 | 21 | 8 | 84 | 37 | 201 |
| Insurance | 12 | 1 | 54 | 40 | 143 | 48 | 11 | 61 | 42 | 160 |
| Retail total | 423 | 345 | 63 | 41 | 123 | 479 | 608 | 53 | 32 | 160 |
| Institutional total | 488 | 627 | 27 | 15 | 98 | 408 | 496 | 27 | 12 | 81 |

# Asymmetric and incomplete pass-through
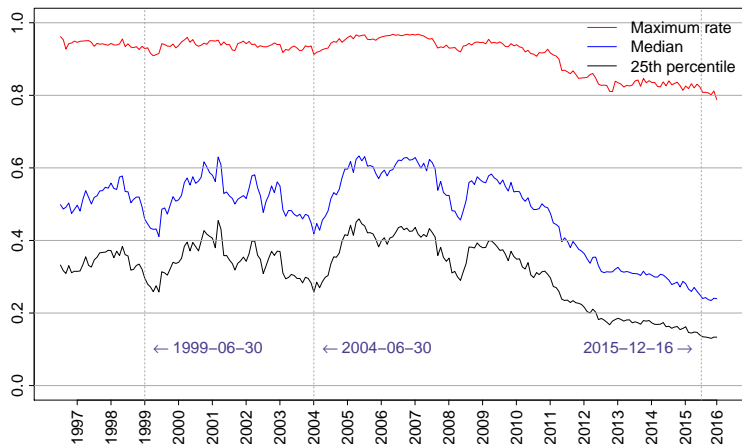


- Historically low pass-through following December 2015 "lift-off"

# Welfare: Aggregate search costs
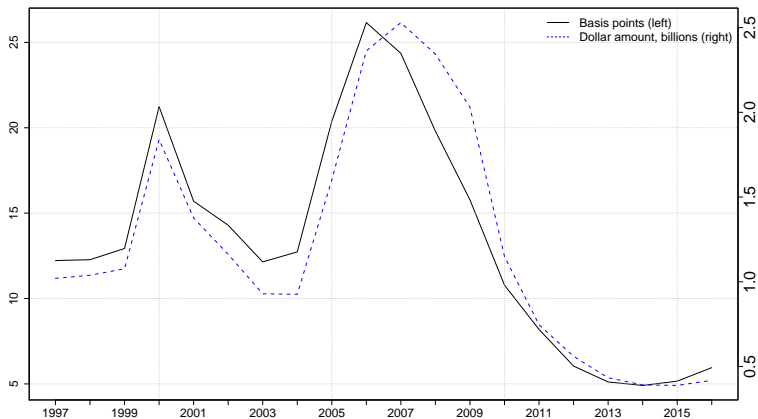


- Sizable welfare losses due to costly search: Around $2.4 bn in search costs in 2006

# Brief literature review

- Competition for deposits and pricing of deposits
  - Incomplete pass-through: Diebold and Sharpe (1990), Driscoll and Judson (2013)
  - Imperfect competition: Hannan and Berger (1991), Neumark and Sharpe (1992), Amel and Hannan (1999),Kiser (2004), Hannan and Prager (2004,2006)
  - Switching costs: Sharpe (1997)
  - Role of advertisement: Honka, Hortacsu, and Vitorino (2016)
  - Monetary policy transmission: Drechsler, Savov, and Schnabl (2017), Duffie and Krishnamurthy (2016)
- Related markets: Mutual funds Hortacsu and Syverson (2004)
- **This paper**: novel dataset on deposit pricing, novel stylized facts on pricing with focus on the cross-sectional dispersion, novel facts on household deposit allocations, new mechanism (costly search), structural estimation across markets and over time

# Conclusion

- Large segment of investors mainly elderly households remains captive (high-search-cost) and has not fully taken advantage of Internet technologies or high-return alternatives such as MMFs
- Through affiliation with MMFs, banks have managed to retain some of their control over more sophisticated and low-search-cost investors
- Monetary policy pass-through is imperfect and asymmetric
  - Pro-cyclical bank profits from deposits
  - Large distortions in consumption-savings decisions of households
  - Pure deadweight losses due to costly search
- Holistic welfare analysis needs to take into account financial stability implications of deposit funding as well as cost of providing deposit insurance, bank supervision and regulation
  - Search costs are arguably orthogonal to such considerations