ETFs, Arbitrage, and Contagion

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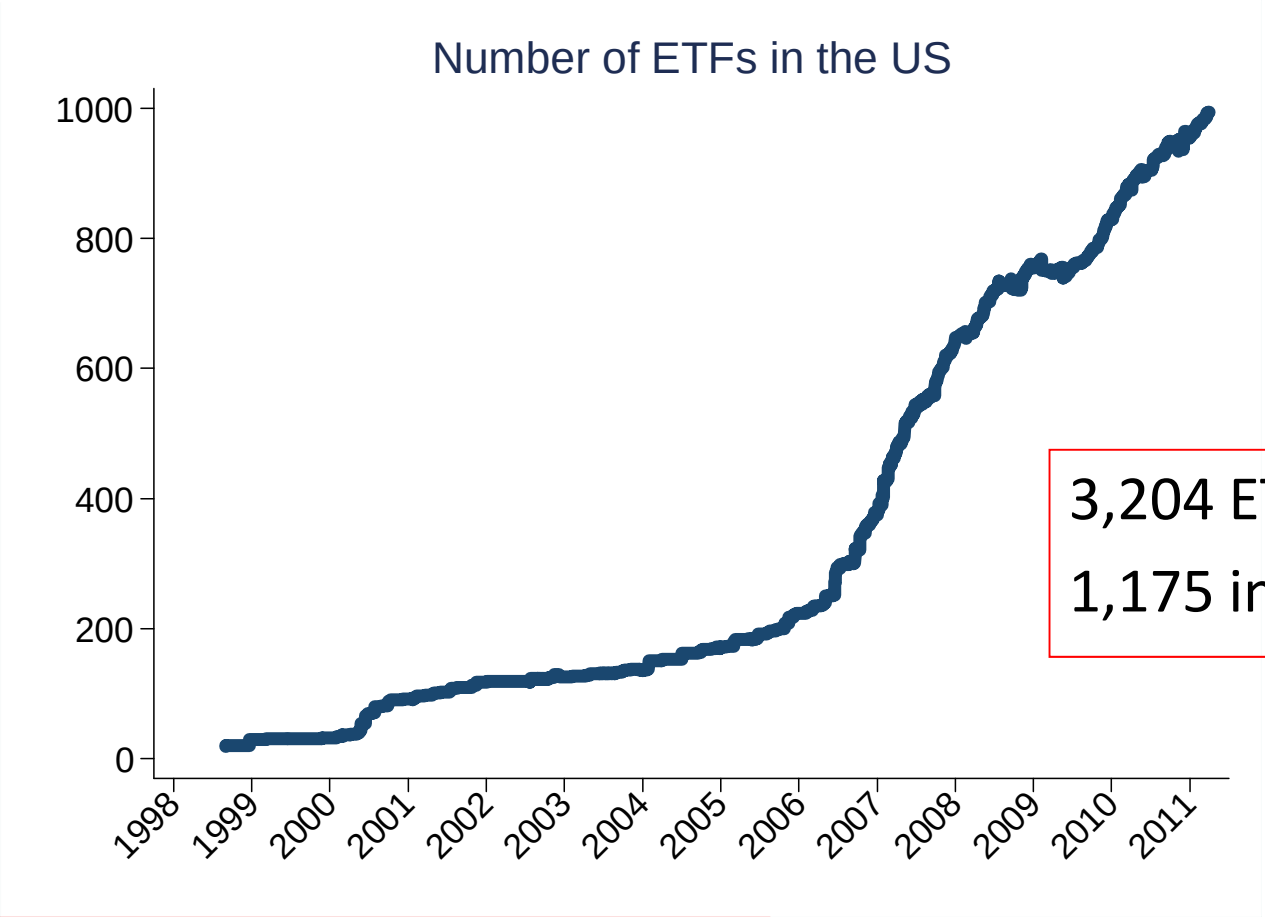
The Growth in the ETF Market



3,204 ETFs worldwide

1,175 in the US

AUM in ETFs globally : $1.5 trillion

ETF trading: up to 40% of volume in U.S. markets

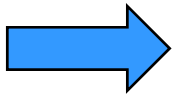
New Issues Are Raised

- Regulators are considering the risks from ETFs to investors and the financial system
  - Illiquidity: Flash Crash, May 6, 2010
  - Counterparty Risk
  - Systemic Risk: run on ETF assets
- Our question: Can ETFs foster contagion of liquidity shocks?

Exchange Traded Funds (ETFs)

"ETFs are investment companies that are legally classified as open-end companies or Unit Investment Trusts (UITs)" (SEC)

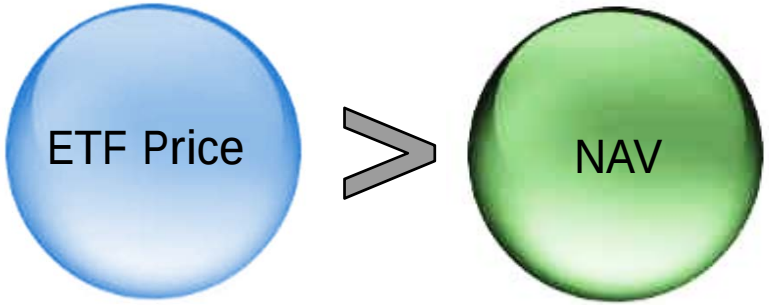
- Different from standard open-end funds in:
  - In-kind creation/redemption
  - Exchange listing



- ETF prices can deviate from NAV
- ETF prices are tied by 'arbitrage' to NAV

ETF ‘Arbitrage’

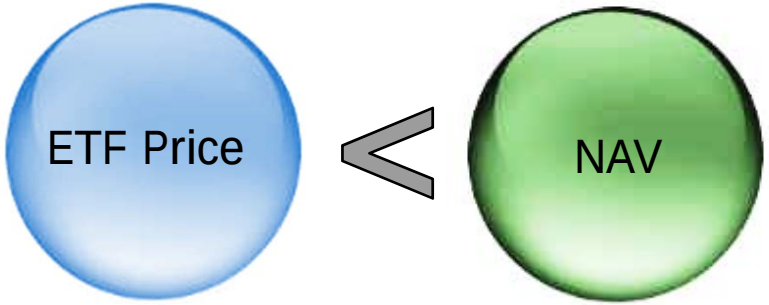
ETF Premium:



Authorized Participants:

- Buy underlying securities
- Create ETF shares in kind
- Sell ETF shares in the market

ETF Discount:



Authorized Participants:

- Buy ETF in the market
- Redeem ETF shares in kind
- Sell the underlying securities

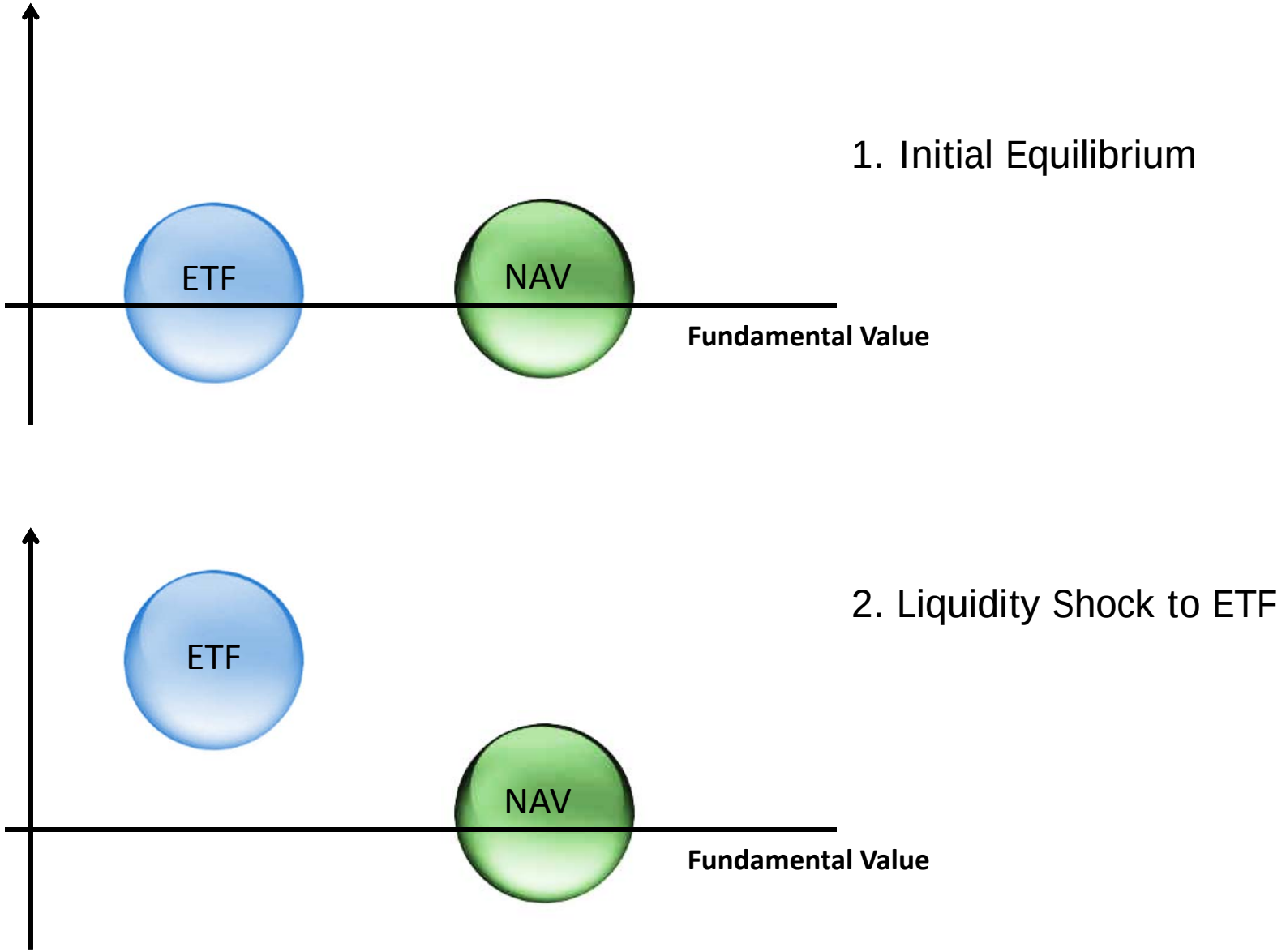
Other forms of ETF ‘Arbitrage’

- Hedge funds can take long/short positions in ETF and underlying securities
  - Wait for price convergence
  - ETF replication can be optimized using a subset of underlying securities
  - High Frequency Trading
- ETF vs. Futures arbitrage

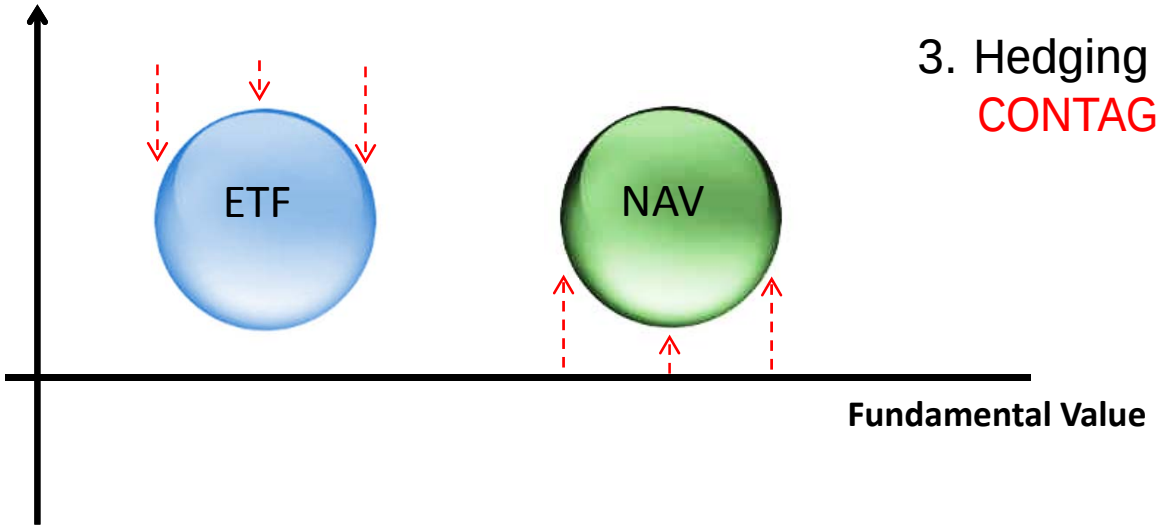
Limited Arbitrage

- Execution risk for APs
- Short selling costs
- Non-fundamental risk and arbitrageurs' short horizon
- Specialized arbitrageurs

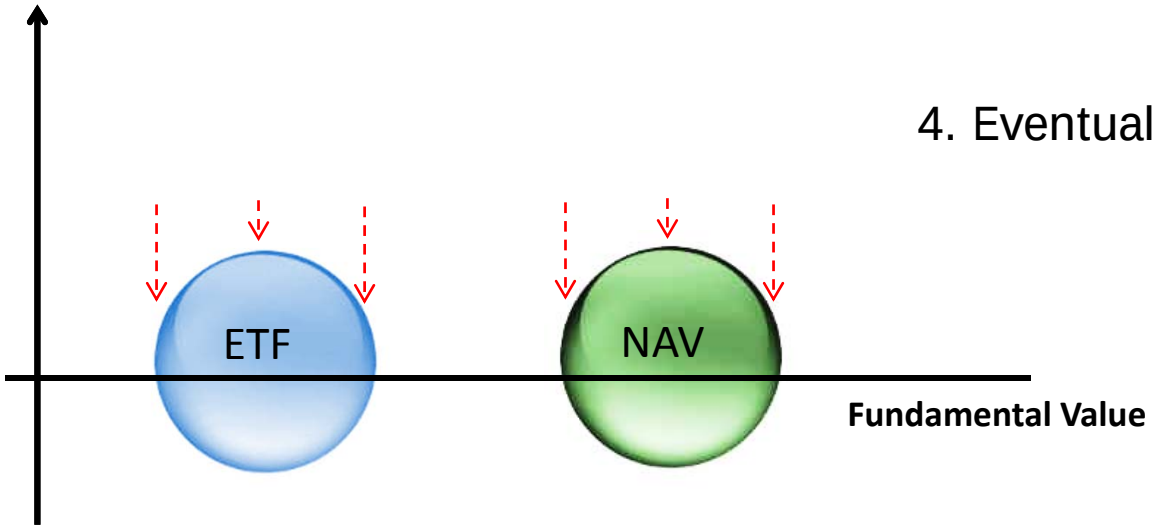
Contagion with Limited Arbitrage



Contagion with Limited Arbitrage (cont'd)



3. Hedging Demand by Arbitrageurs:
   CONTAGION



4. Eventually Liquidity Flows Back

Literature

Limits of Arbitrage

- Shleifer and Vishny (1997), Gromb and Vayanos (2010)

Contagion with Limited Arbitrage

- Risk Averse Arbitrageurs
  - Greenwood (2005), Hau, Massa, and Peress (2010)
- Wealth Effects
  - Kyle and Xiong (2001)
- Liquidity Spillovers
  - Cespa and Foucault (2012)

ETFs

- ETF mispricing and trading strategies
  - Engle and Sarkar (2006), Marshall, Nguyen, and Visaltanachoti (2010), Petajisto (2011)
- Effects of ETF on Volatility and Liquidity
  - Trainor (2010), Bradley and Litan (2010)

Roadmap and Results

1. Provide evidence of limits of arbitrage
   - Arbitrageurs' capital ↓ → Mispricing = (ETF – NAV)/ETF ↑

2. Show non-fundamental shock propagation from ETF to NAV via arbitrage
   - Mispricing (t) ↑ → NAV (t+1) ↑
   - The effect reverts within two days consistent with non-fundamental shock
   - Share creation, order imbalance, and price impacts consistent with arbitrage activity

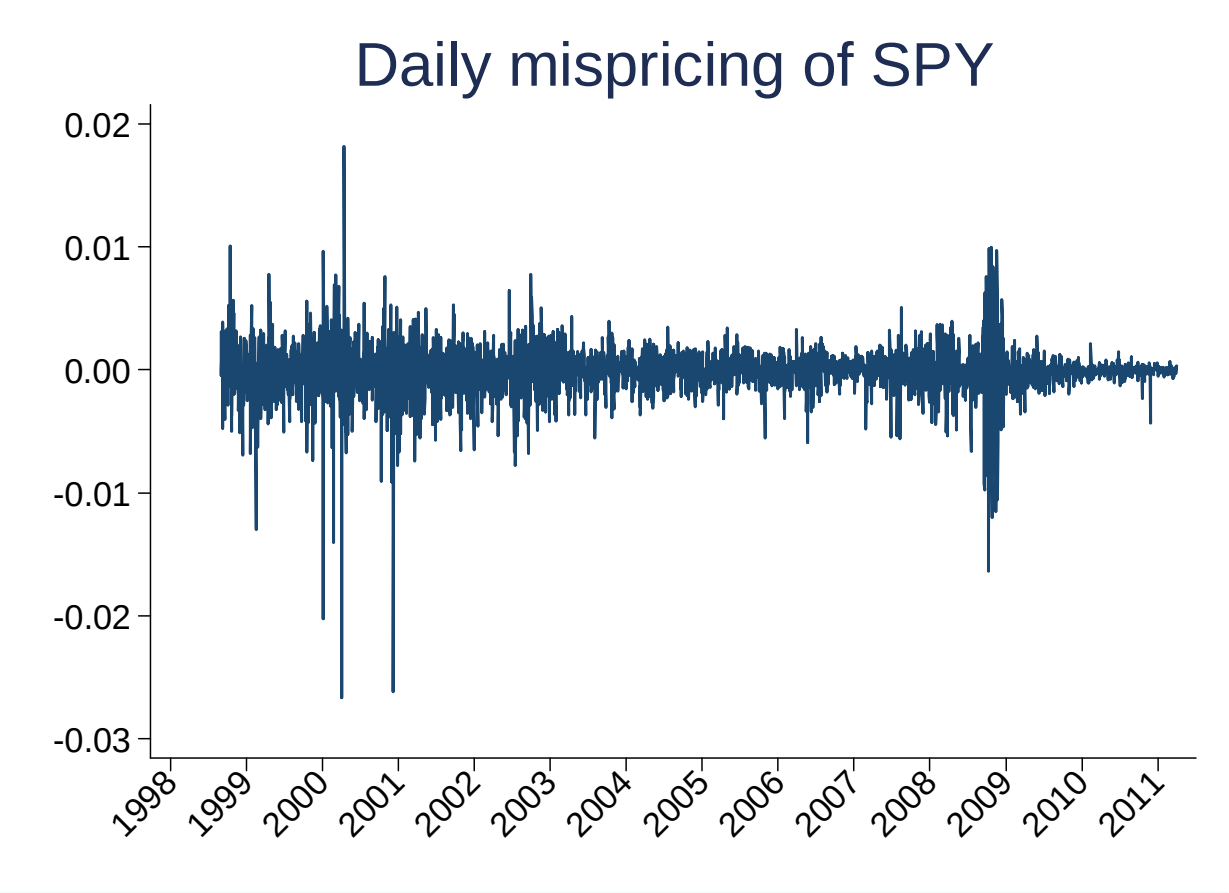
3. Implications of shock propagation:
   - Volatility of stocks owned by ETFs ↑
   - Evidence that ETFs transmitted shocks from Futures to stock market during the Flash Crash

Data

- CRSP – identify 1,261 ETFs (share code 73)
  - Returns (daily)
  - ETFs: Equity, Bonds, Commodities, Real Estate, etc.
- Compustat – shares outstanding (daily)
- OptionMetrics – shares outstanding (daily)
- Lipper, Morningstar – NAV (daily)
- Thomson-Reuters Mutual Fund – ETF holdings in stocks (quarterly)
- Period: 1998-2010

- Flash Crash
  - TAQ – Intraday analysis of Flash Crash
  - CME data of E-mini S&P 500 futures

Time Series of SPY Mispricing



ETF Mispricing = (ETF price – NAV) / ETF price

- Large mispricing in stressed times
- Both positive and negative
- Std. Dev. of daily mispricing of SPY: 21bps

Limits of Arbitrage (time-series)

	Dep. variable: Interquartile range of ETF mispricing		
	Entire sample	Excluding crisis	Equity ETFs
Past week stock market returns	-0.009***	-0.005*	-0.012***
	(-3.171)	(-1.778)	(-6.293)
Past week financial sector returns	-0.003**	-0.002	0.001
	(-2.000)	(-1.242)	(1.268)
Past week average VIX	0.004***	0.003***	0.005***
	(5.691)	(4.017)	(10.134)
Past week average TED spread	0.031***	0.012	0.026***
	(3.227)	(1.170)	(4.040)
Past week average arbitrage profits	-0.037***	-0.011	-0.016**
	(-5.333)	(-1.601)	(-2.338)
Observations	3,098	2,949	3,098
Adj. R^2	0.697	0.700	0.553

- Larger aggregate mispricing as a function of Limits of Arbitrage:
  - Lower returns on market and financial sector (Hameed, Kang, and Viswanathan, 2010)

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- Larger aggregate mispricing as a function of Limits of Arbitrage:
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  - TED spread (Boyson, Stahel, and Stultz, 2010)

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- Larger aggregate mispricing as a function of Limits of Arbitrage:

  - Lower Profits from ETF Arbitrage (Brunnermeier and Pedersen, 2009)

Tests for contagion from ETF to NAV

1. Do ETF price changes predict returns on the underlying securities?

2. Identify non-fundamental shocks

3. Identify arbitrage trading

- Focus on US Equity ETFs (most liquid)

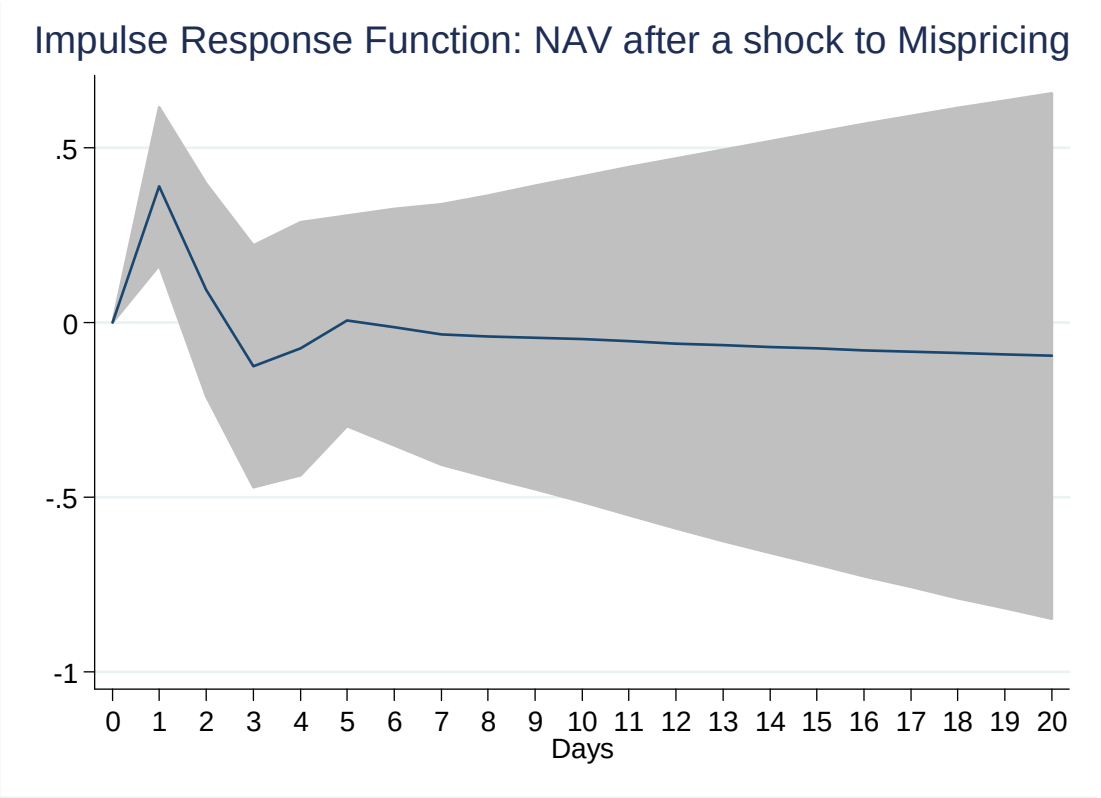
NAV Return (t+1) Predicted by Mispricing(t)

(ETF-day level sample)

	NAV Ret(t+1)		ETF Ret(t+1)	
	(1)	(2)	(3)	(4)
Mispricing(t)	0.118***	0.140***	-0.316***	-0.385***
	(10.126)	(10.159)	(-17.869)	(-19.006)
NAV Ret(t)	-0.071***	-0.067***	0.185***	0.171***
	(-3.952)	(-3.803)	(6.741)	(6.417)
ETF Ret(t)	0.014	0.010	-0.267***	-0.253***
	(1.385)	(0.954)	(-11.561)	(-11.046)
Calendar day fixed effects	Yes	Yes	Yes	Yes
ETF fixed effects	No	Yes	No	Yes
Observations	514,797	514,797	514,835	514,835
Adj. R^2	0.008	0.008	0.068	0.071

- Consistent with shock propagation:
  - ETF price (liquidity shock) ↑ → Mispricing>0 → Arbitrage → NAV ↑
  - About 14% of the mispricing in *t* is closed by NAV change in *t + 1*
- Controlling for NAV Ret(*t*):
  - Control for shocks that hit the NAV and then revert
- Larger effect of arbitrage trades is on ETF price
- Possibly: underlying stock prices are more closely tied to fundamental

Identifying non-fundamental shocks: Reversal of NAV



- A shock to mispricing induces a response in the NAV that wears out in about 2 days
- Consistent with shocks to mispricing being mostly liquidity shocks that propagate to underlying securities

Evidence of arbitrage trades: ΔETF shares

	Δ ETF Shares (t, t+1) (%)			
	(1)	(2)	(3)	(4)
ETF mispricing(t)	0.048***	0.041***	0.057***	0.050***
	(13.526)	(10.780)	(15.506)	(12.772)
NAV Ret(t)			0.014***	0.012***
			(4.763)	(4.429)
ETF Ret(t)			-0.017***	-0.016***
			(-6.718)	(-6.431)
Calendar day fixed effects	Yes	Yes	Yes	Yes
Fund fixed effects	No	Yes	No	Yes
Observations	514,794	514,794	514,794	514,794
Adj. R^2	0.000	0.006	0.000	0.006

- Shares on day *t* increase if mispricing increases on day *t*
  - Evidence of arbitrage trades by Authorized Participants

Evidence of arbitrage trades: Buying/Selling Pressure

Dependent variable:	Buy-sell order imbalance (t+1) of…	
	ETFs	Underlying Stocks
	(1)	(2)
ETF mispricing (t)	-0.873**	0.167**
	(-2.498)	(2.384)
ETF mispricing (1-10 lags)	Yes	Yes
ETF order imbalance (1-10 lags)	Yes	Yes
Observations	365,414	366,308
Adj. R^2	0.130	0.030

- Consistent with arbitrage trading, positive mispricing predicts:
  - Negative demand pressure on ETF
  - Positive demand pressure on underlying stocks

Evidence of arbitrage trades: Hedging Demand (S&P500)

Dependent variable:	Stock Return (t+1) (%)			
	(1)	(2)	(3)	(4)
ETF mispricing (t) × log(Market capitalization)	0.180**			0.128
	(2.118)			(1.422)
log(Market capitalization)	-0.002***			-0.003***
	(-14.689)			(-18.944)
ETF mispricing (t) × Beta		0.252		0.384*
		(1.131)		(1.684)
Beta		-0.008***		-0.008***
		(-21.028)		(-18.661)
ETF mispricing (t) × Idiosyncratic volatility			-3.846	-6.049**
			(-1.442)	(-2.248)
Idiosyncratic volatility			-0.079***	-0.056***
			(-14.823)	(-10.132)
Calendar day fixed effects	Yes	Yes	Yes	Yes
Observations	1,250,138	1,250,385	1,242,366	1,242,366
Adj. R^2	0.118	0.119	0.119	0.120

- Consistent with hedging demand by arbitrageurs, effect of mispricing of S&P500 is larger on:
  - Stocks with higher weight in the index (Greenwood 2005)
  - Stocks with higher beta and lower idiosyncratic volatility (better hedges)

Effect of Δ#ETFs on ΔVolatility and ΔTurnover

(stock-month level sample)

	Monthly change in daily volatility (%)		Monthly change in turnover	
	(1)	(2)	(3)	(4)
# ETFs first reporting to hold the stock	0.016***	0.019***	0.001***	0.001***
	(7.455)	(8.286)	(8.570)	(8.376)
# ETFs last reporting to hold the stock	-0.038***	-0.047***	-0.003***	-0.003***
	(-5.888)	(-6.342)	(-6.261)	(-4.904)
Stock-month controls	Yes	Yes	Yes	Yes
Calendar month fixed effects	Yes	Yes	Yes	Yes
Stock fixed effects	No	Yes	No	Yes
Observations	428,205	428,205	424,989	424,989
Adj. R^2	0.289	0.381	0.060	0.075
Number of stocks		9,269		9,234

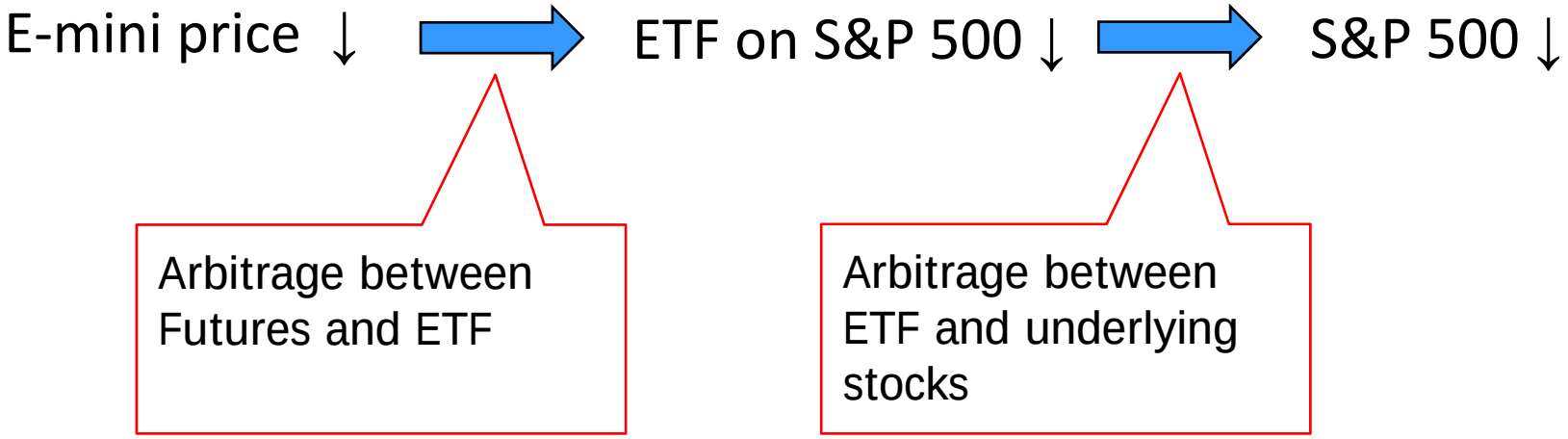
- More/fewer ETFs owning the stocks:
  - Higher/lower Stock Volatility
  - Higher/lower Stock Turnover

The Flash Crash: May 6, 2010

- The S&P 500 plunged by almost 6% in a few minutes and quickly recovered
- Some stocks fell to a few cents in value and ETFs accounted for 60% of cancelled trades
- Shock triggered by large sell order of E-mini futures (75,000 contracts) on S&P 500 by mutual fund (*Waddell and Reed*)
- How did shock propagate to stocks?

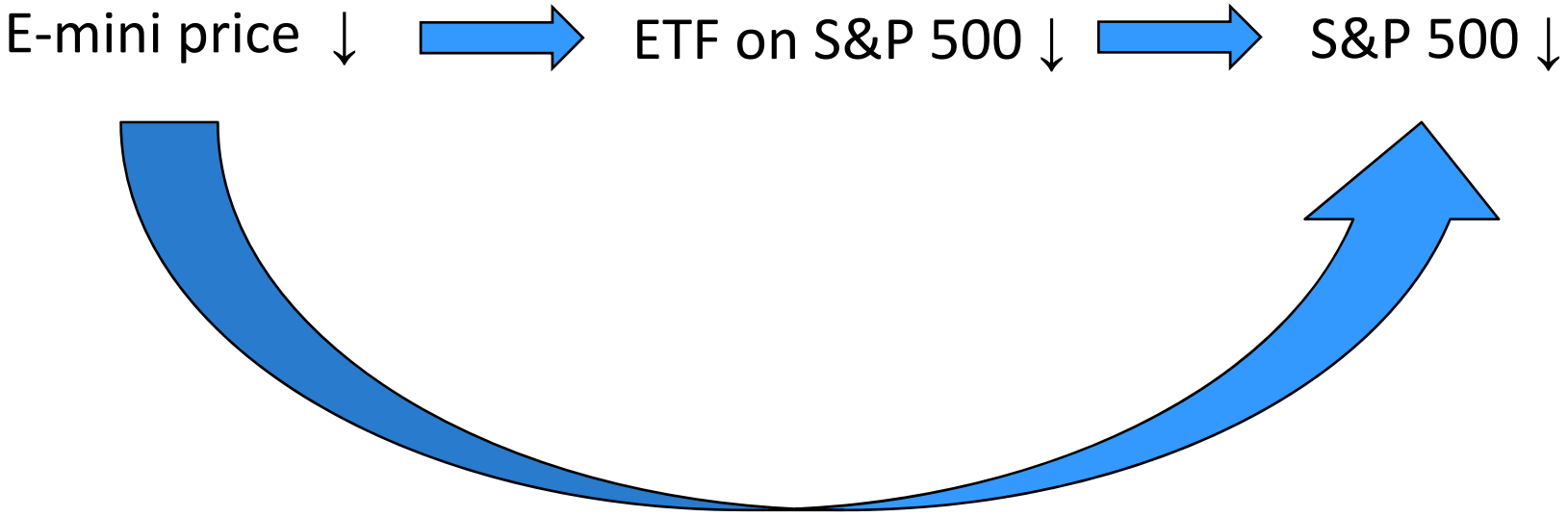
ETFs as a channel for contagion?

Conjecture and test that ETF arbitrage contributed to propagate the shock from futures to spot markets

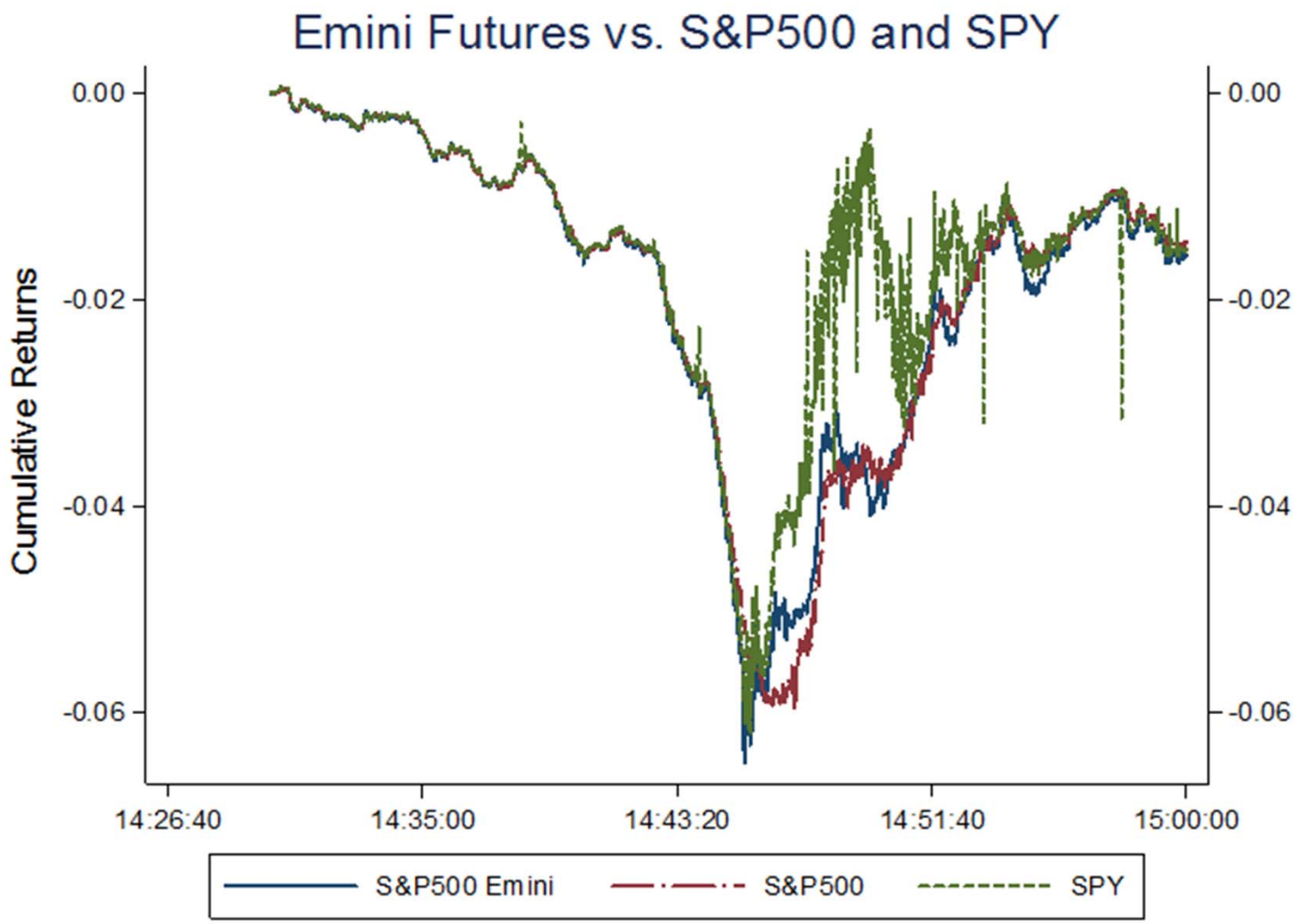


Not the only channel, of course!

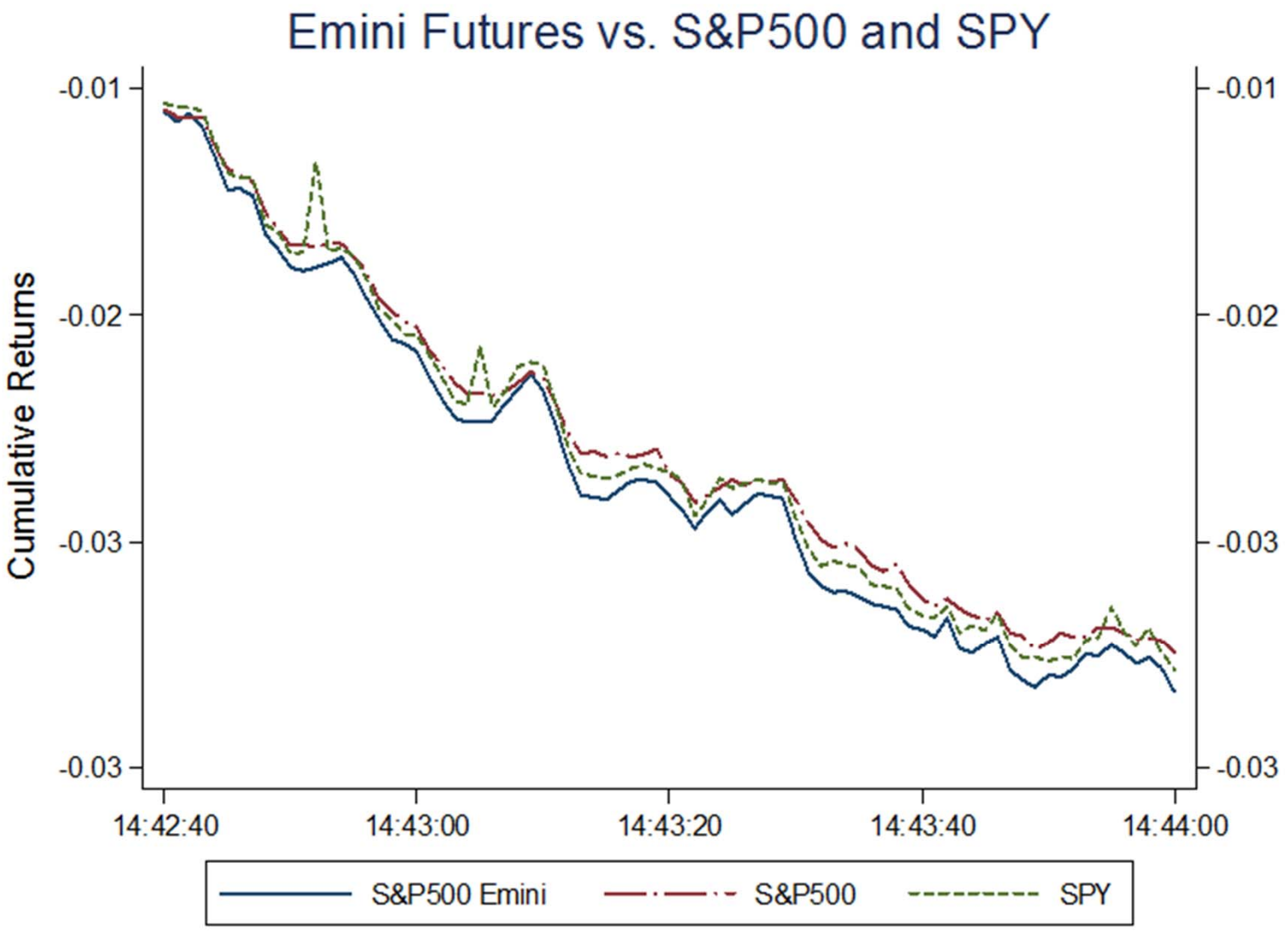
Direct arbitrage between futures and spot market was taking place



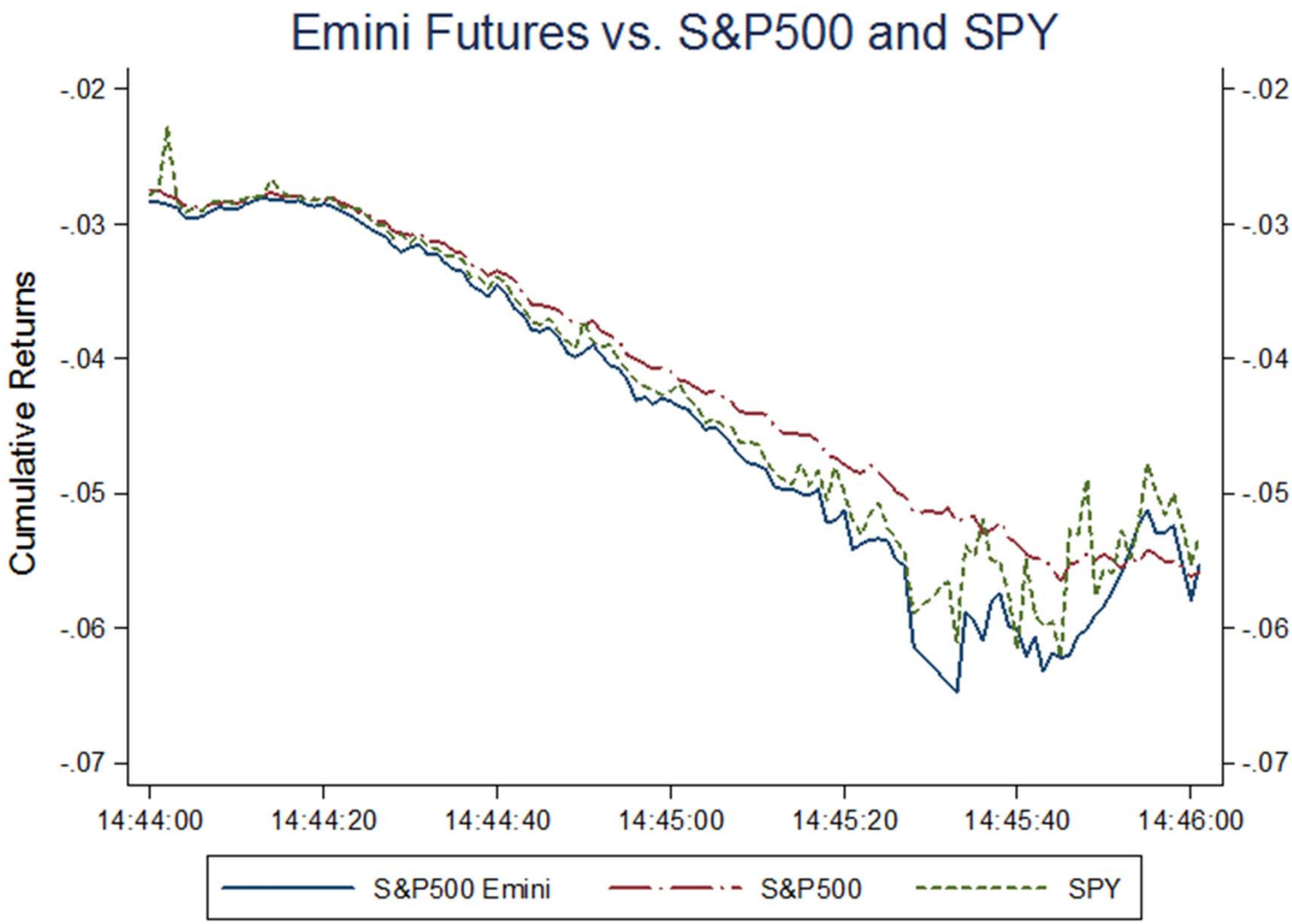
S&P 500, E-mini, and SPY dropped together



E-mini leads, then SPY, then S&P500 (2:42PM - 2:44PM)



E-mini leads, then SPY, then S&P500 (2:44PM - 2:46PM)



S&P500 Return (t+1) Predicted by SPY Mispricing(t)

(second-by-second)

Dependent variable:	Return S&P500 (t+1)		
Sample:	Before trough 14:30:00 - 14:45:45		
	(1)	(2)	(3)
SPY mispricing (t)	0.064***	0.055***	0.025*
	(10.396)	(4.710)	(1.812)
E-mini mispricing (t)			0.073***
			(4.887)
Cum. Ret. S&P500 (t, t-60)		0.082***	0.126***
		(5.516)	(7.344)
Cum. Ret. SPY (t, t-60)		-0.011	-0.004
		(-0.814)	(-0.327)
Cum. Ret. Emini (t, t-60)		-0.058***	-0.110***
		(-4.309)	(-6.813)
Cum. Ret. S&P500 (t, t-600)		-0.000	-0.007
		(-0.041)	(-1.172)
Cum. Ret. SPY (t, t-600)		-0.003	-0.002
		(-0.482)	(-0.349)
Cum. Ret. Emini (t, t-600)		0.007	0.011**
		(1.187)	(1.983)
Observations	945	943	937
Adj. R^2	0.102	0.189	0.223

- The mispricing predicts movements in the S&P, both in the fall and the recovery
  - Controlling for non-arbitrage based stories (Cespa and Foucault, 2012)
  - Controlling for direct arbitrage between futures and S&P 500

Conclusion

- We study shock propagation from ETFs to underlying securities:
  - Evidence of limits of arbitrage between ETFs and underlying securities
  - Evidence that ETF arbitrage affects prices and volatilities of underlying securities
  - Evidence that ETFs served as a conduit for contagion between the futures and the equity markets during the Flash Crash

- Results are consistent with financial innovation causing an amplification of non-fundamental volatility

- Results have implications for debate on High-Frequency Trading

Limits of Arbitrage (cross-section)

	Depedent variable: abs(ETF mispricing)			
Sample:	All ETFs		Equity ETFs	
Sample period:	1998-2010	2001-2010	1998-2010	2001-2010
	(1)	(2)	(3)	(4)
Past week arbitrage profits	-0.007***	-0.007***	-0.005	-0.005
	(-4.575)	(-4.485)	(-1.354)	(-1.403)
ETF relative bid-ask spread	0.118***	0.121***	0.162***	0.162***
	(18.885)	(19.179)	(15.259)	(15.658)
Past month return volatility	0.003	0.003	-0.002	-0.002
	(0.618)	(0.524)	(-0.384)	(-0.265)
Past week average	0.503***	0.503***	0.453***	0.450***
abs(ETF mispricing)	(15.695)	(15.225)	(8.366)	(8.066)
Calendar day fixed effects	Yes	Yes	Yes	Yes
ETF fixed effects	Yes	Yes	Yes	Yes
Observations	876,494	857,145	476,028	465,607
Adj. R^2	0.459	0.462	0.385	0.390

- Absolute ETF mispricing correlates with:
  - ETF-level arbitrage profits
  - ETF bid-ask spread

NAV Return (t) Predicted by Mispricing(t-1)

(ETF-day level sample)

	NAV Ret(t)			
	(1)	(2)	(3)	(4)
Mispricing(t-1)	0.141***	0.164***	0.118***	0.140***
	(10.998)	(11.014)	(10.126)	(10.159)
NAV Ret(t-1)			-0.071***	-0.067***
			(-3.952)	(-3.803)
ETF Ret(t-1)			0.014	0.010
			(1.385)	(0.954)
Calendar day fixed effects	Yes	Yes	Yes	Yes
ETF fixed effects	No	Yes	No	Yes
Observations	515,151	515,151	514,797	514,797
Adj. R^2	0.004	0.005	0.008	0.008

- Consistent with shock propagation:
  - ETF price (liquidity shock) ↑ → Mispricing>0 → Arbitrage → NAV ↑
  - About 14% of the mispricing in *t* – 1 is closed by NAV change in *t*

- Controlling for NAV Ret(*t-1*):
  - Control for shocks that hit the NAV and then revert

ETF Return (t) Predicted by Mispricing(t-1)

(ETF-day level sample)

	ETF Ret(t)			
	(5)	(6)	(7)	(8)
Mispricing(t-1)	-0.454***	-0.539***	-0.316***	-0.385***
	(-27.762)	(-30.757)	(-17.869)	(-19.006)
NAV Ret(t-1)			0.185***	0.171***
			(6.741)	(6.417)
ETF Ret(t-1)			-0.267***	-0.253***
			(-11.561)	(-11.046)
Calendar day fixed effects	Yes	Yes	Yes	Yes
ETF fixed effects	No	Yes	No	Yes
Observations	515,190	515,190	514,835	514,835
Adj. R^2	0.037	0.044	0.068	0.071

- Larger effect of arbitrage trades is on ETF price
- Possibly: underlying stock prices are more closely tied to fundamental

Appendix – ETF industry

Year	# ETFs	Total Mktcap ($bn)
1998	29	9
1999	32	16
2000	92	36
2001	118	59
2002	126	99
2003	136	124
2004	170	181
2005	223	258
2006	373	361
2007	633	507
2008	747	564
2009	822	607
2010	948	834
2011	986	1'019

Identifying non-fundamental shocks using buy/sell pressure

(ETF-day level sample)

	First Stage	Second Stage	OLS
Dependent variable:	Mispricing(t)	NAV Ret(t+1)	NAV Ret(t+1)
Sample:	All	All	OI ETF > 1 st dev
	(1)	(2)	(3)
Mispricing (t) (or predicted(Mispricing (t)))		0.342***	0.089***
		(3.687)	(6.445)
NAV Ret(t)		-0.012	-0.057**
		(-0.516)	(-2.143)
ETF Ret(t)		-0.052**	0.019
		(-2.048)	(1.264)
Large positive OI in ETF	0.001***		
	(17.284)		
Large negative OI in ETF	-0.001***		
	(-14.913)		
Calendar day fixed effects	Yes	Yes	Yes
Observations	386,014	385,946	90,631
Adj. R^2	0.004	0.001	0.004

- Goal: identify liquidity shocks in ETF
- Single out days when order imbalance in ETF is much larger than order imbalance in Underlying Securities
  - Use large ETF order imbalance as an instrument for mispricing in IV regressions: still works!
  - Restrict sample to these days: still works!

ETF industry

Fund Objective Code	AUM ($bn)	# Funds	VW Expense Ratio	Equity ETF
S&P 500 index objective funds	95.6	4	0.09%	Yes
Growth funds	82.6	94	0.21%	Yes
Emerging markets funds	70.9	49	0.61%	Yes
Gold oriented funds	57.6	24	0.44%	No
International funds	53.5	38	0.35%	Yes
Small-cap funds	36.7	30	0.21%	Yes
Mid-cap funds	28.8	32	0.23%	Yes
Intermediate investment grade debt funds	24.6	8	0.18%	No
Treasury inflation protected securities	21.2	5	0.20%	No
Dedicated short bias funds	20.4	97	0.94%	No
Corporate debt funds BBB-rated	18.7	8	0.21%	No
Growth and income funds	17.9	19	0.11%	Yes
Commodities funds	16.7	64	0.78%	No
Latin American funds	15.0	13	0.62%	Yes
China region funds	14.4	19	0.73%	No
Pacific ex Japan funds	13.4	14	0.56%	No
Financial services funds	13.2	26	0.40%	Yes
Natural resources funds	12.3	25	0.40%	Yes
Real estate funds	12.0	15	0.32%	Yes
Short investment grade debt funds	11.2	4	0.16%	No
Equity income funds	10.3	13	0.38%	Yes
High current yield funds	9.7	3	0.46%	Yes
Science & technology funds	9.2	32	0.37%	Yes
Short U.S. treasury funds	8.8	4	0.15%	No
European region funds	8.2	25	0.47%	Yes
Health/biotechnology funds	7.6	22	0.39%	Yes
General U.S. treasury funds	7.5	14	0.15%	No
Basic materials funds	5.9	19	0.39%	No
Currency funds	5.7	32	0.47%	No
Japanese funds	5.5	9	0.55%	Yes
Industrials funds	5.2	22	0.37%	Yes
Ultra-short obligations funds	5.2	3	0.15%	No
Consumer goods funds	5.0	15	0.31%	Yes
Utility funds	4.8	16	0.32%	Yes
Global natural resources funds	4.2	17	0.55%	Yes
Diversified leverage funds	3.8	14	0.95%	No
Specialty/miscellaneous funds	3.7	18	0.56%	No
General municipal debt funds	3.5	6	0.24%	No
Consumer services funds	3.5	16	0.34%	Yes
Global funds	3.0	13	0.39%	Yes
International income funds	2.2	4	0.50%	No
Short municipal debt funds	2.0	6	0.22%	No
Emerging markets debt funds	2.0	2	0.57%	No
Global financial services funds	2.0	7	0.65%	Yes
U.S. mortgage funds	1.9	3	0.25%	No
International real estate funds	1.6	7	0.58%	Yes
Pacific region funds	1.4	4	0.16%	No
Telecommunication funds	1.3	11	0.49%	Yes
International small-cap funds	1.0	3	0.59%	Yes
Total or Average	772.3	948	0.40%	

Appendix – Summary statistics (aggregate time series)

EQUITY ETFs

	N	Mean	S.D.	Min	Median	Max
Daily interquartile range	3104	0.00438	0.00323	0.00116	0.00348	0.0313
Daily fraction of ETFs with positive net mispricing	3104	0.298	0.154	0	0.322	0.728
Past week stock market returns	3099	0.00146	0.0284	-0.186	0.00286	0.2
Past week financial sector returns	3099	0.00248	0.049	-0.272	0.00372	0.373
Past week average VIX	3099	0.226	0.0918	0.1	0.218	0.729

CORRELATIONS		(1)	(2)	(3)	(4)	(5)
Daily interquartile range	(1)	1				
Daily fraction of ETFs with positive net mispricing	(2)	-0.3938	1			
Past week stock market returns	(3)	-0.1402	-0.0503	1		
Past week financial sector returns	(4)	-0.1139	-0.082	0.8849	1	
Past week average VIX	(5)	0.6026	-0.1866	-0.1299	-0.0895	1

Appendix – Summary statistics (cross-section of ETFs)

	N	Mean	S.D.	Min	Median	Max
ETF Ret	709430	0.000276	0.018	-0.0641	0.000773	0.0634
NAV Ret	709430	0.000191	0.0177	-0.0634	0.000704	0.0627
abs(ETF mispricing)	709430	0.00361	0.00593	1.52E-08	0.00145	0.0405
ETF mispricing	709430	0.00036	0.00619	-0.0274	0.000132	0.0271
Past week volatility(NAV)	709430	0.015	0.0123	0.000543	0.0115	0.0774
Past week EFT return	709430	0.00135	0.0376	-0.132	0.00341	0.123
ETF turnover	709430	0.0383	0.1	0	0.00914	0.824
ETF relative bid-ask spread	709430	0.00466	0.00963	0.000126	0.00182	0.0723
Number of times ETF shares changed in past 30 days	709430	3.87	5.68	0	1	25
Average short interest in past 30 days	709430	0.104	0.234	0.000152	0.0205	1.46
Δ ETF Shares (%)	709430	0.142	1.44	-5.17	0	10.3

Appendix – Summary statistics (stock-month level)

	N	Mean	S.D.	Min	Median	Max
Daily volatility within the month (%)	545838	3.8	2.92	0.564	2.91	16.4
Monthly change in daily volatility	543456	-0.00278	2.14	-7.09	-0.0529	8.28
Turnover (1000x#shares traded/#shares outstanding)	547405	0.292	2.9	0	0.0742	883
Monthly change in turnover	536522	30.5	2486	-249058	-0.419	855212
ETF weight in the stock (%)	421903	2.46	2.02	2.42E-06	1.87	9.03
Monthly change in ETF weight	410980	0.0413	0.278	-0.998	0.000562	1.24
Total institutional ownership (%)	556285	43.7	32.5	0	41.6	110
Monthly change in institutional ownership	545740	0.177	2.56	-10.1	0	12.5
# ETFs first reporting to hold the stock	421903	0.54	1.58	0	0	21
# ETFs last reporting to hold the stock	421903	0.113	0.405	0	0	7
# ETFs reporting to hold the stock	421903	14.2	13.7	1	11	87
log(market capitalization/1000)	547405	19.4	2.12	11.7	19.3	27.1
Interquintile mispricing of ETFs in the month	559469	0.00455	0.00288	0.00159	0.0036	0.0163
log(volume)	547526	16.8	2.41	3	17	25.4

Appendix – Summary statistics (Flash Crash)

WHOLE SAMPLE

	N	Mean	S.D.	Min	Median	Max
Return S&P500	1800	-8.13E-06	0.000467	-0.00368	-0.0000138	0.00355
SPY mispricing	1800	0.00342	0.00772	-0.00951	0.000141	0.0324
Return Emini	1794	-6.78E-06	0.00051	-0.00641	-0.0000152	0.00627
Return SPY	1800	-8.52E-06	0.00242	-0.025	-0.0000167	0.0251
S&P500 Order Imbalance	1801	-0.0123	0.0497	-0.34	-0.0059	0.251
SPY average short volume (t, t+5)	1801	0.0016	0.00143	0.000013	0.00117	0.011

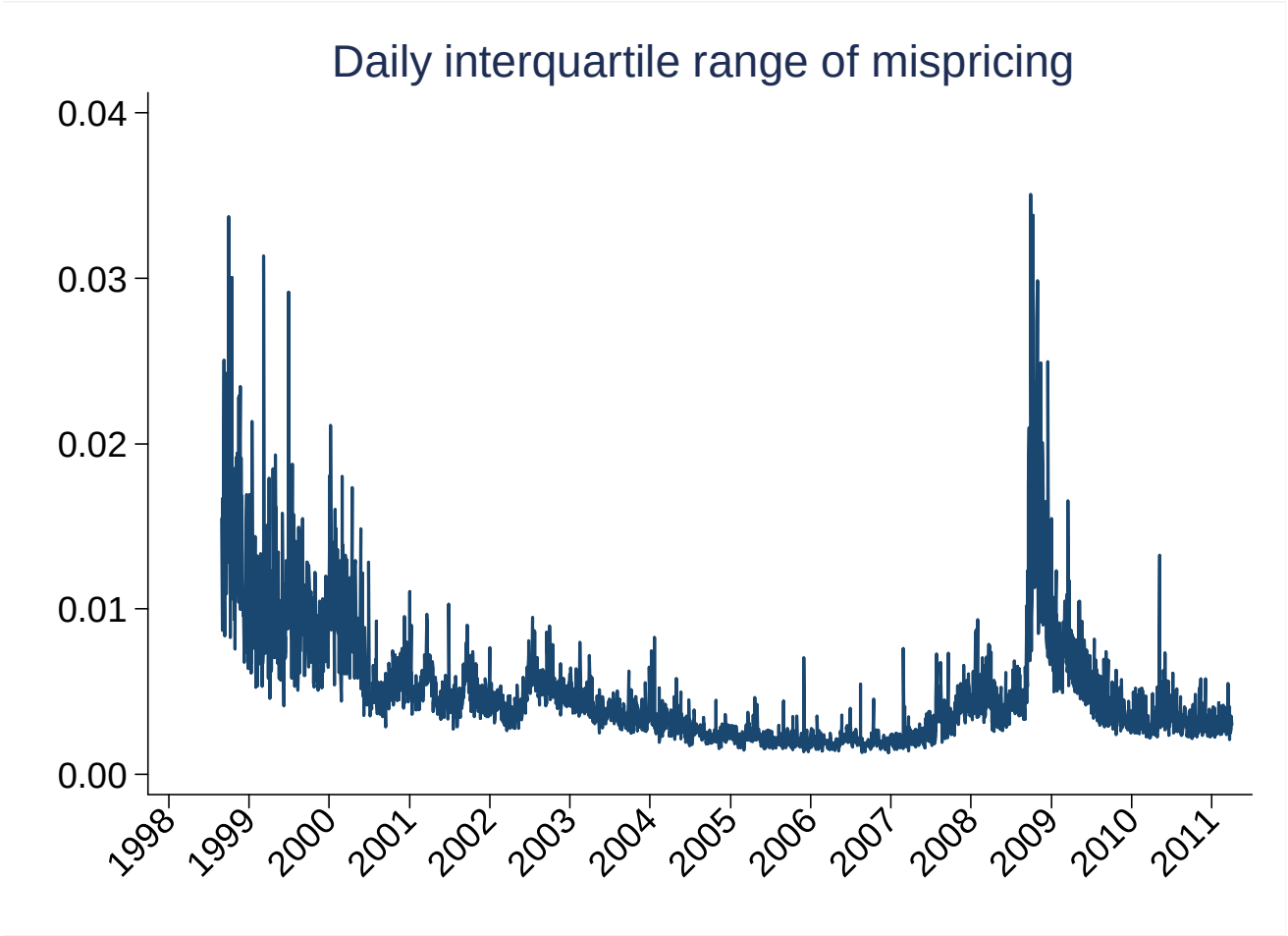
BEFORE TROUGH

	N	Mean	S.D.	Min	Median	Max
Return S&P500	945	-0.0000616	0.000209	-0.00136	-0.0000234	0.000713
SPY mispricing	945	-0.000132	0.00104	-0.00951	0.0000801	0.00526
Return Emini	939	-6.45E-05	0.000453	-0.00641	-0.0000316	0.00627
Return SPY	945	-0.0000679	0.000683	-0.00559	-0.0000307	0.00762
S&P500 Order Imbalance	946	-2.31E-02	0.0579	-0.34	-0.0152	0.251
SPY average short volume (t, t+5)	946	0.00148	0.00118	0.000013	0.00117	0.00916

AFTER TROUGH

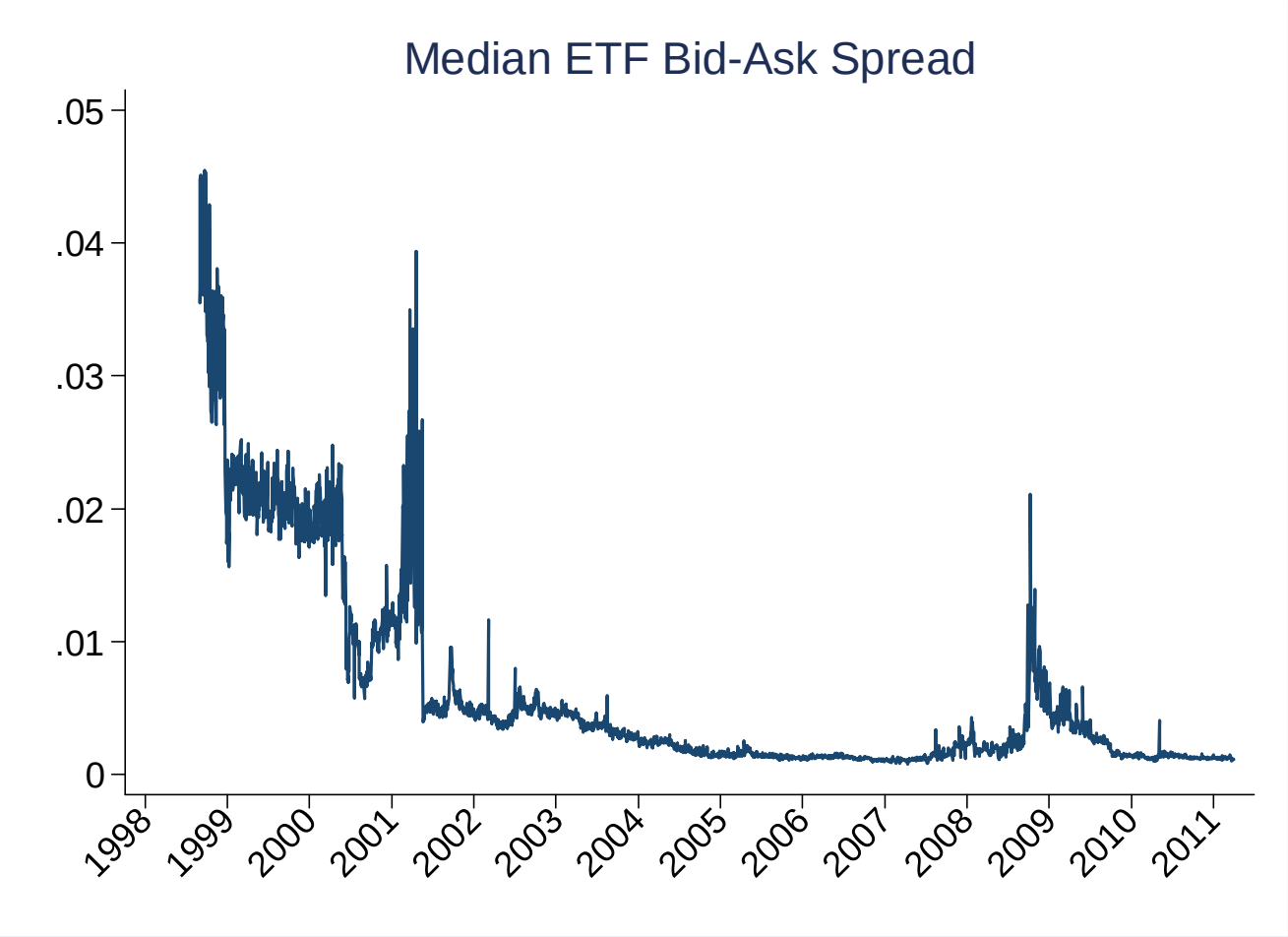
	N	Mean	S.D.	Min	Median	Max
Return S&P500	855	0.0000509	0.000636	-0.00368	0.0000393	0.00355
SPY mispricing	855	0.00735	0.00975	-0.00605	0.00214	0.0324
Return Emini	855	0.0000566	0.000559	-0.00301	0.0000201	0.00298
Return SPY	855	0.0000571	0.00344	-0.025	0.0000257	0.0251
S&P500 Order Imbalance	855	-0.000281	0.0348	-0.223	0.00287	0.14
SPY average short volume (t, t+5)	855	0.00175	0.00166	0.0000158	0.00115	0.011

Time Series of all ETFs Mispricing



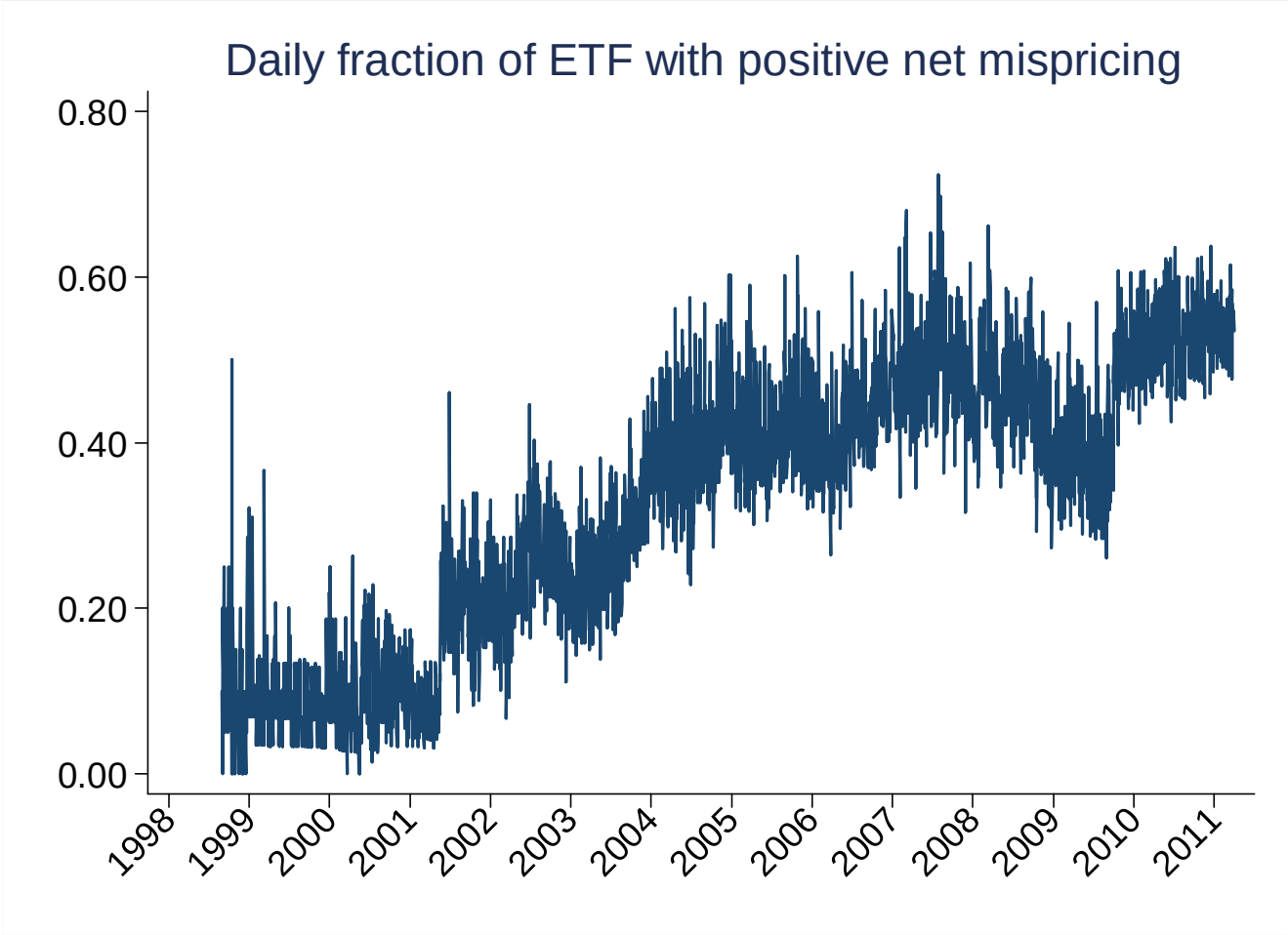
- Initial illiquidity of ETFs
- Mispricing increases in stressed markets

Time Series of ETF bid-ask spread



- Initial illiquidity of ETFs
- Bid-Ask spread increases in stressed markets

Time Series of ETF Net Mispricing



- Net mispricing = |ETF mispricing| – ETF Bid-Ask Spread
- During crisis, more ETFs with mispricing that exceeds bid-ask spread

Effect of ΔETF ownership on ΔVolatility

(stock-month level sample)

	Change in volatility			
I(small stock) × Change in ETF weight			0.088***	0.088***
			(4.160)	(4.128)
Change in ETF weight	0.030**	0.031***	-0.012	-0.011
	(2.556)	(2.618)	(-0.946)	(-0.876)
I(small stock)			0.012***	0.029***
			(2.733)	(3.161)
Change in institutional ownership	0.008***	0.008***	0.007***	0.007***
	(6.555)	(6.818)	(5.535)	(5.475)
I(small stock) × Change in institutional ownership			0.001	0.002
			(0.394)	(0.793)
Stock fixed effects	No	Yes	No	Yes
Calendar day fixed effects	Yes	Yes	Yes	Yes
Observations	431,807	431,807	431,792	431,792
Adj. R^2	0.101	0.102	0.101	0.102
Number of stocks		9,279		9,279

- 1% increase in the ETF weight raises daily volatility by 3 bps
- For the median stock in Dec 2010 (4.3% ETF ownership), volatility increased by 13 bps (3.4% of daily volatility)
- For stock in 90th pctl in Dec 2010 (7.9% ETF ownership), volatility increased by 24 bps (6.3% of daily volatility)

Effect of new S&P500-ETFs introduction on volatility

(stock-month level sample)

Sample: 2 months around	Dependent variable: Daily volatility (%)					
	introduction of IVV			introduction of VOO		
	(1)	(2)	(3)	(4)	(5)	(6)
Post introduction × Stock in index	0.571***	0.475***	0.427***	0.176***	0.183***	0.227***
	(6.955)	(6.090)	(5.757)	(3.305)	(3.689)	(5.120)
Post introduction	-1.464***	-1.365***	-1.408***	-0.404***	-0.250***	-0.398***
	(-36.036)	(-36.000)	(-37.876)	(-11.872)	(-7.622)	(-7.395)
Stock in index	-2.566***	-1.897***		-1.407***	0.157**	
	(-24.854)	(-15.168)		(-28.588)	(2.143)	
Month fixed effects	No	Yes	Yes	No	Yes	Yes
Stock fixed effects	No	No	Yes	No	No	Yes
Observations	13,127	13,092	13,092	8,004	7,973	7,973
Adj. R^2	0.069	0.324	0.301	0.061	0.352	0.255
Number of stocks			6,687			4,029

- Two new S&P500 ETFs: iShares (May, 2000) and Vanguard (Sep, 2010)
- Arguably: exogenous event relative to stock volatility
- Volatility went up for stocks in the S&P 500 in the month after the introduction of the two ETFs:
  - 50 bps increase in daily volatility after iShares
  - 20 bps increase in daily volatility after Vanguard

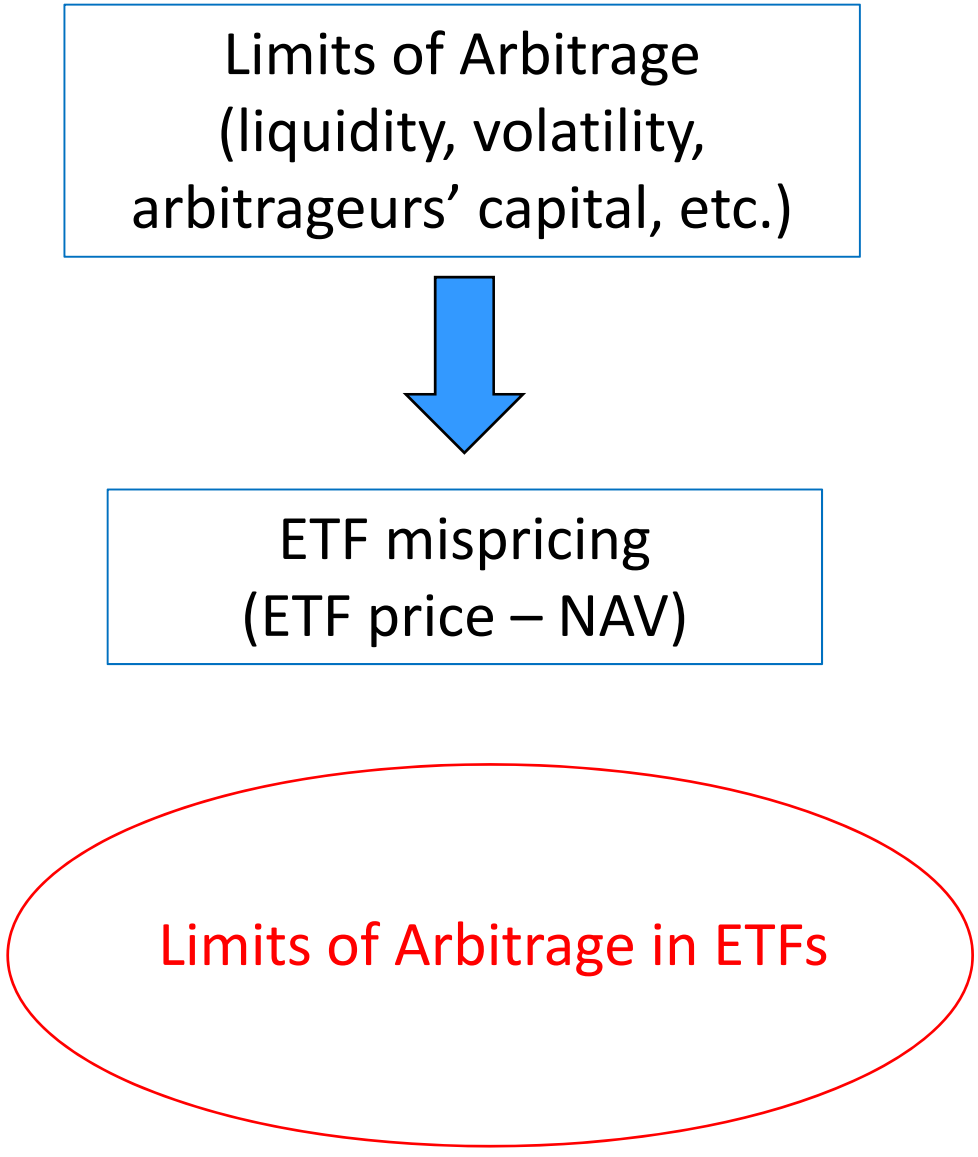
ETF ownership, Volatility, and Limits of Arbitrage

(stock-month level sample)

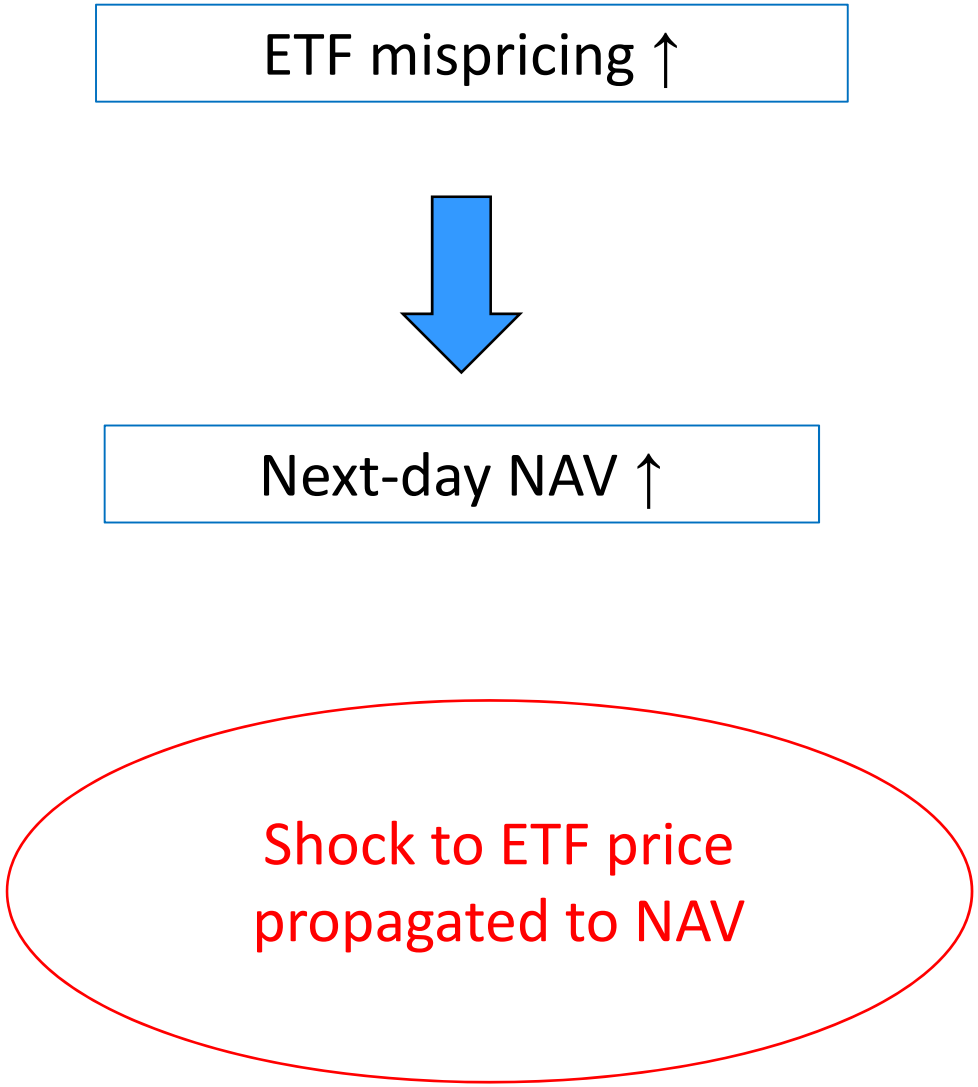
	Daily volatility in month t			
Avg interquartile mispricing × ETF weight	-9.297***	-12.016***	-3.803***	-9.053***
	(-7.136)	(-9.683)	(-2.621)	(-6.520)
Avg interquartile mispricing × Institutional ownership			-0.933***	-0.463***
			(-10.579)	(-5.111)
ETF weight	-0.135***	-0.014	-0.080***	0.010
	(-20.008)	(-1.598)	(-10.672)	(1.148)
Institutional ownership			-0.009***	-0.010***
			(-16.418)	(-13.383)
log(market capitalization)	-1.092***	-1.061***	-1.033***	-0.992***
	(-72.330)	(-67.173)	(-68.584)	(-60.154)
log(volume)	0.771***	0.944***	0.813***	0.967***
	(59.082)	(88.594)	(63.724)	(89.997)
Stock fixed effects	No	Yes	No	Yes
Calendar day fixed effects	Yes	Yes	Yes	Yes
Observations	639,547	639,547	639,411	639,411
Adj. R^2	0.481	0.396	0.492	0.400
Number of permnos		9,081		9,081

- The impact of ETF ownership on stock volatility is smaller at times when limits of arbitrage are stronger
  - Controlling for ownership by all institutions

Preview of Results: Limits of Arbitrage

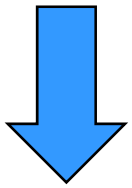


Preview of Results: Effect on Returns



Preview of Results: Effect on Volatility

ETF stock ownership ↑



Stock volatility ↑

ETFs increase volatility of underlying stocks

Preview of Results: Flash Crash