Banks' Risk Exposures

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Matching models to data:

- Consumption: easy
  - model: specify set of goods
    ("all nondurables & services", "housing" vs "other")
  - data: go to NIPA & download aggregated price and quantity measures

  $\longrightarrow$ with many agents: get allocations from expenditure data
- Credit market positions: messy
  - model: specify set of assets
  - data: raw accounting measures on lots of fixed income instruments ("bonds")

  $\longrightarrow$ how to aggregate? how to compare across agents?
- When modeling banks, want to
  - aggregate positions: risk in derivatives vs other business
  - compare institutions: systemic risk?
- This paper:
  - portfolio approach to aggregate & compare positions
  - application to large US banks

Background: what banks do

- historically, banks provide an alternative to markets
  - issue deposits, make loans
- modern banks participate more in markets
  - hold more tradable securities (e.g., MBS)
  - trade in derivatives
  - make markets in bonds, derivatives

Modern Bank Balance Sheet, JP Morgan Chase 2011

Assets		Liabilities	
Cash	6%	Deposits	50%
Securities	16%	Other borrowed money	15%
Trading assets	20%	Trading liabilities	6%
Fed funds + Repos	17%	Fed funds + Repos	10%
Loans	31%		
Other assets	10%	Other liabilities	11%
		Equity	8%

Total assets/liabilities: \$2.3 Trillion

Derivatives: \$60 Trillion Notionals of Swaps

Schedule HC-B—Securities

Dollar Amounts in Thousands	Held-to-Maturity (Column A) Amortized Cost				Held-to-Maturity (Column B) Fair Value				Available-for-Sale (Column C) Amortized Cost				Available-for-Sale (Column D) Fair Value				
	BHCK	Bil	Mil	Thou	BHCK	Bil	Mil	Thou	BHCK	Bil	Mil	Thou	BHCK	Bil	Mil	Thou	
1. U.S. Treasury securities	0211				0213				1286				1287				1.
2. U.S. government agency obligations (exclude mortgage-backed securities):																	
a. Issued by U.S. government agencies[1]	1289				1290				1291				1293				2.a.
b. Issued by U.S. government-sponsored agencies[2]	1294				1295				1297				1298				2.b.
3. Securities issued by states and political subdivisions in the U.S.	8496				8497				8498				8499				3.
4. Mortgage-backed securities (MBS)																	
a. Residential pass-through securities:																	
(1) Guaranteed by GNMA	G300				G301				G302				G303				4.a.(1
(2) Issued by FNMA and FHLMC	G304				G305				G306				G307				4.a.(2
(3) Other pass-through securities	G308				G309				G310				G311				4.a.(3
b. Other residential mortgage-backed securities (include CMOs, REMICs, and stripped MBS):																	
(1) Issued or guaranteed by FNMA, FHLMC, or GNMA	G312				G313				G314				G315				4.b.(1
(2) Collateralized by MBS issued or guaranteed by FNMA, FHLMC, or GNMA	G316				G317				G318				G319				4.b.(2
(3) All other residential mortgage-backed securities	G320				G321				G322				G323				4.b.(3
c. Commercial MBS:																	
(1) Commercial pass-through securities	G324				G325				G326				G327				4.c.(1
(2) Other commercial MBS	G328				G329				G330				G331				4.c.(2
5. Asset-backed securities and structured financial products:																	
a. Asset-backed Securities (ABS)	C026				C988				C989				C027				5.a.
b. Structured financial products:																	
(1) Cash	G336				G337				G338				G339				5.b.(1
(2) Synthetic	G340				G341				G342				G343				5.b.(2
(3) Hybrid	G344				G345				G346				G347				5.b.(3
6. Other debt securities:																	
a. Other domestic debt securities	1737				1738				1739				1741				6.a.
b. Foreign debt securities	1742				1743				1744				1746				6.b
7. Investments in mutual funds and other equity securities with readily determinable fair values									A510				A511				7.
8. Total (sum of 1 through 7) (total of column A must equal Schedule HC, item 2.a) (total of column D must equal	bhct												bhct				

Inferring risk from accounting data

- many securities: how to compress & compare?
- consider model with aggregate risk & many assets
  - any portfolio = collection of contingent claims on aggregate shocks
  - few aggregate states $\Rightarrow$ simple portfolios
- can we think about a bank the same way?
  - statistical evidence:
    cross section of bond values driven by few shocks
  - anecdotal evidence: problems from bets on aggregate events
    house prices (Goldman – MBS)
    credit risk indices (AIG, London Whale)
    sovereign default (German & French banks — Greek bonds)
- "few shocks" works like "few states" $\Rightarrow$ simple portfolios

Portfolio approach to measuring risk exposure

- represent credit market positions as simple portfolios
  - readily comparable across positions, banks
  - conditional distribution of bank's portfolio = risk measure
  - enables measuring the risk exposure in derivatives
- application to large US banks
  - interest rate derivatives often do not hedge other bank business
  - similar exposures to aggregate risk

Related literature

- Bank regulation (Basel II):
  - separately considers credit & market risk
  - credit risk: compute default probabilities using credit ratings or internal statistical models
  - capital requirements for different positions
  - look at positions one by one
- Measures of exposure
  - regress stock returns on risk factor, e.g. interest rates Flannery-James 84, Venkatachalam 96, Hirtle 97,...
  - stress tests: Brunnermeier-Gorton-Krishnamurthy 12, Duffie 12
- Measures of institutional risk
  - measures of tail risk, VaR: Acharya-Pederson-Philippon-Richardson 10, Kelly-Lustig-van Nieuwerburgh 11
- Bank position data
  - derivatives: Gorton-Rosen 95, Stulz et al. 08, Hirtle 08
  - crisis: Adrian & Shin 08, Shin 11, He & Krishnamurthy 11

Outline

1. Bond values described by statistical model with few shocks
2. Bond/debt positions = simple portfolios in a few bonds
3. From regulatory data to simple portfolios: loans, securities, deposits
4. Swaps – definitions and data
5. From regulatory data to simple portfolios: swaps

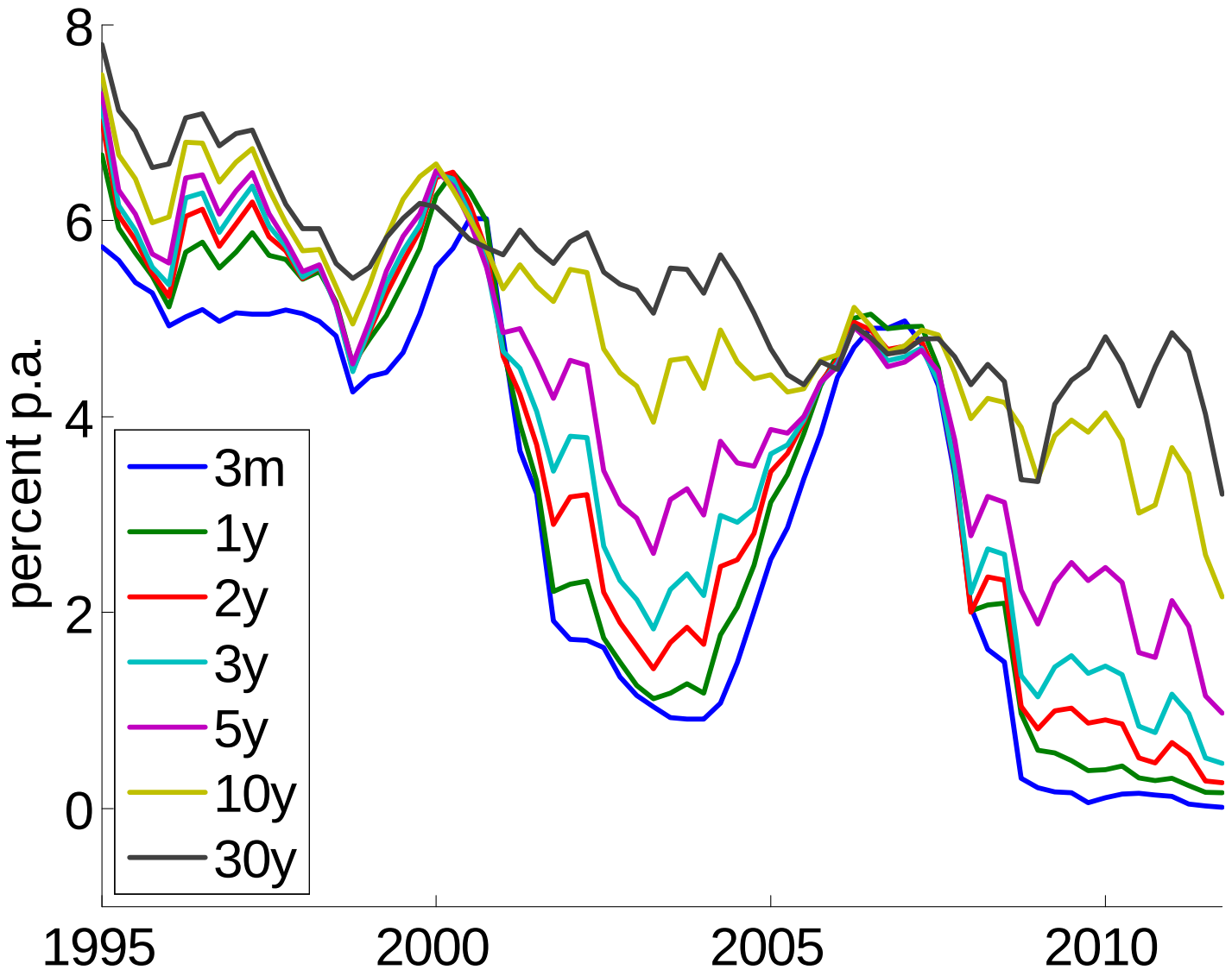
1. Bond values described by stat. model with few shocks

- low dimensional factor models for cross section of bonds

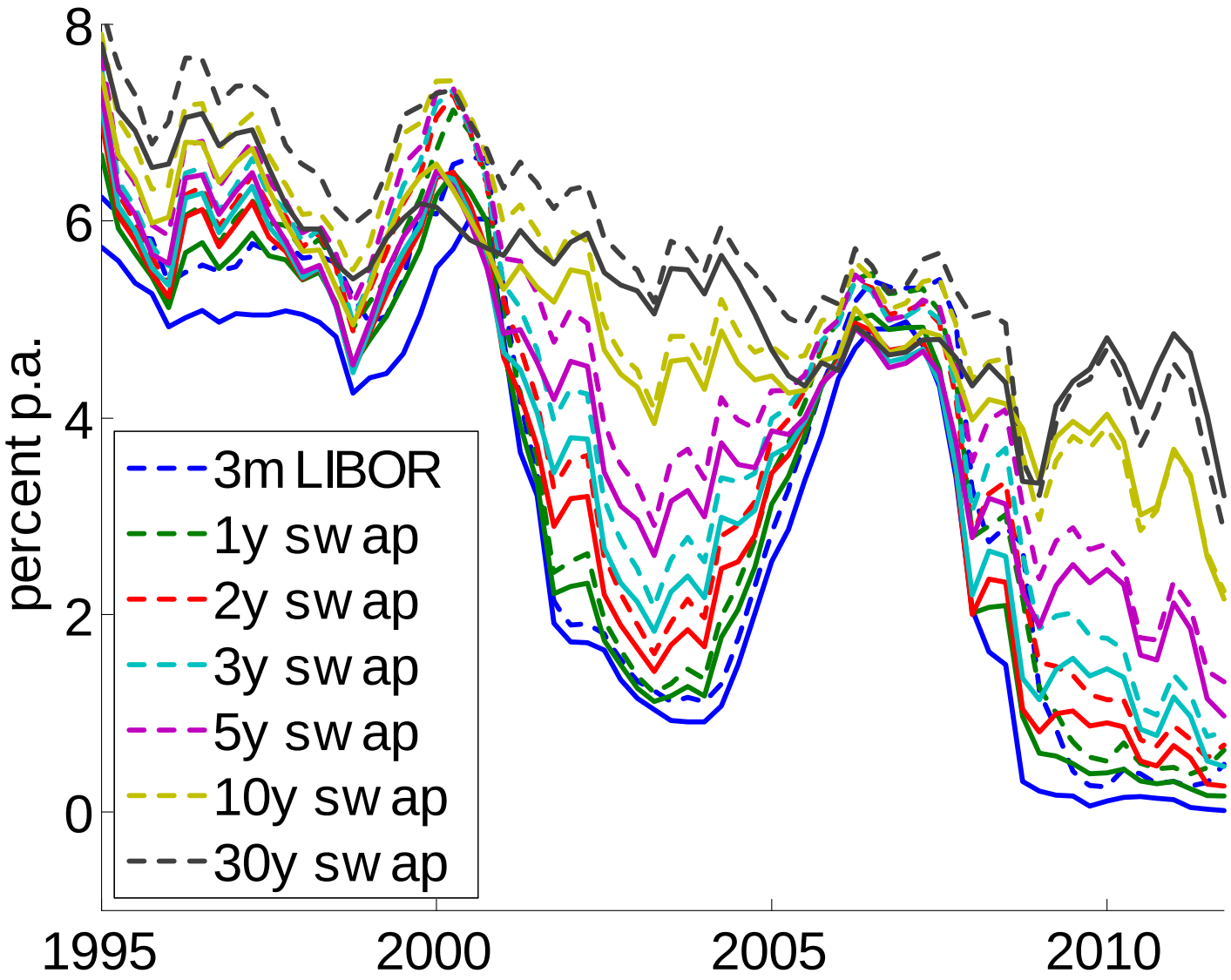
$$\begin{aligned} \text{bond value} \quad & = p\left(f_t, t\right) \\ \text{factors} \quad & f_t = \phi f_{t-1} + \sigma\left(f_t\right)\varepsilon_t \quad \varepsilon_t \sim N\left(0, I_{\#\text{ factors}}\right) \quad \text{innovations} \end{aligned}$$

- bond pricing models
  - w/o credit risk: interest rate is function of factors
  - with credit risk: default prob, loss in default are functions of factors
- here: quarterly model with one factor
  - estimated on cross section of Treasury, LIBOR & swap rates
  - fitting errors low ($<$25 bp) for maturities up to 15 years

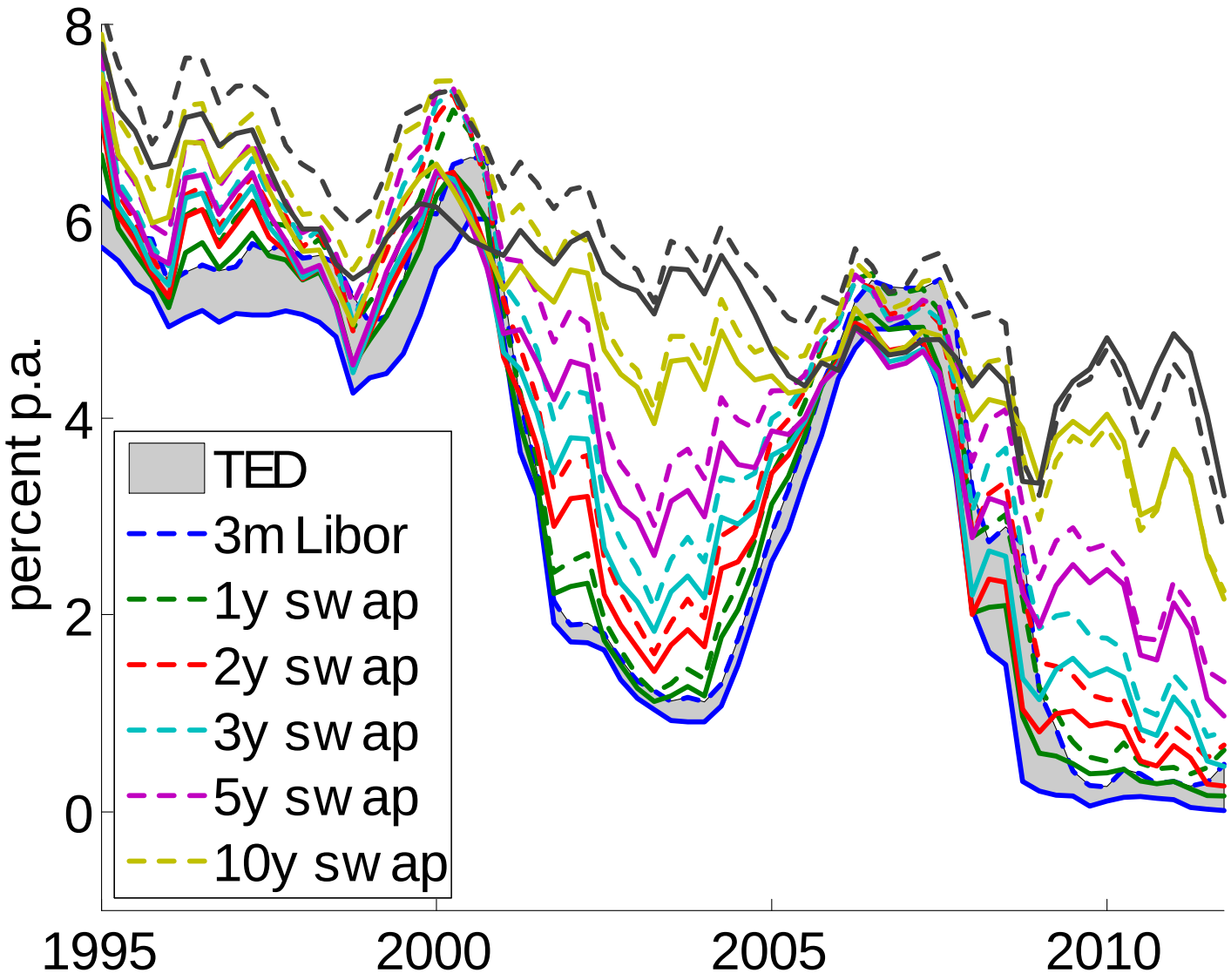
Riskless (solid) zero coupon bond yields



Riskless (solid) & risky (dotted) zero coupon bond yields



Riskless (solid) & risky (dotted) zero coupon bond yields



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2. Bond/debt positions = simple portfolios in a few bonds

- Change in bond value $p_t = p(f_t, t)$ [by Ito's formula]

$$p_{t+1} - p_t \approx p_t \left(\underbrace{\mu_t}_{\text{expected return}} + \underbrace{\sigma_t}_{\text{volatility}} \varepsilon_{t+1} \right)$$

- cash

$$\mu_t = i_t, \quad \sigma_t = 0$$

- represent other bond $\widetilde{p}_t = \widetilde{p}(f_t, t)$ as simple portfolio

$$\widetilde{p}_t \left(\widetilde{\mu}_t + \widetilde{\sigma}_t \varepsilon_{t+1} \right) = \omega_t \; p_t \; \left(\mu_t + \sigma_t \varepsilon_{t+1} \right) + \text{cash}_t \; i_t$$

- say, p is value of 5-year riskless bond
- simple portfolios are holdings ω_t of 5-year riskless bonds & cash
- portfolio weight on 5-year bond increasing in maturity, risk of $\widetilde{p}$

  2 year Treasury: 40% 5-year bond, 60% cash

  10 year Treasury: 150% 5-year bond, −50% cash

  10 year risky bond: 160% 5-year bond, −60% cash

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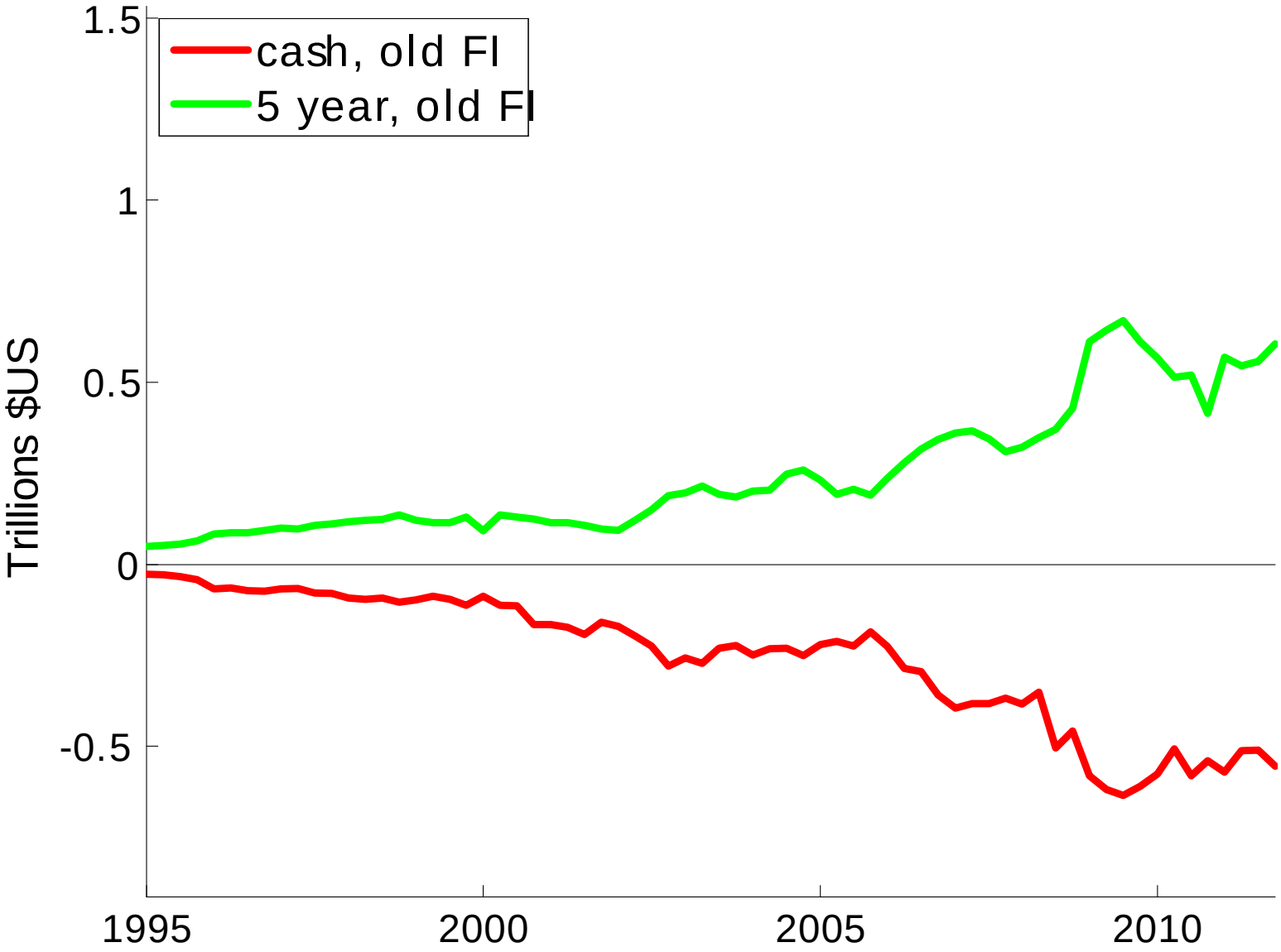
3. From regulatory data to simple portfolios: loans ...

- Quarterly Call report data on bank balance sheets
  - loans: book value, maturity, credit quality
  - securities: fair values, maturity, credit quality
  - cash, deposits & fed funds
- Represent as simple portfolios in 5-year bond & cash

JP Morgan Chase: simple portfolio holdings



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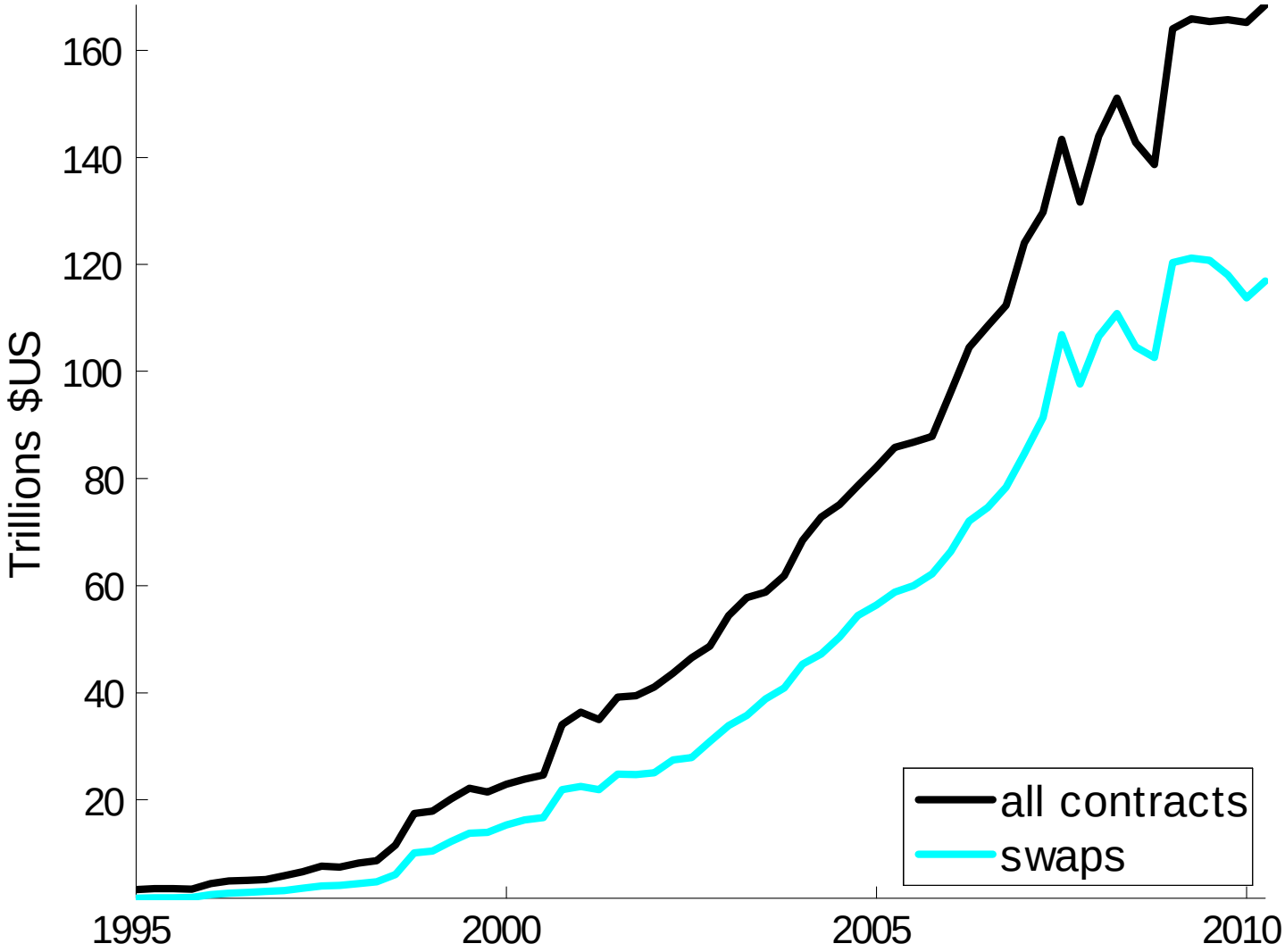
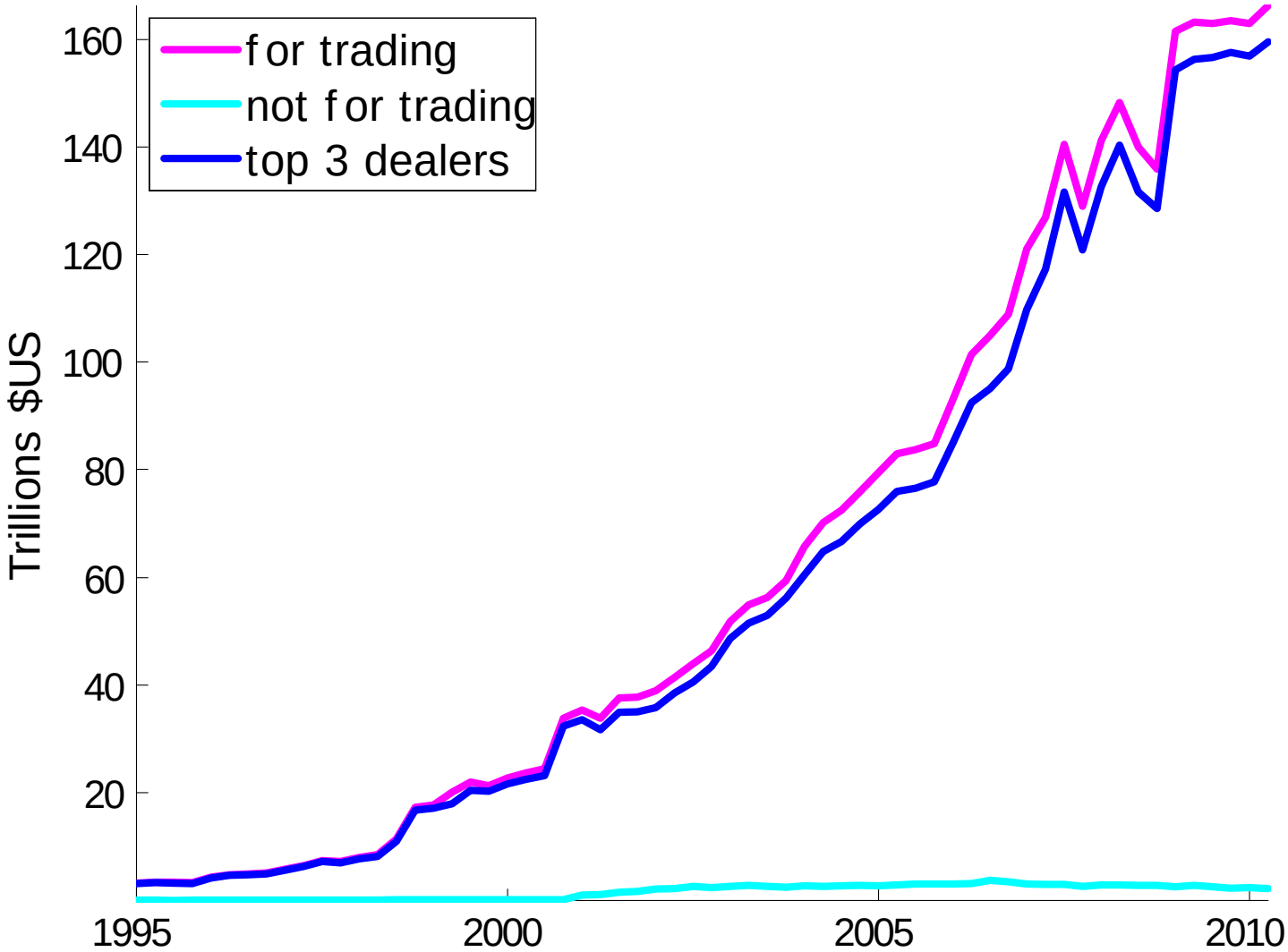
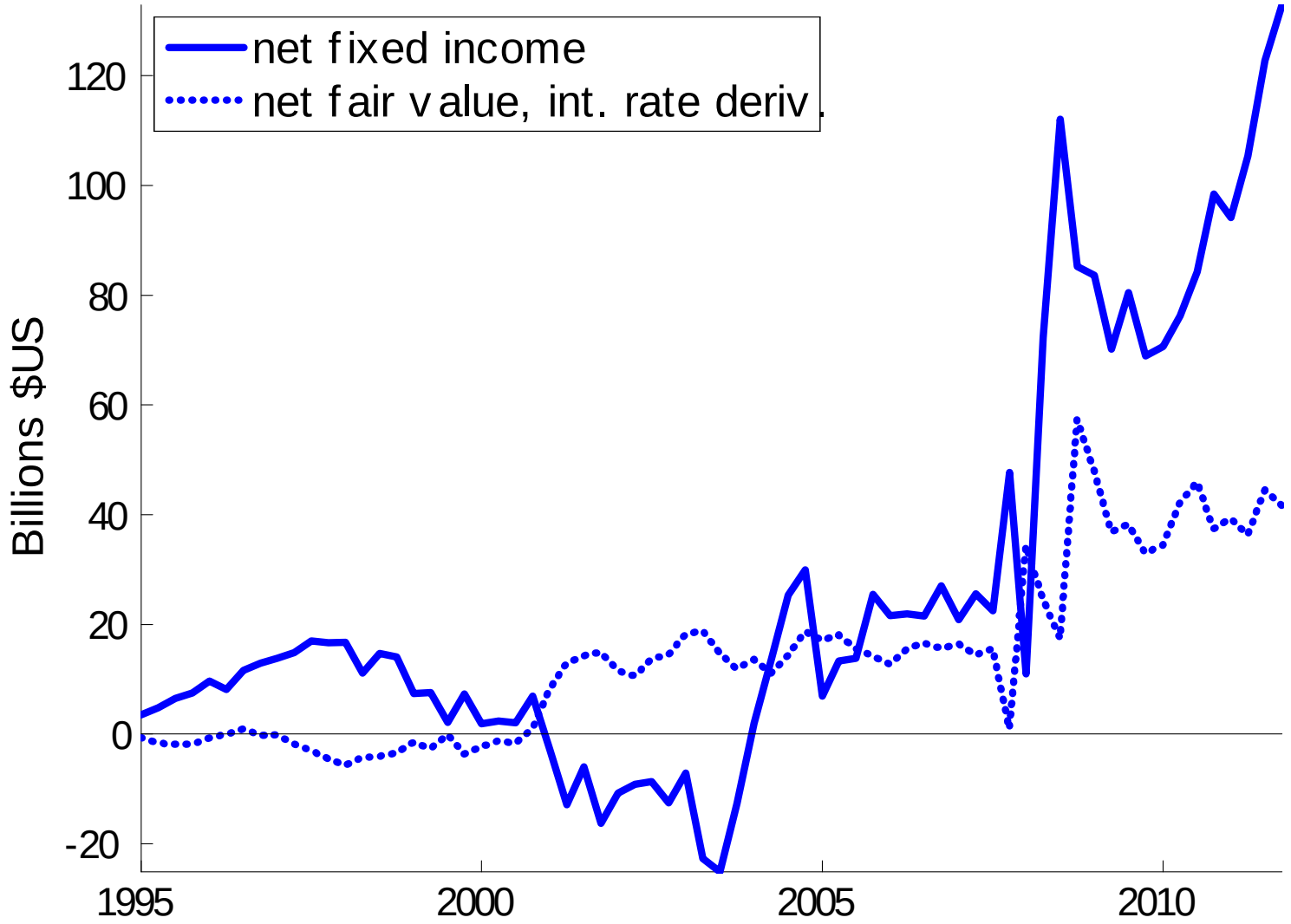
Notionals of Interest Rate Derivatives of US Banks



Concentrated Holdings of Interest Rate Derivatives

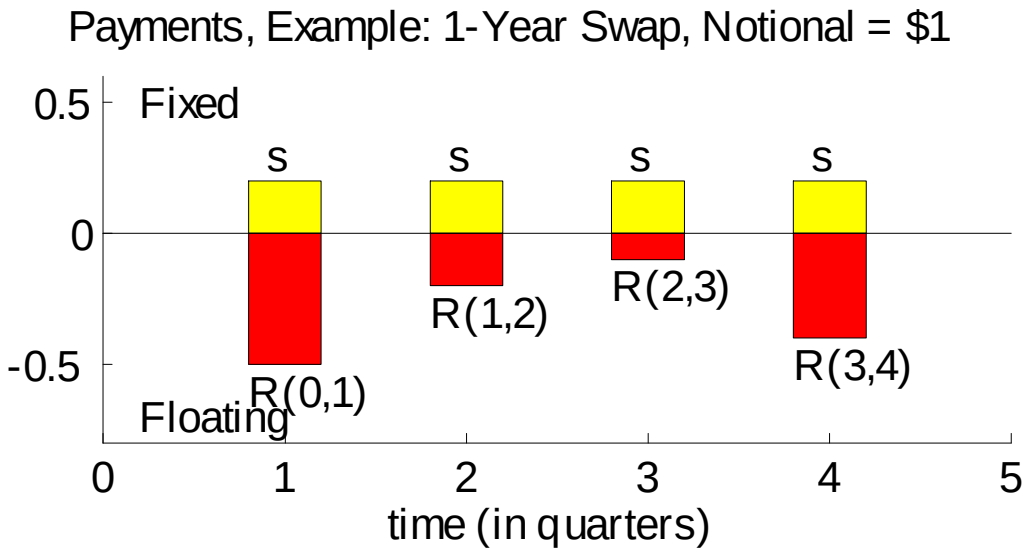


Net fair values of derivatives



4. Swaps – definitions and data

- most derivatives are swaps – bets on direction of rates



- pay-fixed swap vs. pay-floating swap — what holder does
- value of pay-fixed swap goes up when rates go up, standard valuation formulas
- zero-sum: value of pay-fixed swap $=-$ value of pay-floating swap

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- Call Report data on interest rate swaps
  - notionals
  - fair values
- Call Reports do not contain

  sign: pay-fixed or pay-floating swap?

  what fixed-rate was locked in?

  maturity of swaps
- approach: *estimate* positions in the simple portfolio for swaps
  - consists of cash & 5-year pay-fixed swap with some locked-in rate

Estimation of net swap position

- $\{\omega_t\}$ = *net* position in 5-year pay-fixed swaps, rel. to gross notionals
  - ω_t negative if pay-floating swap
  - $|\omega_t|$ small if lots of netting in gross notionals
- infer sequence $\{\omega_t\}$ from

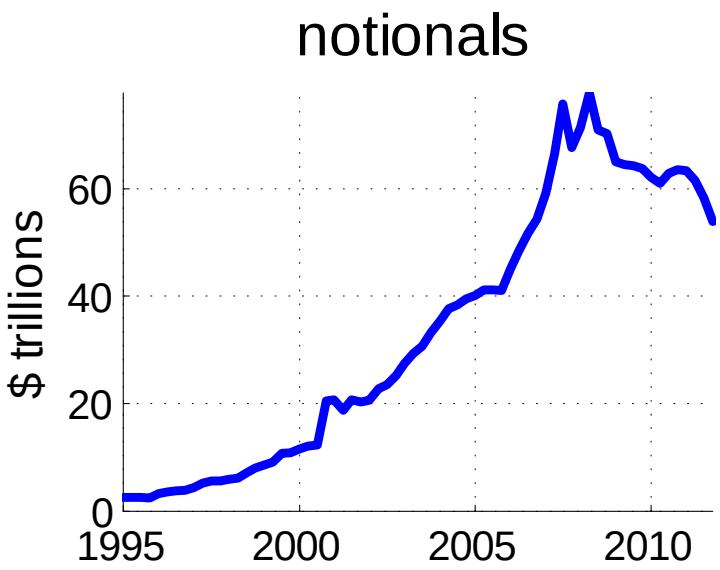
$$\frac{\text{net value}_t}{\text{notionals}_t} = \omega_t \text{ (value of 5 yr swap)} + \text{cash}_t + u_t$$

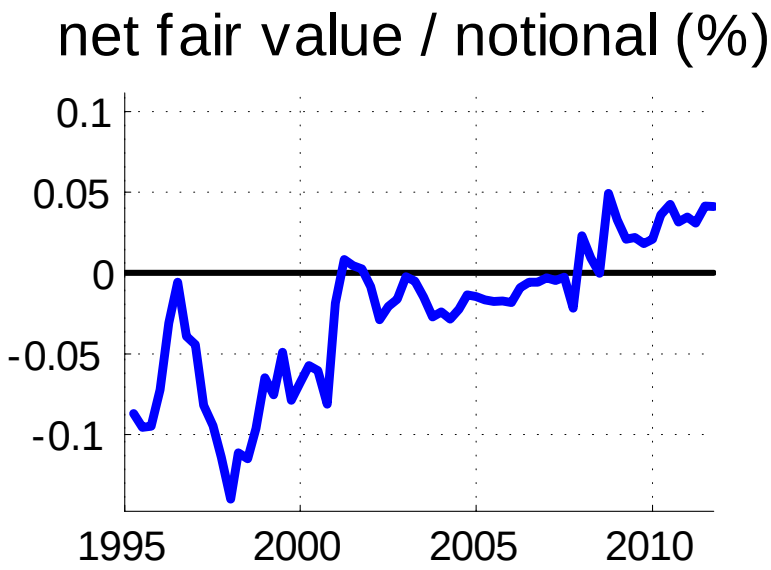
$$\text{value of 5 yr swap} = f(\text{current rates, locked in swap rate})$$

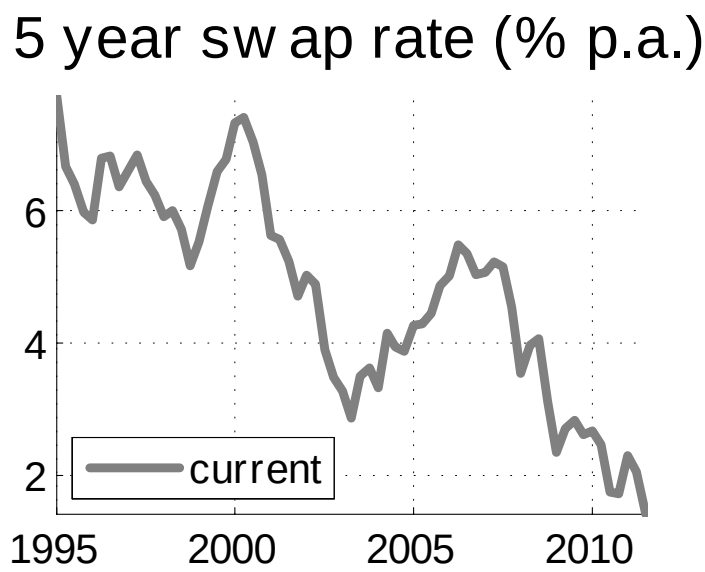
transition equation: updates cash & locked-in swap rate given ω_t

- Bayesian estimation using MCMC

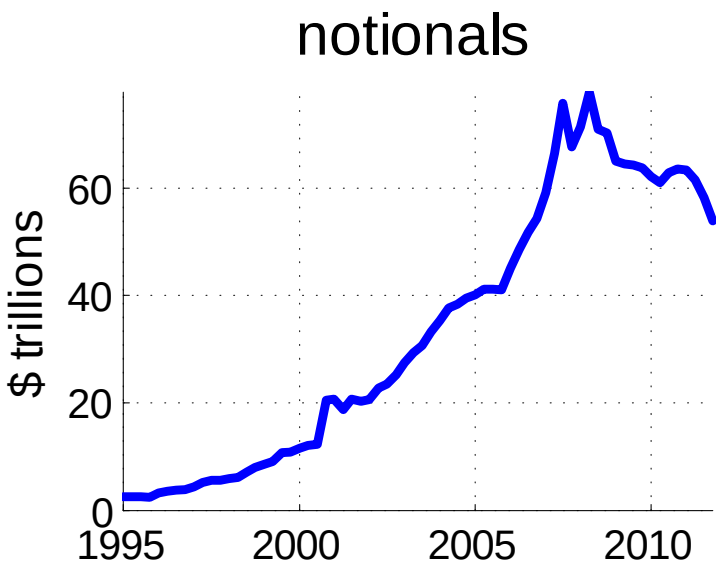
JP Morgan Chase: swap position

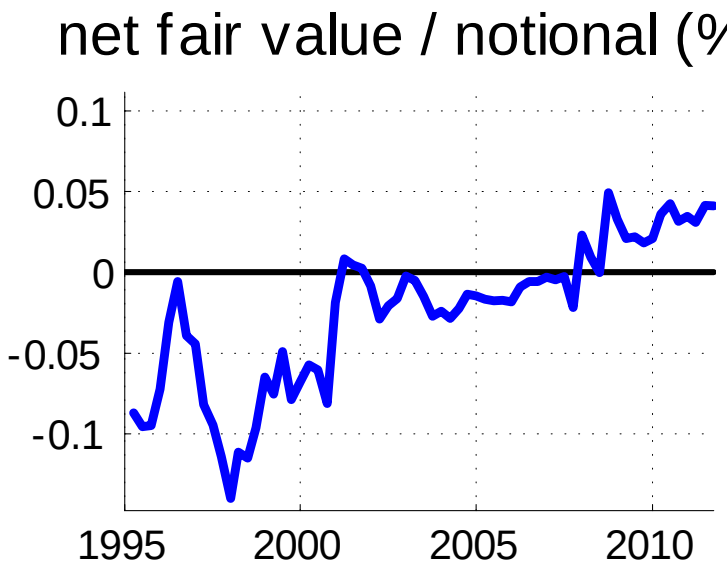


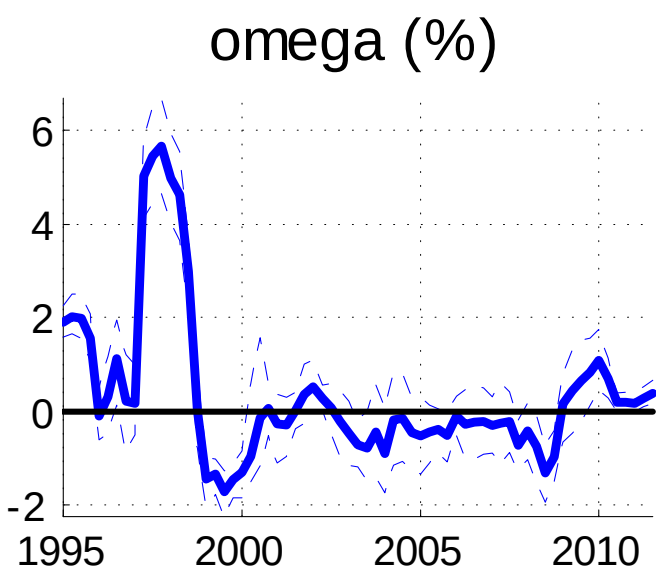


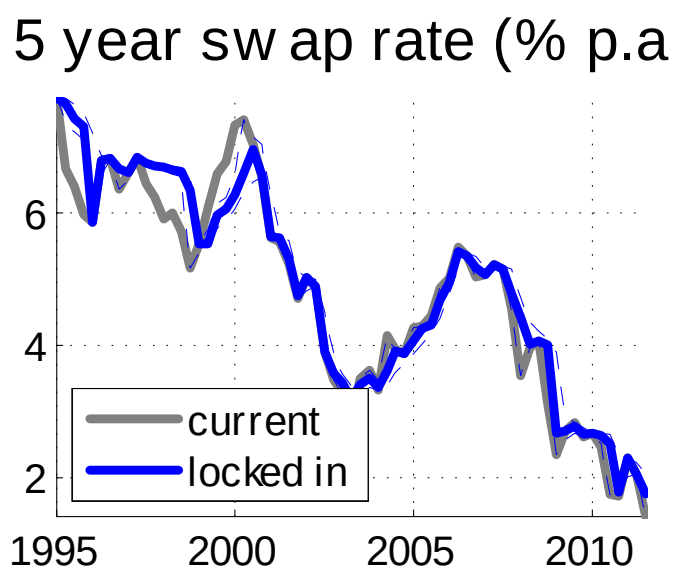


JP Morgan Chase: swap position

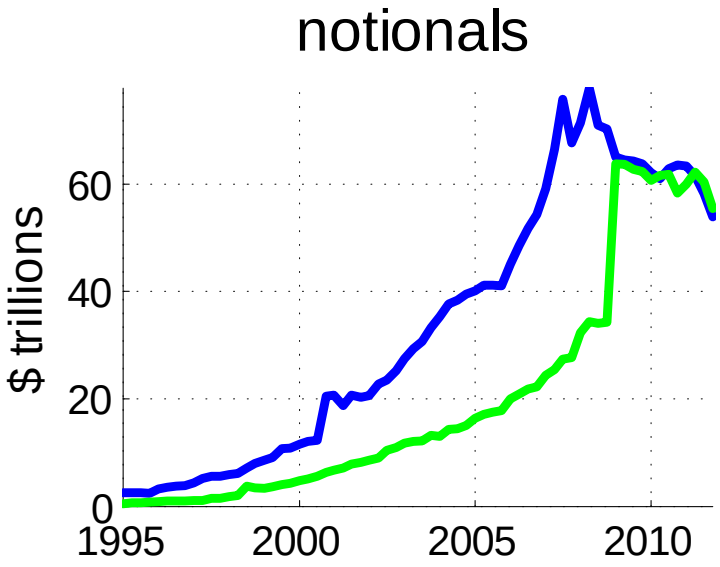


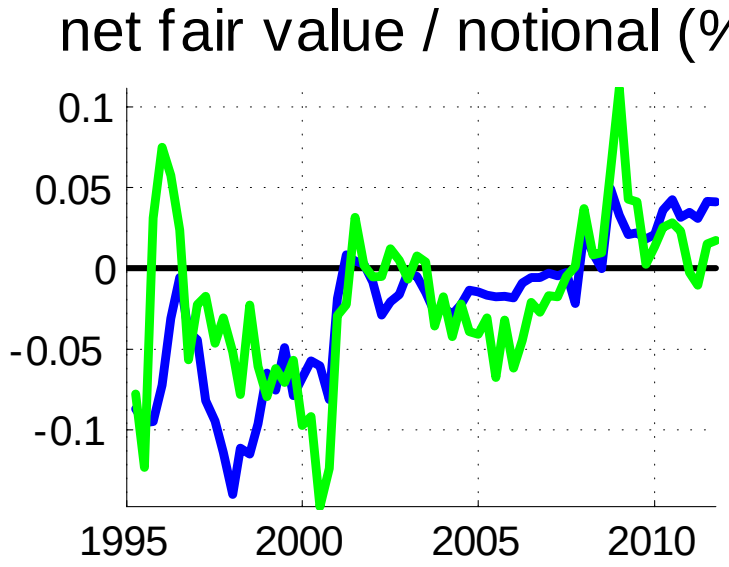


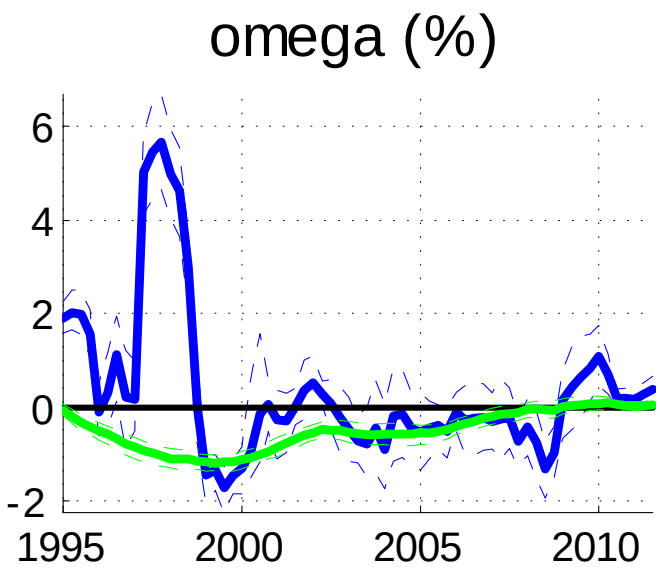


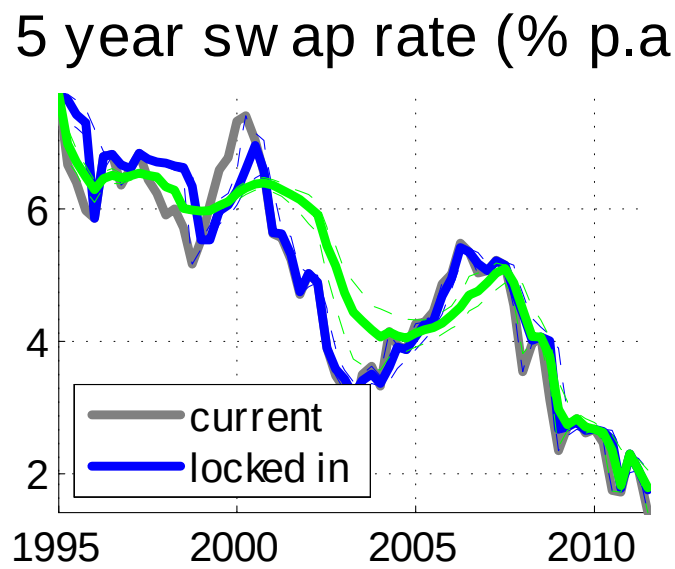


JPMorgan Chase (blue) & BofA (green): swap positions

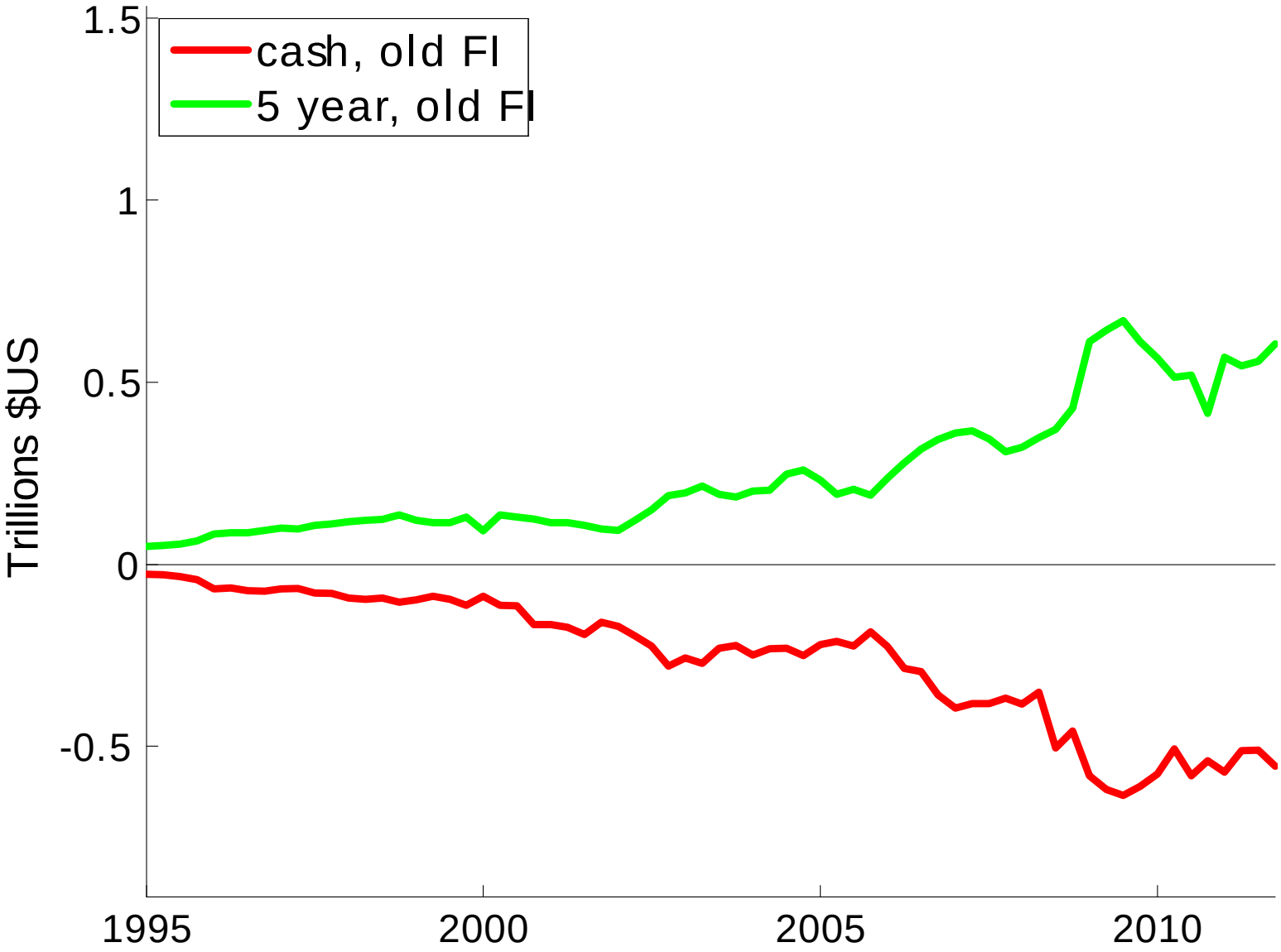








JP Morgan Chase: replicating portfolios



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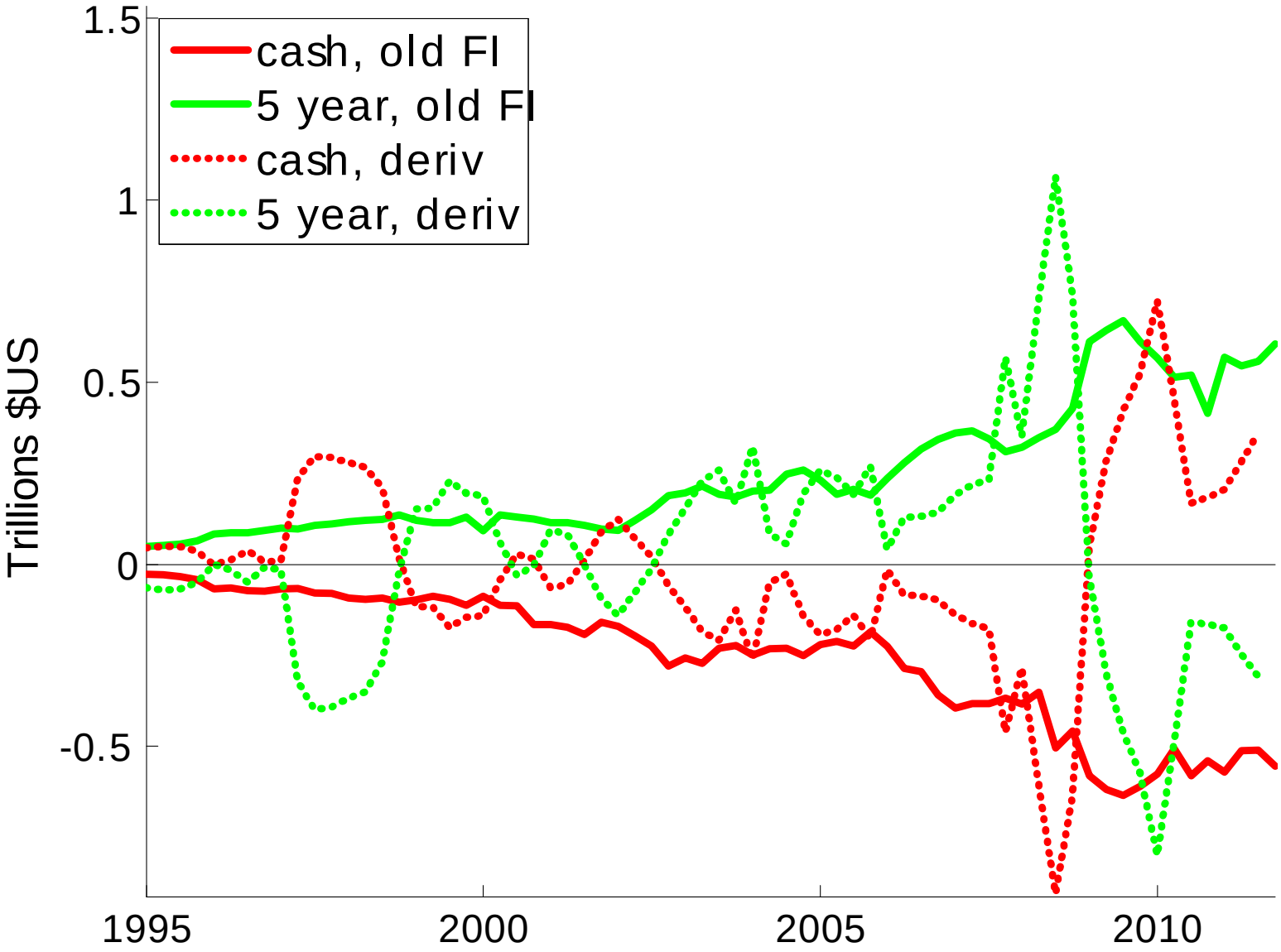
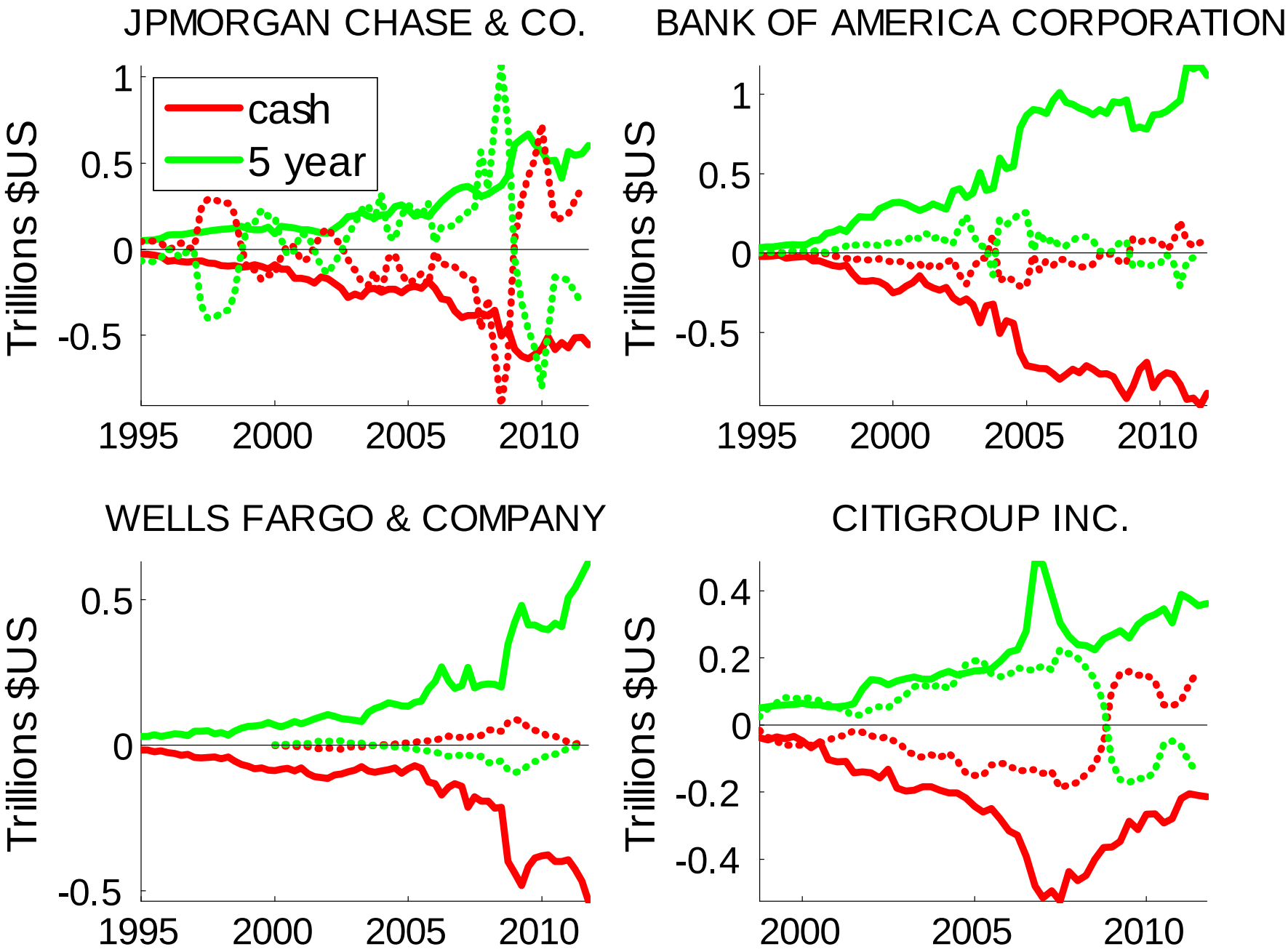
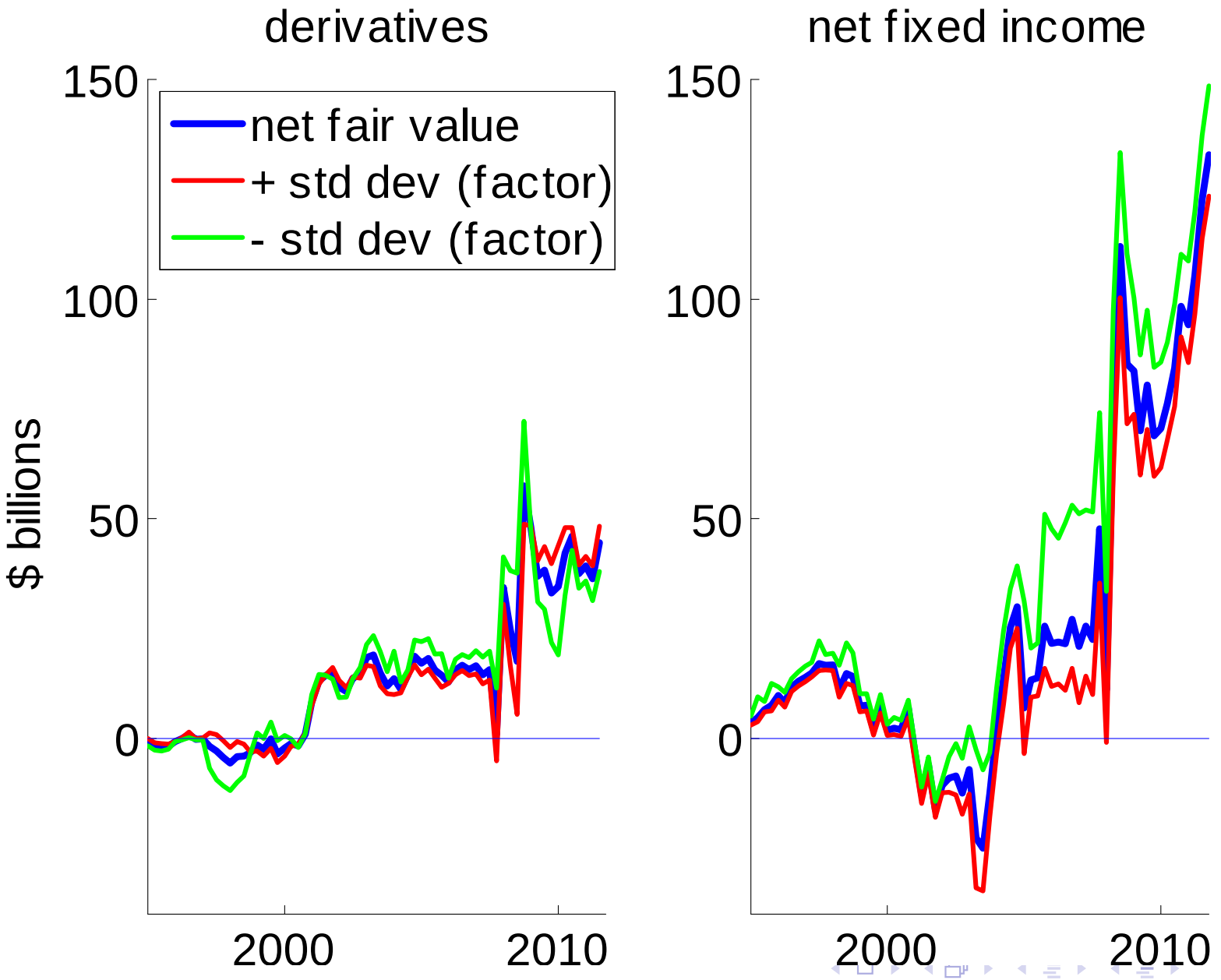



JPMORGAN CHASE & CO.
BANK OF AMERICA CORPORATION
WELLS FARGO & COMPANY
CITIGROUP INC.
cash
5 year
Trillions $US
1
0.5
0
-0.5
0.4
0.2
-0.2
-0.4
1995
2000
2005
2010

JP Morgan Chase, one quarter ahead exposures



Summary

- Methodology to measure exposures in bank positions
- Results for top dealer banks
  Derivatives often increase exposure to interest rate risk,
  some hedging after the crisis
- Possible models for banks:
  risk averse agents that use derivatives to insure (no!)
  agents who double up with derivatives
  agents who provide insurance to others
- Need models with heterogeneous agents,
  position data will inform these models