In Search of a Risk-free Asset

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Outline

Stylized facts on the pricing of FDIC-insured Certificates of Deposit (CDs, time deposits) 1997-2011

1. Large and time-varying dispersion of the yields
2. Rigid yield adjustments
3. Low synchronization of yield adjustments across banks
4. Asymmetric yield adjustments to increasing/descreasing marginal costs

Outline

- Puzzle: homogeneous financial product, large number of competitors, competition in prices
- What is the role of information (search) costs on the part of the investors in this market?
- Develop a model of heterogeneous search cost investors
- Estimate and characterize the implied search cost distribution
- Rationalize the observed yield rigidity and asymmetric price adjustment

Asset pricing perspective

- Pricing of financial assets:

$$P^f_{t,t+k} = \frac{1}{R^f_{t,t+k}} = E\left(M_{t,t+k}|\mathcal{I}_t\right) \tag{1a}$$

$$0 = E\left(M_{t,t+1}(R^i_{t+1} - R^f_{t,t+1})|\mathcal{I}_t\right) \tag{1b}$$

- Law of one price = No-arbitrage condition
- Large financial market: 1.2 trillion in 2007 small time deposits, part of a 6 trillion M2-M1 interest bearing substitutes, including 900 billion Retail Money Market Mutual Funds industry
- Highly competitive market: Post Regulation Q and Riegle-Neal Act, large number of commercial and savings banks, credit unions, retail money funds and low cost access to the treasury market (Treasury direct),
- Important funding source: 40 % of U.S. commercial bank assets funded by time deposits

Sources of price rigidity

- Fundamental questions in Macroeconomics:
  Why don't prices respond contemporaneously to aggregate conditions?
  How does monetary policy impact prices and allocations?

- Source of price rigidity – supply side
  - Time dependent adjustment: Calvo (1983), Taylor (1980)
  - State dependent: Dotsey, King and Wolman (1999)
  - Rational inattention: Sims (1998), Woodford (2009)

- Source of price rigidity and monopoly power – demand side
  - Costly consumer search: Head, Liu, Menzio and Wright (2012, EER), Chevalier and Kashyap (2011)

Related literature

- Deposit rate rigidity / asymmetry of repricing: Diebold and Sharpe (1990), Hannan and Berger (1991), Neumark and Sharpe (1992) and Driscoll and Judson (2009)
- Costly consumer search: Stigler (1961), Burdett and Judd (1983)
- Information costs estimation: Hortacsu and Syverson (2004), Hong and Shum (2006), Moraga-Gonzalez and Wildenbeest (2010)
- Price rigidity in a costly consumer search model: Head, Liu, Menzio and Wright (2012)
- Search costs – interpretation: Lusardi et al. (2010 a,b), Agarwal, Driscoll, Gabaix and Laibson (2009)
- Importance for the aggregate saving: McKay (2011, 2012)

Stylized Facts on the Pricing of FDIC insured CDs

Data

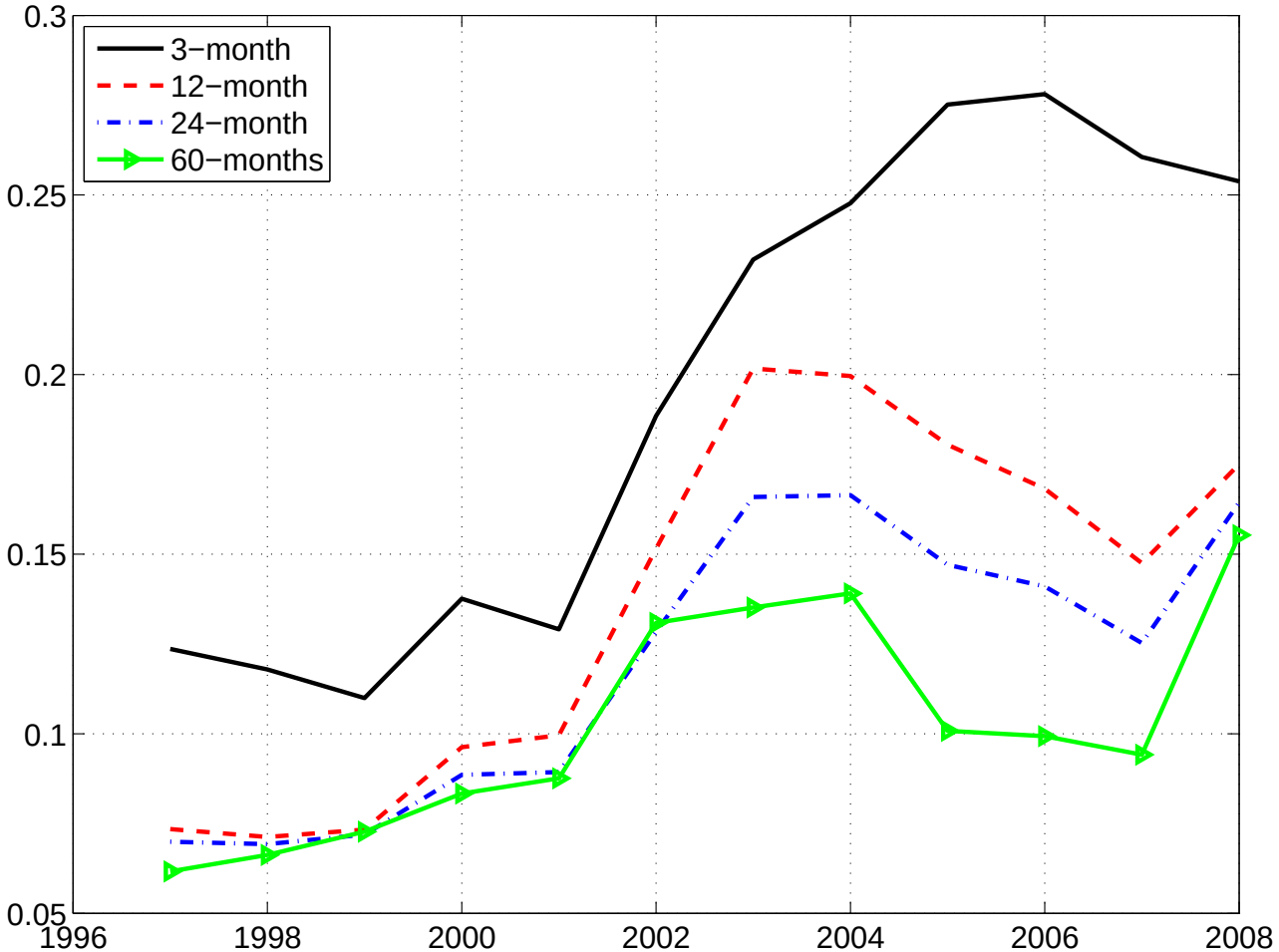
- CD rates: Proprietary dataset obtained from RateWatch on retail deposit yield public offerings by 5,726 US commercial banks, 75,879 branches, over 10,000 cities, weekly observations from January 1997 to June 2011
- Income, wealth and demographic information: U.S. Census and BEA (MSA-level), Survey of Consumer Finance
- Banks' balance sheets and income statements: Reports of Condition and Income ("Call Reports")

The Certificate of Deposit contract: Non-price components (BRM, 2006)

Table : Contract characteristics

		3-month	6-month	1-year	2.5-year	5-year
Penalty (days)	median	90	90	180	180	180
	mean	70.32	96.35	151.62	201.18	246.67
	std	27.91	37.87	58.14	76.75	157.86
Min. deposit amount	median	1000	1000	1000	1000	1000
	mean	1642.35	1444.53	1325.50	1361.67	1795.41
	std	1959.57	1721.50	1490.28	1556.77	2430.28
Yield	median	2.86	3.75	4.00	3.90	4.07
	mean	2.88	3.59	3.81	3.80	4.06
	std	1.22	1.20	1.07	0.88	0.83
		Spearman rank correlation				
Min.amount - yield	Rank corr.	-0.10	-0.01	0.02	-0.01	0.05
	p-value	0.35	0.93	0.85	0.94	0.63
Penalty (days) - yield	Rank corr.	-0.31	-0.15	-0.10	0.09	0.17
	p-value	0.00	0.15	0.31	0.41	0.11
Min.amount - penalty (days)	Rank corr.	0.03	0.00	-0.19	-0.21	-0.13
	p-value	0.77	0.99	0.07	0.06	0.22

The coefficient of variation



Yield dispersion: MSA level, 2003 and 2007

- Measure of price dispersion $DISP = P(90) - P(10)$ computed for 2003 and 2007, 366 MSA deposit markets

			2003			
P90-P10	3-month	6-month	12-month	24-month	36-month	60-month
min	0.04	0.16	0.24	0.19	0.07	0.00
p25	0.43	0.53	0.63	0.67	0.71	0.81
p50	0.54	0.65	0.78	0.85	0.89	0.98
p75	0.69	0.80	0.93	1.05	1.10	1.25
max	1.37	1.37	1.62	1.66	1.96	2.46
			2007			
P90-P10	3-month	6-month	12-month	24-month	36-month	60-month
min	0.37	0.62	0.39	0.07	0.05	0.25
p25	1.45	1.52	1.20	1.04	1.04	0.98
p50	1.88	2.00	1.47	1.31	1.25	1.17
p75	2.34	2.29	1.79	1.58	1.51	1.37
max	3.77	3.26	3.30	3.24	2.41	2.16

- Multi-market banks – price uniformly across markets
- Persistent yield dispersion: Among small vs large banks, “mortar-and-brick” banks vs internet banks

Fact 2: Yield rigidity

- Duration in weeks between price (yield) adjustments

Target Fed Funds	decreased			unchanged			increased		
	p25	p50	p75	p25	p50	p75	p25	p50	p75
3-month	0	3	11	1	7	20	1	6	16
6-month	0	2	7	2	6	17	2	5	12
12-month	0	2	6	1	5	15	1	5	11
24-month	0	2	6	1	5	14	1	5	12
36-month	0	2	6	0	5	14	1	5	12
60-month	0	1	5	0	3	12	0	3	12

- Asymmetry of yield adjustments $D^+ = D^0 > D^-$

Fact 3: Synchronization of yield adjustments

- Fraction of adjusters

Target Fed Funds	decreased			unchanged			increased		
	p25	p50	p75	p25	p50	p75	p25	p50	p75
3-month	0.13	0.20	0.28	0.08	0.11	0.13	0.10	0.12	0.14
6-month	0.16	0.26	0.36	0.09	0.13	0.16	0.12	0.14	0.16
12-month	0.18	0.27	0.36	0.11	0.14	0.17	0.13	0.14	0.17
24-month	0.16	0.25	0.36	0.10	0.13	0.16	0.12	0.13	0.14
36-month	0.15	0.24	0.36	0.09	0.12	0.15	0.10	0.12	0.13
60-month	0.15	0.24	0.34	0.09	0.11	0.14	0.09	0.11	0.12

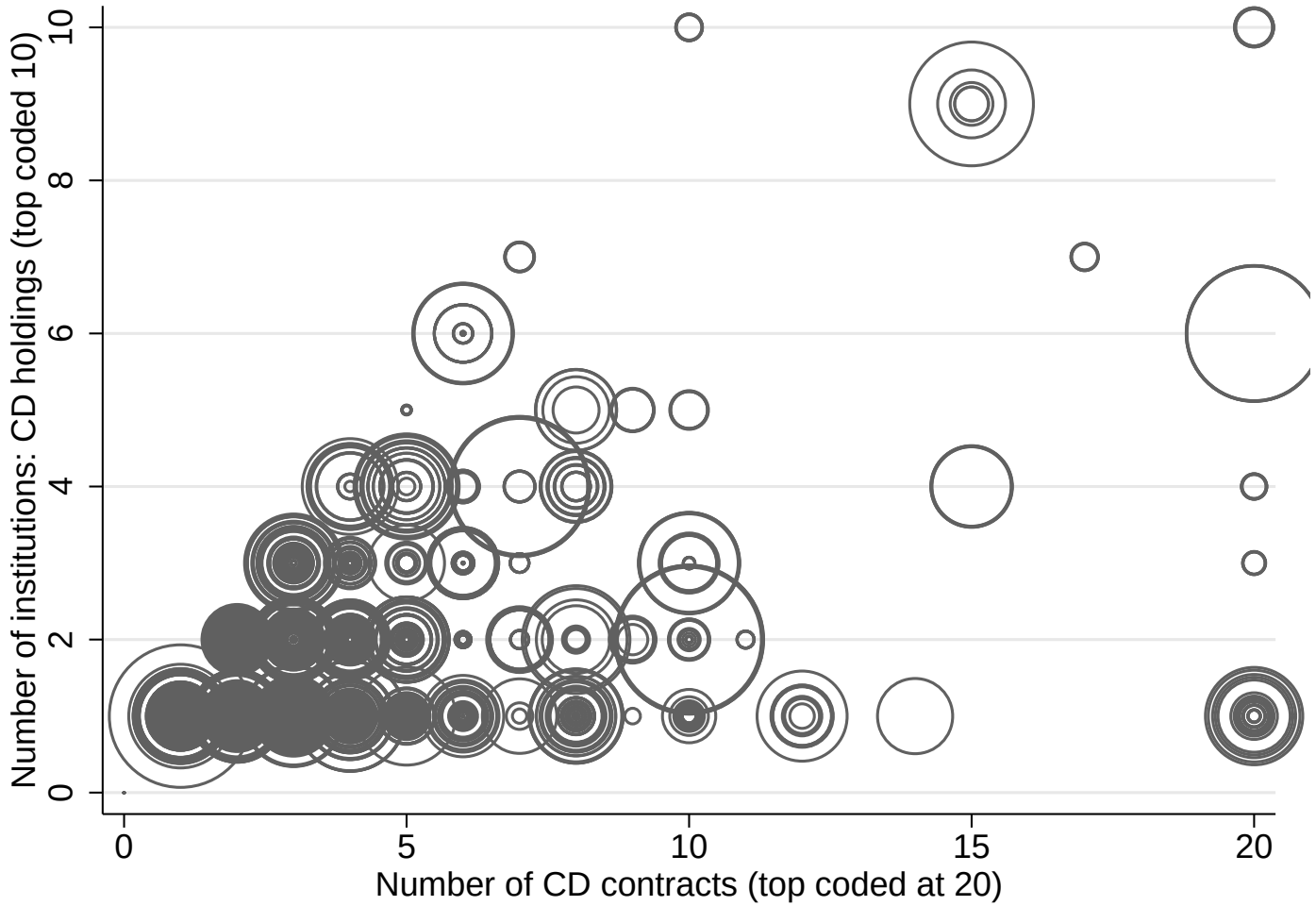
- Asymmetry of yield adjustment: $\Phi^{+} = \Phi^{0} < \Phi^{-}$

Who is the investor in FDIC insured CDs?

Participation

- SCF 2007: 16 % participation rate with median investment: 20,000 USD and 2 contracts
- Participation increases with age, income and net-worth
- 45 % contracts with an institution different from the main checking account
- Reasons to search: Financial advisory (e.g. BankRate.com, Google-Finance, DepositsAccount.com), CD-ladder investment strategy, binding FDIC insurance limit, Fixed maturity of contract relationship
- Role of the Internet – 41 % of US HH age 55 + have no internet connection in 2006 (Census), small fraction (less than 20 %) of US HH report the Internet as a main source of information for investment decisions (SCF, 2007)

Participation: Number of CD contracts / Number of institutions



Source: SCF, 2007

A model of heterogeneous search cost investors

Model: Overview

- **Banks**
  - Choose assets (loans) and liabilities (insured and uninsured)
  - Uninsured deposits: wholesale market (fed funds) with a *common* cost of funds
  - Insured deposits: Banks compete in prices following mixed strategies $F_P(P^d)$ on $\mathcal{S} = [P_{min}, P_{max}]$
- **Investors**
  - Heterogeneous in information (search) costs $\xi \sim_d F_\xi(\xi)$
  - Search (non-sequentially) for the best (risk-adjusted) return on their savings
  - Outside option – a risky asset return
- Equilibrium concept of Burdett and Judd (1983)

Non-sequential search

- Non-sequential search: Choose n

$$P_{min}(n) \equiv min\{P_1, ..., P_n\} \sim_d 1 - (1 - F_P(P))^n$$

- Optimal choice of the sample size for type ξ – $n(\xi)$

$$V^d(\xi) = \max_n \left\{ -(n-1) \times \xi + \int_{P^d_{min}}^{P^d_{max}} \phi^d(P^d_\tau) n (1 - F_P(P))^{n-1} f_P(P) dP \right\}$$

- Gain from extra search $n \to n+1$

$$\Delta_n = \int_{P_{min}}^{P_{max}} \phi^d(P)(1 - F_P(P))^{n-1} \left\{ 1 - (n+1) F_P(P)^n \right\} f_P(P) dP$$

- Optimal choice problem of type ξ redefined:

$$n^*(\xi) = argmax_{n \in \mathbb{N}} \left\{ \Delta_n \text{ s.t.} \Delta_n \geq \xi \right\}$$

Market segmentation

- The market becomes segmented according to the intensity of search

$$\begin{aligned} &\text{“Uninformed” investors: } q_1 = 1 - F_\xi(\Delta_1) \\ &\vdots \\ &q_k = F_\xi(\Delta_{k-1}) - F_\xi(\Delta_k) \\ &\vdots \\ &\text{“Informed” investors: } q_N = 1 - \sum_{j=1}^{N-1} q_j \end{aligned} \tag{2}$$

- Ex-post information heterogeneity among market segments

$$P_{min}(k) \sim_d 1 - (1 - F_P(P))^k, \ \textit{for } k = 1, .., N \tag{3}$$

Banks' problem:

- Deposit demand function

$$g^D(P^d) = \underbrace{(1 - h^d(P^d))}_{\textit{Intensive demand}} \underbrace{\left(\frac{1}{N}\sum_{k=1}^{N} q_k k (1 - F_p(P^d))^{k-1}\right)}_{\textit{Extensive demand}} \tag{4}$$

- Deposit profit function

$$\pi^d(P^d \mid F_P(P^d)) = (P_j^d - \tilde{P})(1 - h^d(P_j^d))\left(\frac{1}{N}\sum_{k=1}^{N} q_k k (1 - F_p(P^d))^{k-1}\right)$$

- Symmetric Nash equilibrium in mixed strategies

$$\pi^d(P^d \mid F_P(P^d)) = \begin{cases} \pi^{d*} & \text{if } P^d \in \mathcal{S} \\ < \pi^{d*} & \text{if } P^d \notin \mathcal{S} \end{cases}$$

Source of Monopoly Power

- The equilibrium price offer distribution
  - Case $q_1 = 1$: the price offer distribution is degenerate at the monopoly price $\bar{P}$.
  - Case $q_1 = 0$: The price offer distribution is degenerate at the perfectly competitive price $\tilde{P}$.
  - Case $0 < q_1 < 1$: The price offer distribution is non-degenerate
- Ratio of min/max mark-up:

$$(P_{min} - \tilde{P})/(P_{max} - \tilde{P}) = \underbrace{\frac{q_1}{\sum_{k=1}^{N} k q_k}}_{Extensive\ margin} \times \underbrace{\frac{(1 - h^d(P_{max}))}{(1 - h^d(P_{min}))}}_{Intensive\ margin} \tag{5}$$

Identification and estimation of the search cost distribution

Structural estimation: Maximum likelihood estimation

- Maximum likelihood problem:

$$max_{\Theta^p \in \Theta^p_{\mathcal{A}}} \left\{ \frac{1}{M} \sum_{j=1}^{M} ln\, f_P(P_j^d | \Theta^p) \right\} \tag{6}$$

where $z = F_P(P)$ implies $P(z) = F_P^{-1}(z)$ solves

$$(P(z) - \tilde{P})(1 - h(P(z))) \sum_{k=1}^{N} k q_k (1-z)^{k-1} = (P_{max} - \tilde{P})(1 - h(P_{max}))q_1 \tag{7}$$

- By the implicit function theorem and $\frac{\partial P(z)}{\partial z} = \frac{1}{f_P(P(z))}$

$$f_p(P) = \frac{\psi'(P)}{\psi(P)} \times \frac{\sum_{k=1}^{N} k q_k (1 - F_P(P))^{k-1}}{\sum_{k=1}^{N} k(k-1) q_k (1 - F_P(P))^{k-2}}$$

- $\Theta^p = \{\beta, \gamma, \sigma, \{\theta_i\}_{i=1}^p\} \subset \Theta^p_{\mathcal{A}}$ where $F_\xi(\cdot) \approx \hat{F}_\xi(\cdot | \{\theta_i\}_{i=1}^p)$

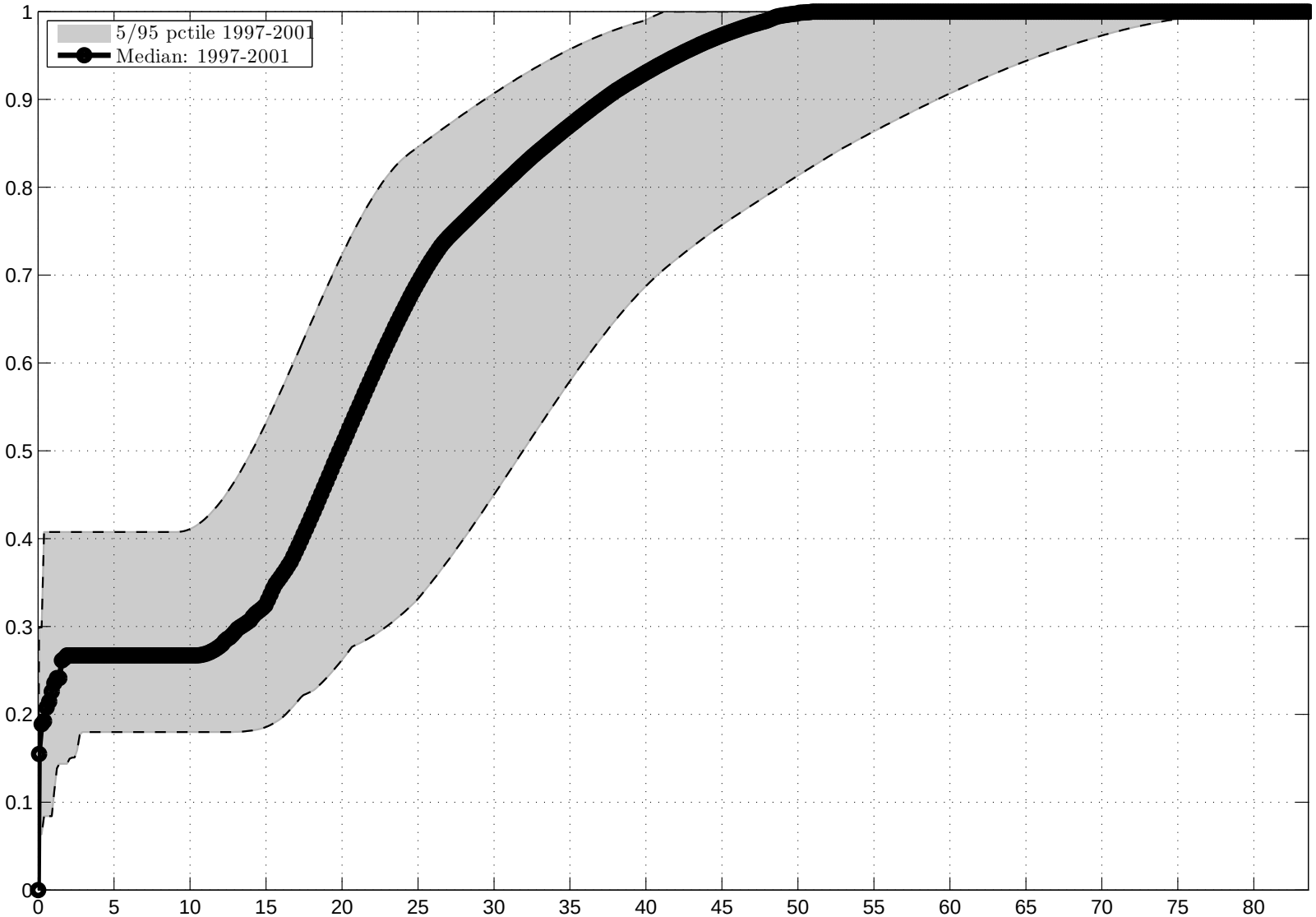
Structural estimation

- Select one market - Chicago-Naperville-Joliet, IL-IN-WI

	Pop.	Number banks	Deposits	Share 65+	HHI index	DISP 12-m
1997	8862719	259	7080	0.11	0.04	0.78
1998	8949190	256	8010	0.11	0.04	0.61
1999	9035654	260	8340	0.11	0.04	0.72
2000	9113234	252	9860	0.11	0.05	1.27
2001	9169580	258	10420	0.11	0.05	0.92
2002	9206032	253	11520	0.11	0.05	0.97
2003	9233303	293	21700	0.11	0.08	0.79
2004	9260676	292	21810	0.11	0.06	0.95
2005	9276302	266	23780	0.11	0.07	1.52
2006	9297749	263	25990	0.11	0.07	2.02
2007	9337140	264	27230	0.11	0.06	1.78
2008	9384555	262	28280	0.11	0.06	1.29
2009	9429498	259	29500	0.11	0.06	1.04
2010	9474363	241	29470	0.11	0.06	0.70

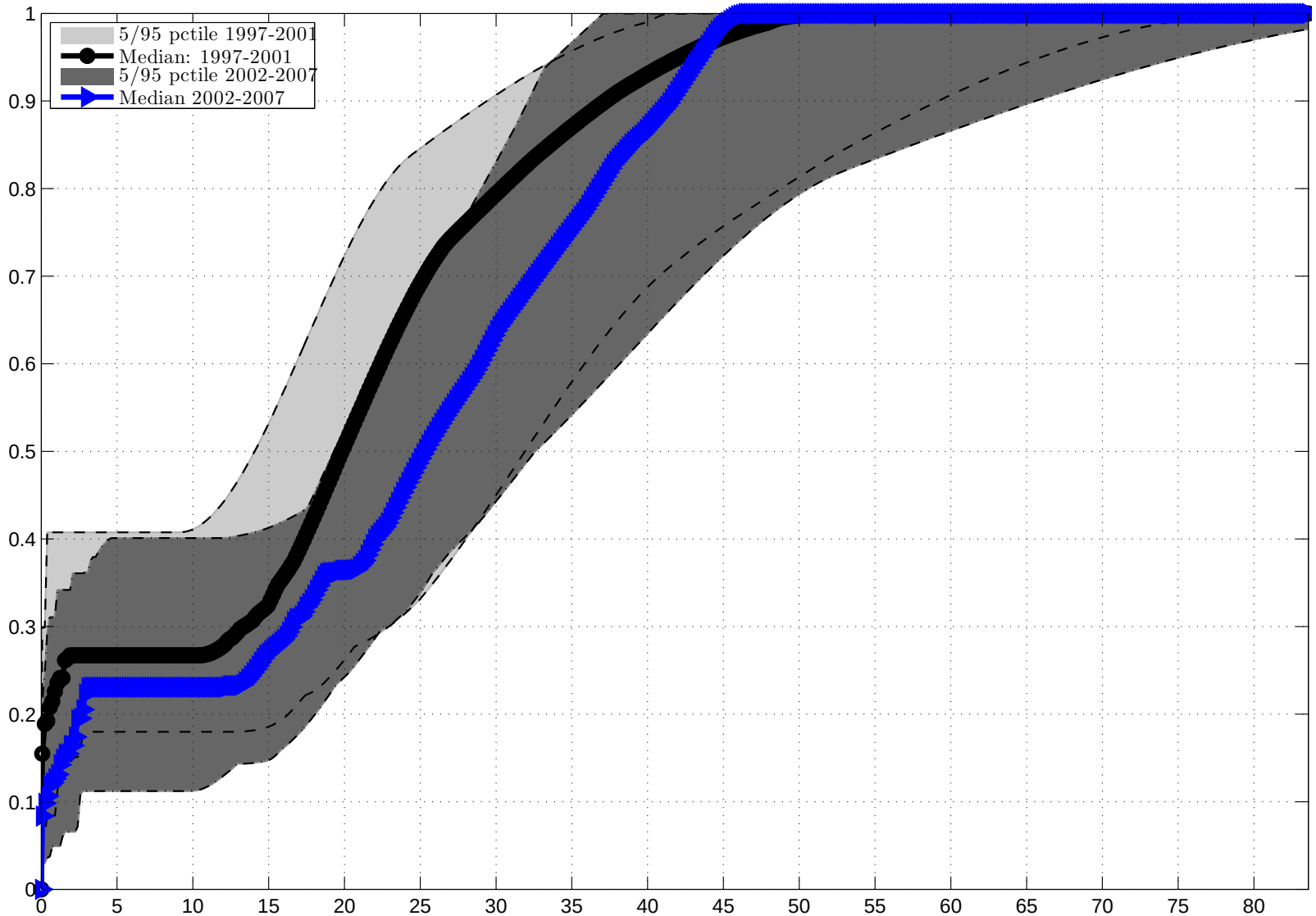
- Stable market structure - number of banks, HHI, share of households 65+

Estimated distribution of search costs: “Pre-Internet banking” period 1997 – 2001

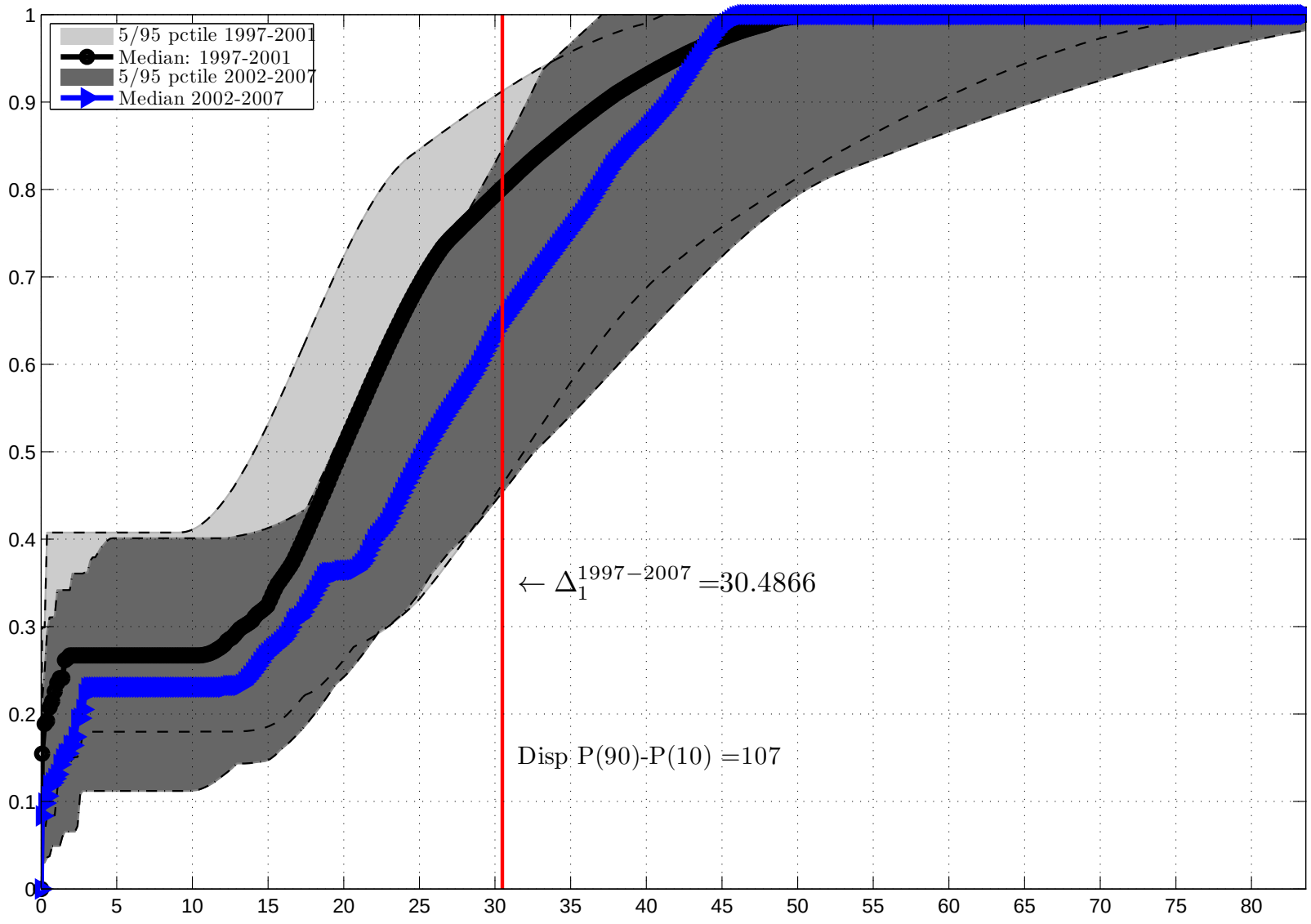


Office of the Comptroller of the Currency: By year-end the end of 2001, 50 % of banks offered internet banking 2001

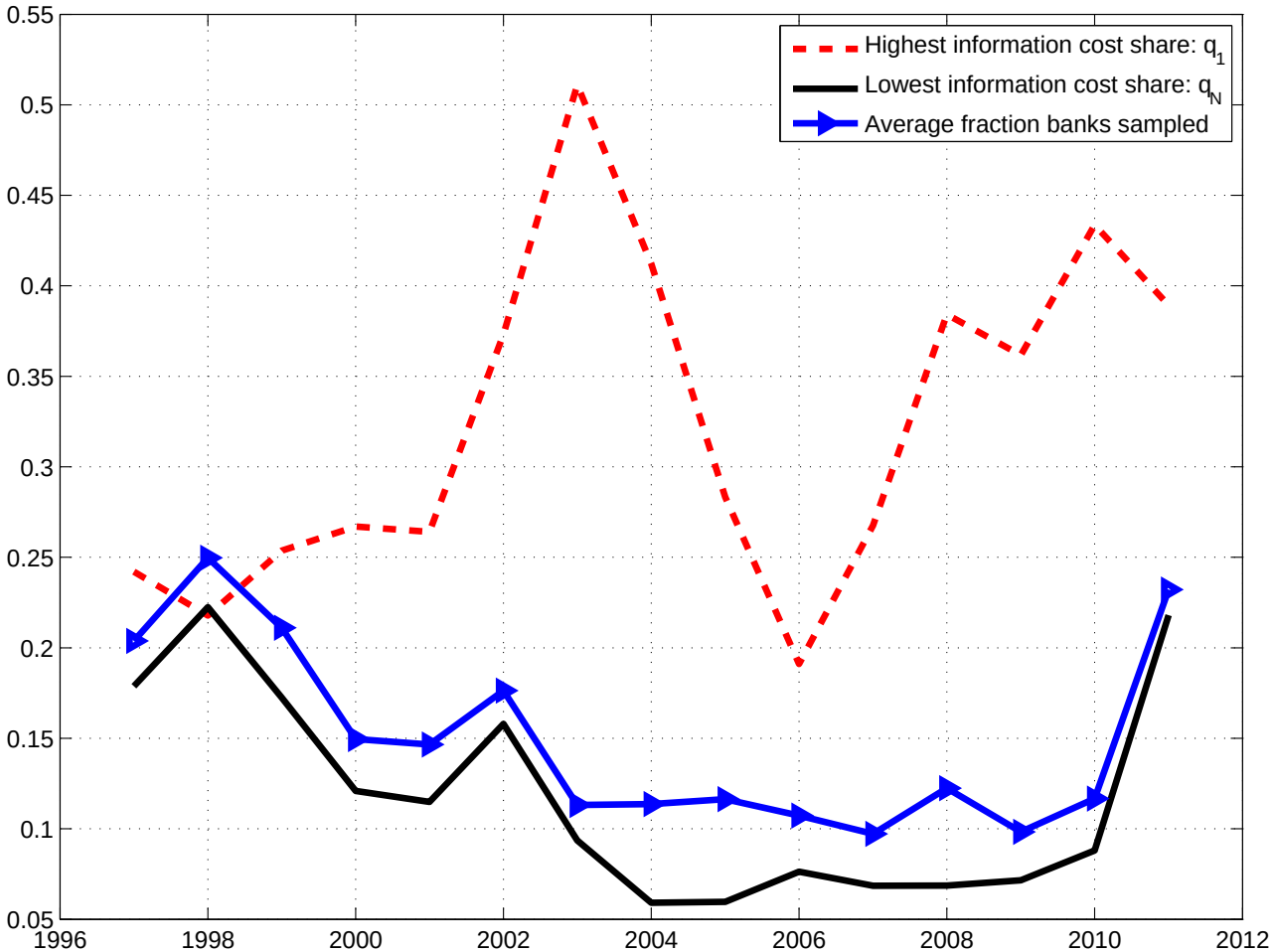
Estimated distribution of search costs: 1997-2001 vs 2002-2007



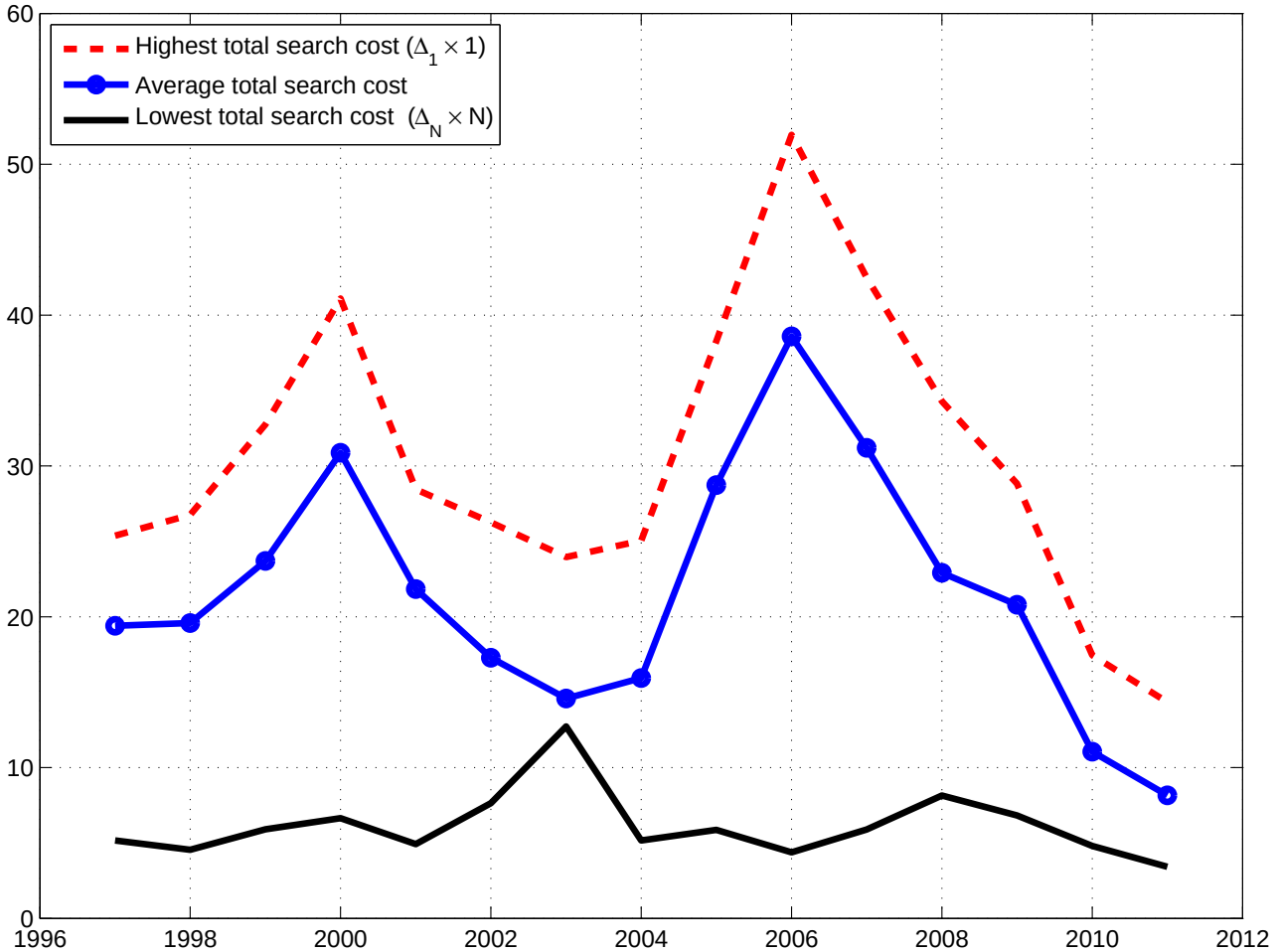
Estimated distribution of search costs



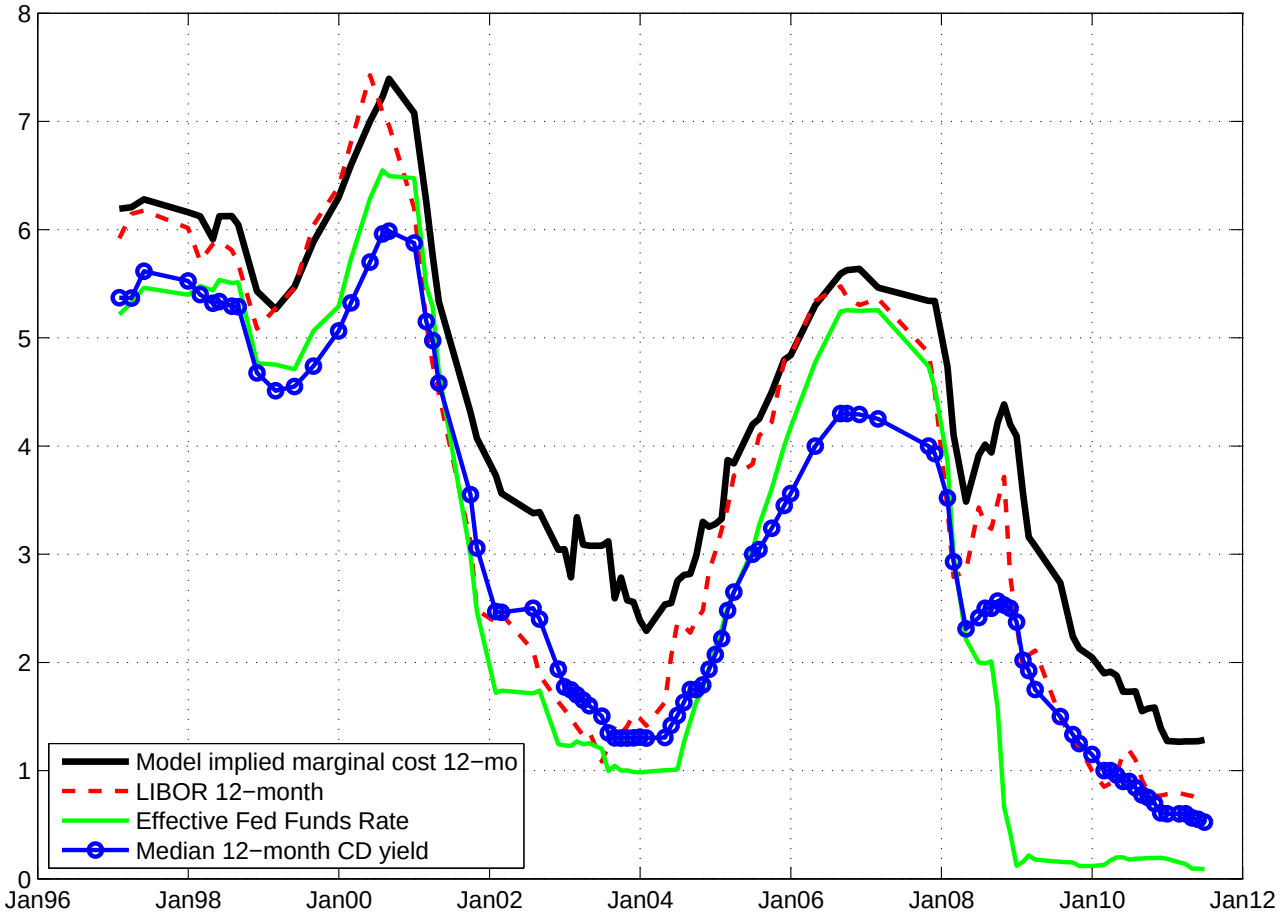
Intensity of search



Total search costs and welfare



Model implied marginal cost of funds



Price rigidity

Monetary policy regimes

- Monetary policy: Changes $\tilde{R}$ in a sequence of steps of size $\kappa^{\pm}$
- Policy regimes:
  - Monetary policy tightening T_+ periods - $\tilde{R}$ increased
  - Monetary policy easing T_- periods - $\tilde{R}$ decreased
  - Monetary policy neutrality T_0 periods - $\tilde{R}$ unchanged
- Examine the degree of incomplete pass-through $\frac{\partial P_{min}}{\partial \tilde{P}}$
- Examine the expected duration of prices (D^+, D^0, D^-), the fraction of adjusters (Φ^+, Φ^0, Φ^-)

Price rigidity and imperfect pass-through

- Incomplete pass-through
  - Response of P_{min} (R_{max}) taking as given the reservation price P_{max} around $\sigma = 1$

$$\frac{\partial P_{min}}{\partial \tilde{P}} \approx 1 - \frac{q_1}{\sum_{k=1}^{N} k q_k} < 1$$

  - When $\tilde{R}$ low, R_{max} low and price dispersion is low. Incentives to search are low, hence pass-through is also lower than when $\tilde{R}$ high/price dispersion is high
  - $P_{min,t+T_+} < .. < P_{min,t+i} < .. < P_{min,t}$ for $i = 1, 2, .., T_+$.
  - $P_{min,t+T_-} > .. > P_{min,t+i} > .. > P_{min,t}$ for $i = 1, 2, .., T_-$.
- Price rigidity: Indifference region $\mathcal{Z}_{t+1} = \mathcal{S}_{t+1} \bigcap \mathcal{S}_t$, a new equilibrium level ${\pi^d_{t+1}}^*$, no incentives to reprice

Repricing policy

- Admissible repricing policy: if $F_{P,t}(P)$ equilibrium in t all banks reprice according to $P^*_{t+1}(P_t)$, then $F_{P,t+1}(P)$ is an equilibrium in $t+1$

- Examine:

$$P^*_{t+1}(P_t, \rho) = \begin{cases} P' & \text{if } P_t \notin \mathcal{S}_{t+1} \\ \{P_t, P'\} \text{ with prob.}(\rho, 1-\rho) & \text{if } P_t \in \mathcal{S}_{t+1} \\ & P' \sim G_{t+1}(P) \end{cases} \tag{8}$$

Asymmetric price adjustment

- The repricing policy leads to asymmetric price adjustment
- Fraction of adjusters: $\Phi^{-}_{t+i}(\rho) > \Phi^{+}_{t+i}(\rho)$
- Average duration of prices: $D^{+}(\rho) > D^{-}(\rho)$
- Monetary policy neutrality: $D^{0}(\rho) = D^{+}(\rho)$ and $\Phi^{0}_{t+i}(\rho) = \Phi^{+}_{t+i}(\rho)$

Discussion and Conclusion

Conclusion

- Presented evidence that costly information acquisition could rationalize the empirical facts on the pricing of FDIC insured CDs
  - Large yield (price) dispersion
  - Incomplete and asymmetric interest rate pass-through (price rigidity)
- The role of the Internet/Internet banking/Price comparison websites (BankRate,Google Finance, Yahoo Finance etc)
- Search for better yield, Post Regulation Q and the rise of retail MMMF
- Pricing of large denomination (>100 K) certificates of deposit
- The role of the deposit insurance limit for bank competition – Shy, Stenbacka and Yankov (2013)