(Why) Have Financial Markets Become More Volatile?
The Role of Index Trading

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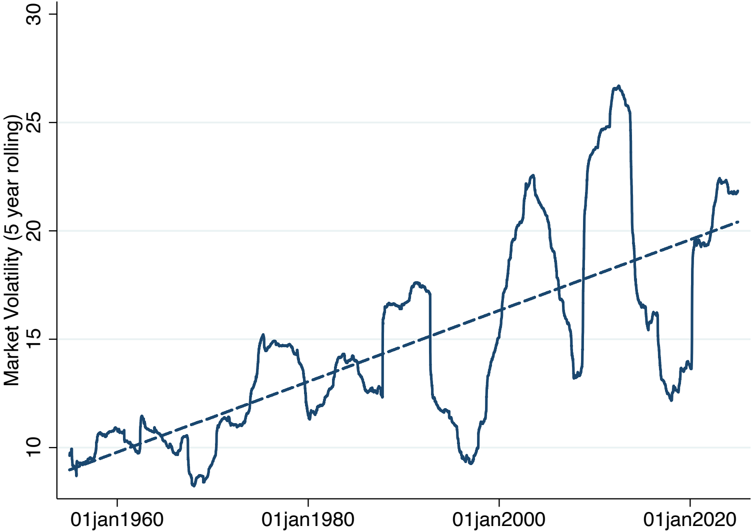
New Fact: Rising Stock Market Volatility, Past 70 Years



Stock Market Volatility

Volatility doubles since 1955 from 10% to 20%

- Not volatility of fundamentals, holds excluding recessions / extreme events
- *Market* volatility, not idiosyncratic volatility
- Smaller increase as we go from daily ($>$100%) to weekly (75%) to monthly returns (40%)

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  - **We used to trade stocks, now we trade the stock market ... nearly 24 hours a day**

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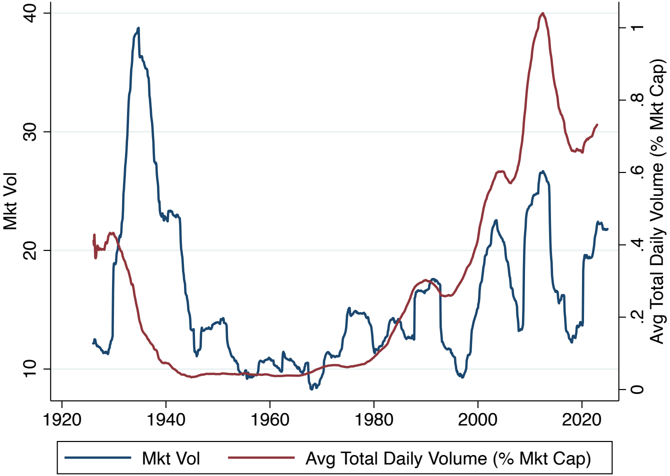
- Coincides w/ *increased trading of the market* (e.g., indices) vs trading individual stocks
  - **We used to trade stocks, now we trade the stock market ... nearly 24 hours a day**
- Causal evidence from introduction of E-mini S&P500 futures, increased variance of market during non-trading hours but not average idiosyncratic variance of individual stocks
- Increased trading hours causes higher volatility (e.g., reverse of 1968 Wednesday closures)

Volatility and Total Volume



Increase in volume largely driven by “trading the market”

Outline

- Connections to literature
- Understand the facts
- Rise of trading the market index
- Natural experiment using introduction of E-mini futures & changes in trading hours
- Model w demand shocks: introduce index trading

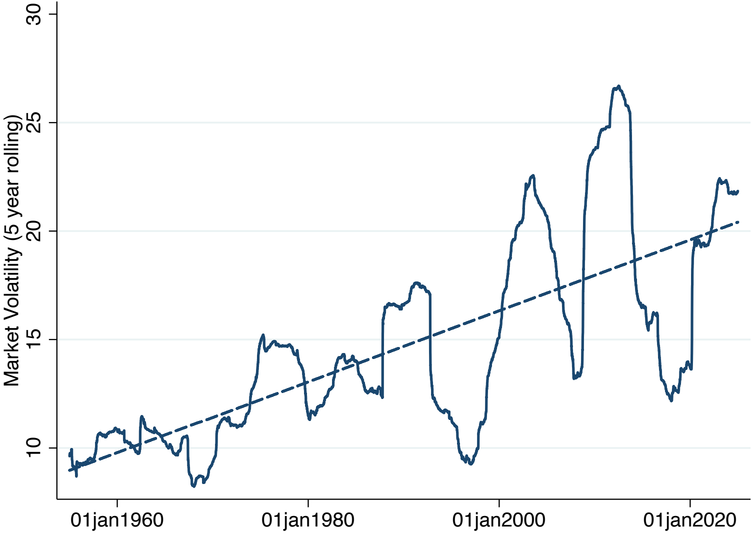
Connections to literature

- Index inclusions: e.g., Shleifer ...
- Benchmarking: e.g., Basak and Pavlova
- ETF trading and volatility of underlying: e.g., Ben-David et al....
- Trading and volatility: e.g., French and Roll (1986)
- Trends in idiosyncratic vol: e.g., Campbell et al (2000)

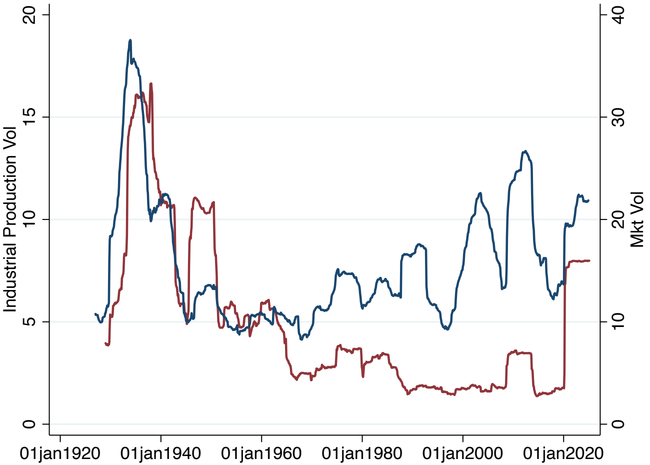
Literature documents that non-information-based trading can increase volatility and comovement New fact about aggregate volatility, lean on and extend earlier literature on trading and stock volatility

Understanding the Rise of Market Volatility

Rising Stock Market Volatility, Past 70 Years



Volatility of fundamentals: IP Growth



Divergence in macro vs stock vol in last 60 years. Much more robustness: vol of GDP growth, vol of corp profits, exclude recessions, etc

Longer Horizon Returns

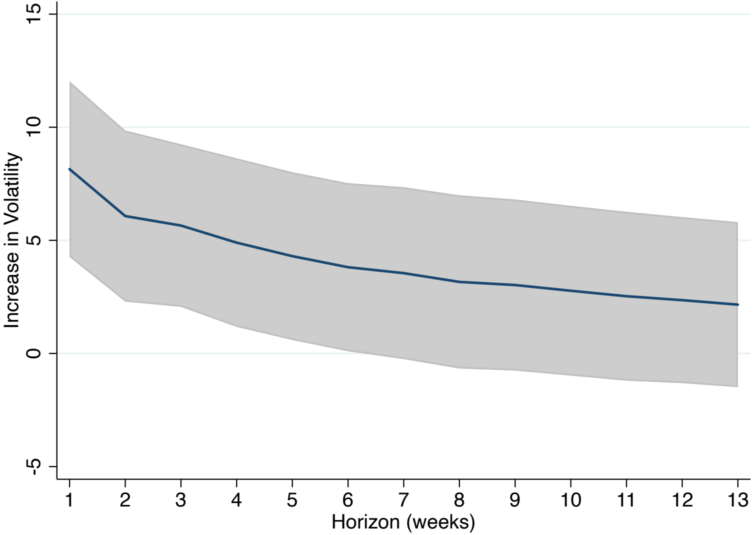
Trend = 0 in 1955, 1 in 2025

	(1) Daily Data	(2) Weekly	(3) Monthly (4-week)
Trend	11.48***	8.19***	4.88***
	(1.90)	(2.02)	(1.85)
Constant	8.32***	10.76***	12.33***
	(1.18)	(1.16)	(1.06)
N	17,620	3,652	3652
R^2	0.52	0.37	0.19

Vol based on daily returns increases 130%, weekly 75%, monthly 40%

Effects must be about patterns in financial markets that affect dynamics, not fundamentals

Longer Horizon Returns



Reminder: Vol and Autocorrelation

Let r_t be log return on day t, and $r_t + r_{t+1}$ be the log 2-day return. Then

$$
\begin{aligned}
var(r_t + r_{t+1}) &= var(r_t) + var(r_{t+1}) + 2cov(r_t, r_{t+1}) && (1) \\
&= 2\sigma^2 (1 + \rho) && (2)
\end{aligned}
$$

where $\rho = corr(r_t, r_{t+1})$

Negative autocorrelation, $\rho < 0 \Rightarrow var(r_t + r_{t+1}) < 2\sigma^2$, volatility decreases with horizon

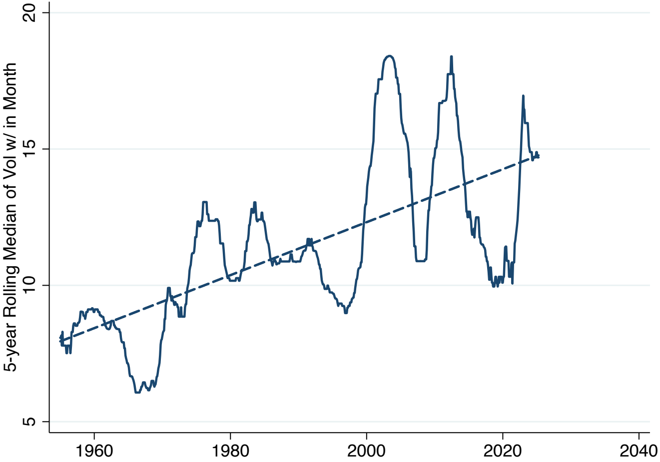
Concerns about Stale Prices

- If some stocks don't trade in a day, market autocorr> 0 & daily variance "too low"
- Robustness: use *volume* weighted returns within 500 largest stocks

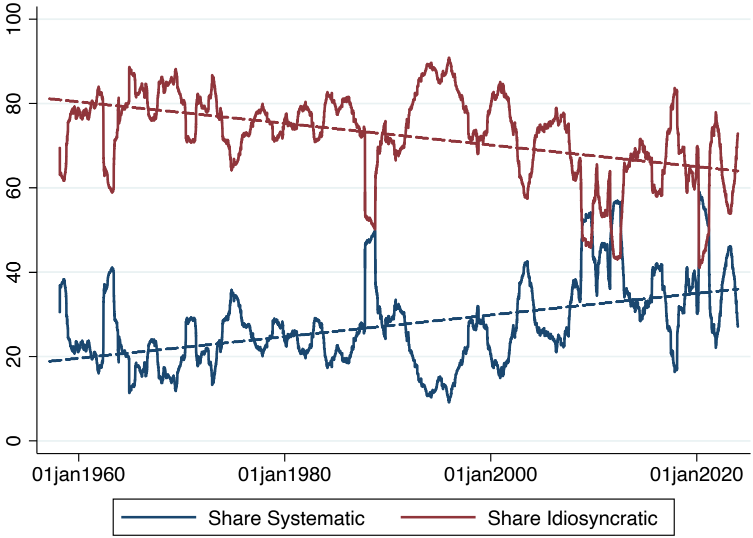
	(1) Volume Weights	(2) Mkt Cap Weights
Trend	13.03***	11.48***
	(3.31)	(1.90)
Constant	11.35***	8.32***
	(2.06)	(2.20)
Observations	17,620	17,620
R-squared	0.36	0.52

Concerns About "Outliers" in Volatility

Vol is right skewed with some extreme events. Compute volatility in a month using daily returns in that month, then compute rolling 5-year *median* of monthly observations



Rise in systematic risk for individual stocks



The Role of Trading the Market Index

Trading the market index

"*There's been an incredible movement to indexing [...], and yet there's been an incredible increase in trading volume. [...] What's happened, unfortunately, is it turns out, like a lot of things that can be used for good, they can also be used for bad. And you know, index funds are the ideal market timing vehicle. [...] And I think that really comes to what happened to the marketplace is it's kind of instead of individual stock selection, it's kind of like a big gambling casino*"

–David Booth[1]

[1] Odd Lots Podcast, Eugene Fama and David Booth on the Birth of Modern Finance, minute 27

Trading the market index

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–David Booth[1]

Translation: people used to trade stocks, now they trade the stock market... in huge amounts

[1] Odd Lots Podcast, Eugene Fama and David Booth on the Birth of Modern Finance, minute 27

Trading the market index

Argument: more vol in market index bc more people trading the market index. Examples:

- Rise of index investing since 1980s
- S&P500 futures in 1980-90's, SPY ETF in 90's
  - Volume went from 50% to about 250-300% of total market volume over last 30 years
- Options, other ETFs

Trading the market: preliminary evidence

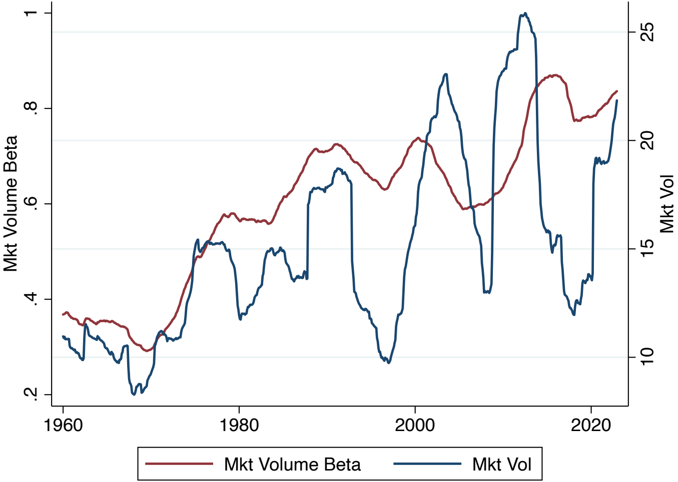
Suppose I buy the market portfolio. My trade creates volume for every stock i proportional to market cap of stock i.

Cross-sectional regression *at every time period* t:

$$Volume_{i,t} = a_t + b_t MktWeight_{i,t-1} \times TotVolume_t + \varepsilon_{i,t} \tag{3}$$

If all trades were investors trading the market index, then $b_t = 1,\ R^2 = 1,\ a_t = 0$

Trading the market



Similar increase in R^2, decrease in a_t

Causal Evidence: Trading the Market Causes Mkt Vol

E-mini futures introduced Sept 9, 1997, led to large volume trading in S&P500

- Could trade index futures during non-trading hours, unlike individual stocks
- Compare variance of S&P500 overnight vs intraday before and after
- ... relative to the same comparison for individual stocks in the S&P500 (idiosyncratic vol)
- ... controls for, e.g., "more news arrived overnight" during this period
- We use 1 month rolling variances, so effect fully there in October 9, 1997

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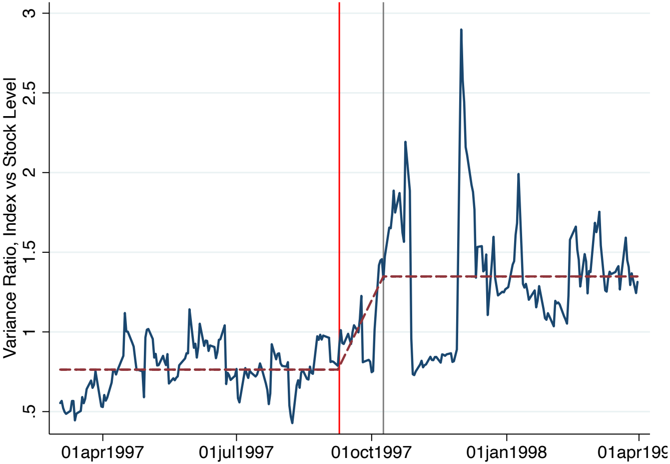
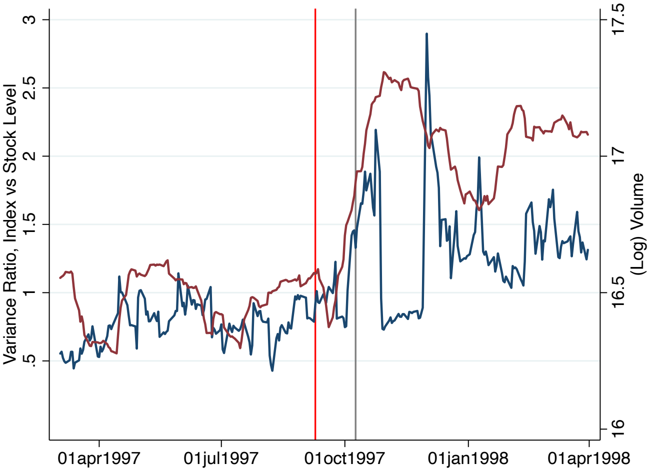
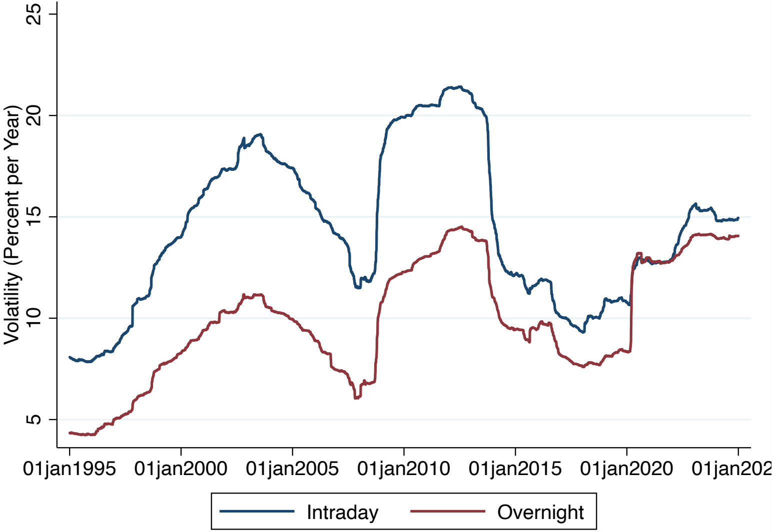


Causal Evidence: Lines up with spike in futures volume



The rise of overnight volatility on S&P500



Causal Evidence 2: IV using trading hours

French and Roll (1986)

- Paperwork backlog in 1968, NYSE closed on Wednesdays from June-December 1968
- *Thursday return is now a 2-day return*
- But ... variance of Thursday return didn't change! Total weekly variance falls

We exploit 8 changes in trading hours on NYSE, 1952-1985. Additional examples:

- 1952 cut from 6 to 5 trading days / week
- extensions of trading day from 4 hours in 1969 to eventually 6.5 hours today

Causal Evidence 2: IV using trading hours

$$
\begin{aligned}
ln(\sigma_t) &= a + b \times ln(VM_t) + \varepsilon_t && (4) \\
ln(VM_t) &= a_0 + \gamma \times ln(trading\ hours_t) + \nu_t && (5)
\end{aligned}
$$

Use trading hours only in 6 month window before and after changes as instrument for weekly volume (VM) to see how trading activity affects volatility (σ).

Assumptions: (1) increase in trading hours only affect volatility through increased trading activity, (2) decision to increase hours does not depend on volume 6 months before / after change (not saying increased demand for trading doesn't affect trading hours in general)

On (2): robust to tighter 3-month window, tradeoff on statistical precision

Causal Evidence: IV using trading hours

	(1) OLS	(2) IV	(3) First Stage
	σ on VM	σ on VM	VM on Hours
Log Volume	0.72***	1.42**	
	(0.12)	(0.72)	
Log Trading Hours			1.02***
			(0.31)
Observations	326	326	326
R-squared	0.54	0.49	0.90
FE: Week & Event	Y	Y	Y

A Model of Index Trading

Model of Index Trading

Similar to Campbell Grossman Wang (1993), CARA normal setting

- No index trading
  - Investors (B & C) w demand shocks trade individual stocks (1 & 2)
  - Arbitrageur (A) accommodates (mostly idiosyncratic) demand

- Introduce index trading: low cost way to hold market
  - Investors (B & C) w demand shocks now trade the market
  - Arbitrageur (A) accommodates systematic demand

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- Introduce index trading: low cost way to hold market
  - Investors (B & C) w demand shocks now trade the market
  - Arbitrageur (A) accommodates systematic demand
  - **Result**: market volatility $\uparrow$, market trading $\uparrow$, market autocorrelation $\downarrow$

Model Setup: Cash Flows

Dividends for stocks 1 & 2

$$\begin{aligned} D_{1t} &= \frac{1}{2} D_{mt} + \varepsilon_t, \\ D_{2t} &= \frac{1}{2} D_{mt} - \varepsilon_t, \end{aligned} \tag{6}$$

where $D_{mt} \sim N\left(0, \sigma_m^2\right)$, $\varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right)$

Note: $\pm\varepsilon_t$ just defines "idiosyncratic risk" w 2 assets, vs N uncorrelated shocks w N large

Trading Individual Stocks

Beliefs of individual traders (extrapolation):

$$E_t^{B}\left(D_{1t+1}\right) = \rho D_{1t} \tag{7}$$
$$E_t^{C}\left(D_{2t+1}\right) = \rho D_{2t} \tag{8}$$
$$\tag{9}$$

Demands:

$$X_{1t}^{B} = \frac{\alpha + (1+\beta)\,\rho D_{1t} - R_f P_{1t}}{a\sigma_R^2} \tag{10}$$
$$X_{2t}^{C} = \frac{\alpha + (1+\beta)\,\rho D_{2t} - R_f P_{2t}}{a\sigma_R^2} \tag{11}$$

Model of Index Trading

Rational Arb A

$$X_t^A = \frac{1}{\tilde{a}} \Sigma_t^{-1} (\mu_t - R_f P_t) \tag{12}$$

where $\mu_t = E_t(P_{t+1} + D_{t+1})$

Result: arb takes *stock level risk* ε, individual stocks volatile bc individual demand shocks, gain from stock level reversal

Introduce Index Trading

Now B & C investors can (and do) trade in *both* stocks 1 & 2, belief $\rho D_{m,t}$

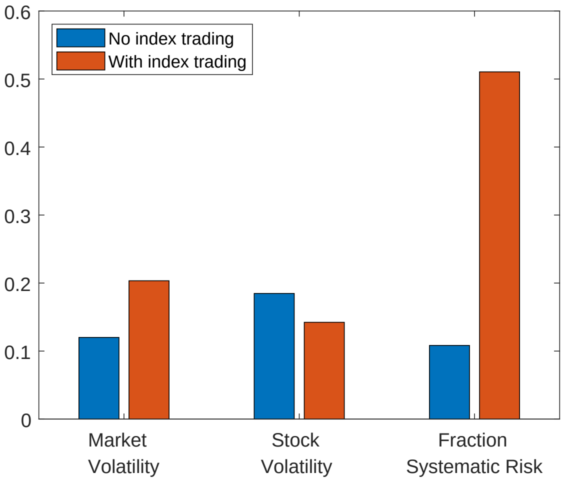
$$X_{m,t}^{B,C} = \frac{\alpha_m + (1+\beta_m)\,\rho D_{mt} - R_f P_{mt}}{a\,(1+\beta_m)^2\,\sigma_m^2}$$

Arb

$$X_t^A = \frac{\alpha_m - R_f P_{mt}}{\tilde{a}\,(1+\beta_m)^2\,\sigma_m^2}.$$

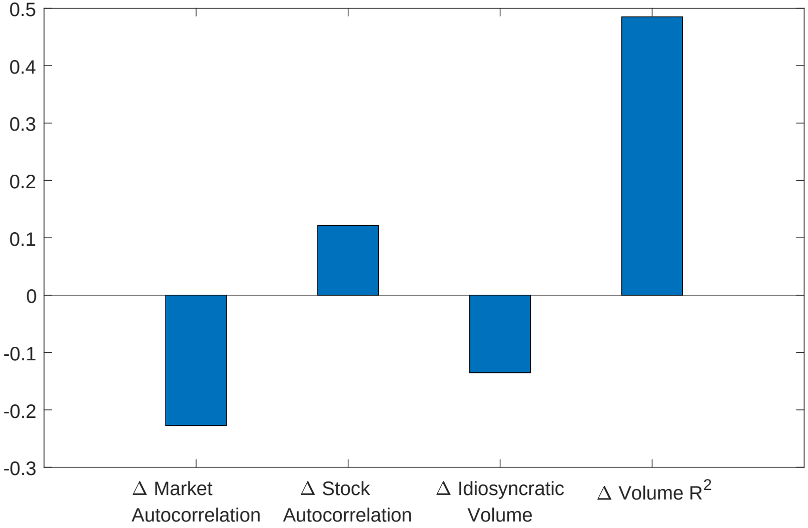
Result: arb takes *only market level risk*, overall market volatile bc of demand shocks, gain from market reversal

Model Results: Market Volatility



Mkt vol ↑, share of systematic risk ↑

Model Results: Autocorrelations and Volume



Conclusion

Stock market volatility doubles since 1950's from 10% to 20%

- Not volatility of fundamentals, holds excluding recessions
- *Market* volatility, not idiosyncratic volatility
- Smaller increase as we go from daily (>100%) to weekly (75%) to monthly returns (40%)
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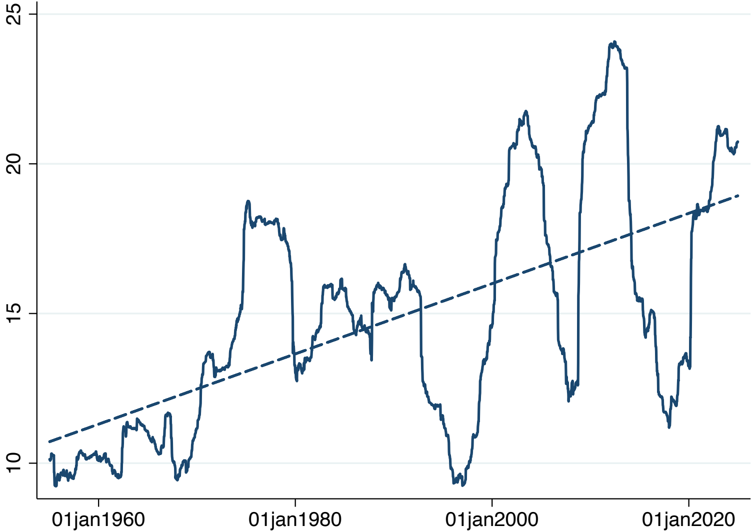
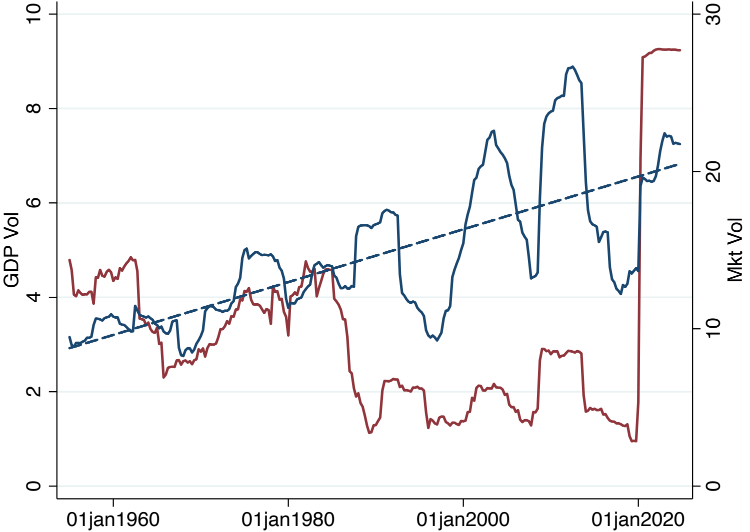
Weekly return data



Not driven by vol of fundamentals: GDP Growth



Not driven by vol of fundamentals

	(1)	(2)	(3)	(4)	(5)	(6)
Trend	11.49***	13.90***	11.82***	10.99***	11.41***	10.35***
	(1.89)	(1.56)	(2.03)	(2.12)	(1.50)	(1.25)
Recession		4.83***				
		(1.38)				
Vol ΔIndProd			0.51			
			(0.35)			
Vol ΔUnemp				0.38		
				(0.58)		
Vol ΔGDP					0.38	
					(0.32)	
Vol ΔCorpProfit						0.20***
						(0.04)
Constant	8.94***	5.51***	7.16***	8.84***	7.73***	5.14***
	(1.09)	(1.26)	(1.67)	(1.15)	(1.40)	(1.07)
Observations	840	840	840	840	292	291
R-squared	0.52	0.67	0.55	0.52	0.56	0.76

Excluding COVID: 1955-2019

	(1)	(2)	(3)	(4)	(5)	(6)
Trend	11.17***	13.30***	16.20***	14.29***	16.60***	10.51***
	(2.23)	(1.79)	(2.85)	(2.77)	(2.90)	(1.37)
Recession		4.91***				
		(1.41)				
Vol ΔIndProd			1.58**			
			(0.66)			
Vol ΔUnemp				7.71*		
				(4.37)		
Vol ΔGDP					1.71**	
					(0.76)	
Vol ΔCorpProfit						0.20***
						(0.04)
Constant	9.05***	5.66***	2.24	2.70	1.70	5.08***
	(1.19)	(1.31)	(3.01)	(3.76)	(3.40)	(1.07)
Observations	780	780	780	780	272	272
R-squared	0.45	0.63	0.55	0.52	0.57	0.73

Summarizing Horizons and Autocorrelations

- Broad patterns do not appear driven by stale prices
- Increase in Volatility of 115% (Volume-Weight Large Caps) and 75% (Weekly)
- Monthly (and longer) numbers lower but poorly estimated: realized vs true autocorr(s) create noise

Specific to Market Index: Systematic vs Idiosyncratic

Increased vol is at *market index* level

Specific to Market Index: Systematic vs Idiosyncratic

Increased vol is at *market index* level

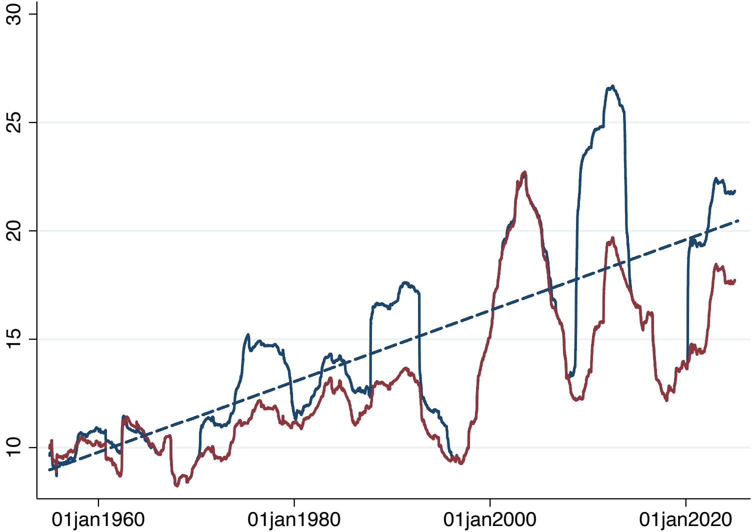
Rolling 5-year regression for every stock i:

$$r_{i,t} - r_{f,t} = \alpha + \beta(r_{mkt,t} - r_{f,t}) + \varepsilon_{i,t} \tag{13}$$

Share idiosyncratic: $var(\varepsilon_{i,t})/var(r_{i,t} - r_{f,t})$

Take value-weighted average shares (results hold using equal-weight average too)

Not just recessions



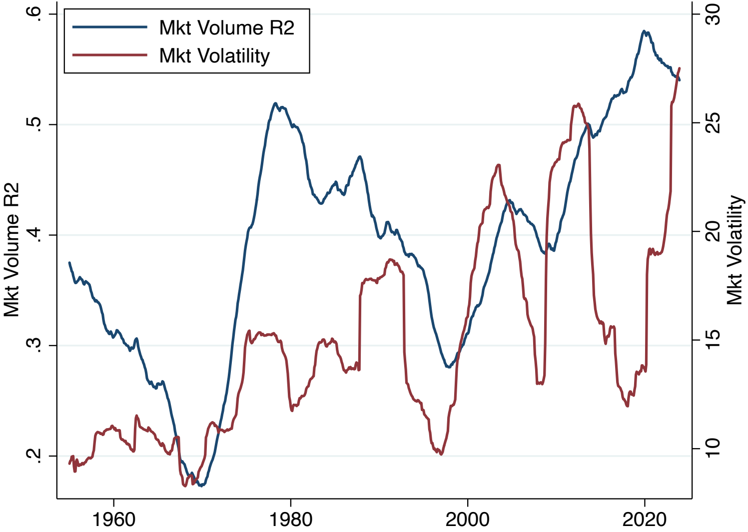
Longer Horizon Returns

Increase in vol more pronounced using daily return data (vs weekly or monthly returns)

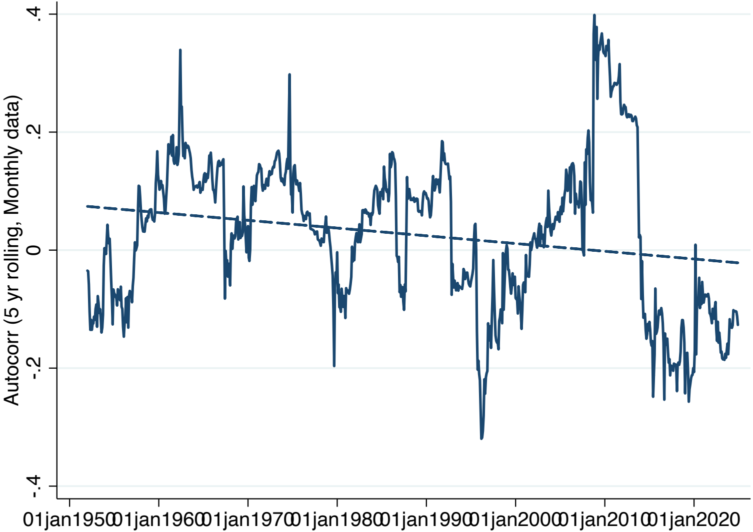
- Driven by lower autocorrelation of returns
- Rules out "fundamental" stories immediately
- Must be about financial market behavior itself

Construct rolling 5-year volatilities using weekly and monthly returns

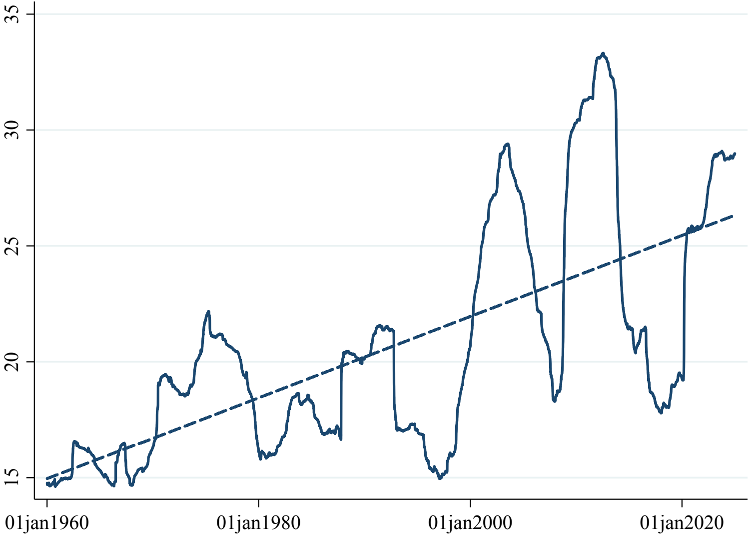
Trading the market: R-squared



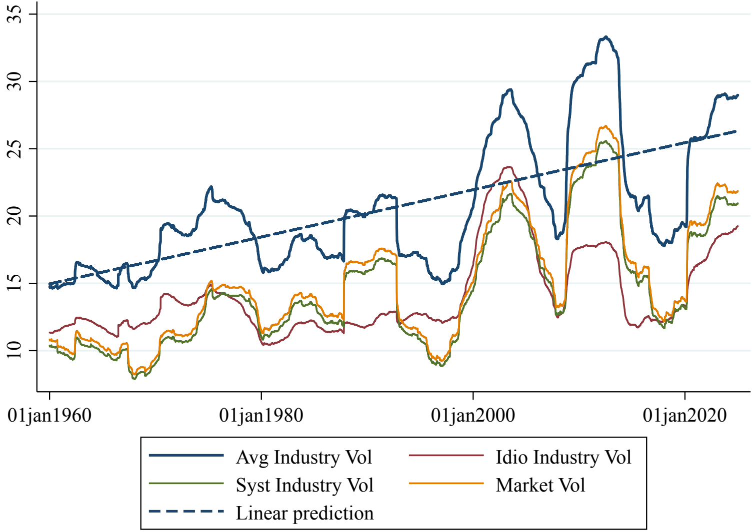
Realized Autocorrelation of Monthly Returns



Industry returns



Industry returns: Mostly mkt vol not idiosyncratic



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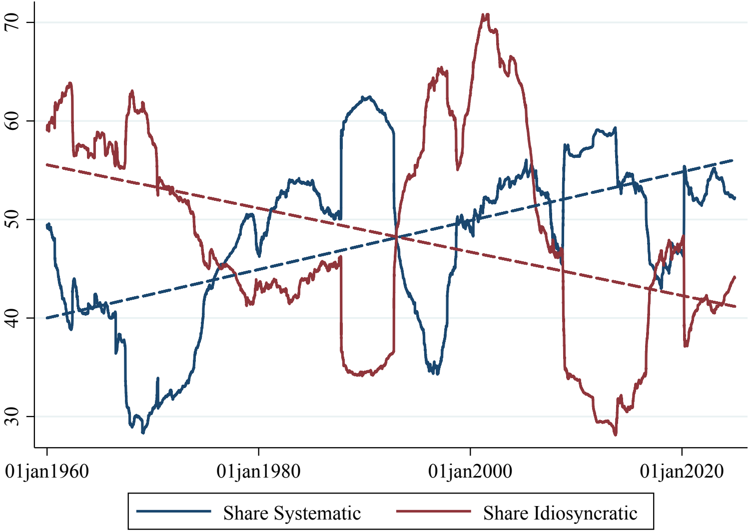

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	(1.90)	(2.02)	(1.67)	(1.27)	(0.93)
Depression					15.00***
					(2.99)
Constant	8.32***	10.76***	13.08***	15.43***	14.54***
	(1.18)	(1.16)	(0.96)	(1.16)	(0.87)
N	17,620	3,652	876	2,502	2,502
R^2	0.52	0.37	0.25	0.20	0.53

Vol based on daily returns increases 130%, weekly 75%, monthly 40% (noisy)