Tails that Wag the Dog:
The Financial Consequences of Extreme Events

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The Risk Capital Vicious Cycle

- Leveraged Financial Intermediaries (LFIs)
    - Banks
    - Non-bank financial intermediaries (former I-banks, some insurers)
    - Hedge Funds
    - Insurance and reinsurance companies

- Two key linkages

- Negative shocks to prices and/or capital levels

- =>Decline in the supply of risk capital
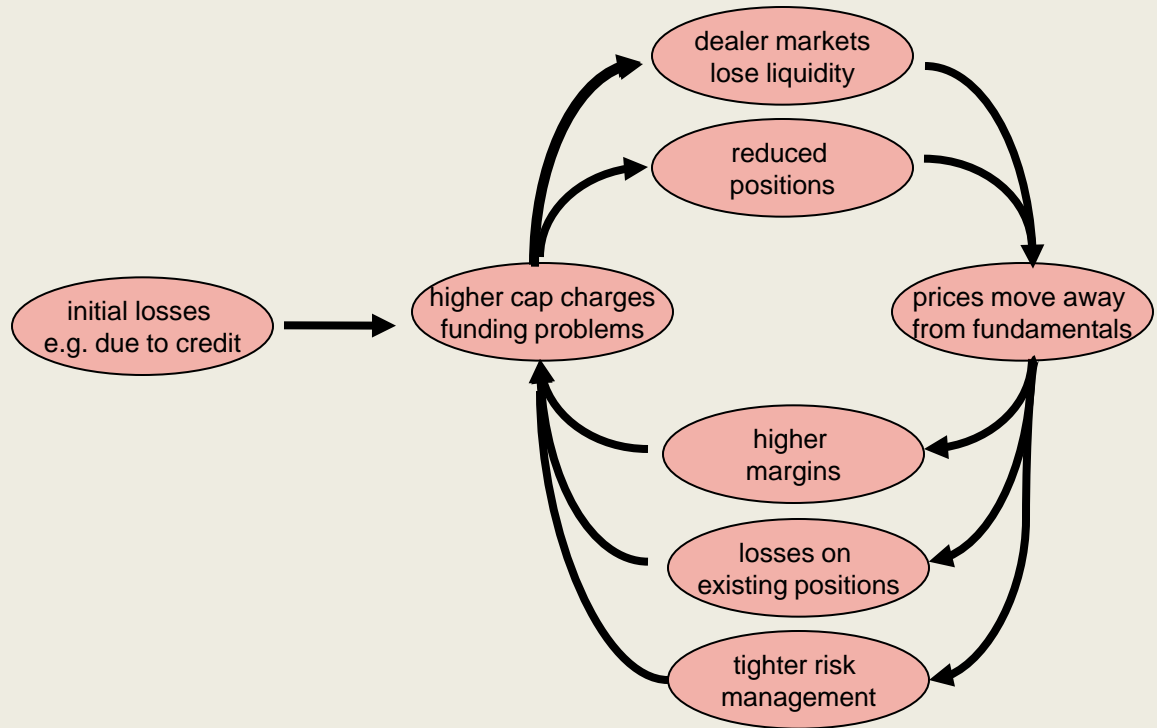
- =>Decline in economic activity

The First Linkage:
Shocks to LFI risk capital reduce LFIs' willingness to supply it

•Risk capital is
   •supplied by LFIs: banks and non-bank intermediaries

•Shocks come from several sources (a al Brunnermeier and Pedersen, 2008):
   •Changes in LFI capital
   •Changes in risk levels
   •Changes in assets' trading liquidity

Acharya, Pedersen, Philippon and Richardson (2009)

The Second Linkage:
Distortions in shadow returns affect underlying economic activity

- Declining prices and stressed intermediaries at the center of markets lead to fear, bank runs, market runs , and now even, consumption runs
- Demand for "liquidity" – meaning safe and available purchasing power is overwhelming
- Fundamentals become endogneous to lower asset prices and the state of markets

First linkage

wealth losses

market breakage liquidity down

runs on markets and Institutions

counterparty concerns

fundamentals adjust to prices

precautionary savings higher

risk aversion up flight to safety

reduced aggregate supply

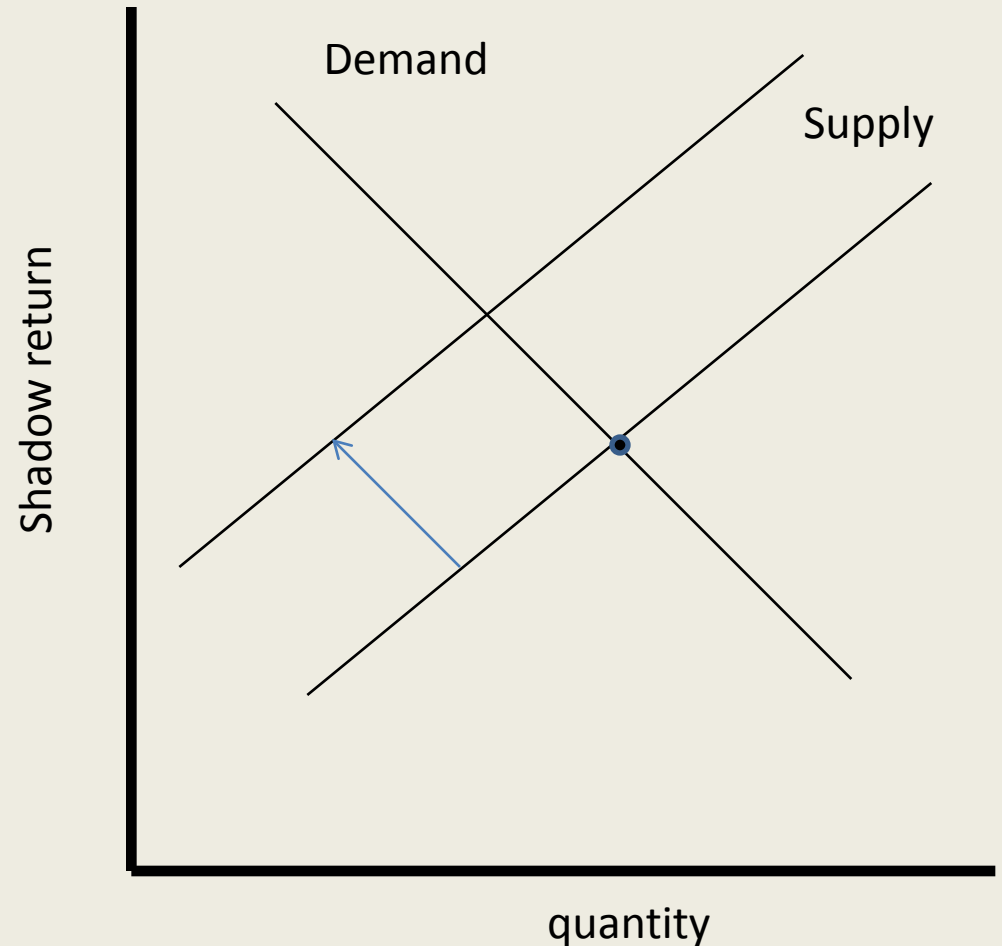reduced aggregate demand

The First Linkage:
Shocks to LFI risk capital reduce LFIs' willingness to supply it

- Risk capital is
  - supplied by LFIs: banks and non-bank intermediaries
  - demanded by end users: less levered investors, home buyers, customers, etc.

- Shadow return is the yield required to bear risk of illiquid assets

- Constriction of supply and deleveraging with lower prices magnifies the shock

Demand

Supply

Shadow return

quantity

The First Linkage:
Shocks to LFI risk capital reduce LFIs' willingness to supply it

- Risk capital is
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- Shadow return is the yield required to bear risk of illiquid assets

- Constriction of supply and deleveraging with lower prices magnifies the shock

- Some interpret as evidence that the supply curve becomes backward bending

- Increase in cost of risk capital together with decline in quantity available is decisive for a net supply shock
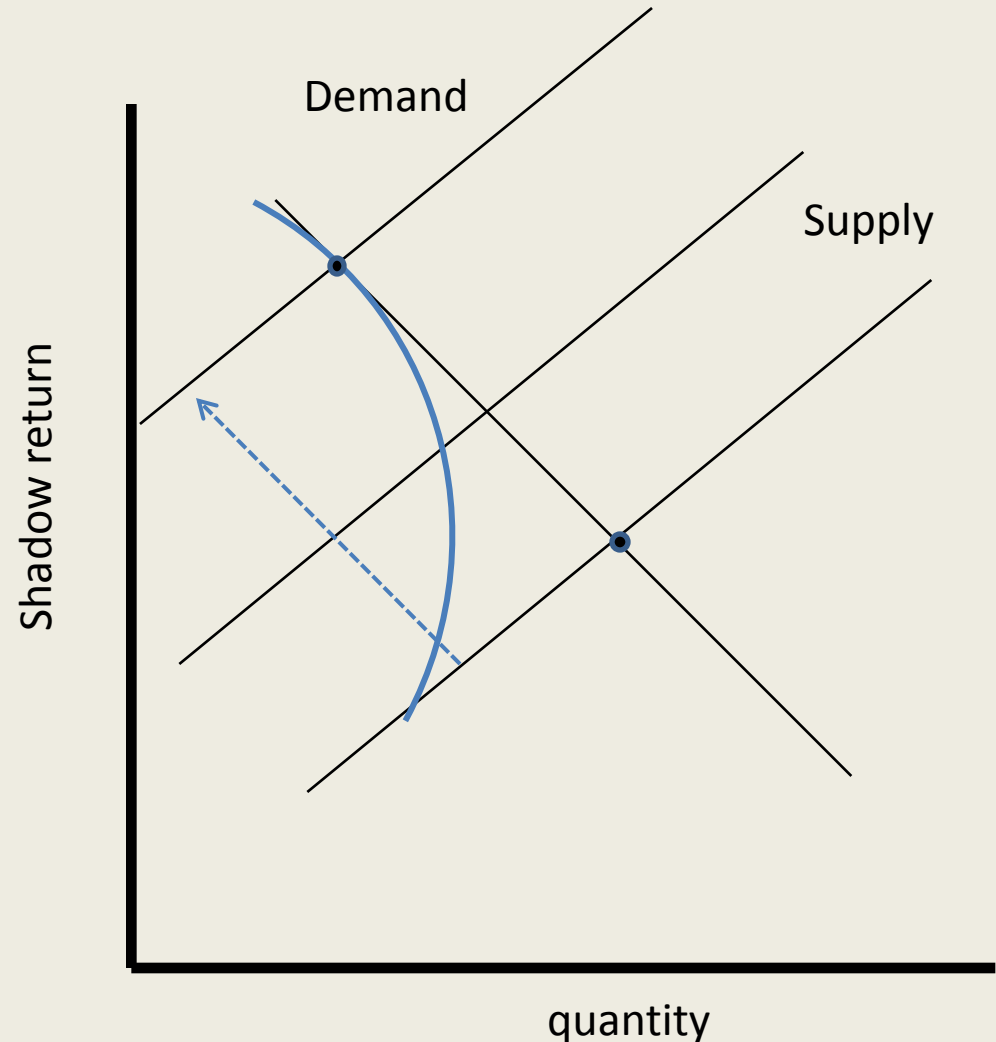
Risk concentrated in LFIs is problematic

- A simple example: market for catastrophe risk associated with natural perils
    - Millions of households and corporates face risks of property destruction through natural perils
    - Transfer risk to property/casualty insurers in bundled products like homeowners insurance or property insurance
    - Insurers collect concentrated risks of natural perils and seek to transfer these to reinsurers through dedictated peril indemnity contracts
- Simple because there is no second linkage:
    - Cat events (e.g., hurricane, earthquake) are exogenous and random so that they are not the result of underlying economic shocks
    - Actuarial probabilities can be estimated objectively using models of physical phenomena which don't depend on human behavior
    - No systematic market or other pervasive financial exposure so that excessive costs of risk capital can be measured

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Catastrophe reinsurance shocks

•Observation: A negative shock to intermediary risk capacity, results in an increase in the cost of reinsurance AND a decline in the quantity of reinsurance consumed.

•Over time, capital flows in to arbitrage opportunities
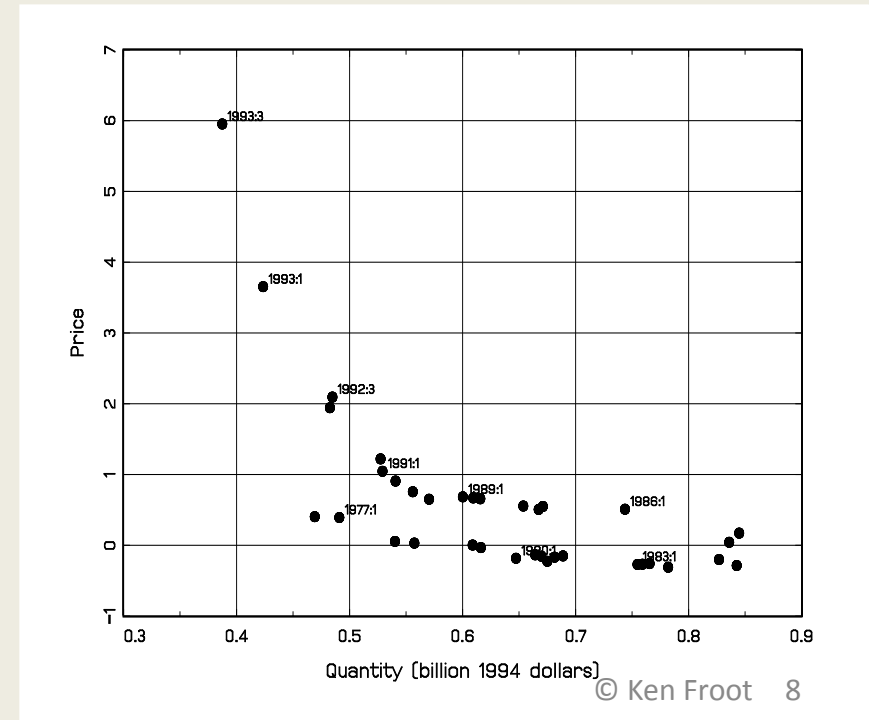
U.S. Cat Property Rate On Line
(Premiums for a call spread for a given limit and retention)
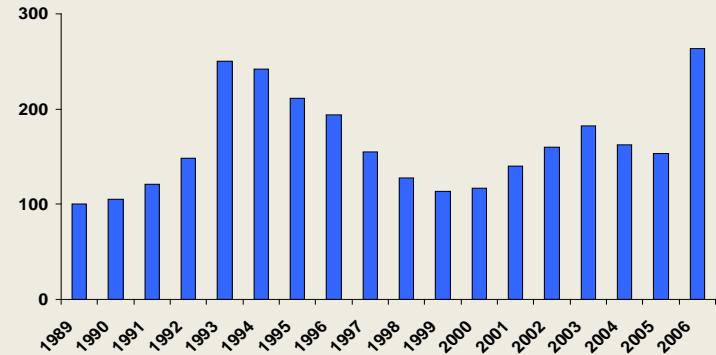
U.S. Cat Property Price of Reinsurance Relative to Actuarial Value
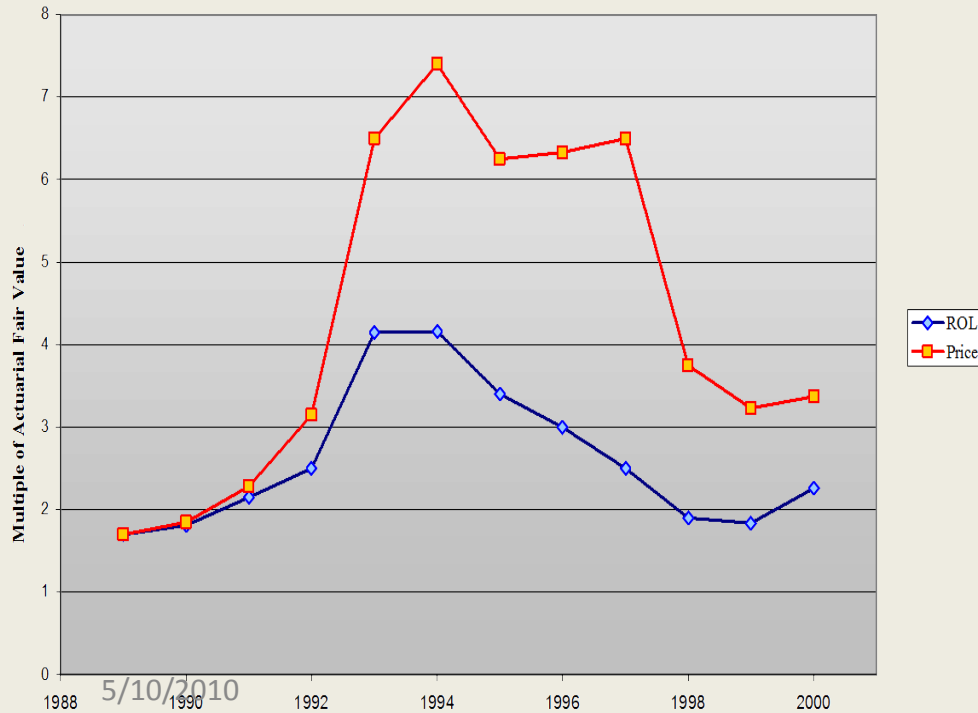
U.S. Cat Property Price and Quantity transacted

5/10/2010

Impact of KRW on Rate on Line

Region	Strike	Expected Loss	2005	2006
US hurricane	$50B	2.5%	1.4x	6x*
US hurricane	$30B	4.9%	1x	5.1x
US hurricane	$20B	8.1%	1.4x*	4x
US earthquake	$15B	4.3%	1.7x	3.5x
US earthquake	$20B	3.2%	1.8x	3.6x
US 2nd event	$10B	5.2%	1.4x	4.8x
US 2nd event	$20B	1.2%	n/a	10.4x

Pricing shown as a spread to risk-free (typically 3m UST)

Expected losses shown as market standard model output (not NCL estimates)

Lessons from Natural Catastrophes

- Concentrated intermediary exposures imply a greater likelihood of large shocks to intermediary capital

- Shocks to intermediary capital are not rapidly replenished and therefore lead to higher shadow costs of capital and reduced quantity of intermediation

- Tempting to tell demand driven story following events, but not borne out by the facts.

- No endogneity – event occurrence does not change the distribution of outcomes.

Back to THIS crisis: Risk sharing has been disappointing Concentrations large compared to LFI capital & assets

	Loans	HELOC	Agency MBS	Non-Agency AAA	CDO subord	Non CDO subord	Total	
Banks & Thrifts	2,020	869	852	383	90		4,212	39%
GSEs & FHLB	444		741	308			1,493	14%
Brokers/dealers			49	100	130	24	303	3%
Financial Guarantors		62			100		162	2%
Insurance Companies			856	125	65	24	1,070	10%
Overseas			689	413	45	24	1,172	11%
Other	461	185	1,175	307	46	49	2,268	21%
Total	2,925	1,116	4,362	1,636	476	121	10,680	
	27%	10%	41%	15%	4%	1%		

Source: Lehman Brothers (April 2008), Krishnamurthy (2008).

Type of Institution	% Buyer of AAA ABS
Banks	30
Conduits	12
SIVs	8
Hedge funds	2
MM funds	26
Credit funds	17
Others	5

Source: Financial Times, 1 July 2008

As of 2007, about 30% of outstanding private nonfinancial debt was held by depository institutions.
Source: Morgan Stanley

The first linkage

- Most important and our focus
  - Second linkage is better accepted
  - Can erupt spontaneously causing declines in economic activity
- Amplified by concentrated risk and leverage (as in the reinsurance example).
- Amplified crucially in this case by the decline of a public good: liquidity
  - To delever, LFIs needed to sell the assets into those markets where they served as market makers and conduits for financing
  - Results:
    - Collapse of liquidity in these markets, some catastrophic
    - Greater price elasticity of asset sales
    - Even lower prices relative to fundamentals and even greater needs to sell
      - » Direct effect of even higher price of risk capital and lower capacity
      - » Indirect effects of fear, runs on banks, certain markets, and consumption
    - Greater illiquidity and impeded price discovery
- This mechanism breaks what otherwise seems a clean separation between systemic risks (macro) and market functioning (micro)

LFI balance sheet

- Assume imperfectly liquid assets financed by debt (90%) and equity (%10)
- Leverage is 10:1
- Market for the assets is "made" by LFIs, who use risk capital both to fund client positions and make markets themselves

Securities	67		Debt	90
Market making activities	33		Equity	10
Total Assets	100		Total Capital 100	

Shock to security values

- Shock reduces security values to 98
- Equity worth 8
- What do you do if you want leverage to stay at 10:1?

Securities	67	65		Debt	90	
Market making activities	33	33		Equity	10	8
Total Assets	98			Total Capital	98	

Reduce assets to free up capital

(or issue equity at lower prices)

- Reduce assets proportionately and pay down debt by 18
- Back to leverage of 10:1
- Capital committed to market making falls by 18%
- Securities become more illiquid
- Securities quantities (given price) reduced by 12/65 = 18%

Securities	67	65	53	Debt	90	72
Market making activities	33	33	27	Equity	10	8

Total Assets	80	Total Capital 80

But its worse than that:
Security sales take place with less capital committed to market making

- Securities quantities (given price) reduced by 12/65 = 18%
- Greater illiquidity and asset sales reduces prices by (say) 5%,
- Price elasticity is 5/18
- And the vicious cycle begins, with equity down, etc. necessitating further securities sales, BUT at EVEN HIGHER price elasticities

Securities	67	65	53	50	Debt	90	72
Market making activities	33	33	27		Equity	10	8	5

Additional round of deleveraging needed

Total Assets 77   Total Capital 77

But it's worse than that:
Security sales take place with less capital committed to market making

- A "Liquidity linkage" that connects microstructure with system-wide developments
  - Cutbacks in risk capital devoted to market making activities and a higher shadow price of funding for customers
  - Markets are degraded. Price discovery and liquidity are compromised. Collateral requirements need to increase by that much more so deleveraging is worse.
  - LFI's are more stressed

Illiquidity became a major issue in many markets made by LFIs

- Equities not among them
- Equity markets remain competitive and reasonably liquid
  - Customer to customer
  - Transparent pre and post trade
  - Relatively little intermediation or warehousing by dealers
  - values famously fall
  - Limit book declines
  - Spreads rise
- And yet
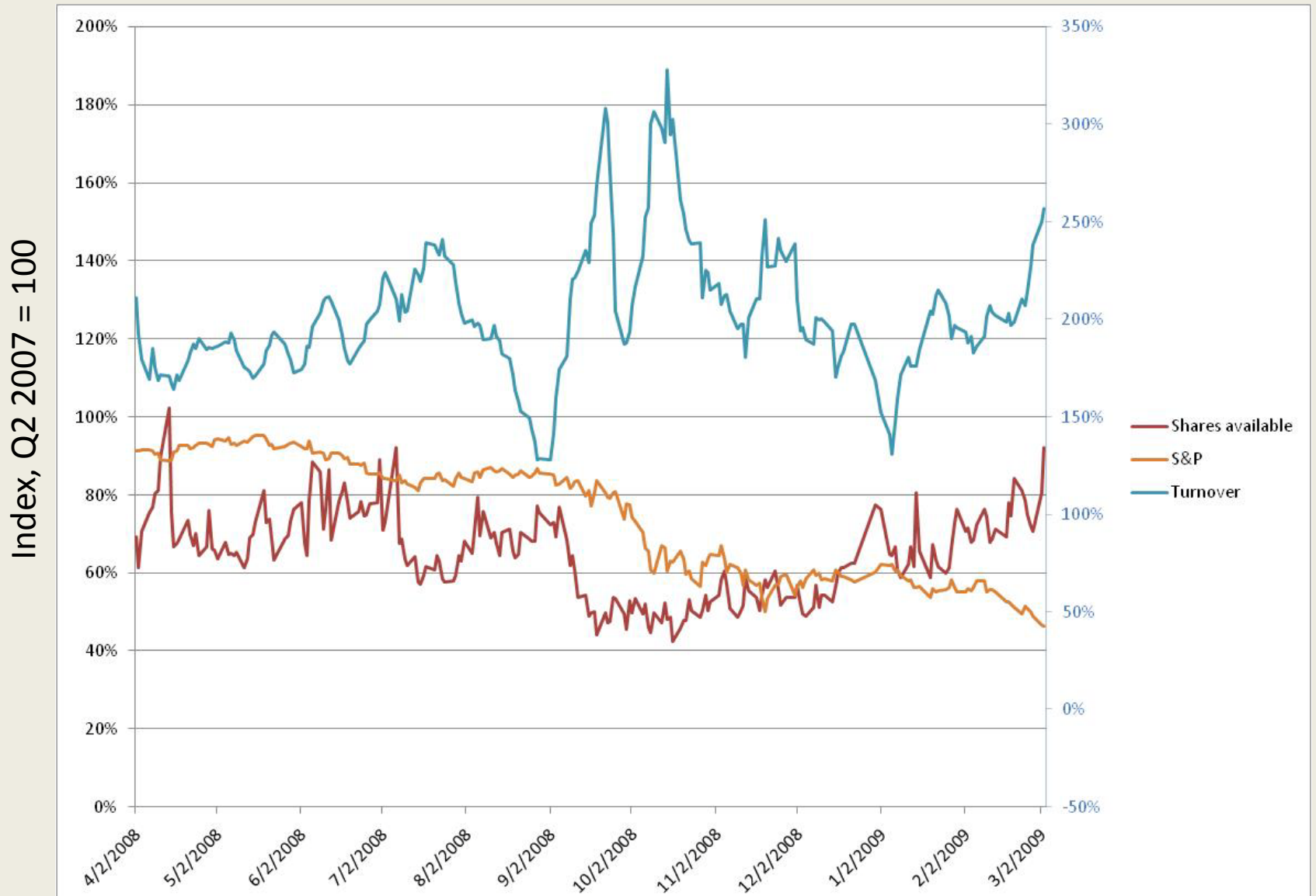 - Turnover and price discovery remain pretty well in tact

Liquidity of equity markets

(3500 large-cap companies traded on US markets)

Liquidity of equity markets

(3500 large-cap companies traded on US markets)

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Q: Has the liquidity premium in equities risen in the crisis?

- **Excess return of S&P inclusions**
    - Return from announcement to inclusion date (dated by inclusion date)
    - Averages for 1970s, 1980s, and 1990s: 1%, 3% and 6%, respectively, consistent with secular growth in indexing (Quinn and Wang, 2003)

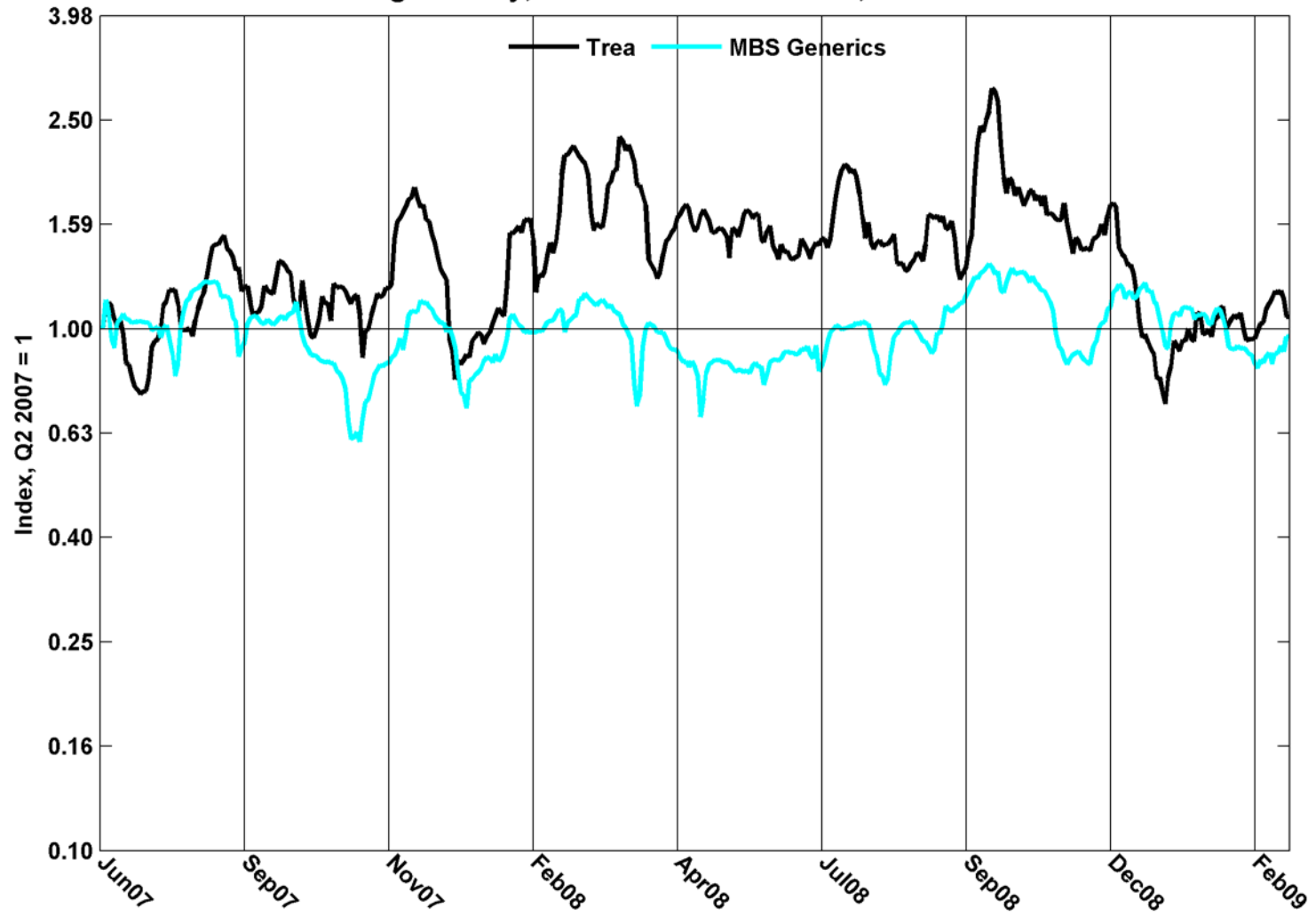|	# Observations	Avg.	Median
1H:2006	15	5.9%	4.7%
2H:2006	16	4.2%	4.0%
1H:2007	19	1.2%	1.3%
2H:2007	21	7.0%	5.2%
1H:2008	10	5.0%	5.0%
2H:2008	27	4.9%	3.5%
1H:2009	3	8.1%	9.8%

- **A: Not much**

Bonds, traded in dealer markets, behaved very differently

- Volumes have fallen, particularly in those submarkets where dealer inventory has been large

- Institutional investors have also moved from trading among themselves toward selling, as institutions buy/sell ratio has fallen
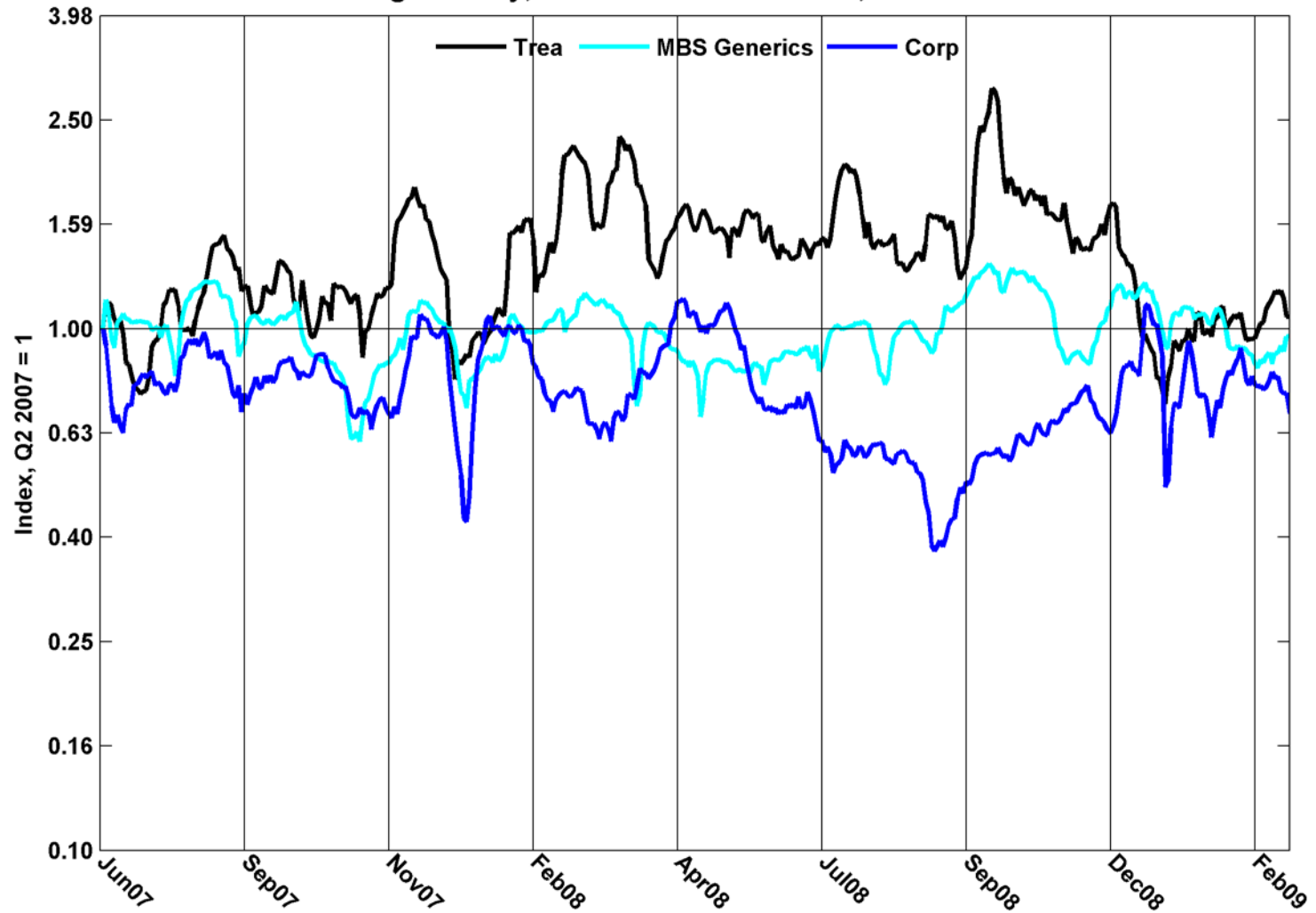
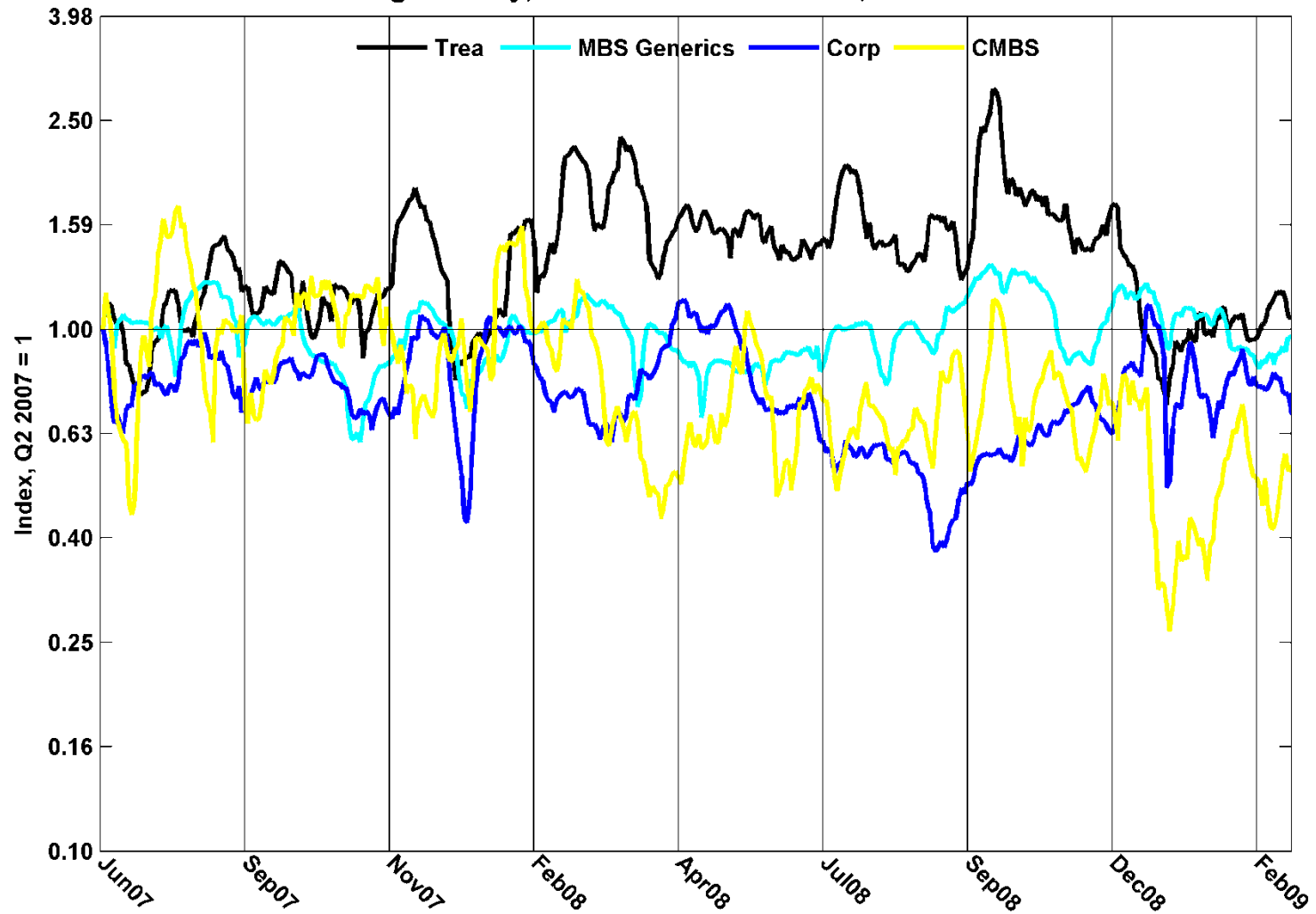Relative Trading Activity, Fixed Income Sectors, Volume at Market Value
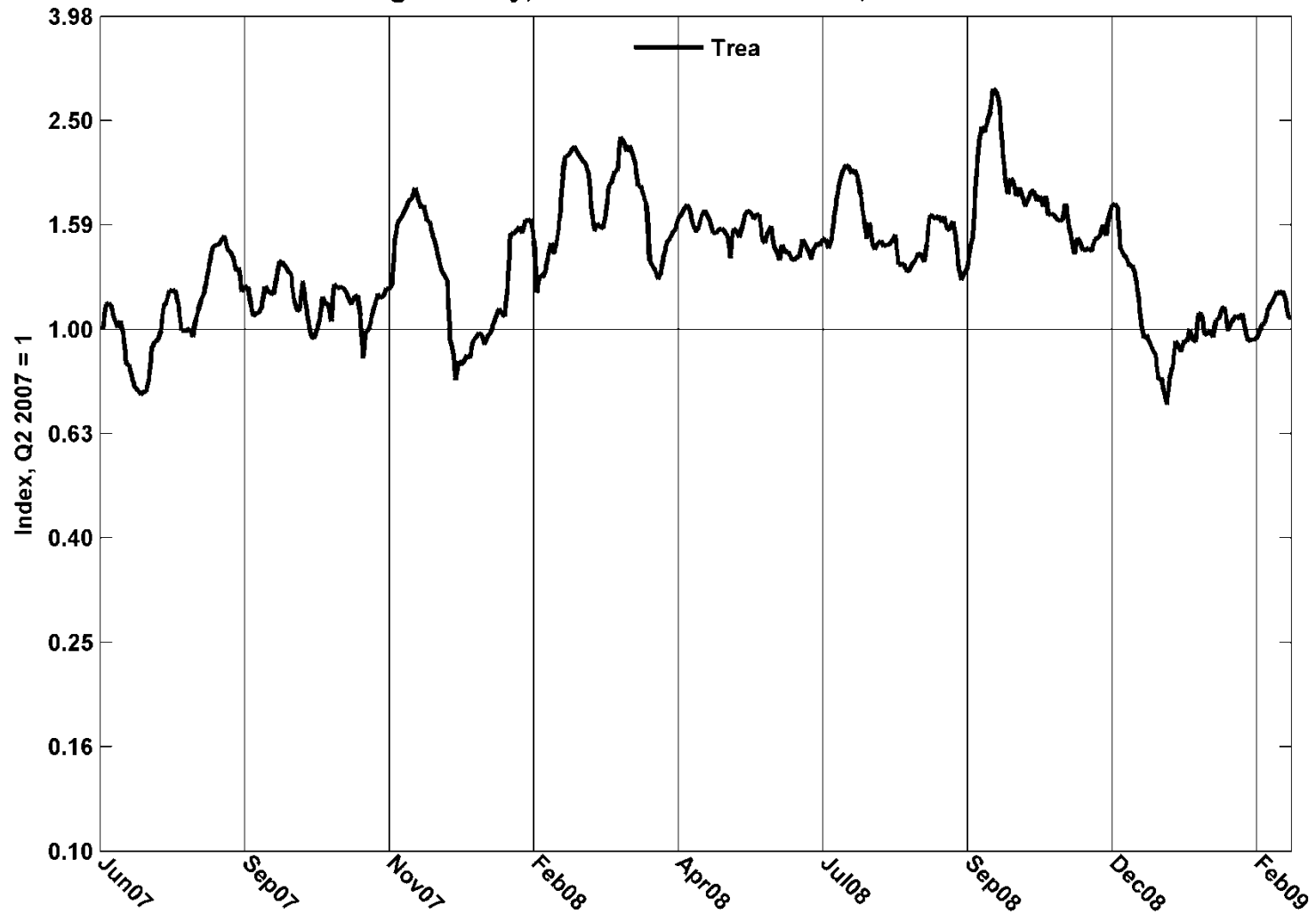
Relative Trading Activity, Fixed Income Sectors, Volume at Market Value

Relative Trading Activity, Fixed Income Sectors, Volume at Market Value

Legend: Trea — MBS Generics — Corp

Y-axis (Index, Q2 2007 = 1): 3.98, 2.50, 1.59, 1.00, 0.63, 0.40, 0.25, 0.16, 0.10

X-axis: Jun07, Sep07, Nov07, Feb08, Apr08, Jul08, Sep08, Dec08, Feb09
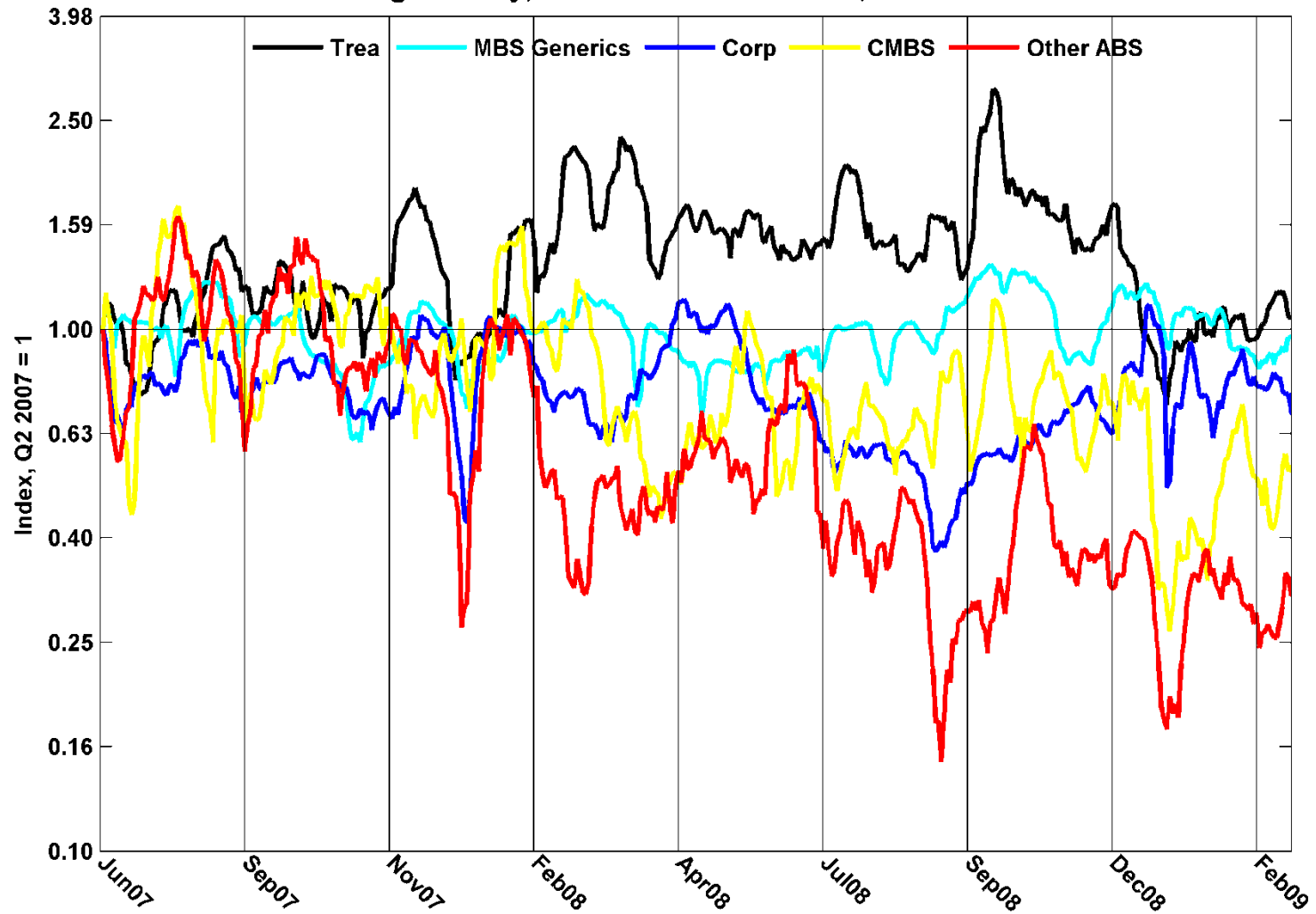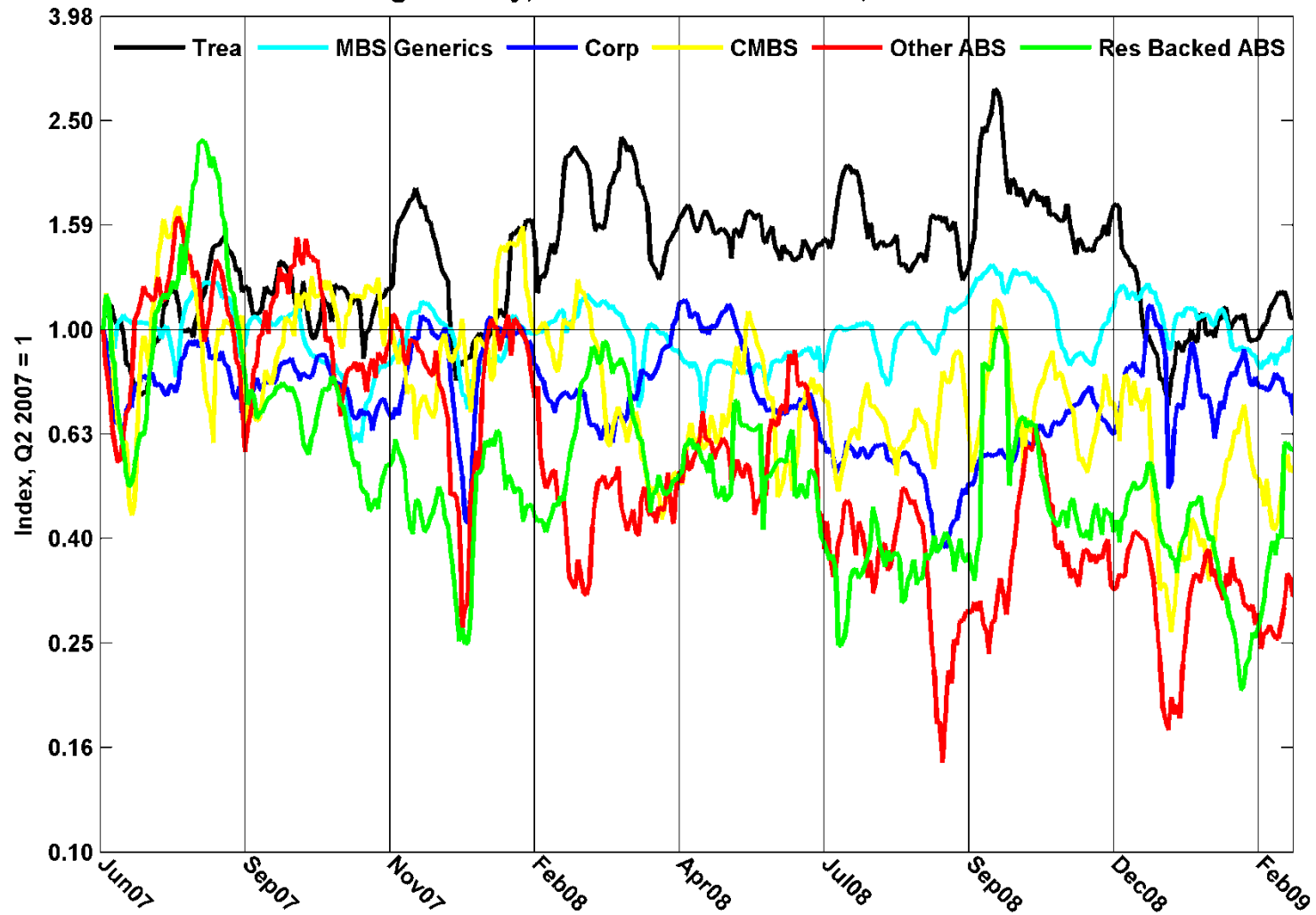
Relative Trading Activity, Fixed Income Sectors, Volume at Market Value

Relative Trading Activity, Fixed Income Sectors, Volume at Market Value

Relative Trading Activity, Fixed Income Sectors, Volume at Market Value

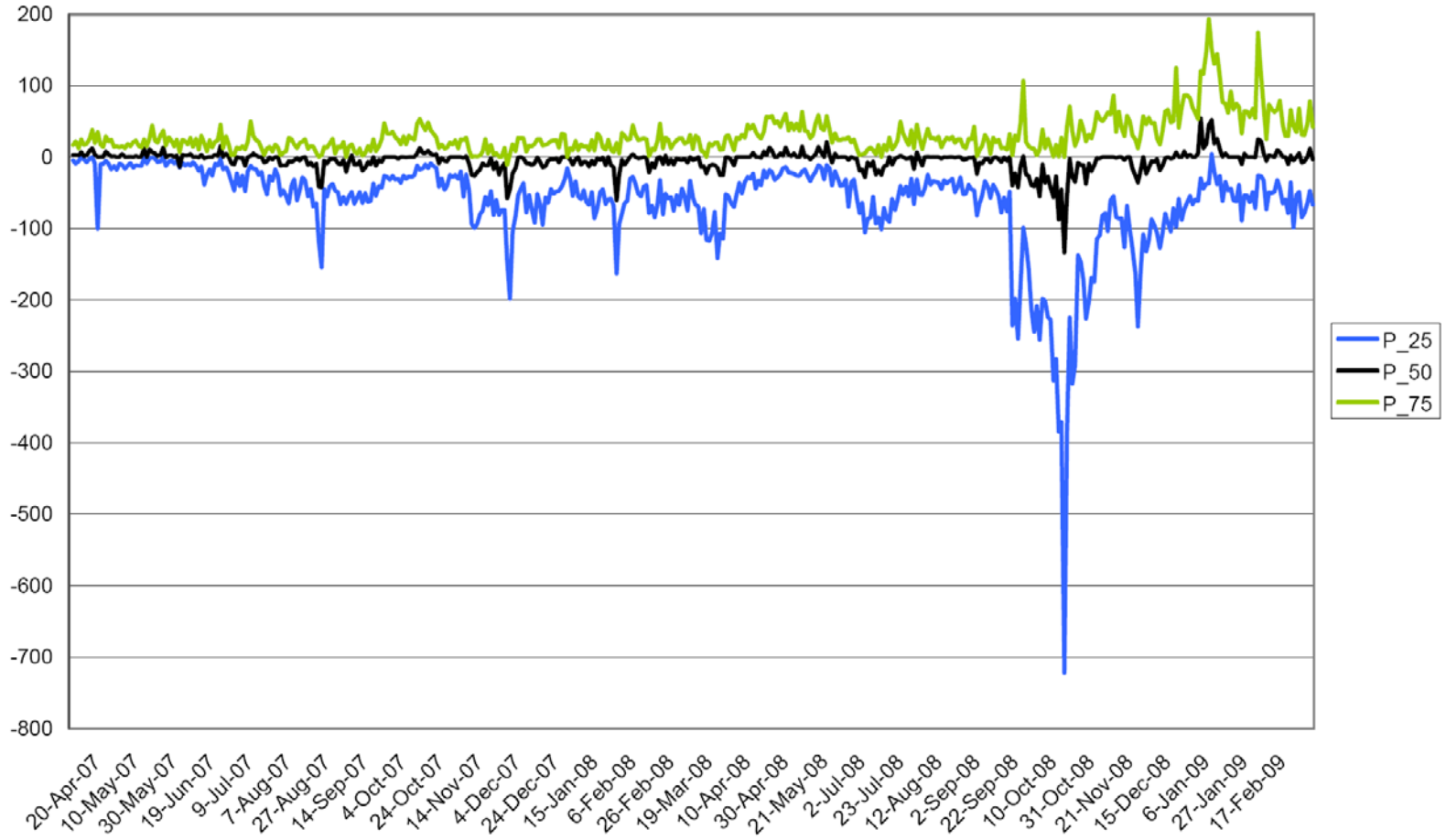# These dealer intermediated markets

- Saw substantial disruption in function and decline in activity

- Greater in those markets where dealers held greater inventory

- Exhibit greater opacity which further degrades function

Opacity and illiquidity

- Pre trade and post trade transparency is lacking in several markets, mitigated somewhat by TRACE

- Heavy dealer intermediation with high transaction costs and large dealer profits

- Opacity seems in the interest of dealers, not customers
  - Note: There are claims that TRACE has eroded liquidity because dealers no longer wish to commit so much capital when others have the same information.

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Figure 2: Custody-Reuters Price Discrepancy Distribution (Apr 2007 - Feb 2009)
Discrepancy Percentiles 25, 50, 75. (Daily Values)

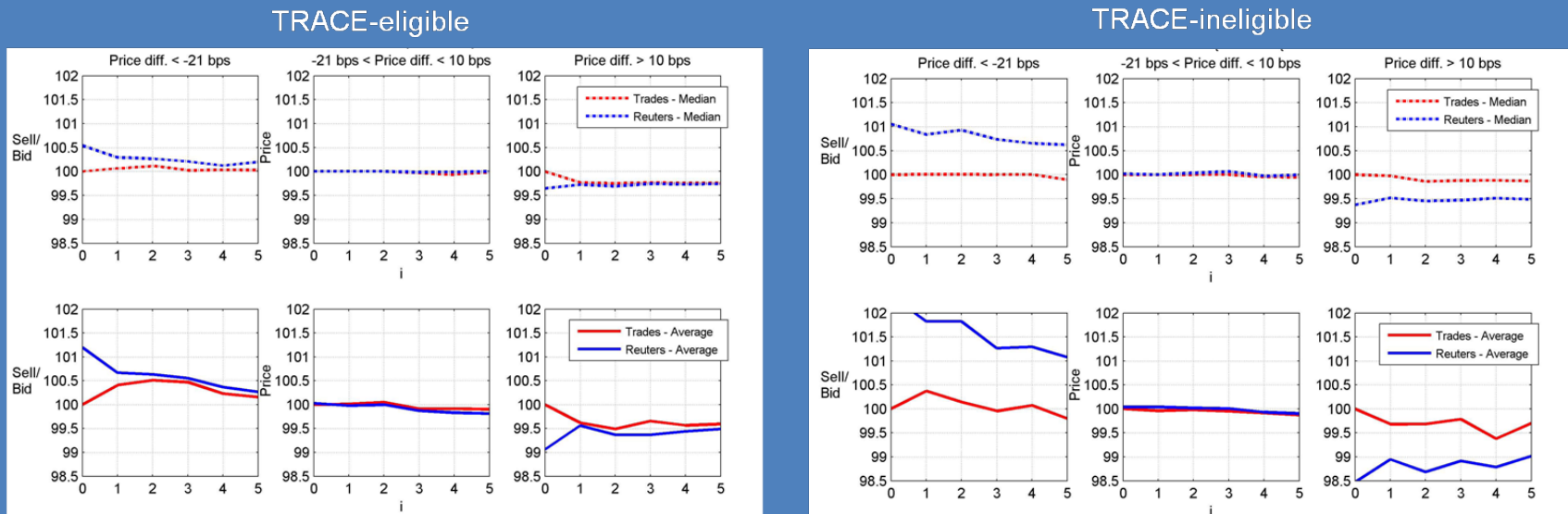# Opacity and illiquidity
Evolution of quote/trade price disparities for corporate bonds

Reuters Bid Prices vs. State Street Observed Sell Prices

Aug. 2007 – Jul. 2008

Note: Date t=0 prices normalized to 100

How bad is the opacity?
Persistence of Price Discrepancies
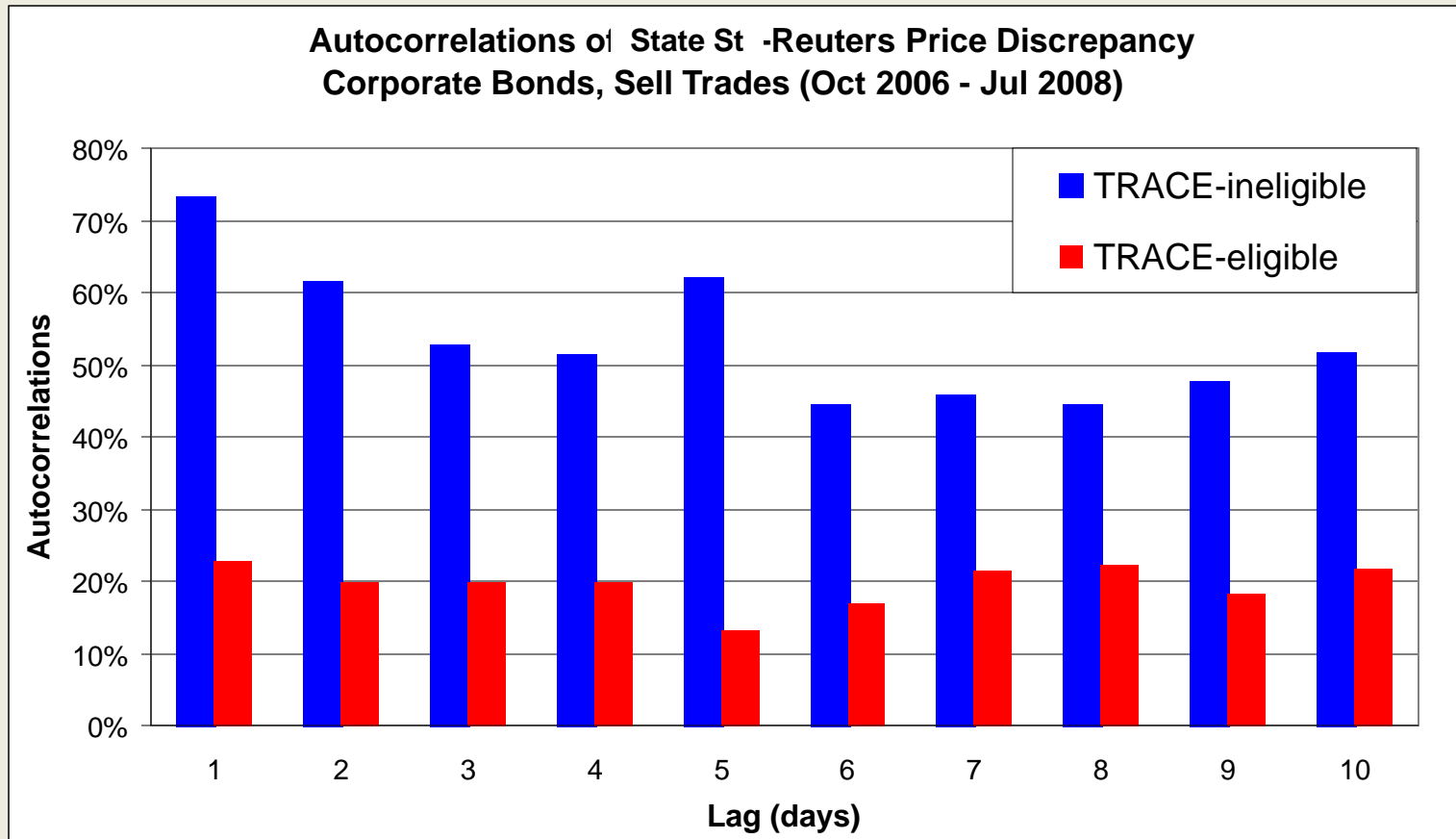
Autocorrelations of State St -Reuters Price Discrepancy
Corporate Bonds, Sell Trades (Oct 2006 - Jul 2008)

These dealer intermediated markets

- Saw substantial disruption in function and decline in activity

- Greater in those markets where dealers held greater inventory

- Exhibit far greater opacity which further degrades function

- What about prices?

Liquid asset prices, like equities, may well have fallen commensurately with the decline in economic activity

- Coval, Jurek and Stafford (2009) show that recent corporate cds prices are in line with level and volatility of equity prices

- They find cds prices consistent with equity prices and the economy, perhaps even a bit high.
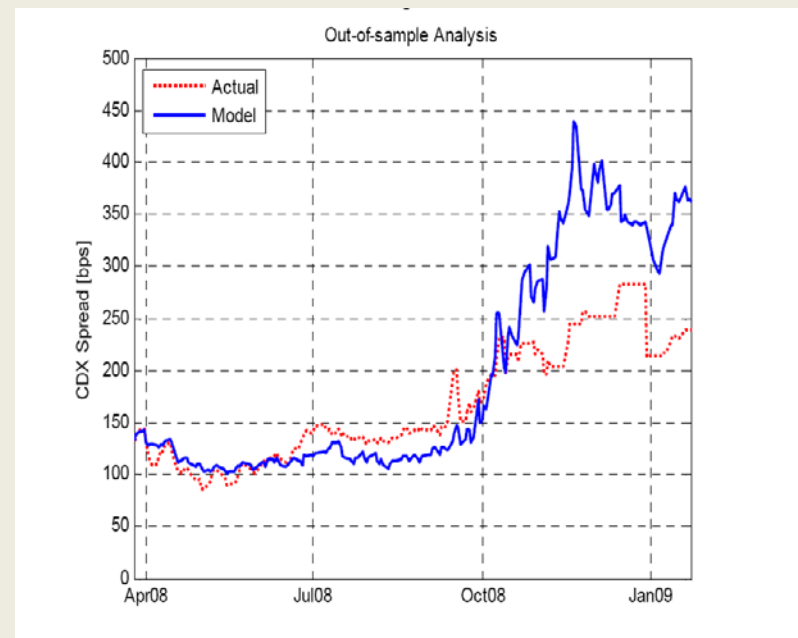
Source: Coval, Jurek and Stafford (2009)

# But Pascal's wager is a reminder to be cautious

- If the underlying economic state is indeed endogenous, then the causes and propagation mechanisms of the cycle, not the consistency of prices per se, is most important

- Prices may be "fair" given where we are, but perhaps we need not be in such a bad mess

- Is this an argument for making higher prices?

Perhaps, for philosophers (and other normal people). But could be too much to ask of economists

- Perhaps a more palatable argument is that dealer-intermediated illiquid asset prices have fallen by more because, in part, of the impairment of the dealers themselves
  - A good example would be the "basis" between cds and underlying bond prices
    - It has grown to be unusually large
    - Bonds have become cheap compared with short cds
  - Basis spreads have been on the order of 400bps
  - For a corporate bond with 7 year duration, this represents substantial relative underpricing of 25%-30%

Cash and Derivative Spreads for Investment Grade Corporate Bonds
2004 to 2009

STW for ML IG Index
CDXNA-IG 5 Yr
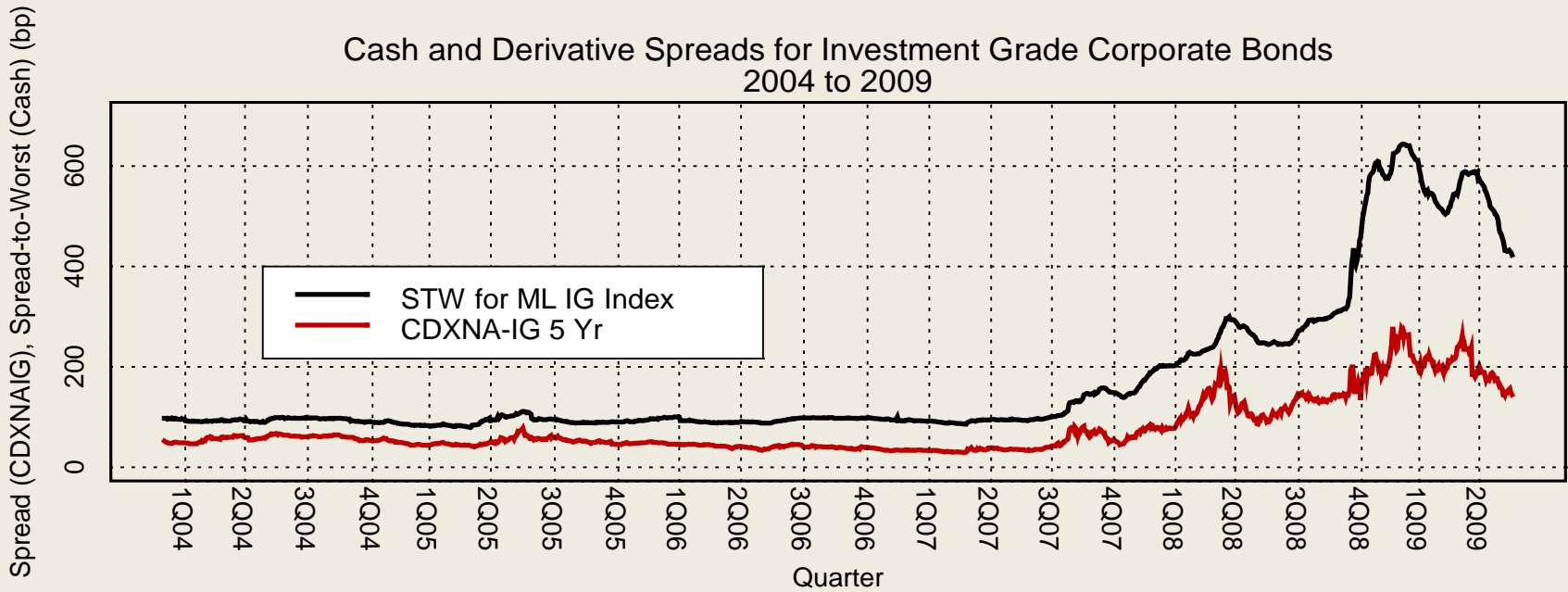
Spread Between Cash and Derivatives for Investment Grade Corporate Bonds
2004 to 2009

Cash and Derivative Spreads for Investment Grade Corporate Bonds
2004 to 2009
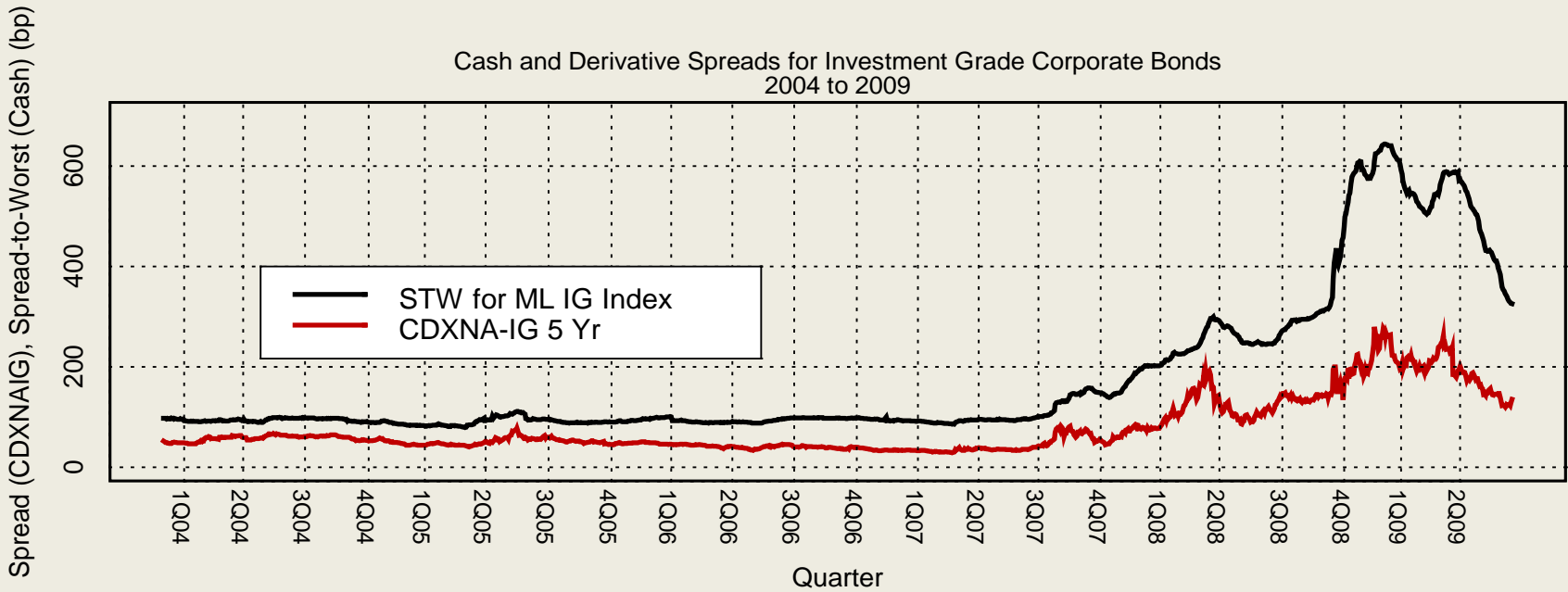
Spread (CDXNAIG), Spread-to-Worst (Cash) (bp)

STW for ML IG Index
CDXNA-IG 5 Yr

Quarter

Spread Between Cash and Derivatives for Investment Grade Corporate Bonds
2004 to 2009

Bond OAS - CDS Basis

Quarter
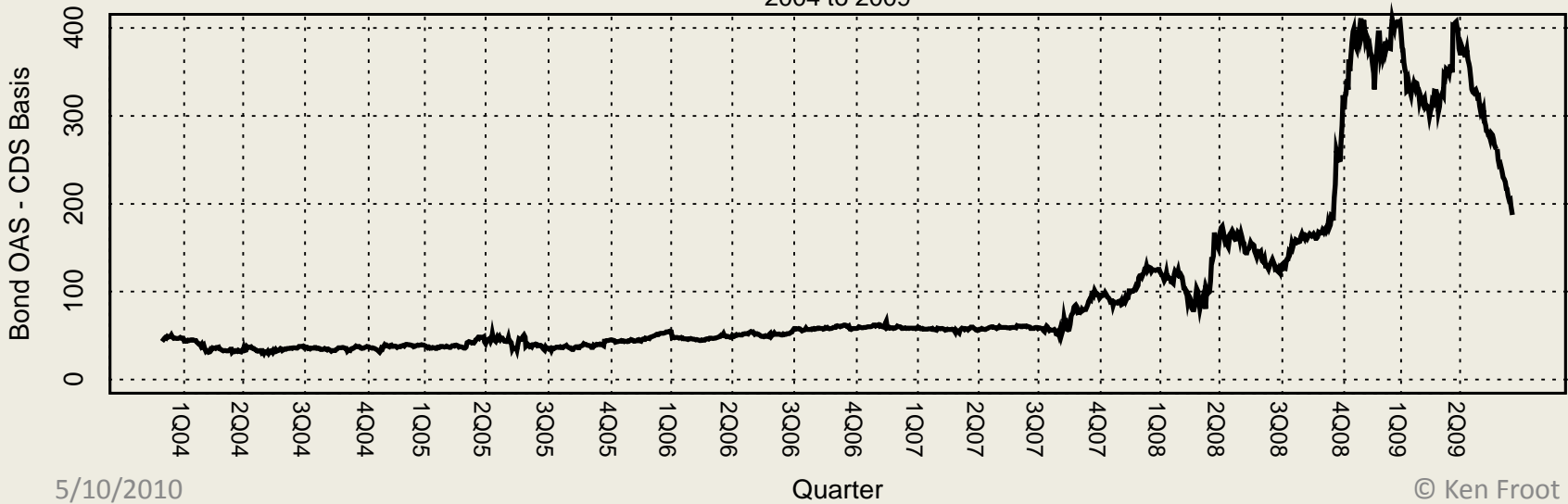
Same basis pattern observed in the CDX IG11 index of 125 issues as in a broad cross section of just under 4000 issues and 1000 issuers

Basis for Investment Grade and High Yield Corporate Bonds

Correlations with CDX ~98%
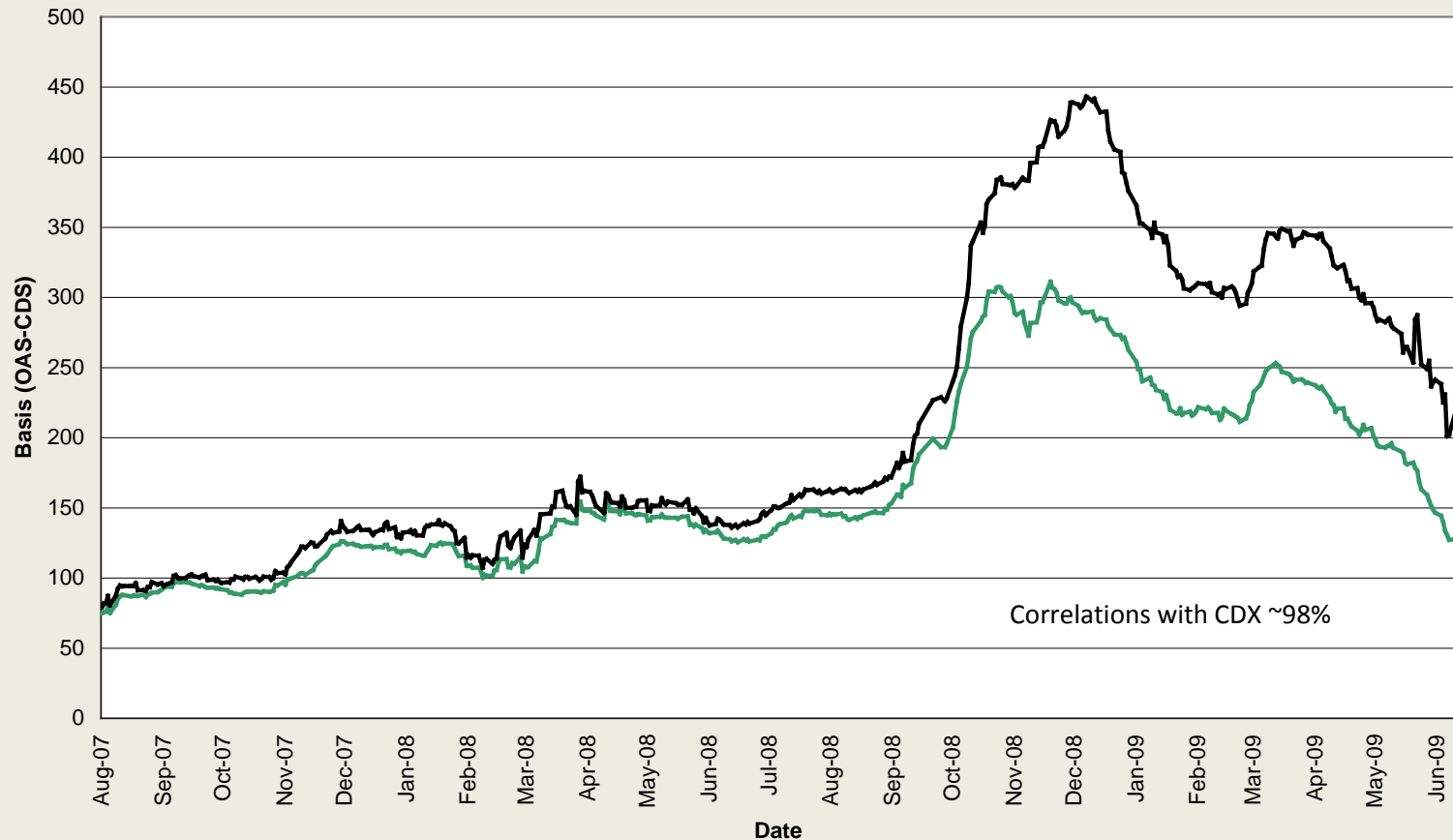
Basis by Rating, exluding CCC, CC, C

Legend: AAA, AA, A, BBB, BB, B

Y-axis: Basis (OAS-CDS), ranging from -300 to 700

X-axis: Date, from Aug-07 to Jun-09
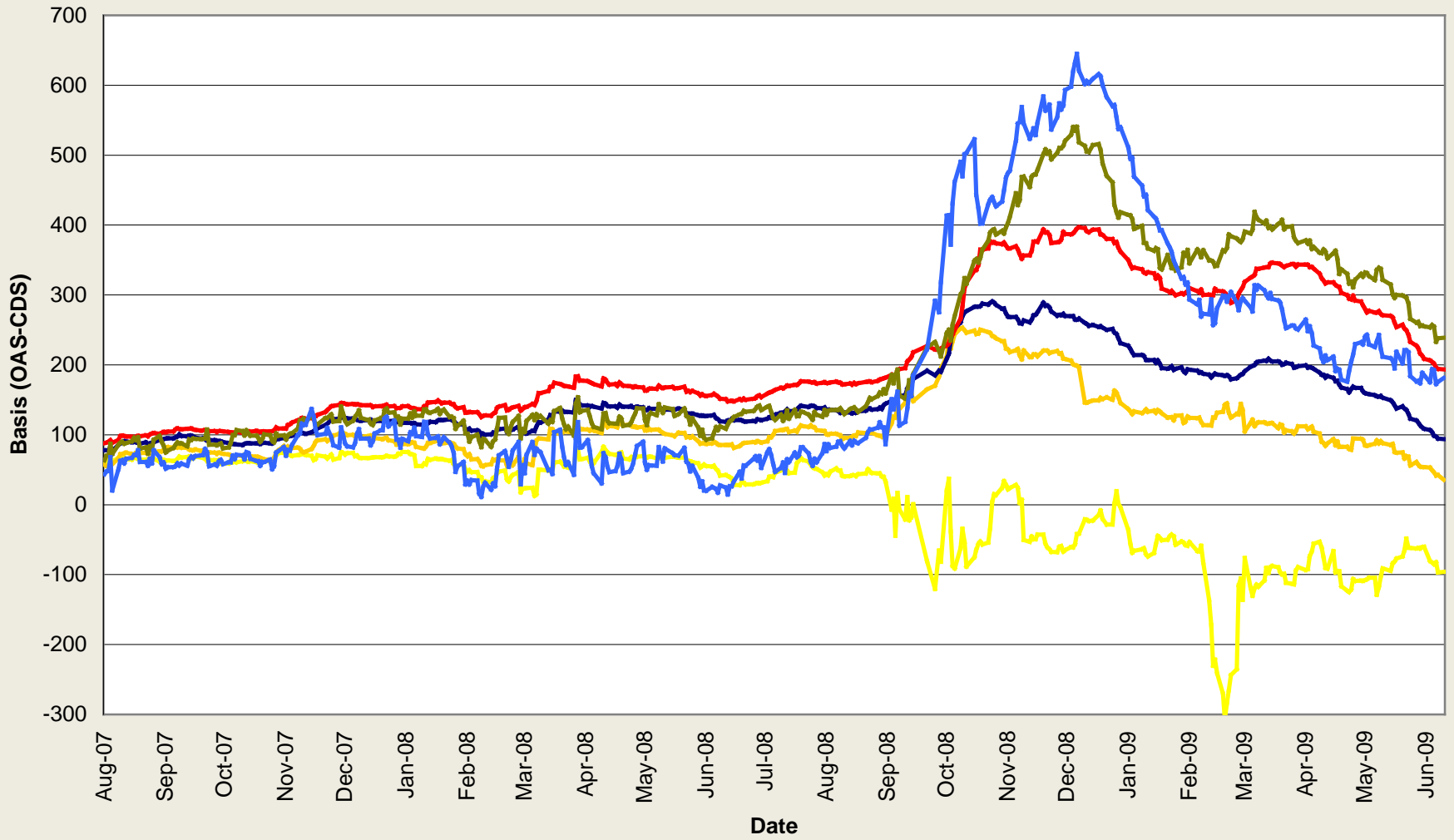
Potential explanations for the bond-cds basis

- Liquidity of bonds is less than that of cds
  - Lower trading volumes and higher transaction costs
  - Bond positions are more collateral intensive
  - Leverage to finance bond positions fell precipitously in September
- Second order:
  - Cds have additional counterparty risks
    - But cds settle up regularly to prevent counterparty exposure accumulation
  - Cds have contractual risks and may lack rights of cash instrument
    - E.g., Cds fair poorly voluntary or some negotiated debt exchanges
  - Cds may have a cheapest to deliver physical settlement option which can be valuable
    - Goes other way
  - Distortions of LIBOR
    - Used in basis, though bond spreads are over "risk free"

Is there evidence that bond illiquidity is responsible for basis?

- Lehman trigger led to collapse in all forms of funding, including that of banks
  - LIBOR – OIS spread spiked, but receded quickly
  - Banks become credit worthy, but their risk capital remained at low levels and was very expensive so that little funding of client positions or market making was done

Difficulties in bank financing were coincident with liquidity shortfalls in bonds, but dissipated faster

CDS Bond Basis vs. Libor OIS
January 2007 to May 2009

Legend:
— Basis
— Libor OIS

Y-axis: Spread (bp)
X-axis: Quarter
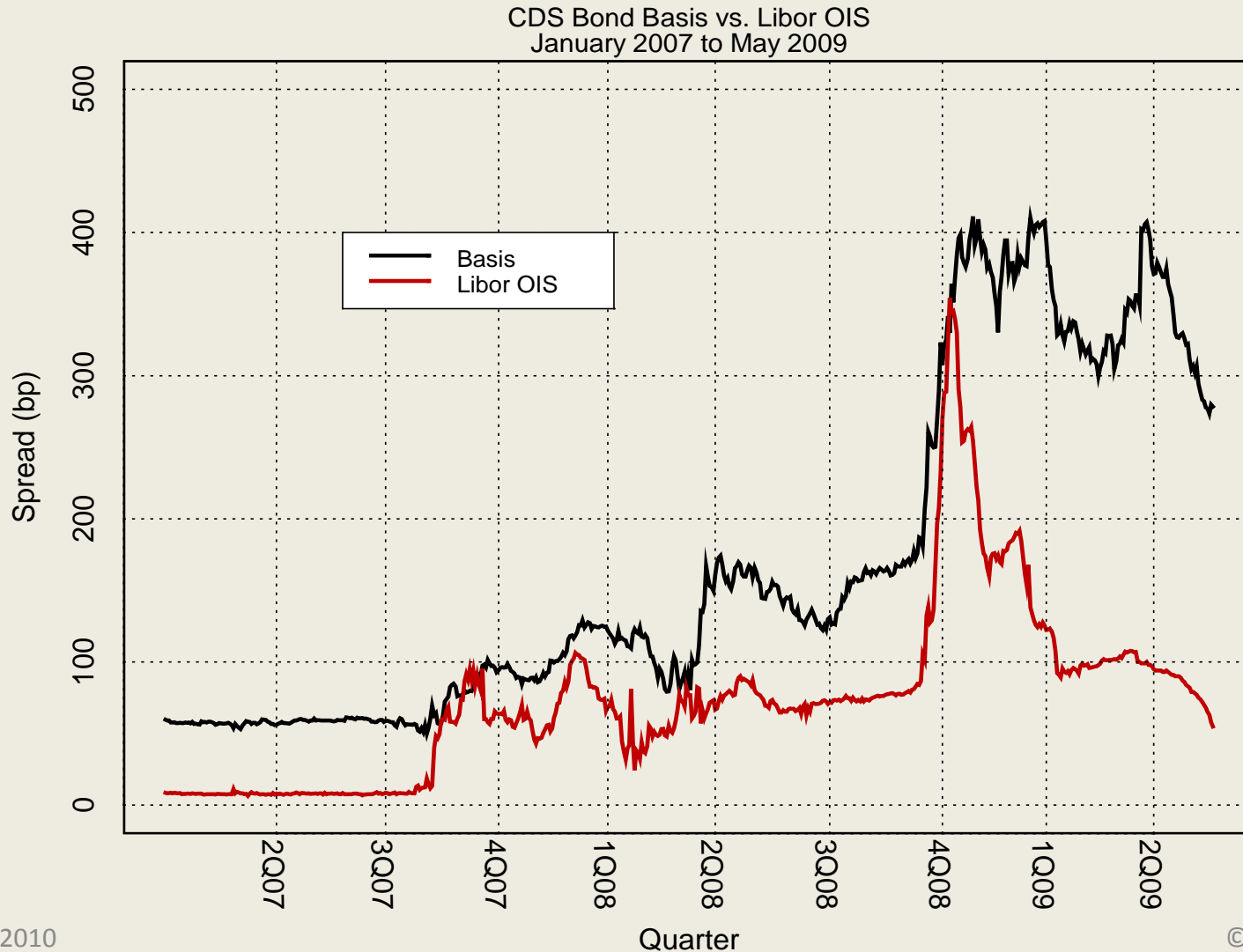
Is there evidence that bond illiquidity is responsible for basis?

- Regressions are a cleaner approach
  - Cross sectional to explain individual bond-cds bases
  - Does liquidity explain them?
  - Several measures of cross-sectional liquidity
    - Tranche into deciles a bond's trading intensity and use to measure liquidity
    - Mean absolute price discrepancy
    - On/off the run status of bond
    - Trace eligibility
    - Rating

Panel regressions suggest bonds in higher liquidity deciles have lower basis spreads than those in lower deciles

Regression Results of OAS-CDS Spreads on Liquidity Deciles, Reuters Bid-Ask Spread, Grade Dummy, and Financial Industry Dummy, Aug 2007 - Feb 2009.

Model	Full Period	Aug 07 - Aug 08	Sep 08 - Feb 09
Constant	162.4 [12.66]	88.7 [13.01]	249.9 [7.65]
Liquidity Decile (by Volume)	2.4 [3.92]	0.2 [0.63]	10.5 [6.84]
Log Mean Abs Price Discrepancy*	7.9 [5.73]	13.4 [17.93]	5.8 [1.68]
Rating (AAA=1, C=9)	3.0 [3.15]	-11.9 [-22.99]	31.4 [12.97]
On the Run Dummy (< 180 days)	-60.8 [-15.28]	-7.4 [-3.89]	-84.8 [-5.35]
TRACE-eligible Dummy	-17.0 [-2.57]	-3.9 [-1.12]	-26.8 [-1.61]
Sample Size	85,347	54,260	31,087
R Squared	0.44%	1.44%	0.92%

T-stats in brackets
Liquidity Decile: 1=highest, 10=lowest
* standardized variable

Coefficient on liquidity deciles has become highly significant
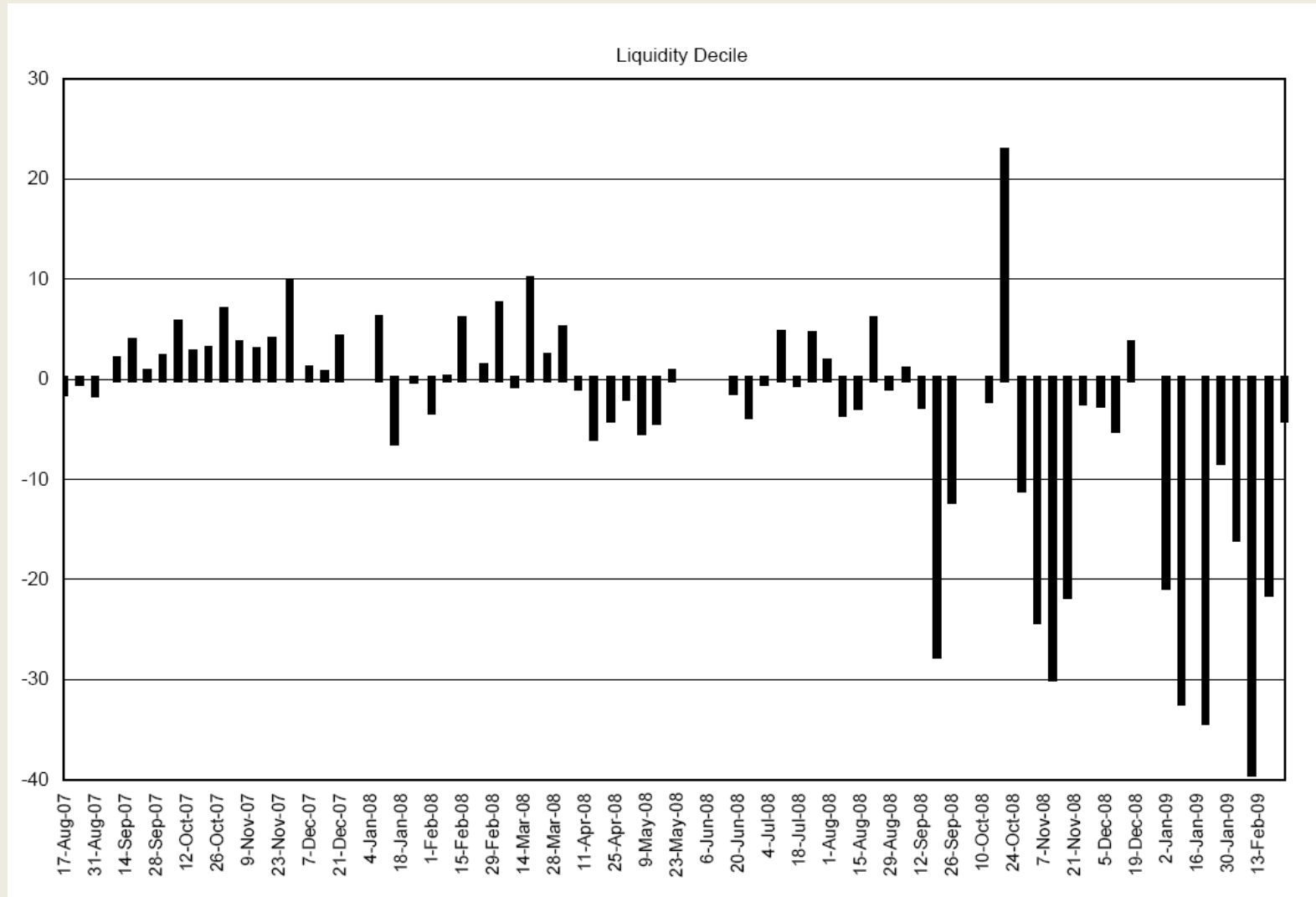
Liquidity Decile

On the Run Dummy Coefficient

71 weekly cross-sectional regressions of Negative Basis on Liquidity Decile, Mean Abs Price Discrepancy, Rating, On the Run Dummy, TRACE-eligible Dummy, and Log Debt Outstanding

Regression Results of OAS-CDS Spreads on Liquidity Proxies and other Controls, Sep 2008 - Feb 2009.

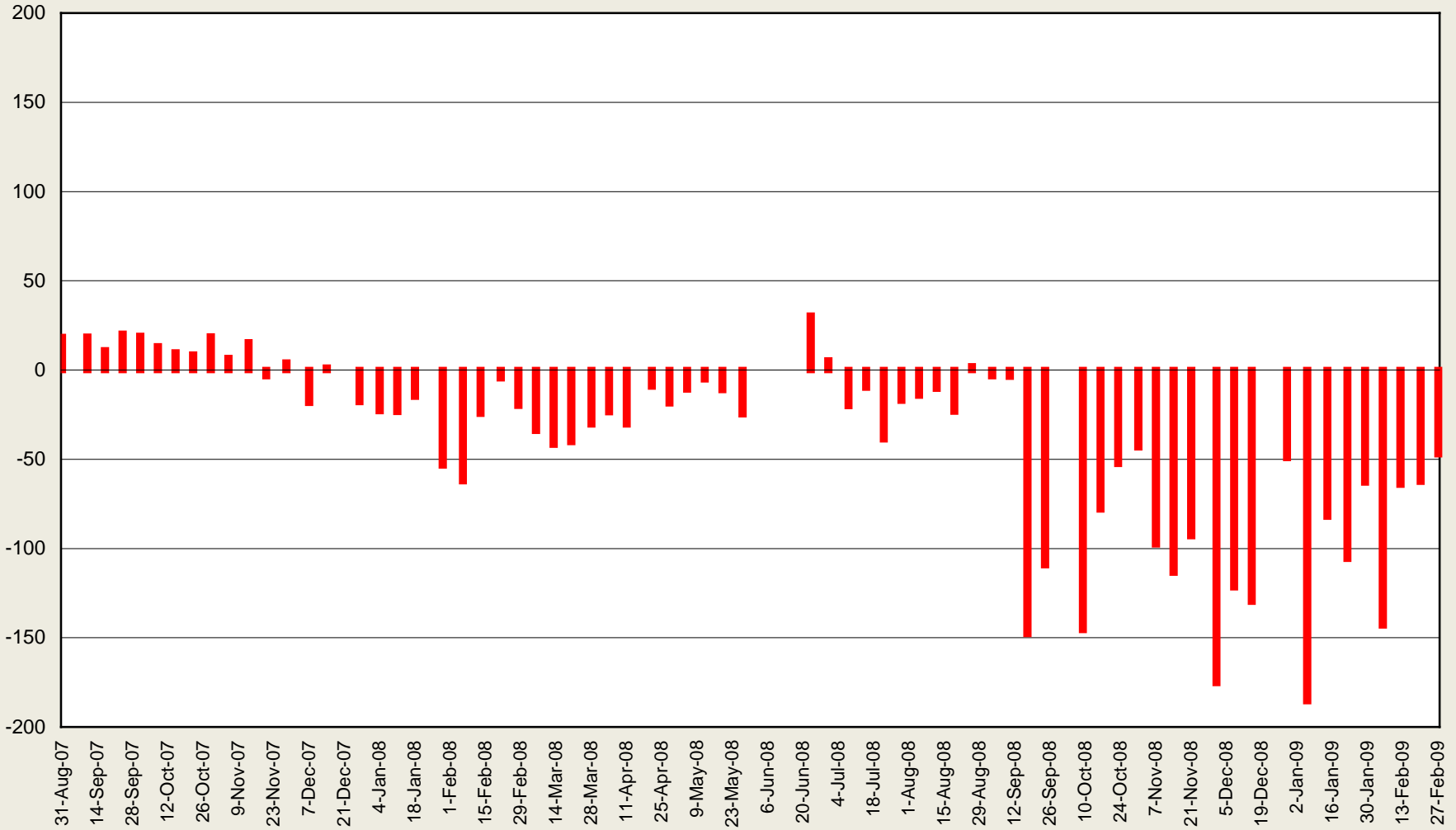| Model	1	2	3	4	5	6	7
Constant	388.3 [30.92]	296.4 [11.65]	211.6 [8.08]	228.0 [7.01]	254.2 [7.74]	461.5 [12.15]	582.1 [14.44]
Liquidity Decile (by Volume)	12.0 [8.02]	10.3 [6.63]	10.8 [6.95]	10.8 [6.93]	10.8 [6.97]	3.9 [2.33]	1.9 [1.13]
Log Mean Abs Price Discrepancy*		13.9 [4.15]	7.2 [2.14]	6.7 [1.96]	5.4 [1.56]	7.8 [2.28]	6.0 [1.75]
Rating (1=AAA, 9=C)			32.1 [13.27]	32.1 [13.24]	31.3 [12.92]	15.6 [5.55]	-3.6 [-1.00]
TRACE-eligibile Dummy				-14.2 [-0.85]	-26.1 [-1.56]	-15.1 [-0.90]	-17.3 [-1.03]
On the Run Dummy (< 180 days)					-85.8 [-5.39]	-86.8 [-5.46]	-87.5 [-5.51]
Log Debt Outstanding*						-43.3 [-10.81]	-35.3 [-8.63]
Market Cap Decile							-14.5 [-8.85]
Sample Size	31,110	31,110	31,110	31,110	31,110	31,110	31,110
R Squared	0.21%	0.26%	0.82%	0.82%	0.92%	1.29%	1.54%

T-stats in brackets
Liquidity Decile: 1=highest, 10=lowest
* standardized variable

Cross-sectional basis "reversion" regressions

Change in OAS to Basis Level					
Jan 02, 2009 to May 26, 2009					
delta OAS (bp)		Basis (bp)		Regression	
mean	median	mean	median	beta	t-stat
288.0	181.6	401.8	303.4	0.28	22.64

Change in Basis to Basis Level					
Jan 02, 2009 to May 26, 2009					
delta Basis (bp)		Basis (bp)		Regression	
mean	median	mean	median	beta	t-stat
169.6	103.8	401.8	303.4	0.47	44.73

Dec 01, 2008 to May 26, 2009					
delta OAS (bp)		Basis (bp)		Regression	
mean	median	mean	median	beta	t-stat
313.0	213.6	426.3	340.4	0.37	26.27

Dec 01, 2008 to May 26, 2009					
delta Basis (bp)		Basis (bp)		Regression	
mean	median	mean	median	beta	t-stat
190.8	134.6	426.3	340.4	0.48	40.33

Cross-sectional basis "reversion" regressions

Change in OAS to Basis Level

Jan 02, 2009 to May 26, 2009

Quintile	delta OAS (bp) mean	delta OAS (bp) median	Basis (bp) mean	Basis (bp) median	Regression beta	Regression t-stat
1 (lowest)	234.3	128.6	-166.5	26.0	-0.25	-6.69
2	142.5	136.6	203.4	203.9	0.10	0.46
3	164.0	162.5	303.3	303.2	0.01	0.07
4	210.4	207.6	444.7	439.1	0.53	2.96
5 (highest)	686.7	553.1	1212.8	796.6	0.34	11.18

Dec 01, 2008 to May 26, 2009

Quintile	delta OAS (bp) mean	delta OAS (bp) median	Basis (bp) mean	Basis (bp) median	Regression beta	Regression t-stat
1 (lowest)	184.9	141.1	-129.3	52.3	0.00	0.00
2	175.4	173.9	243.6	245.5	1.13	3.40
3	228.1	208.0	339.3	340.4	0.54	2.02
4	230.1	242.3	464.7	456.1	0.49	1.67
5 (highest)	746.5	544.4	1213.3	796.8	0.38	11.03

Change in Basis to Basis Level

Jan 02, 2009 to May 26, 2009

Quintile	delta Basis (bp) mean	delta Basis (bp) median	Basis (bp) mean	Basis (bp) median	Regression beta	Regression t-stat
1 (lowest)	-95.9	-0.1	-166.5	26.0	0.39	10.19
2	66.5	68.1	203.4	203.9	0.57	3.10
3	98.9	96.8	303.3	303.2	0.34	2.00
4	151.9	140.4	444.7	439.1	0.55	3.80
5 (highest)	624.6	413.4	1212.8	796.6	0.47	17.85

Dec 01, 2008 to May 26, 2009

Quintile	delta Basis (bp) mean	delta Basis (bp) median	Basis (bp) mean	Basis (bp) median	Regression beta	Regression t-stat
1 (lowest)	-88.2	31.3	-129.3	52.3	0.39	9.42
2	79.7	95.2	243.6	245.5	1.02	3.75
3	131.2	128.4	339.3	340.4	0.25	1.08
4	163.7	178.1	464.7	456.1	0.88	3.05
5 (highest)	667.7	432.7	1213.3	796.8	0.42	15.44

It need not be this way….

- Conclusion: In a crisis, dealer-centricity of markets combined with poor risk sharing may substantially contribute to vicious cycles, particularly if market function and basic customer liquidity is severely compromised

- Implications:
  1. Some argue that macro (e.g., systemic risk) and micro (e.g., opacity and the quality of markets) are two distinct issues.
     a. The bond market situation blurs this distinction – degraded liquidity, greater opacity, and compromised balance sheets resulted in greater systemic stress on capital, reduced credit extension, and weaker economic activity.
     b. Reducing systemic risk require contingent resources OTHER than capital

It need not be this way....

- Conclusion: In a crisis, dealer-centricity of markets combined with poor risk sharing may substantially contribute to vicious cycles and contagion, particularly if market function and basic customer liquidity is severely compromised

- Implications:
  - 3. Underpricing of illiquid instruments can be alleviated through more efficient risk-based funding
  - 4. System redesign should be a high priority
    - Transparency, opacity and system-wide plumbing are set exogenously
    - The skill sets and trading behaviors of bond investors are endogenous
    - Market structure is in between
    - Monopolistic competition among dealers is not conducive to enhanced liquidity
      - Trading can be investor to investor
      - Electronic capabilities allow decentralized, competitive market making. This reduce the returns to scale problem plaguing dealers
      - Costs should reflect informational asymmetries plus a bit
      - Coordination function to transition market structure from dealer to exchange centricity is lacking but can be done efficiently by government