Market turbulence, monetization, and universality

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Flash crash, India

Flash crash, QCOR, (4days)

Same crash, lower resolution

QCOR, once more (3 days)

QCOR, volatility fluctuation

AMRN, midday spike

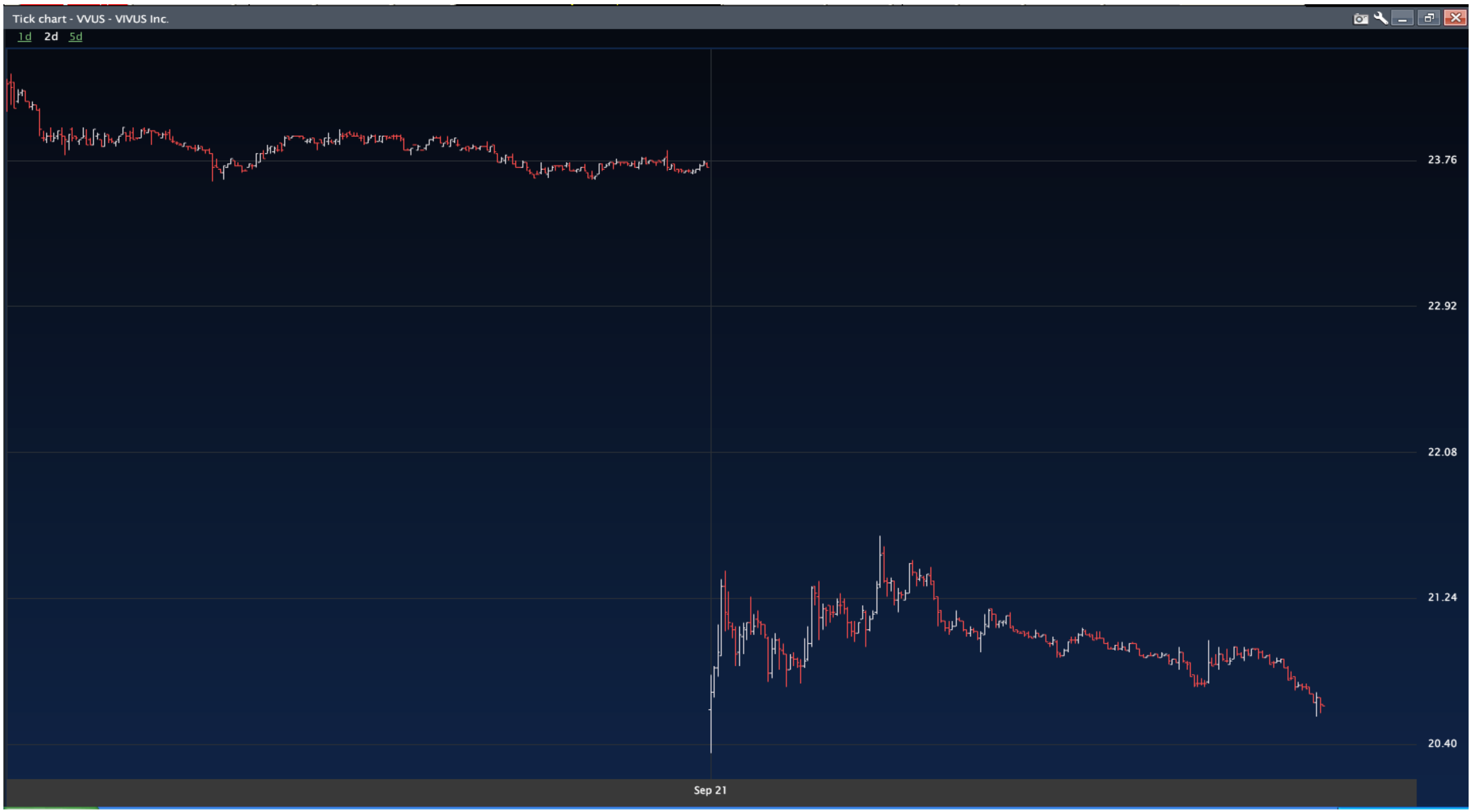
GOOG, leaked bad earnings

RIMM, good earnings

VVUS, premarket crash

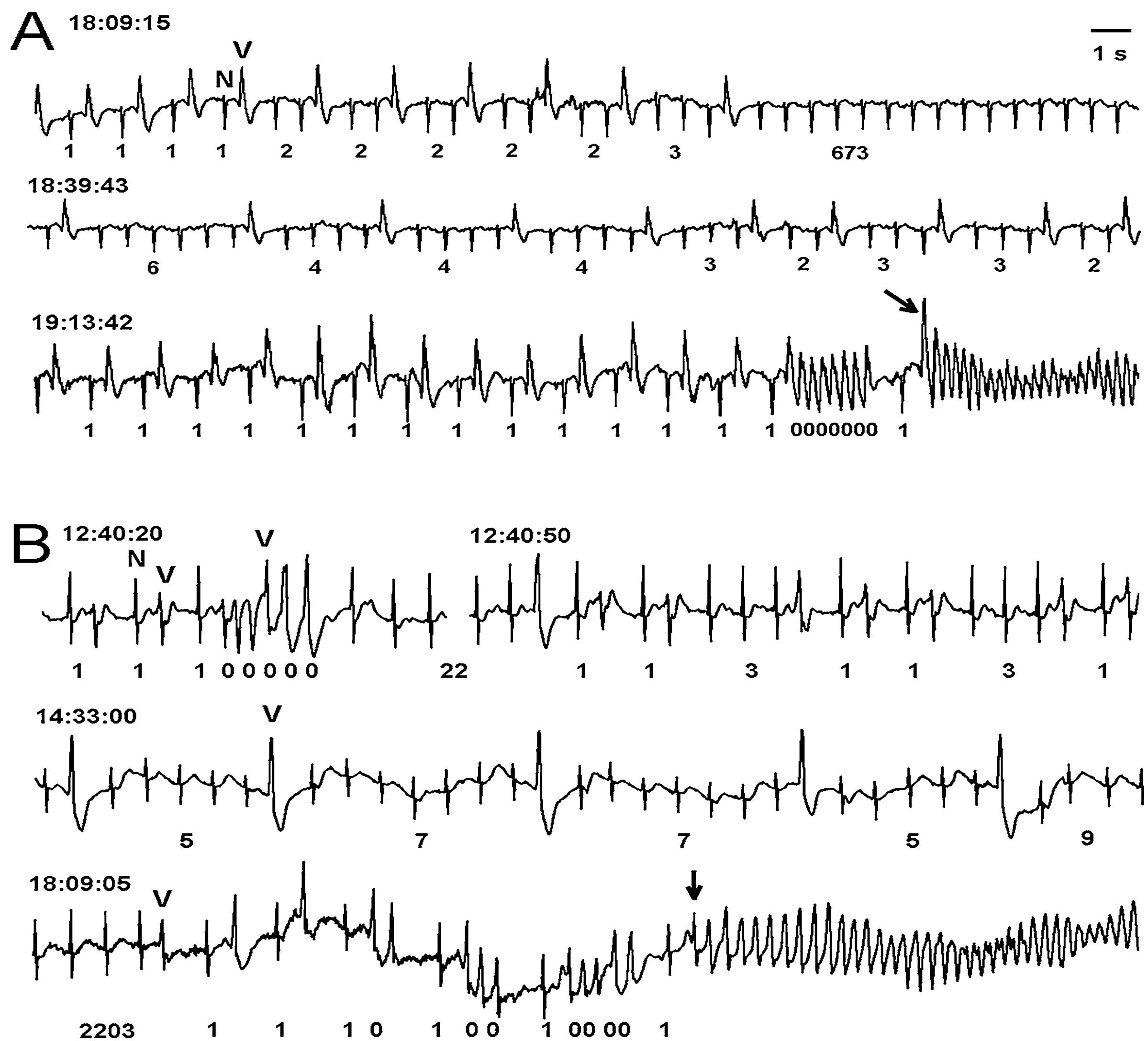
Note the pre/post opening volume differences

VVUS, same graph missing premarket activity

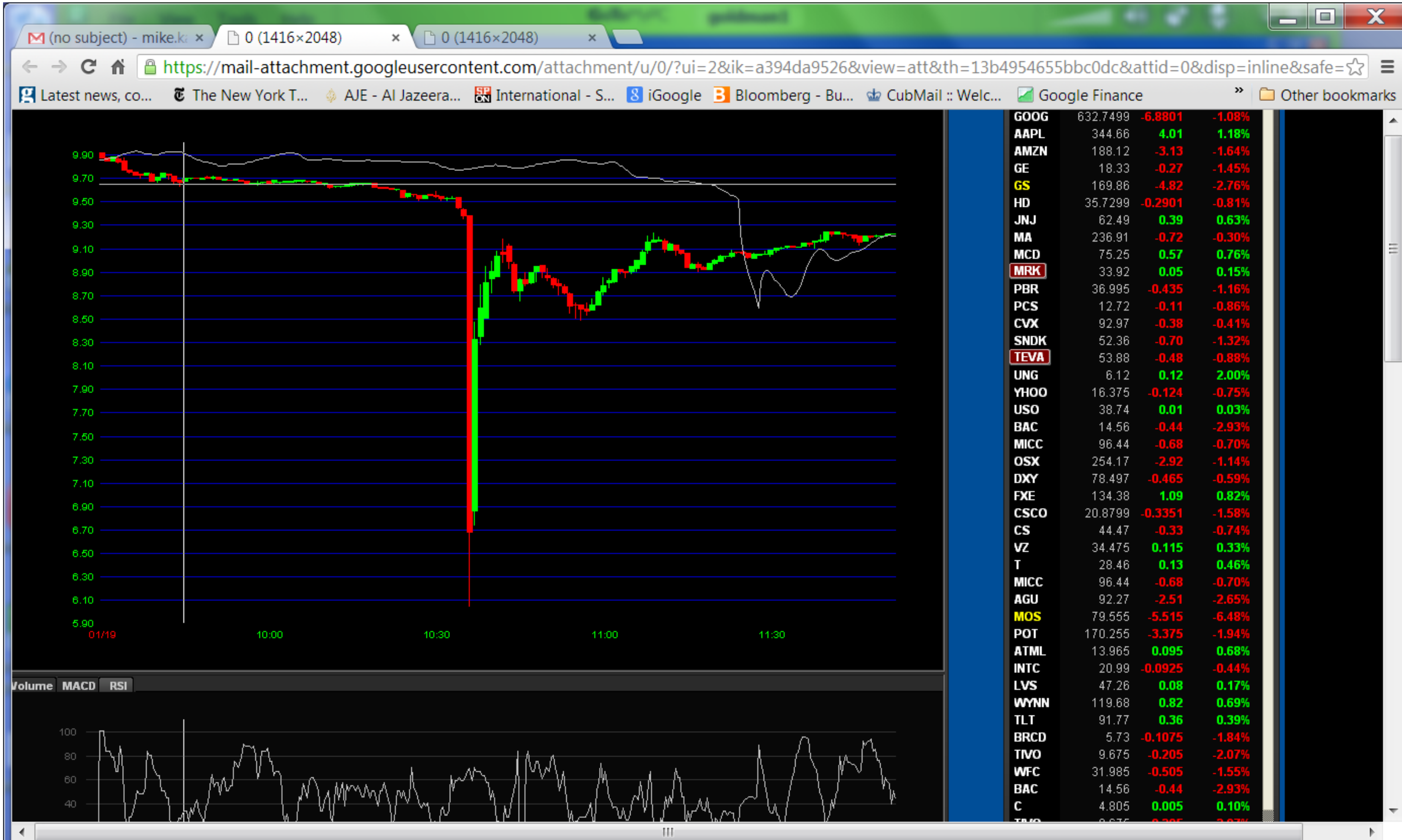


Water drop

Cardiac shock (Leon Glass, et. al)



MNKD flash crash



AAPL flash crash, feb 10, 2011 14:10

This past December - these happen all the time!

Open systems and shocks

- All natural open systems are subject to shocks according to chance, or experiment, or natural periodicity (weather)
- To the extent that we continue to recognize relatively stable features (slow variables) of these open systems- the systems must ***dissipate*** these shocks
- Systems which fail to dissipate inflows of energy ($$, particles, etc.) explode or evolve into something else

dissipation

- It is not that explosive or evolutionary events are not possible
- We are simply restricting ourselves to systems which have natural time frames over which approximate stability is recognizable

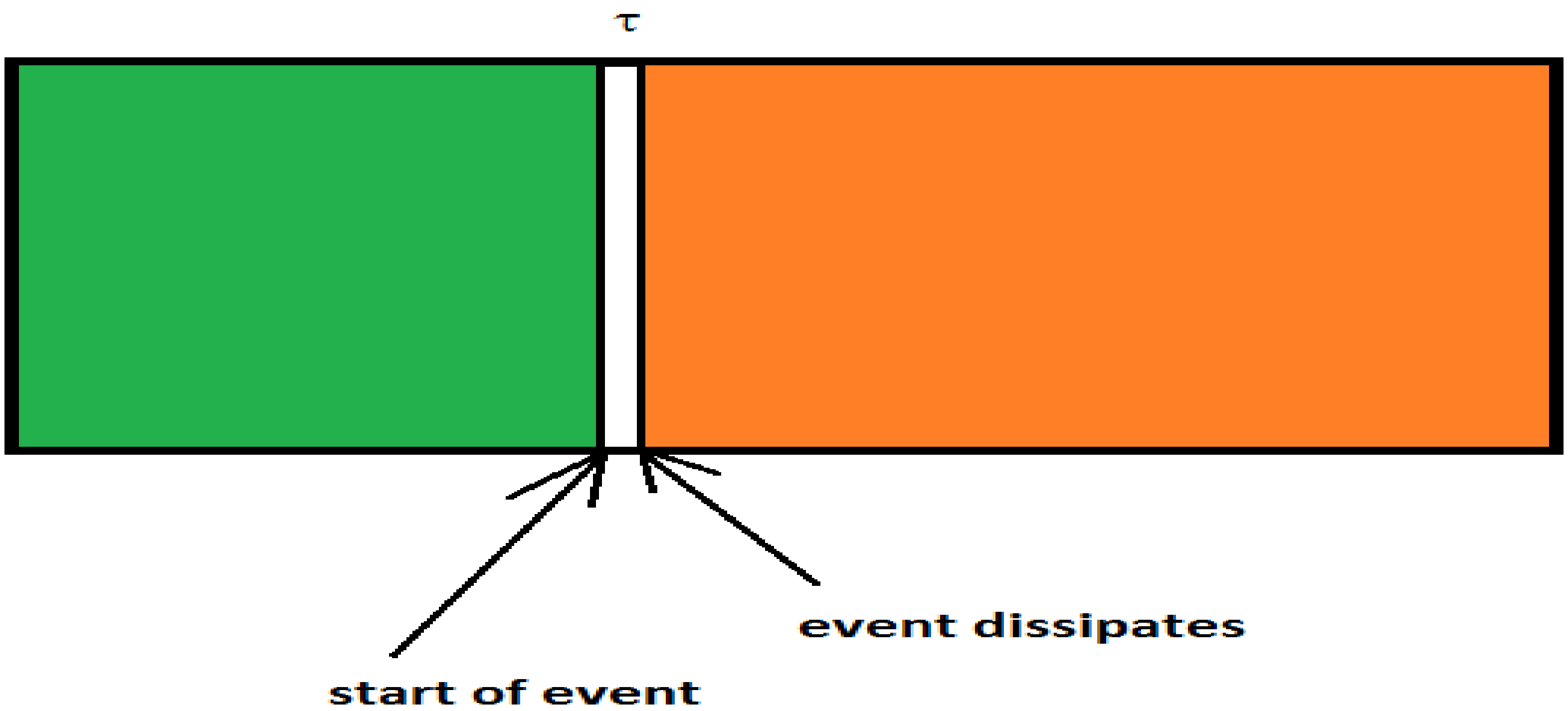
Time scales

- Suppose that for system, Y, there is a natural lifetime, T >> t.
  - Here, for concreteness, we might let $\boldsymbol{t}$ be the length a trade(s) will stay on; then **T** is say the time until expiration (or years, or the time until bankruptcy, etc.)
- Suppose that $t \sim \tau$.
  - Here, we want $\boldsymbol{\tau}$ to be the temporal size of a disturbance (a crash, earnings announcement, news, etc.)

Time scales

- In the standard trading we are interested in uneventful temporal spaces with identifiable boundary conditions
- Therefore we can generate economic models which do the things we want (price securities) between these boundaries
- Even if an event takes place we want to imagine that it is outside the regions we are solving for

Temporal regions



Temporal regions

- So in typical trading we are interested in pricing within the green and orange regions
- Here in this talk we are interested in the white region of width, τ.
- Why?
- Because τ is of a tradable width; we can put on trades of length $t \sim \tau$

Time scales

- There are *at least* 4 time scales:
  - T, t, τ and $\Im$
- $\Im$ is the ultrafast time scale of a jump or crash
- T >> t ~ τ >> $\Im$
- $\Im$ is typically not a financial time scale at all in that there may be no trades intermediate between a trade, say, of $30.00, pre-event, and $26.30, post-event
- In the illustration before, $\Im$ is essentially the width of the border between the green and white zones
- On the other hand, looking at the AAPL and RIMM events, it looks as if there is "kick-back" - a big move and a nearly as big anti-move-, so it will be safest to say we are ignoring trading at scale $\Im$

Price fluctuations

- Looking back at the RIMM or AAPL events, we see that prices may fluctuate in a range (wiggle space) and with beating (frequency)

Price fluctuations

- In the shock region prices evolve *out-of-equilibrium*
- It is important to understand what this means: **for some time-scale in the shock region all market prices of derivative securities will be "mispriced" (*with extreme likelihood*)**
- Why should this be true?
- Because options reflect an expected payout over a *mesoscopic* time-frame

Price fluctuations

- To the extent that trading occurs on a shorter time scale over which dissipation is happening the options will be underpriced…
- To the extent that trading occurs on a longer time scale over which dissipation is happening the options will be overpriced
- Here a time scale we are referring to is the inherent quasi-equilibrium time scale of the options markets

Decay vs. drift

QCOR: a practical volatility consideration

- It would not be surprising to experienced market participants that the implied volatility of QCOR immediately after the crash would be extremely elevated. The front month (September) IV was in fact ca. 380 compared with ca. 115 for the October options volatility. Over the subsequent two days until expiration, the IV dropped quickly back down to the low one hundreds. In dollar amounts, we can note that after the event, the Sep 31 straddle traded for $6.60 when the stock was at the strike.

QCOR: a practical volatility consideration

- One can see from the price of QCOR over the days following the event, that a high volatility did not in fact *“accurately reflect”* the subsequent behavior of the stock. The stock eventually settled down to unspectacular movement. However, on the scale of minutes, QCOR *did* move with a high volatility; on the scale of days its volatility was much lower.

QCOR: a practical volatility consideration

- Was the Sep 31 straddle a sale at **$6.60**? If so, why was the market **6.20-6.80** and not substantially smaller- say **3.80-4.00**? The answer is that it was a sale only to those people trading on the time scale of days, not minutes. In a thermodynamic economy, Black-Scholes and its kindred models are single time scale models. All traders in this universe have equal assessments of prices and values. In the real world traders have different temporal horizons. This is why they may trade with each other.

Are options mispriced?

- The assertion of *mispricing*- really a mismatching of time scales is a **tradable assertion**
- It can be verified by asking if dispersion trading is 1) profitable and 2) preferentially profitable in times of shock
- Caveat: currently I have no hard (statistical/mathematical) proof of these assertions but I do have limited experimental verification
- Let’s examine these now:

Oil shocks

- Kevin Kwan, Hongyi Wu and Zhengwen Zhang (three CU students) examined the response of stocks comprising the oil index, XLE, to shocks in the underlying commodity, oil.
- XLE is a broad index in that not all stocks are expected to move in direct (+) correlation with the price of oil
- The strategy, crudely defined, was to find an acceptable shock size, then dispersion ($-neutral) trade the scattered underliers for a suitable time and unwind

Oil shocks

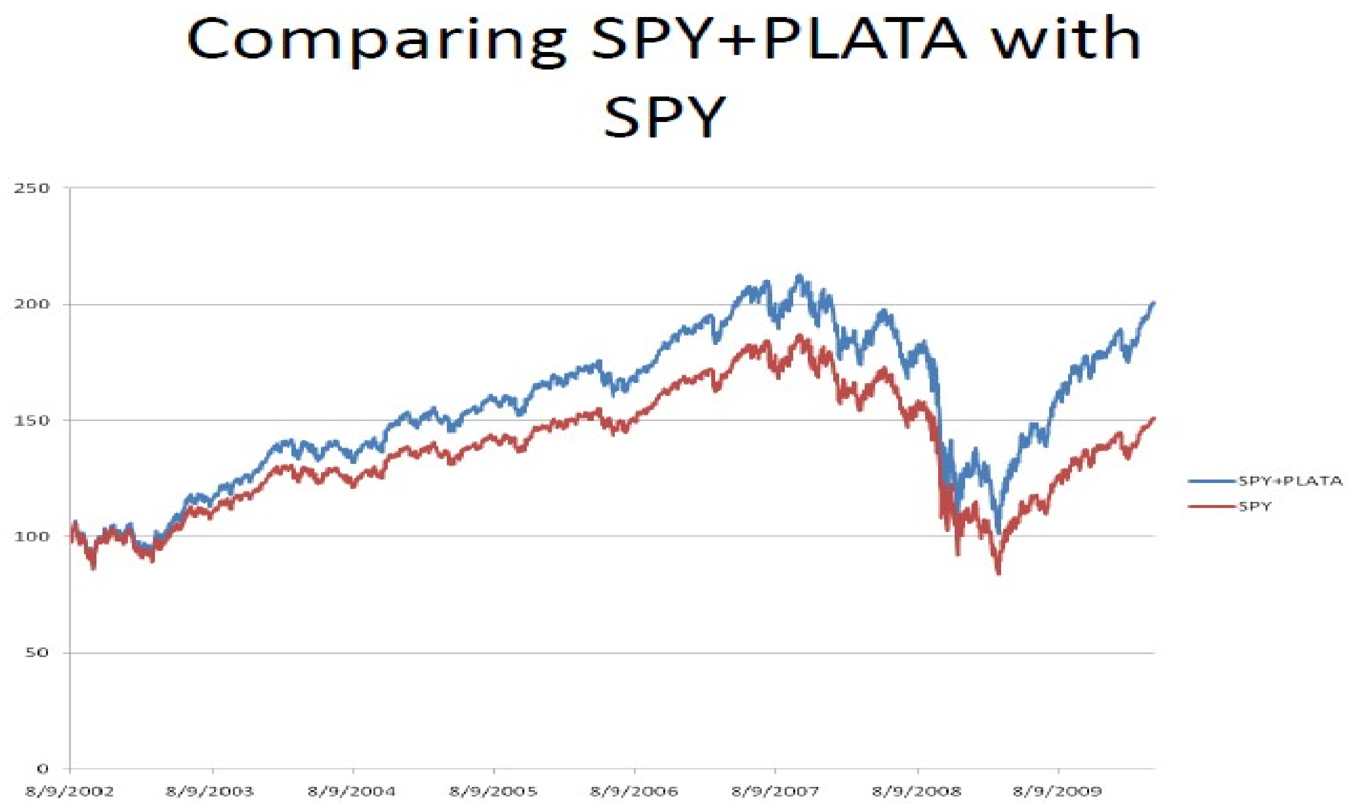
- The “crude” results: return over unadjusted trading period (4 years) → 15%
- Sharpe ratio ~ 1.5

- Return when no shock ~ -1.5%
- Strategy is a loser (small) if no shock

Broad market shocks

- Avellaneda constructed a “juiced-up” broad index which added dispersion trading back into a general fund
- Here is the pictorial evidence:

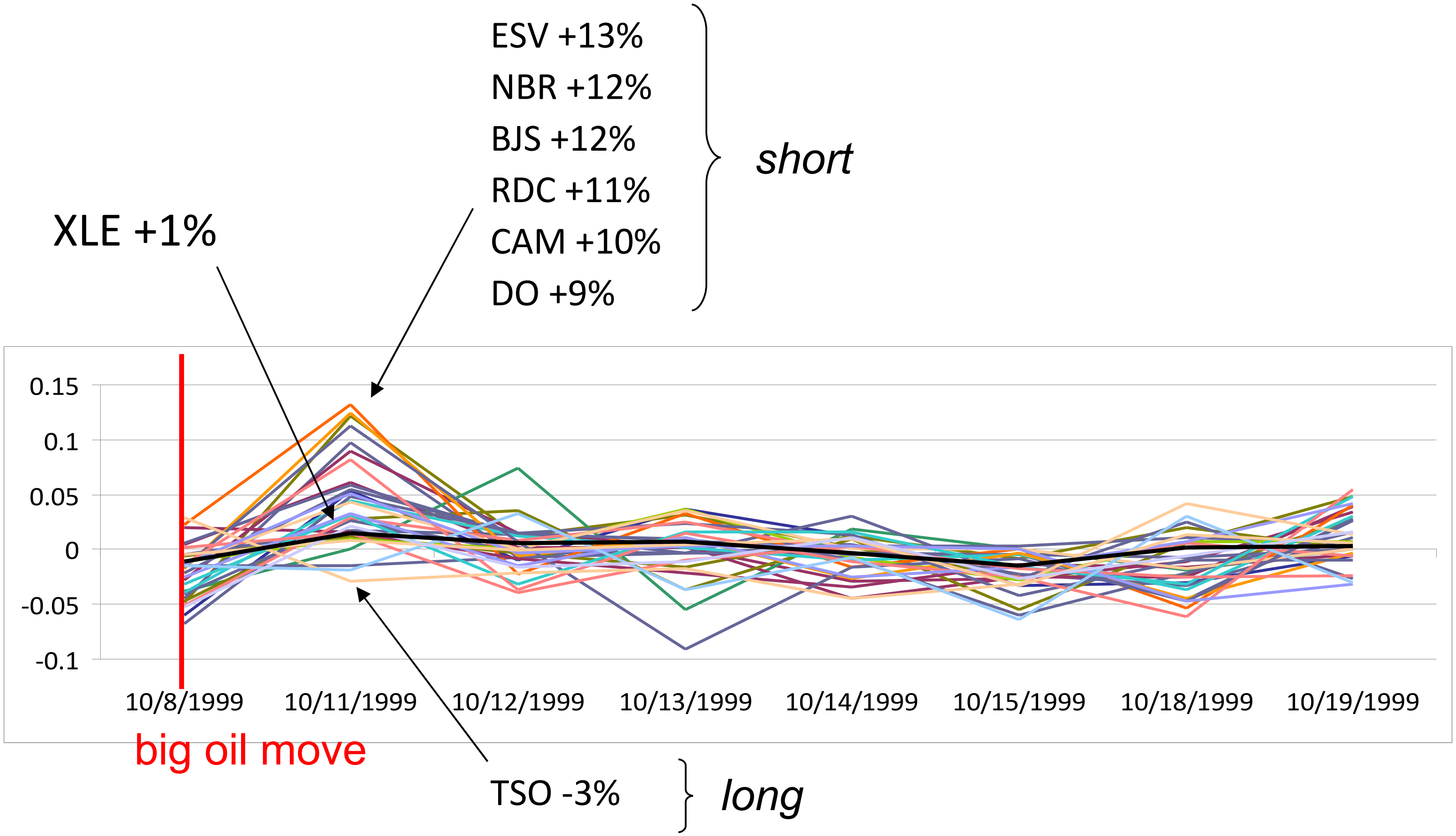
Broad market dispersion



Oil shocks in greater detail

- Here is a synopsis of the Kwan, et al. approach to monetizing shock dissipation in oil:

Strategy: Short Stock that “Diverged High”, Buy Stock that “Diverged Low”



- Successful implementation depends on calibration of appropriate parameters

Strategy Consists of 8 Parameters

- "For every p_1% change in the oil price over p_2 days, check if at least p_3 oil stocks diverged by at least p_4% from XLE within the next p_5 days"

- "If so, short $1000 of those that diverge high, buy $1000 of those that diverge low *(assuming you started that day with $1000)"*

- "Stop the trade if you gain p_6% or lose p_7%, or if p_8 days pass"

Parameters for Entering the Trade

Parameter	**Intuition**
p_1% change in oil price…	At least 5%, otherwise the shock is too small
…over p_2 days	Over several days, to ensure a definite trend and exclude noise
At least p_3 stocks to diverge…	Need divergence in many stocks, to exclude company-specific events *(e.g, earnings)*
…by at least p_4% from the index… ** Including day of shock itself*	To trade on a clear divergence, instead of noise

Parameters for Exiting the Trade

Parameter	Intuition
Stop gain p_6%	Stop after stocks converge, or stop losing if they continue to diverge.
Stop loss p_7%	
Parameter	**Intuition**

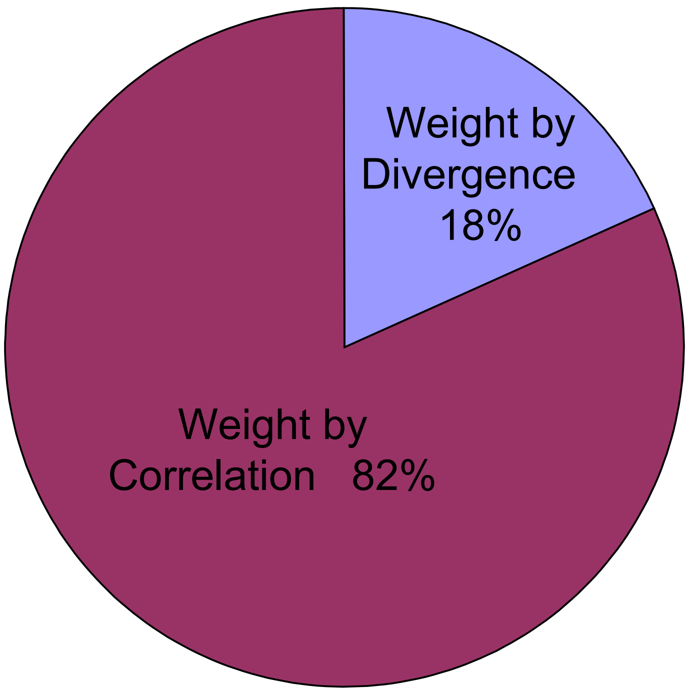
Optimal Parameters

- Back-tested 317,520 combinations of parameters

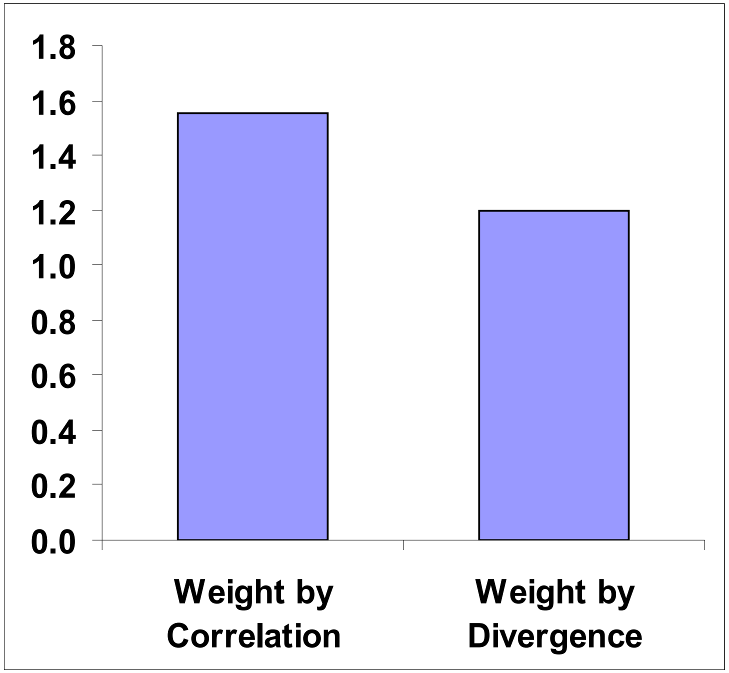
Parameter	Optimal Value
p_1% change in oil price…	5% shock
…over p_2 days	5 days
At least p_3 stocks to diverge…	8 stocks
…by at least p_4% from the index…	3% points
…within the next p_5 days (Look Window)	3 days

Weighting by Correlation Better than Weighting by Divergence

Proportion of Trials* Weighting Strategy Outperforms



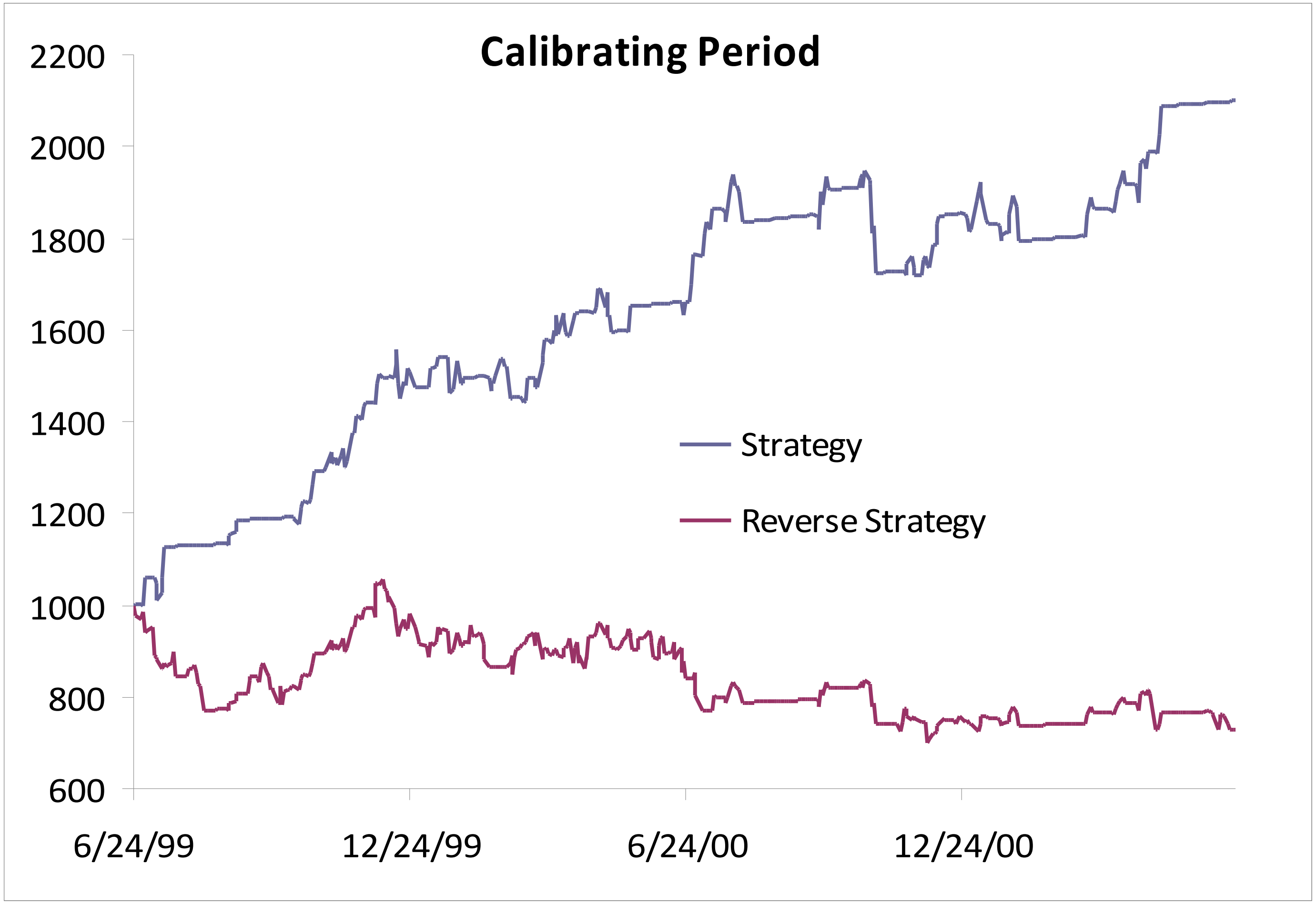
Best Sharpe Ratio



** Over 30,000 parameter combinations*

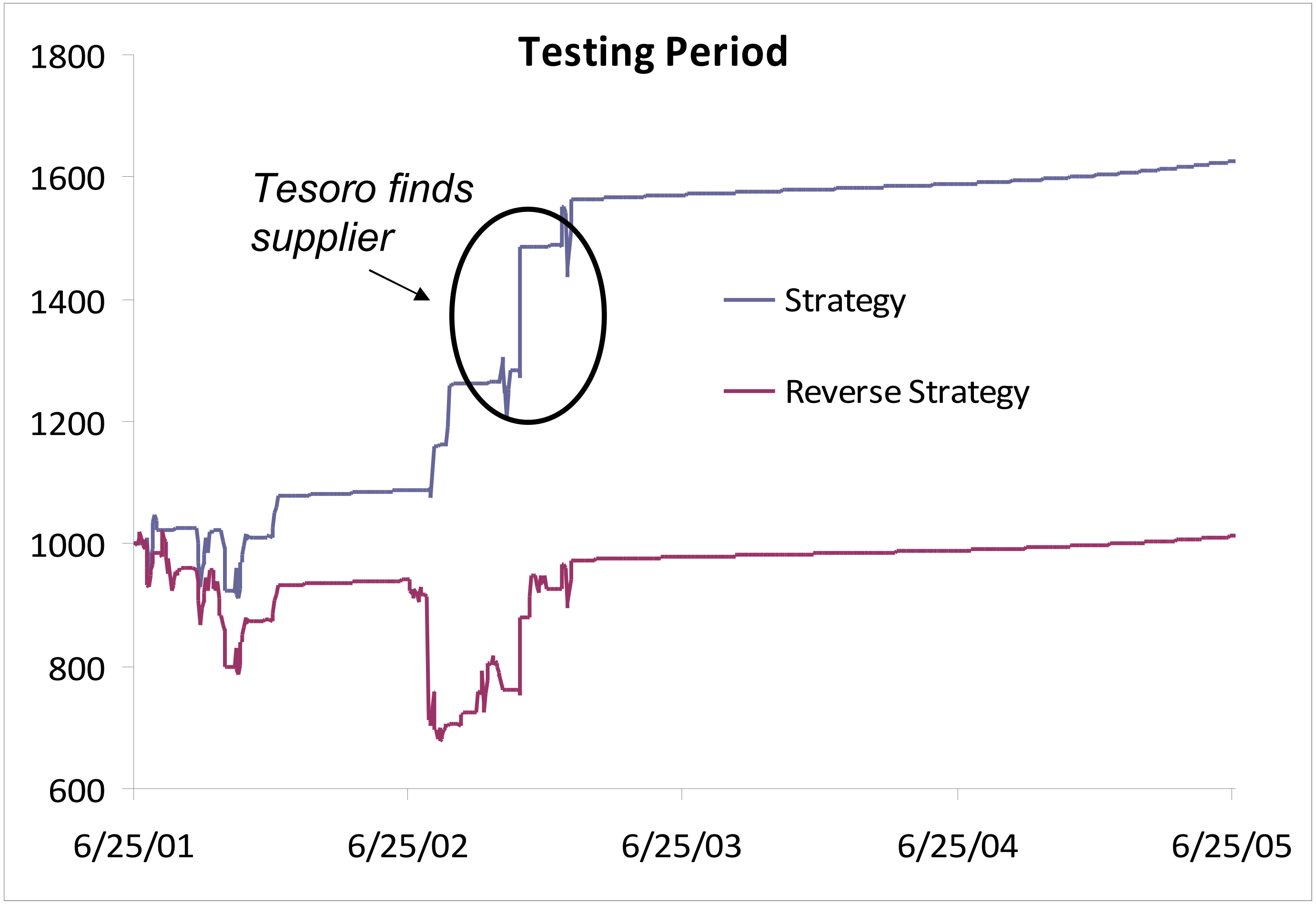
- Weighting by divergence is risk-seeking: low-correlation stocks may diverge far and never come back

“Reverse Strategy” Fails



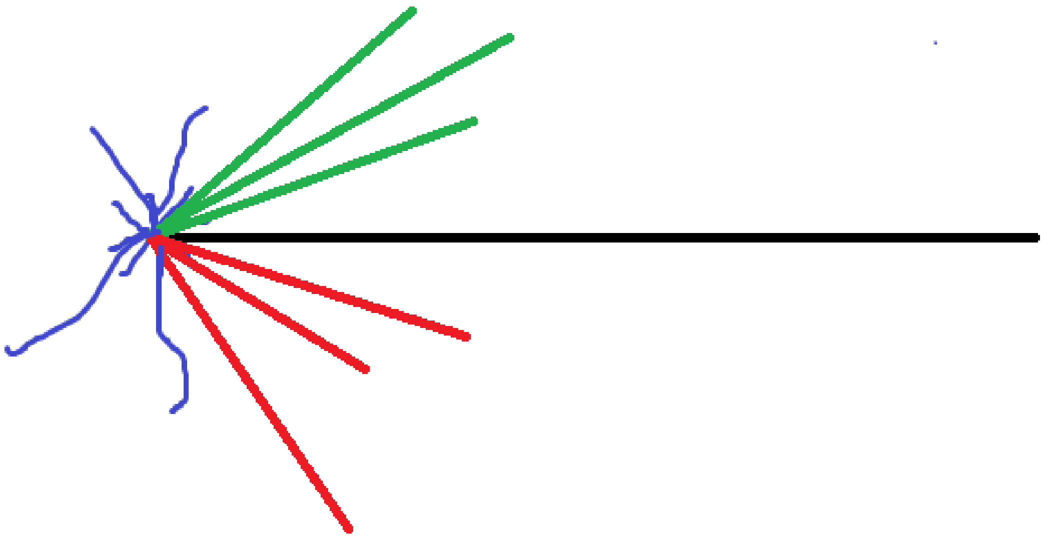
- Reverse strategy: check for divergence on every day, instead of only days following oil price shock

Testing Strategy from 2001-2005



- Strategy works – but possibly with luck
- No trades after 2003

Dissipation revisited



What is the strategy?
If scattering is subsequent to a shock (blue), then reversion is likely (dissipation).
If there is no shock, then price divergence may be fundamental.

Universality?

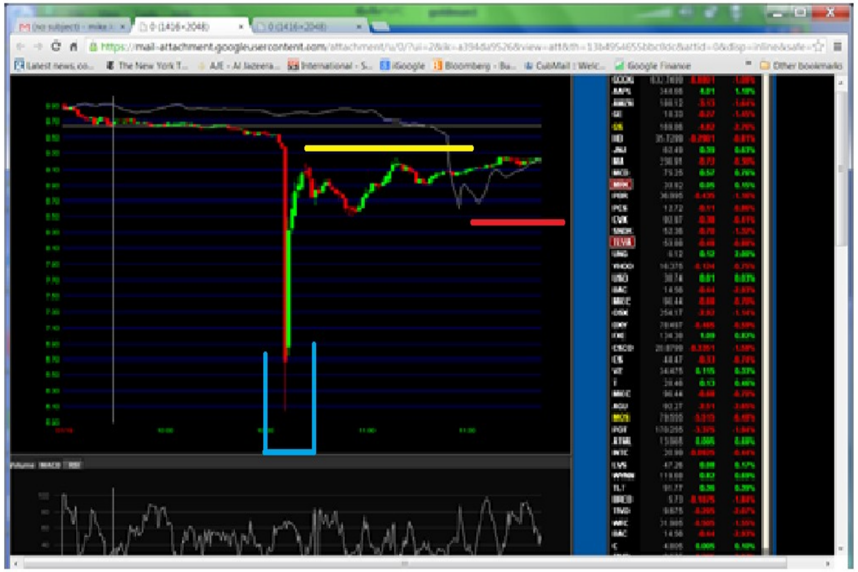
- In physical systems, energy is transferred from local shocks to the system globally, ultimately in the form of heat
- The transfer may be by cascade from large-scale turbulence to smaller and smaller length scales
- Paradigm: Kolmogorov (1941)

To finance?

- Since stock prices are 1-d, how is "energy" removed?
- We need a stand-in for energy in the form of stock price fluctuations: $< (S_0\text{-}S_t)^2> \sim \sigma^2{}_t$
- What would a mechanism be for reducing $\sigma^2{}_t$ to a baseline volatility, $\sigma^2{}_\infty$?

What is the picture?

MNKD flash crash



Region of non-universal behavior
Region of (sampling) frequency dependent behavior
Region of frequency independent behavior

Intermediate asymptotics

- We expect that $\sigma^2{}_t\,(\upsilon,t)$,
- Whereas $\sigma^2{}_\infty\,(t)$

- If there is a universal scalable dissipation the yellow area is where it must reside

The role of impact

- Each directed trade pushes the stock price up or down
- The presence of traders can in certain circumstances herd a stock (i.e. pinning)
- However unlike in physical systems stock prices move with the arrival of trading, not its absence

impact

- Certain features of markets determine the arrival rate of stock orders
- These involve electronic processing, pricing policy, intervention policy (trading halts), etc.
- In typical markets there are traders acting at differing frequencies
- Their actions will both move the stock in response to shock, and dissipate the subsequent price fluctuations

markets

- This means that our intuition is that shock dissipation will be different according to market rules: BRA vs USA vs TOKYO vs SHANGHAI vs FRANKFURT vs TORONTO, etc.
- To be determined….

conclusions

- Financial systems behave similarly to open natural systems (weather, biological, chemical, physical, etc.) in dissipating shocks
- If dissipation is “fast enough”, then it may be monetized via dispersion trading
- Shocks initiate a region of *out-of-equilibrium* prices
- To be discovered: a fluctuation-dissipation theorem for finance; is there a scaling law for temporal price dissipation?

Thanks

- My Columbia students, especially Kevin Kwan, Hongyi Wu and Zhengwen Zhang
- Marco Avellaneda