

High Frequency Quoting: Short-Term Volatility in Bids and Offers

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Disclaimers

- ❑ I teach in an entry-level training program at a large financial firm that is generally thought to engage in high frequency trading.
- ❑ I serve on a CFTC advisory committee that discusses issues related to high frequency trading.
- ❑ I accept honoraria for presentations at events sponsored by financial firms.

What does quote volatility look like?

- ❑ In US equity markets, a bid or offer can originate from any market participant.
 - “Traditional” dealers, retail and institutional investors.
- ❑ Bids and offers from all trading venues are consolidated and disseminated in real time.
 - The highest bid is the National Best Bid (NBB)
 - The lowest offer is the National Best Offer (NBO)
- ❑ Next slide: the NBBO for AEPI on April 29, 2011

Figure 1. AEPI bid and offer, April 29, 2011

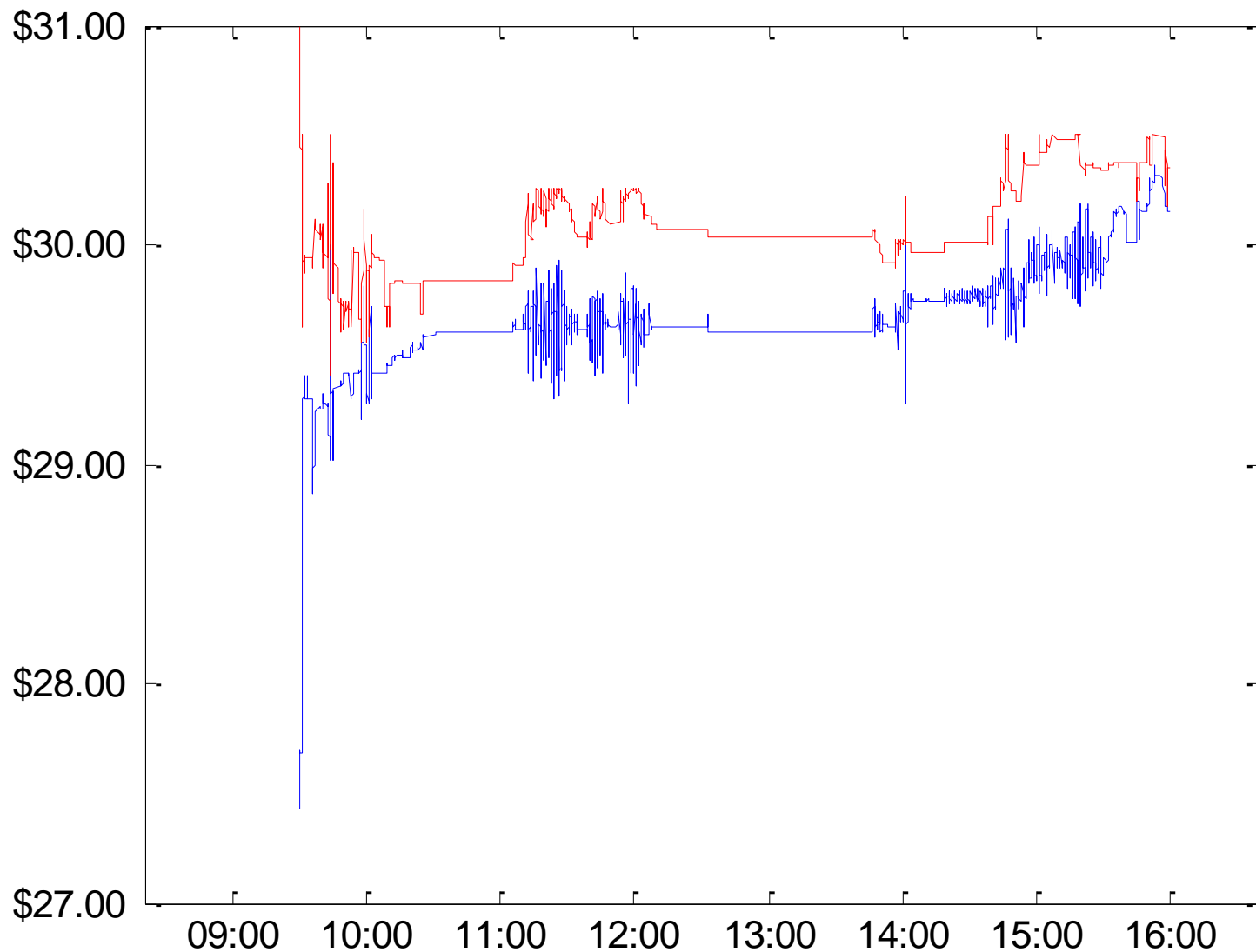
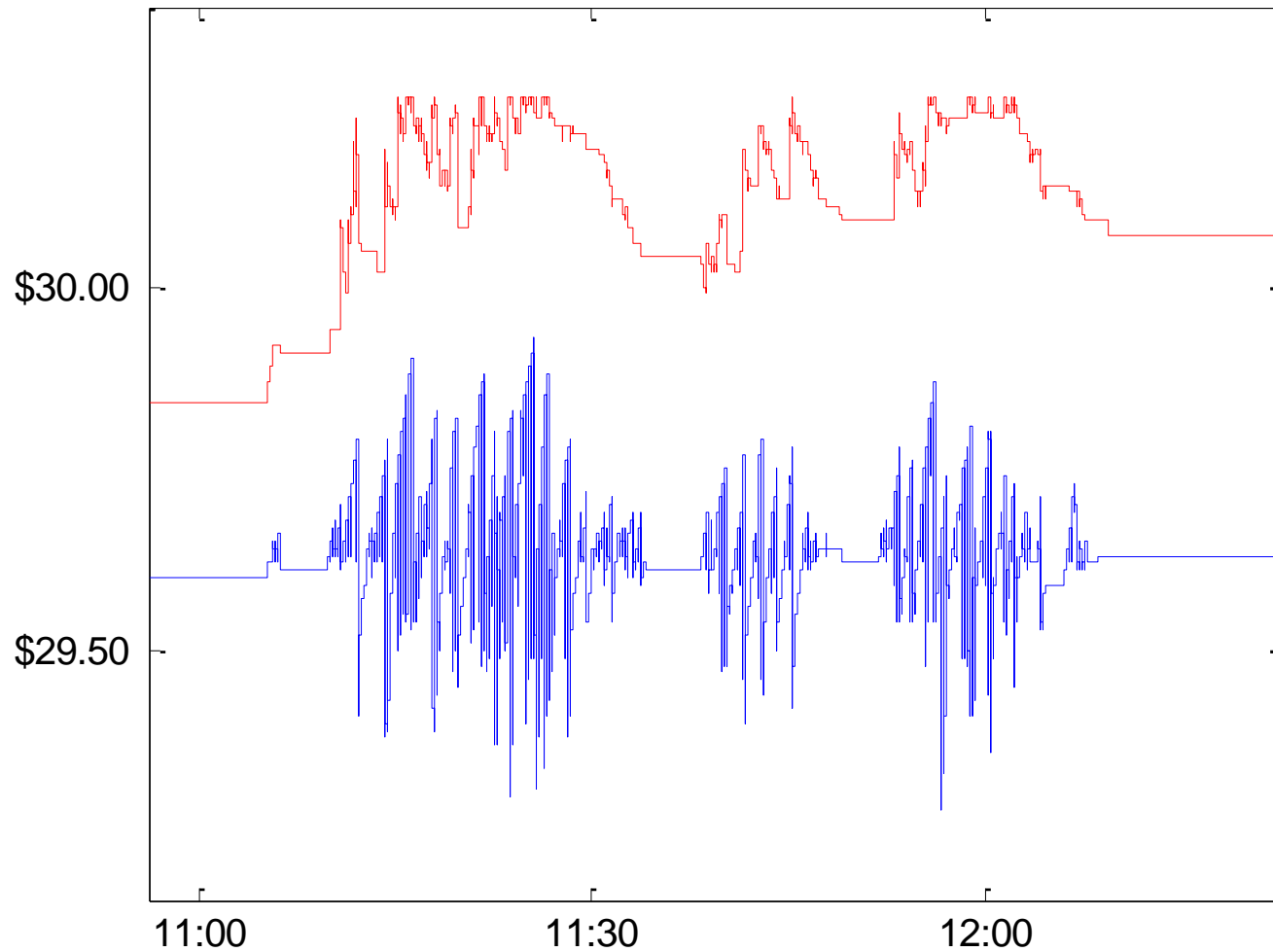


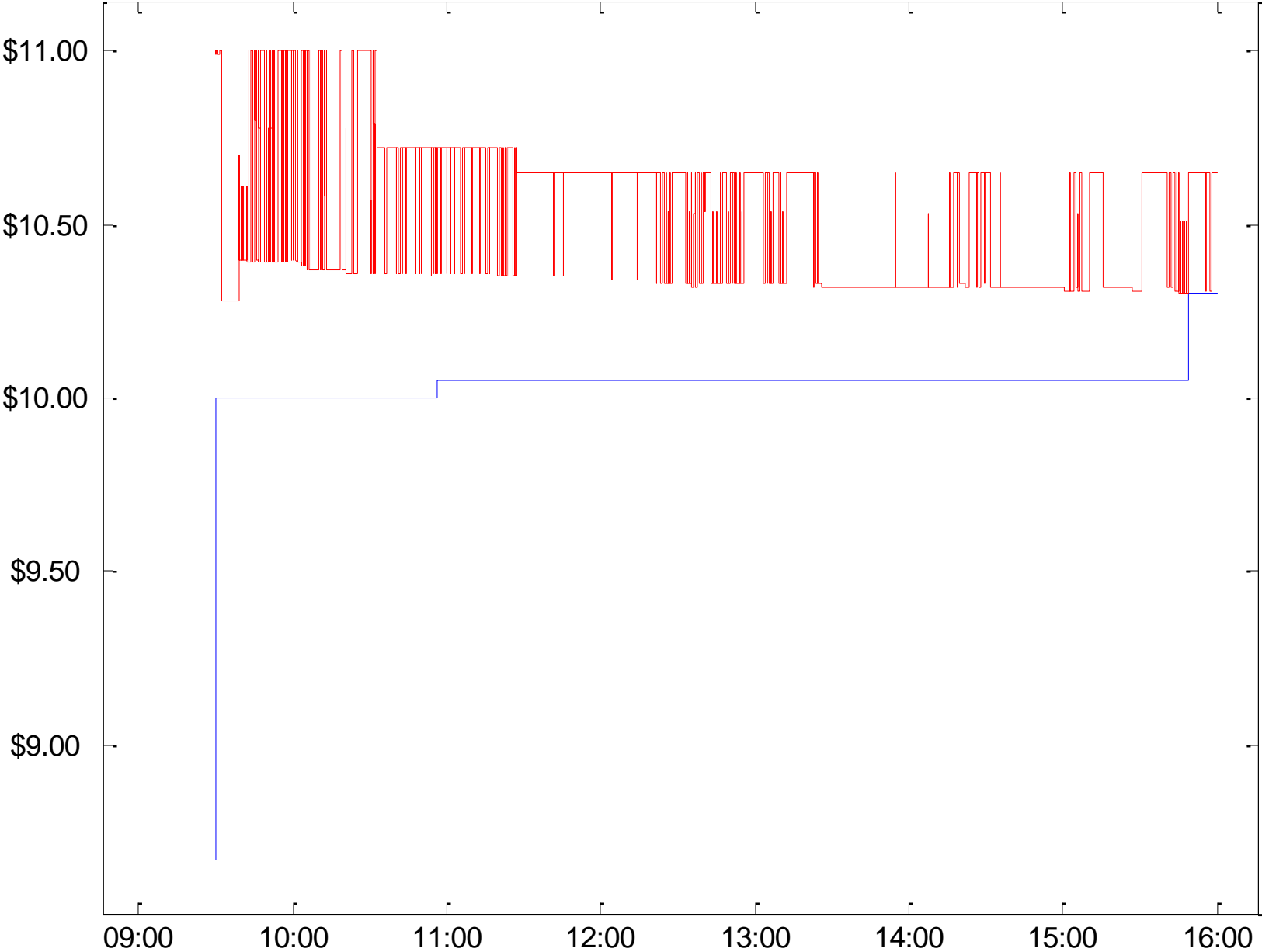
Figure 1. AEPI bid and offer on April 29, 2011 (detail)



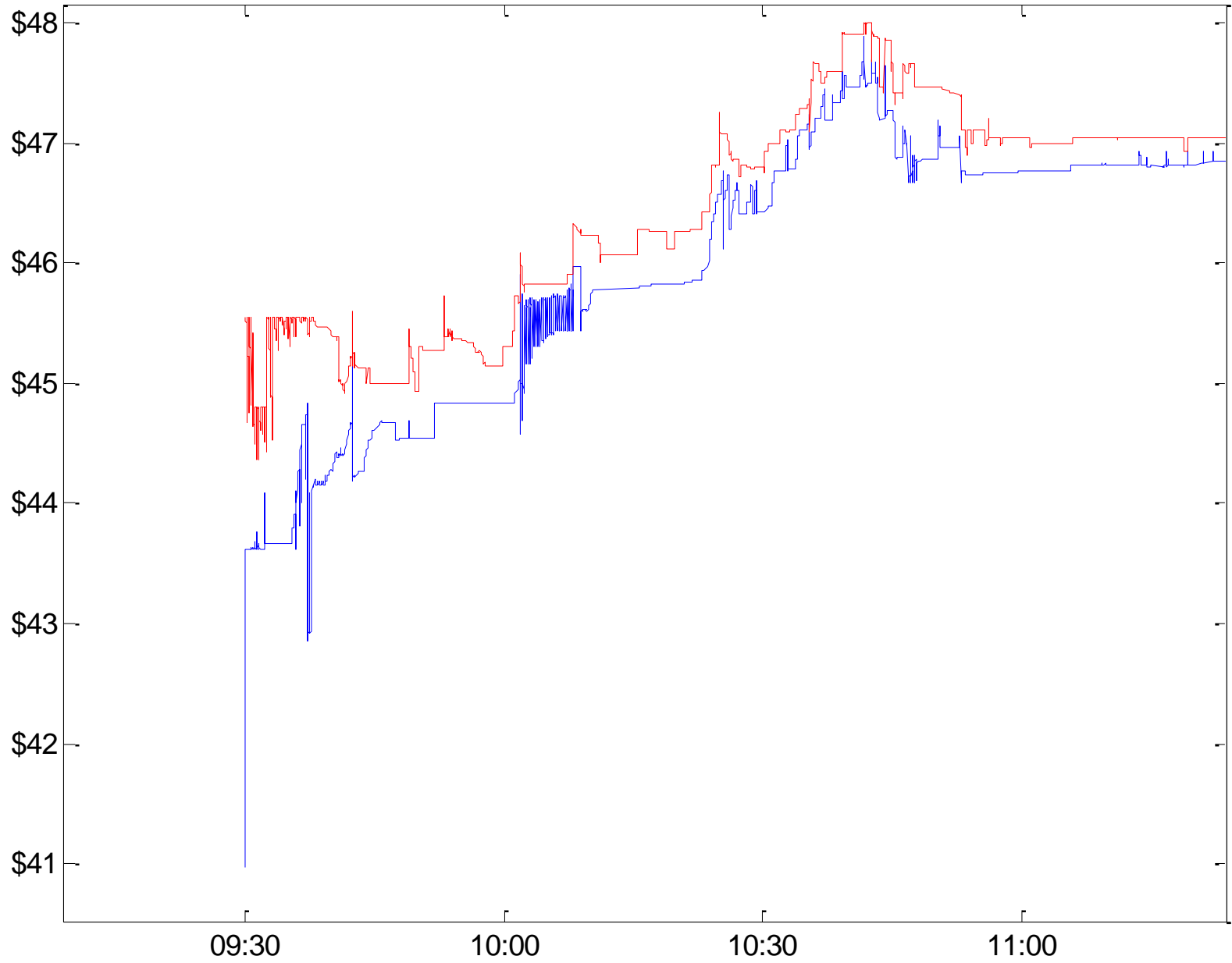
Features of the AEPI episodes

- ❑ Extremely rapid *oscillations* in the bid.
- ❑ Start and stop abruptly
- ❑ Mostly one-sided
 - activity on the ask side is much smaller
- ❑ Episodes don't coincide with large long-term changes in the stock price.

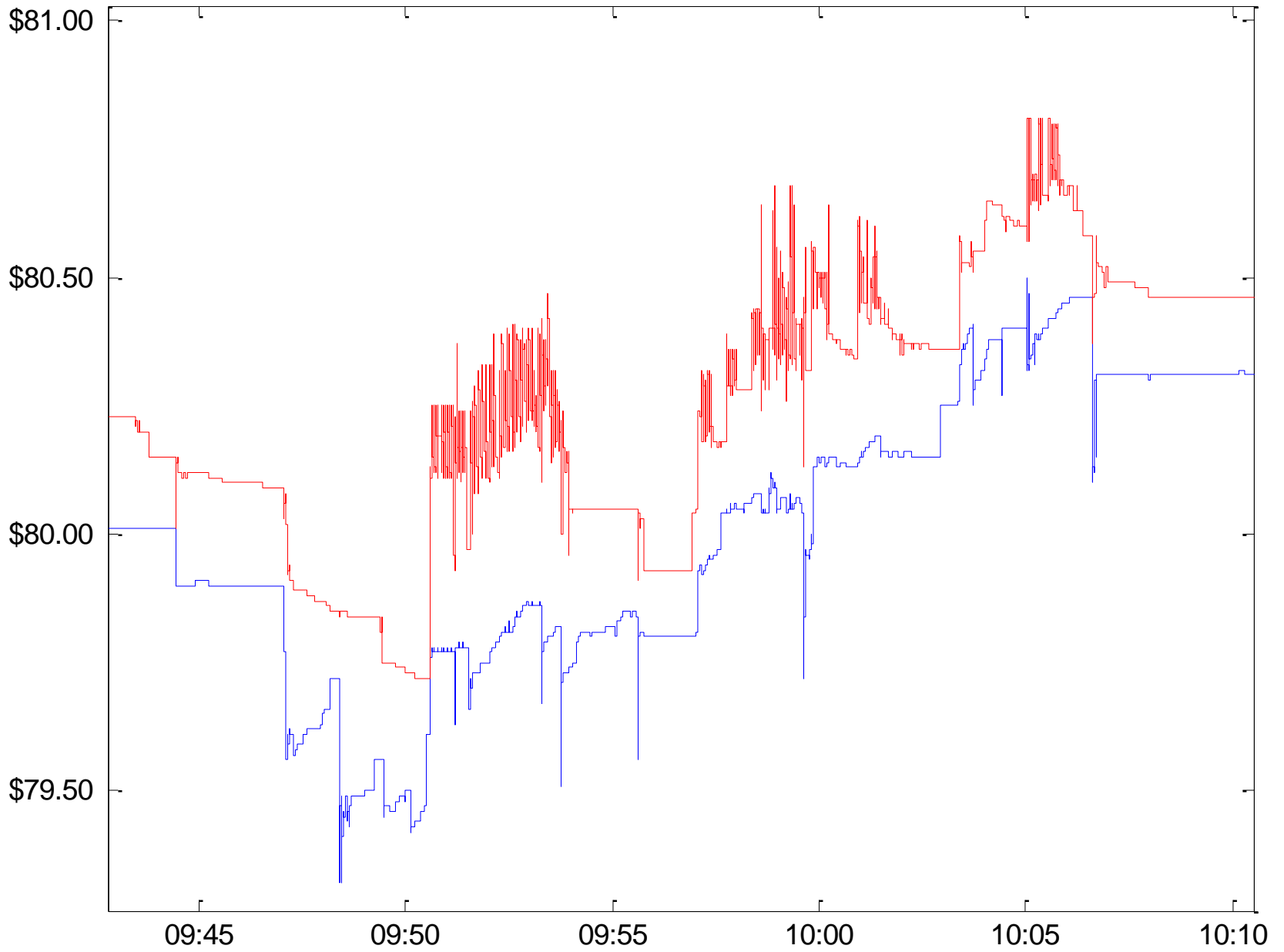
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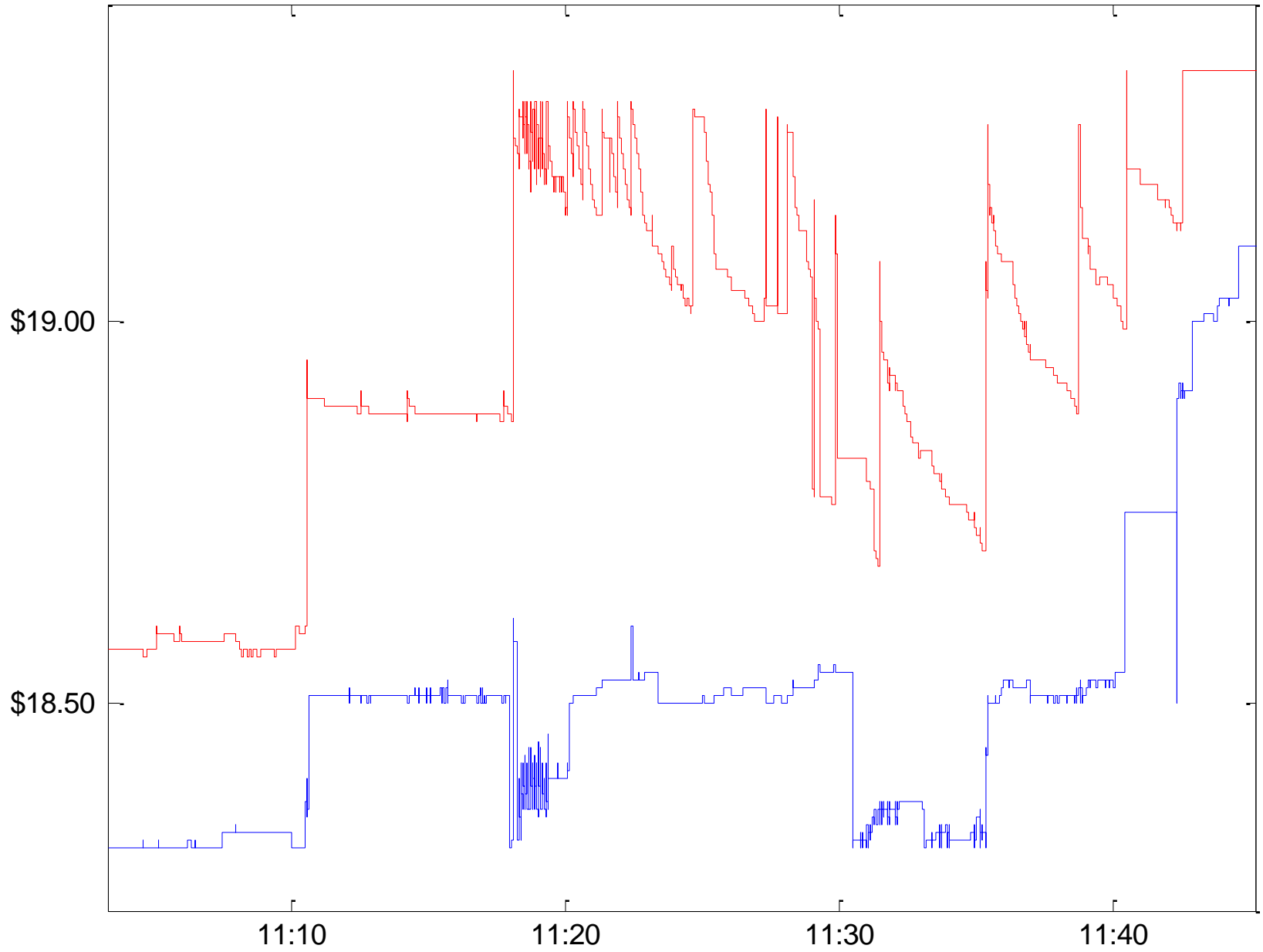
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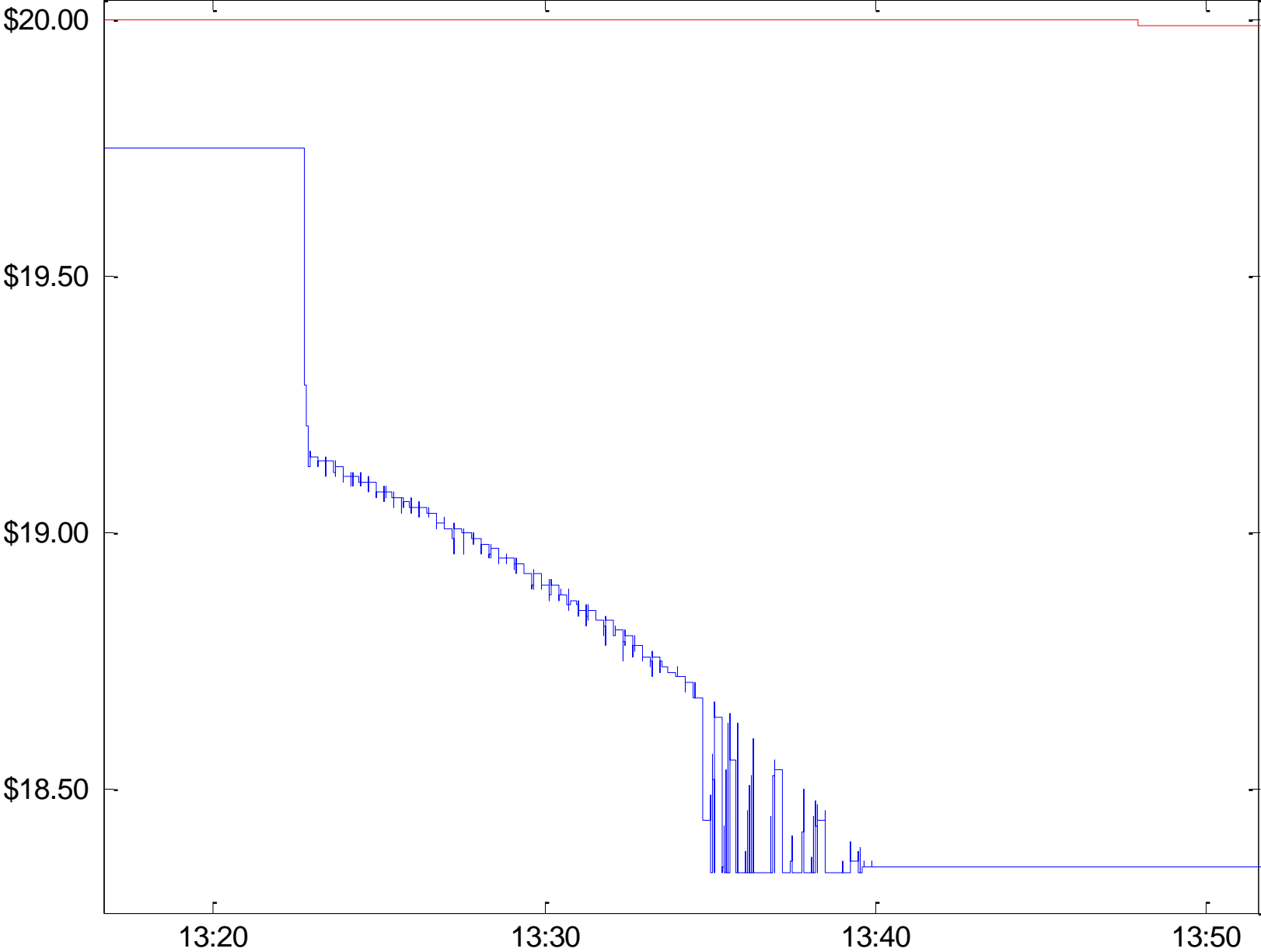
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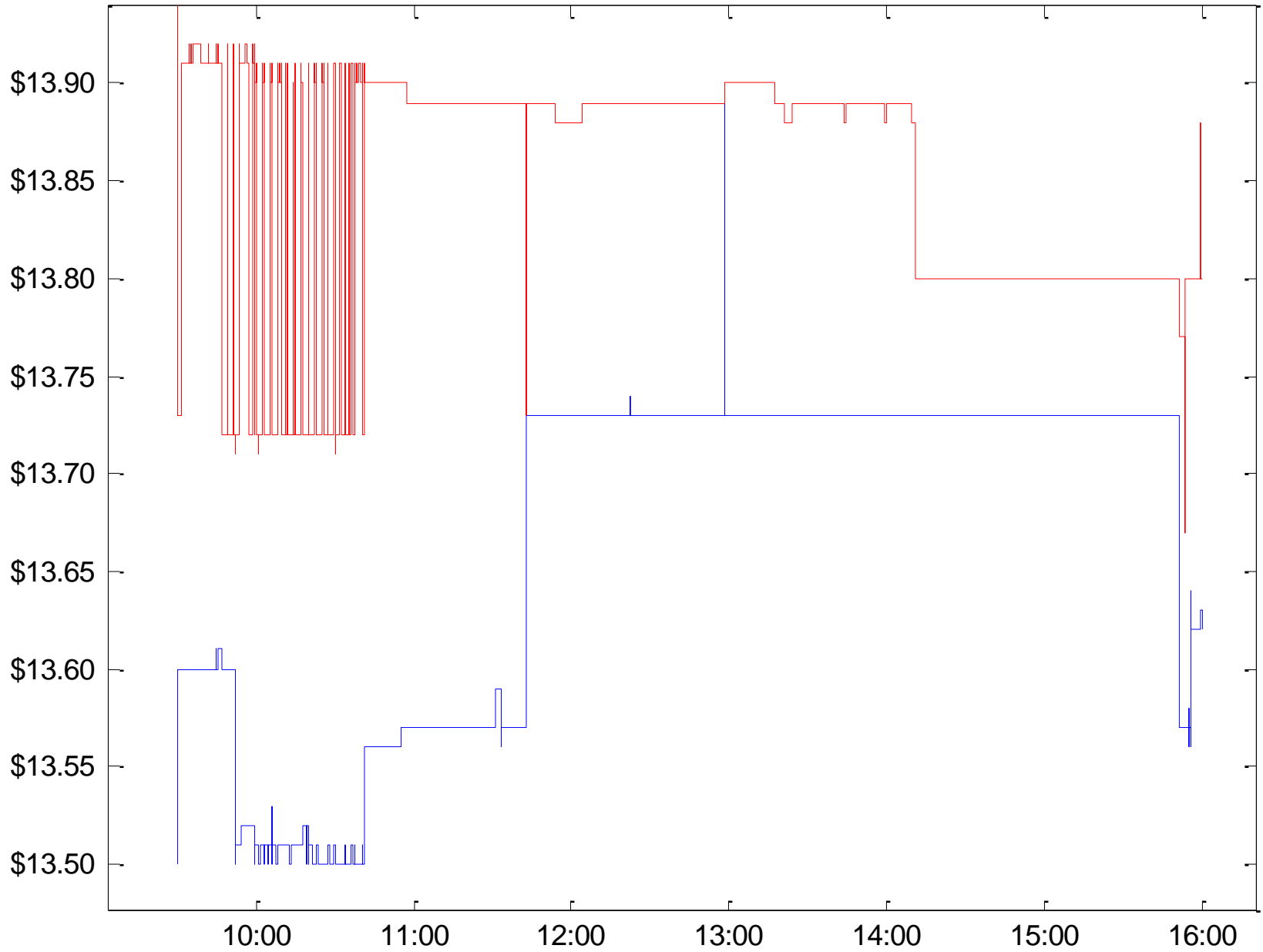
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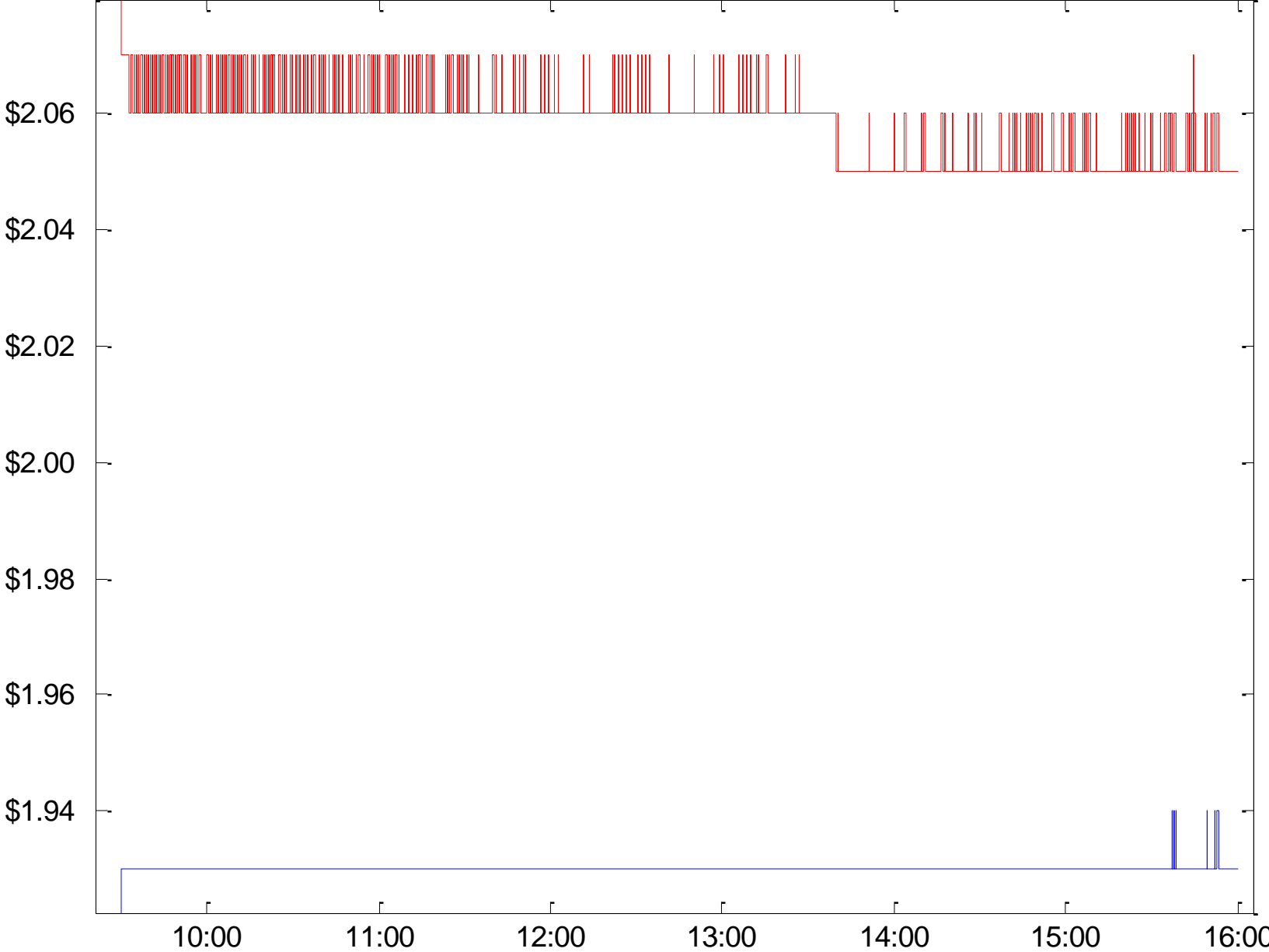
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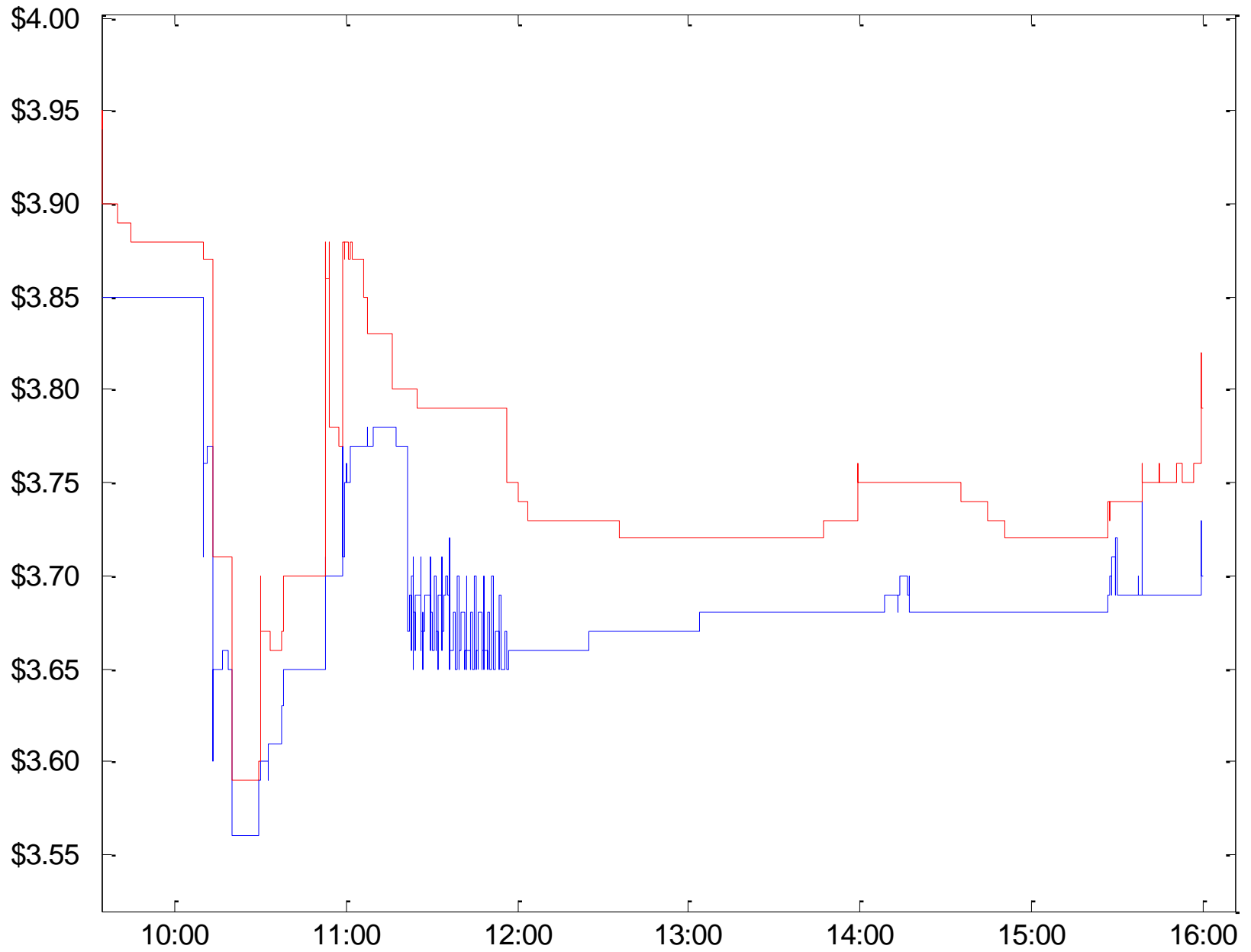
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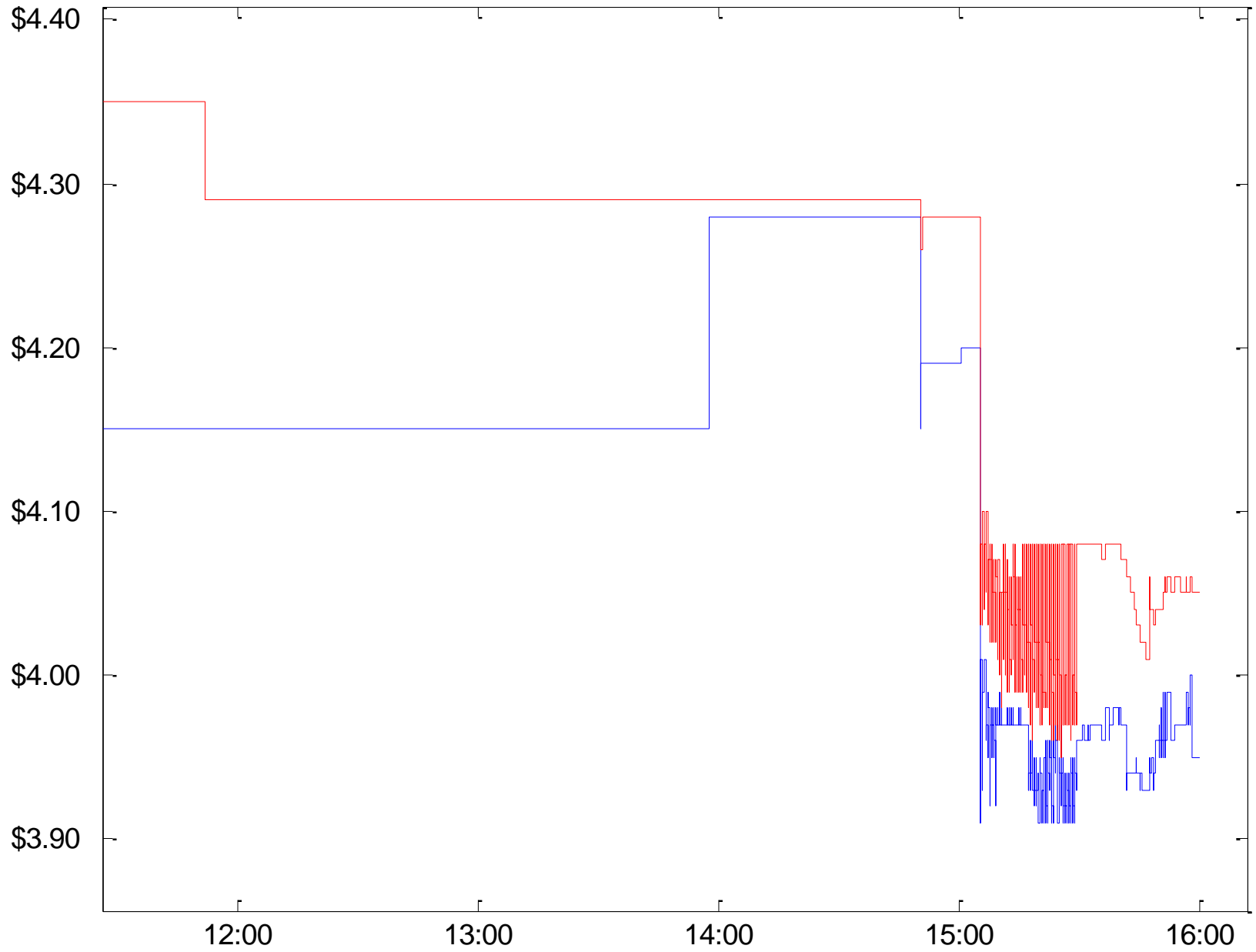
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Quote volatility: the questions

- ❑ What is its economic meaning and importance?
- ❑ How should we measure it?
- ❑ Is it elevated? Relative to what?
- ❑ Has it increased along with wider adoption of high-speed trading technology?

Context and connections

- Analyses of high frequency trading (HTF)
- Traditional volatility modeling
- Methodology: time scale resolution and variance estimation

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HFT in US equity markets: background

- US equities are traded in multiple venues (market centers)
 - Traditional exchanges, “dark pools,” etc.
- Virtually all market centers are electronically accessible ...
 - *but not instantaneously*
- High-frequency / low latency trading involves the use of technology to pursue a first-mover advantage.
- A new class of specialized traders has arisen.
 - Getco, Virtu, Jump, etc.

“HF traders are the new market makers.”

- Provide valuable intermediation services.
 - Like traditional designated dealers and specialists.
- Hendershott, Jones and Menkveld (2011): NYSE message traffic
- Hasbrouck and Saar (2012): strategic runs / order chains
- Brogaard, Hendershott and Riordan (2012) use Nasdaq HFT dataset in which trades used to define a set of high frequency traders.
- Studies generally find that HFT activity is associated with (causes?) higher market quality.

“HF traders are predatory.”

- They profit from HF information asymmetries at the expense of natural liquidity seekers (hedgers, producers of fundamental information).
- Jarrow and Protter (2011); Foucault and Rosu (2012)
- Baron, Brogaard and Kirilenko (2012); Weller (2012); Clark-Joseph (2012)

Context and connections

- Analyses of high frequency trading
- **Volatility modeling**
- Methodology: time scale resolution and variance estimation

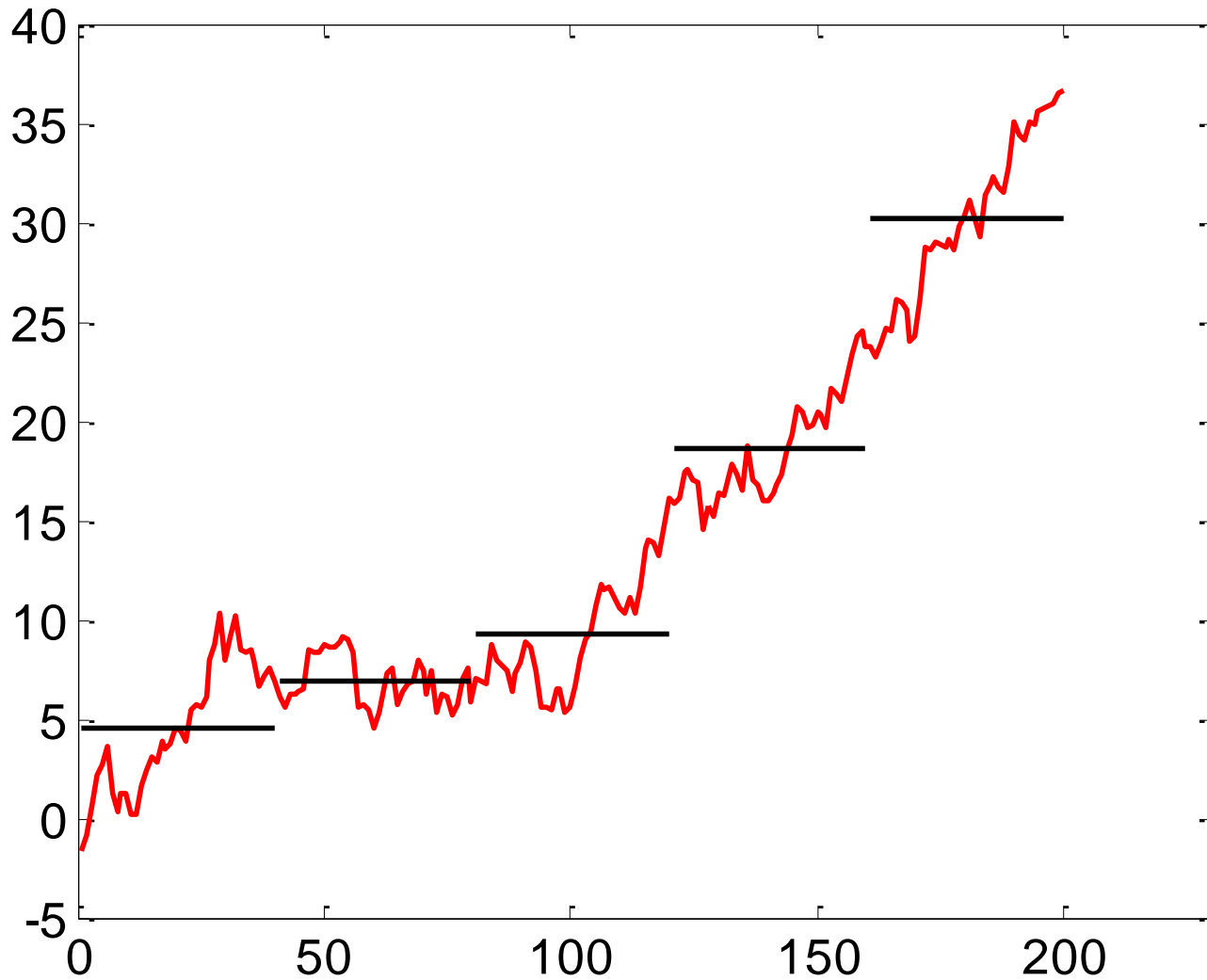
Volatility Modeling

- Mainstream ARCH, GARCH, and similar models focus on fundamental/informational volatility.
 - Statistically: volatility in the unit-root component of prices.
 - Economically important for portfolio allocation, derivatives valuation and hedging.
- Quote volatility is non-informational
 - Statistically: short-term, stationary, transient volatility
 - Economically important for trading and market making.

Realized volatility (RV)

- Volatility estimates formed from HF data.
 - $RV = \text{average (absolute/squared)}$
price changes.
 - Andersen, Bollerslev, Diebold and Ebens (2001), and others
- At high frequencies, microstructure noise becomes the dominant component of RV.
- Hansen and Lunde (2006) advocate using local level averaging (“pre-averaging”) to eliminate microstructure noise.

Pre-averaging



Quote volatility is microstructure noise

- Present study
 - Form local level averages
 - Examine volatility centered on these averages.
- Other contrasts with mainstream volatility modeling
 - Trade prices *vs. bid and offer quotes*
 - “Liquid” securities (indexes, Dow stocks, FX) *vs. mid- and low-cap issues*

Quote volatility: the economic issues

- Noise
- Execution price risk
 - For marketable orders
 - For dark trades
- Intermediaries' look-back options
- Quote-stuffing
- Spoofing

Quote volatility and noise: “flickering quotes”

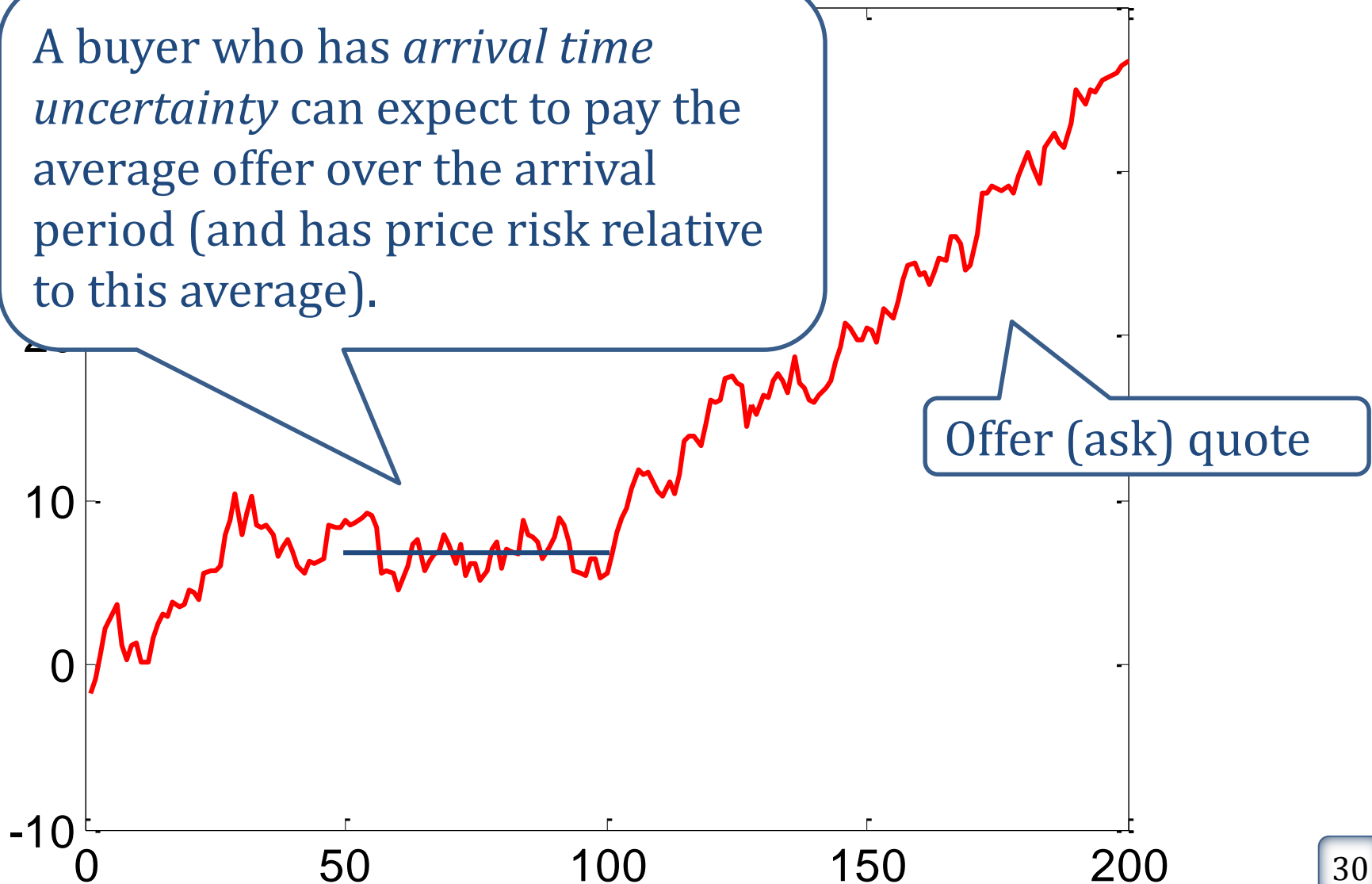
- Noise degrades the informational value of a price signal.
- “The improvements in market structure have also created new challenges, one of which is the well-known phenomenon of “ephemeral” or “flickering” quotes. Flickering quotes create problems like bandwidth consumption and decreased price transparency.”
 - CIBC World Markets, comment letter to SEC, Feb. 4, 2005.

Execution price risk for marketable orders

- A marketable order is one that is priced to be executed immediately.
 - “Buy 100 shares at the market” instructs the broker to buy, paying the current market asking price (no matter how high).
- All orders face arrival time uncertainty.
- Time uncertainty → price uncertainty

Execution price risk for marketable orders

A buyer who has *arrival time uncertainty* can expect to pay the average offer over the arrival period (and has price risk relative to this average).



Execution price risk for dark trades

- A dark trading venue does not display a bid or offer.
 - Roughly 30% of total volume is dark.
- In a dark market the execution price of a trade is set *by reference* to the bid and offer displayed by a lit market.
- Volatility in these reference prices induces execution price risk for the dark trades.

Is this risk zero-mean and diversifiable?

- For low-cap stocks, the volatility over three seconds averages 2.5 basis points (0.025%)
 - In a portfolio of 100 trades, the volatility is 0.25 basis points.
- What if, for particular agents, the risk is not zero-mean?

Quote volatility and look-back options

- Many market rules and practices reference “the current NBBO”
 - Due to network latencies, “current” is a fuzzy term.
 - In practice, “current” means “at any time in the past few seconds”
- One dominant party might enjoy the flexibility to pick a price within this window.

Internalization of retail orders

- Most retail orders are passed to “broker dealers” who agree to match the NBBO.
 - A dealer who receives a retail buy order will sell to the buyer at the NBO.
 - *NBO as of when?*
 - The dealer has an incentive to pick the highest price within the window of time indeterminacy.
- “Lookback option” Stoll and Schenzler (2002)

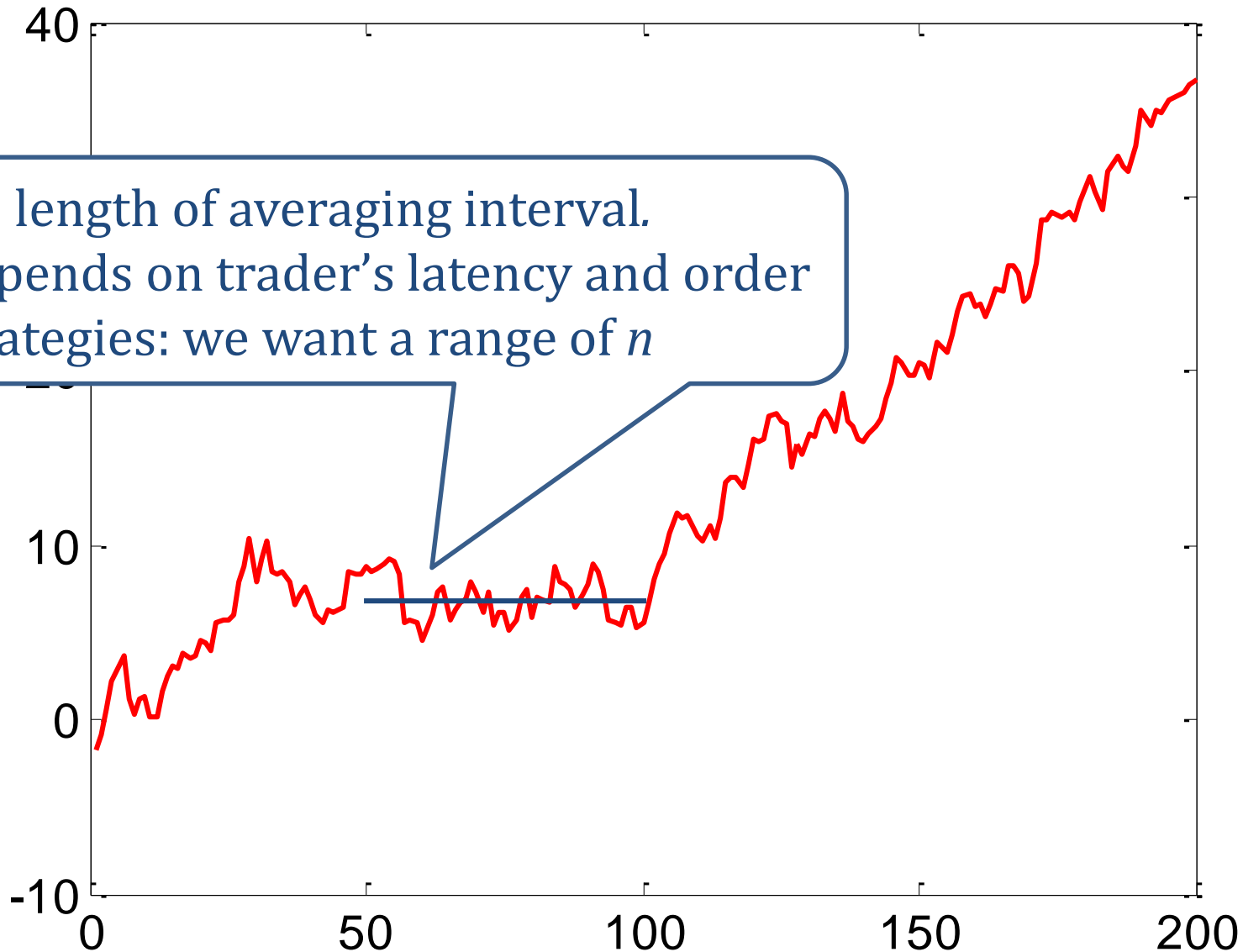
“Spoofing” manipulations

- ❑ A dark pool buyer enter a spurious sell order in a visible market.
- ❑ The sell order drives down the NBBO midpoint.
- ❑ The buyer pays a lower price in the dark pool.

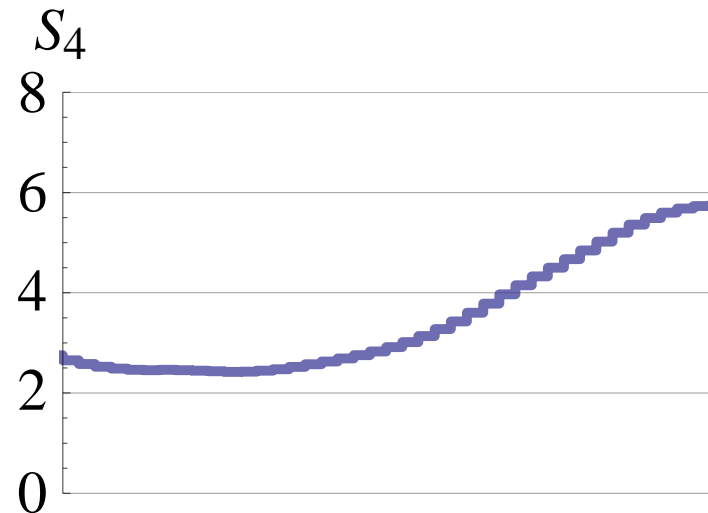
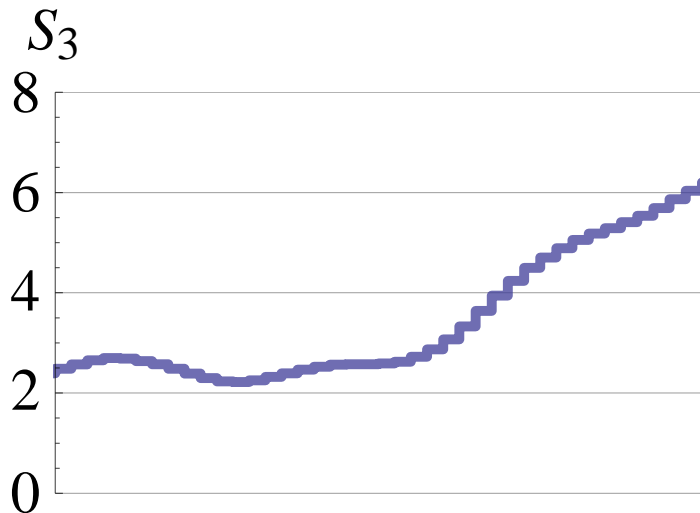
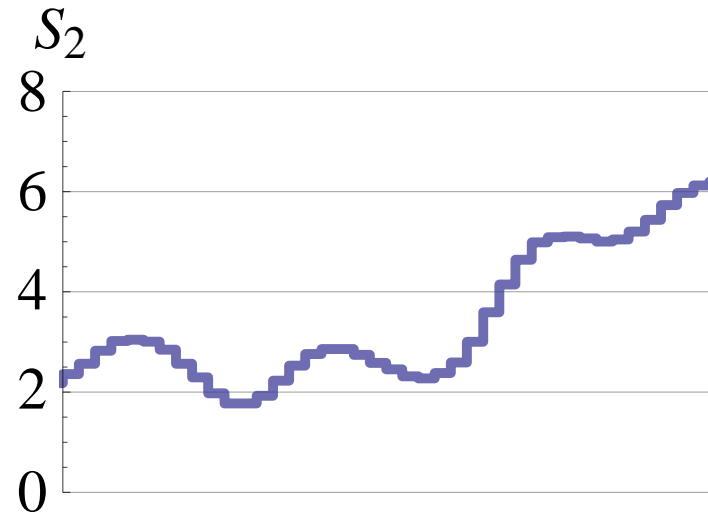
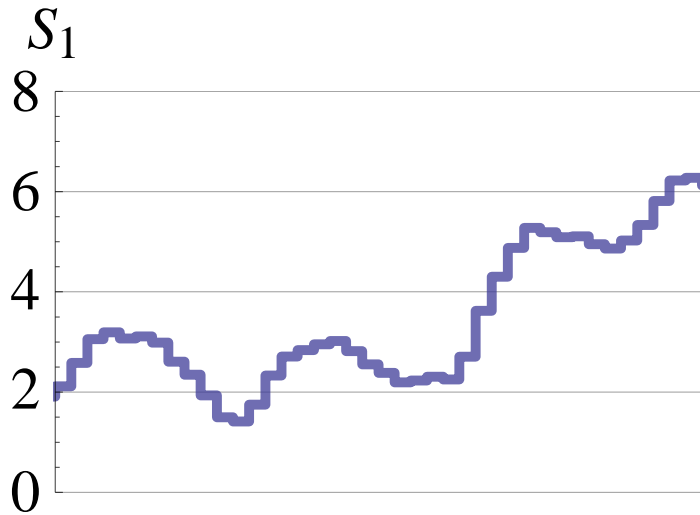
Descriptive statistics: computation and interpretation

Local variances about local means

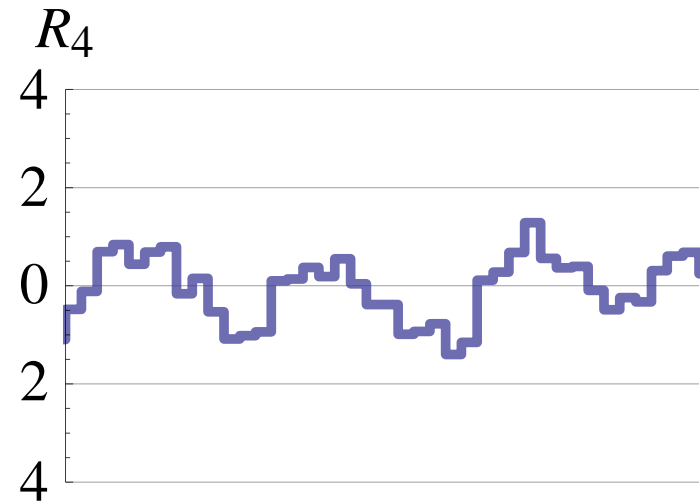
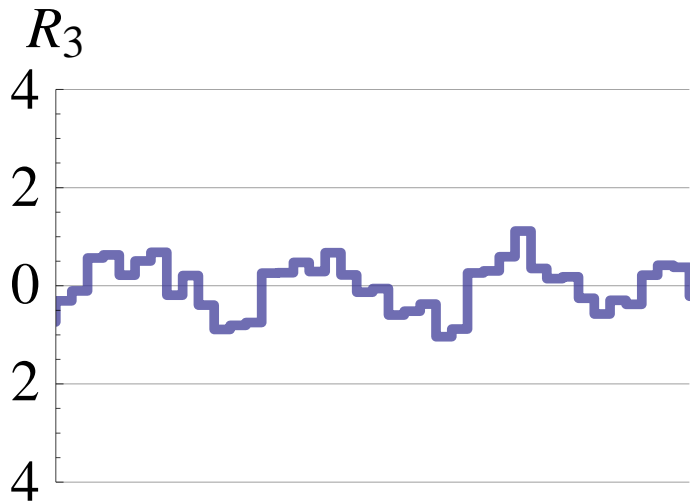
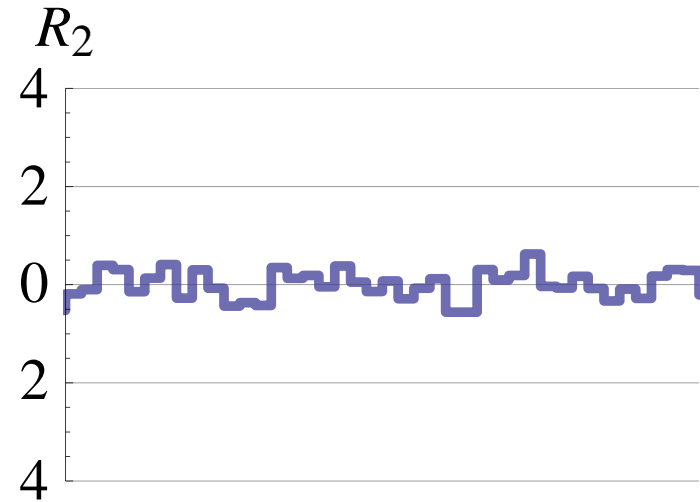
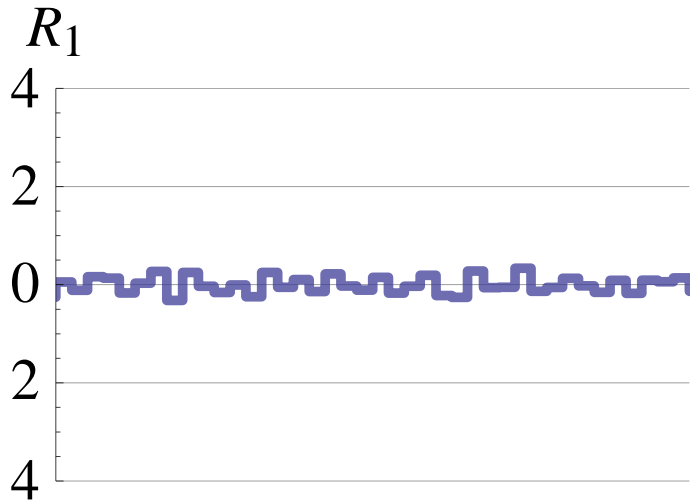
n = length of averaging interval.
Depends on trader's latency and order
strategies: we want a range of n



Average (*Smooth*) components

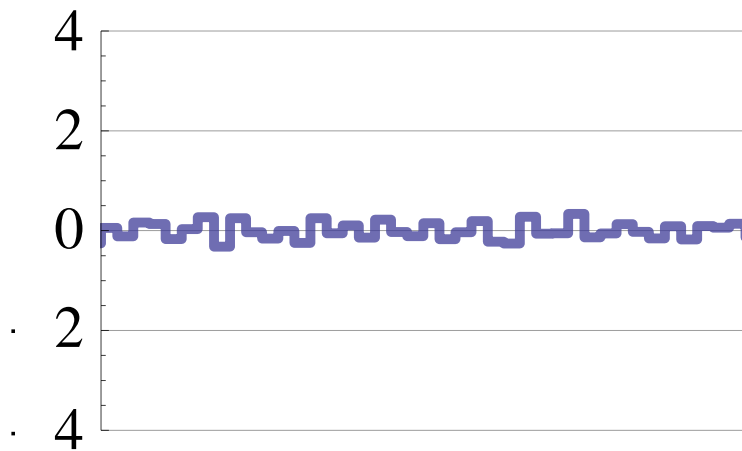


Residual (*Rough*) components

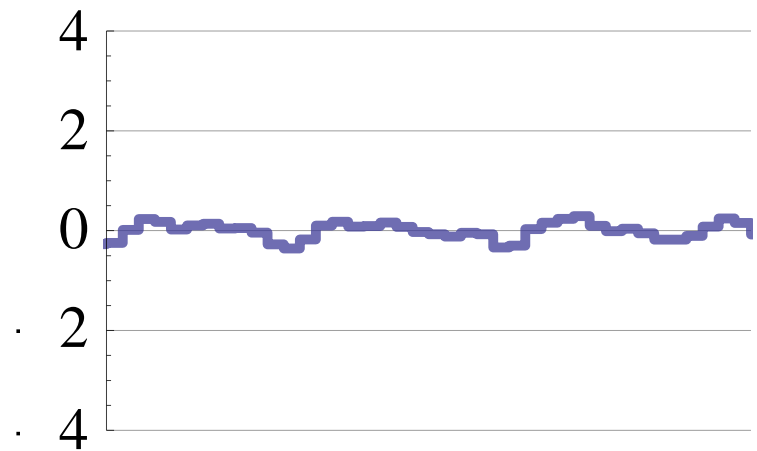


Incremental (*Detail*) components

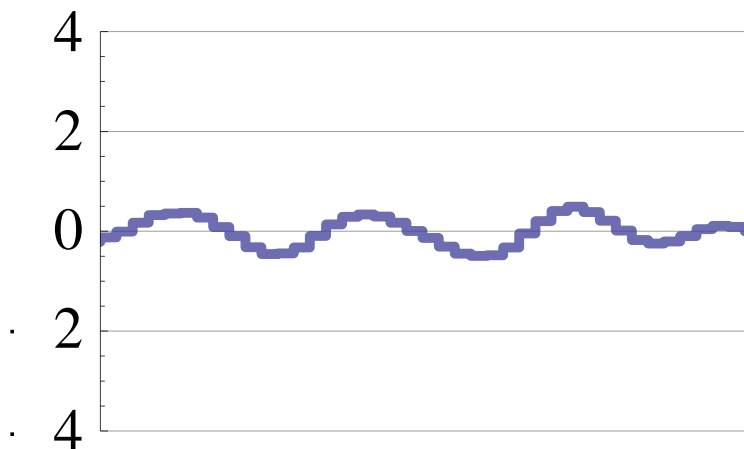
$D_1: R_1$



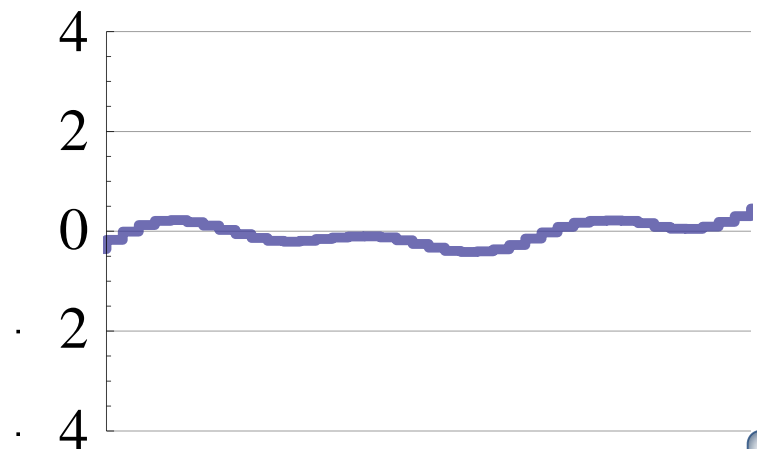
$D_2: R_2 \cdot R_1$



$D_3: R_3 \cdot R_2$



$D_4: R_4 \cdot R_3$



Variances

- For computational efficiency, let averaging window n increase as a dyadic (“powers of two”) sequence.
 - $n_j = n_0 2^j$
 - Here, $n_0 = 50 \text{ ms}$
- σ_j^2 is the *rough variance* over interval n_j .
- $\nu_j^2 = \sigma_j^2 - \sigma_{j-1}^2$ is the incremental (detail) variance.
 - Generally called the *wavelet variance*.

Interpretation

- To assess economic importance, I present the (wavelet and rough) variance estimates in three ways.
 - In mils per share
 - In basis points
 - As a short-term/long-term variance ratio

Mils per share

- Variances are computed on bid and offer price levels.
- Reported volatilities are scaled to *mils/share*.
 - One mil = \$0.001
- Most trading charges are assessed per share.
 - Someone sending a marketable order to a US exchange typically pays an “access fee” of about three mils/share.
 - An executed limit order receives a “liquidity rebate” of about two mils/share.

Basis points (One bp = 0.01%)

- Volatilities are first normalized by price (bid-ask average)
- The rough volatility in basis points:
 - $\frac{\sigma_j}{Price} \times 10,000$
- “One bp is a one cent bid-offer spread on a \$100 stock.”

The short/long variance ratio

- For a random walk with per period variance σ^2 , the variance of the n -period difference is $n\sigma^2$.
- An conventional variance ratio might be
 - $V = \frac{60 \times \text{one minute return variance}}{\text{one hour return variance}}$
- For a random walk, $V = 1$.
 - Microstructure: we usually find $V > 1$.
- Extensively used in microstructure studies: Barnea (1974); Amihud and Mendelson (1987); etc.

Variance ratios may also be constructed from rough and wavelet variances

□ The wavelet variance ratio is

$$\blacksquare V_{j,J} = 2^{J-j} \times \frac{v_j^2}{v_{J=16}^2}$$

□ The rough variance ratio is

$$\blacksquare VR_{j,J} = 2^{J-j-1} \times \frac{\sigma_j^2}{v_{J=16}^2}$$

□ For a random walk, $V_{j,J} = VR_{j,J} = 1$

The empirical analysis

CRSP Universe 2001-2011. (Share code = 10 or 11; average price \$2 to \$1,000; listing NYSE, Amex or NASDAQ)

In each year, chose 150 firms in a random sample stratified by dollar trading volume

**2011 April TAQ
with one-
millisecond time
stamps**

**High-resolution
analysis**

2001-2011
April TAQ data
with one-second
time stamps

Lower-resolution
analysis

Table 1. Summary Statistics, 2011

		Dollar trading volume quintile				
	Full sample	1 (low)	2	3	4	5 (high)
No. of firms	149	29	30	30	30	30
NYSE	47	0	5	7	16	19
Amex	6	2	2	0	1	1
NASDAQ	96	27	23	23	13	10
Avg. daily trades	1,346	33	431	1,126	3,478	16,987
Avg. daily quotes	24,053	1,067	7,706	24,026	53,080	181,457
Avg. daily NBBO records	7,203	354	3,029	7,543	16,026	46,050
Avg. daily NBB changes	1,265	121	511	1,351	2,415	4,124
Avg. daily NBO changes	1,179	106	460	1,361	2,421	4,214
Avg. price	\$15.77	\$4.76	\$5.46	\$17.86	\$27.76	\$51.60
Market capitalization of equity, \$ Million	\$690	\$41	\$202	\$747	\$1,502	\$8,739

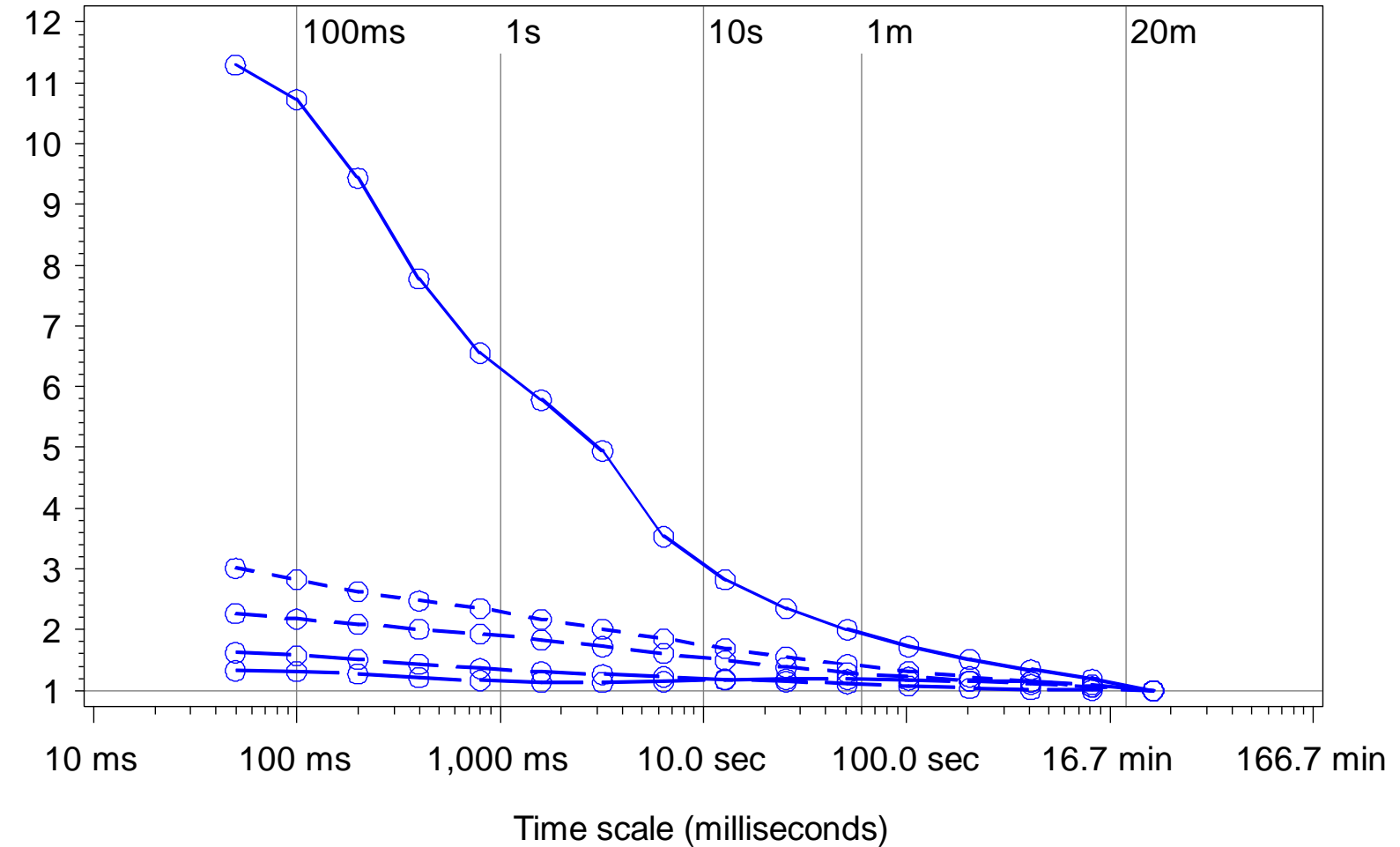
Table 2. Time scale variance estimates, 2011

Time scale	Rough volatilities			Wavelet volatilities			
	(1) σ_j , mils	(2) σ_j , bp	(3) Variance ratio	(4) v_j , mils	(5) v_j , bp	(6) Variance ratio	(7) Bid-Offer Corr
< 50 ms	0.29	0.17	4.22				
50 ms	0.40	0.23	3.99	0.28			
100 ms	0.56	0.32	3.79	0.3			
200 ms	0.77	0.44	3.53	0.3			
400 ms	1.06	0.61	3.21				
800 ms	1.47	0.84	2.90				
1,600 ms	2.04	1.17	2.64	1.1			
3.2 sec	2.84	1.61	2.40	1.9			
6.4 sec	3.94	2.22	2.12	2.7			
12.8 sec	5.48	3.04	1.88	3.8			
25.6 sec	7.61	4.17	1.69	5.2			
51.2 sec	10.57	5.70	1.54	7.3			
102.4 sec	14.65	7.80	1.42	10.1			
3.4 min	20.29	10.67	1.32	13.9			
6.8 min	28.11	14.61	1.23	19.3			
13.7 min	38.85	19.98	1.16	26.66	13.53	1.08	0.89
27.3 min	53.24	27.16	1.08	36.00	18.17	1.00	0.90

A trader who faces time uncertainty of 400 ms incurs price risk of 1.06 mils/share or 0.61 basis points.

At a time scale of 400 ms., the rough variance is 3.21 times the value implied by a random walk with variance calibrated to 27.3 minutes.

Figure 2. Wavelet variance ratios across time scale and dollar volume quintiles



Avg dollar volume rank

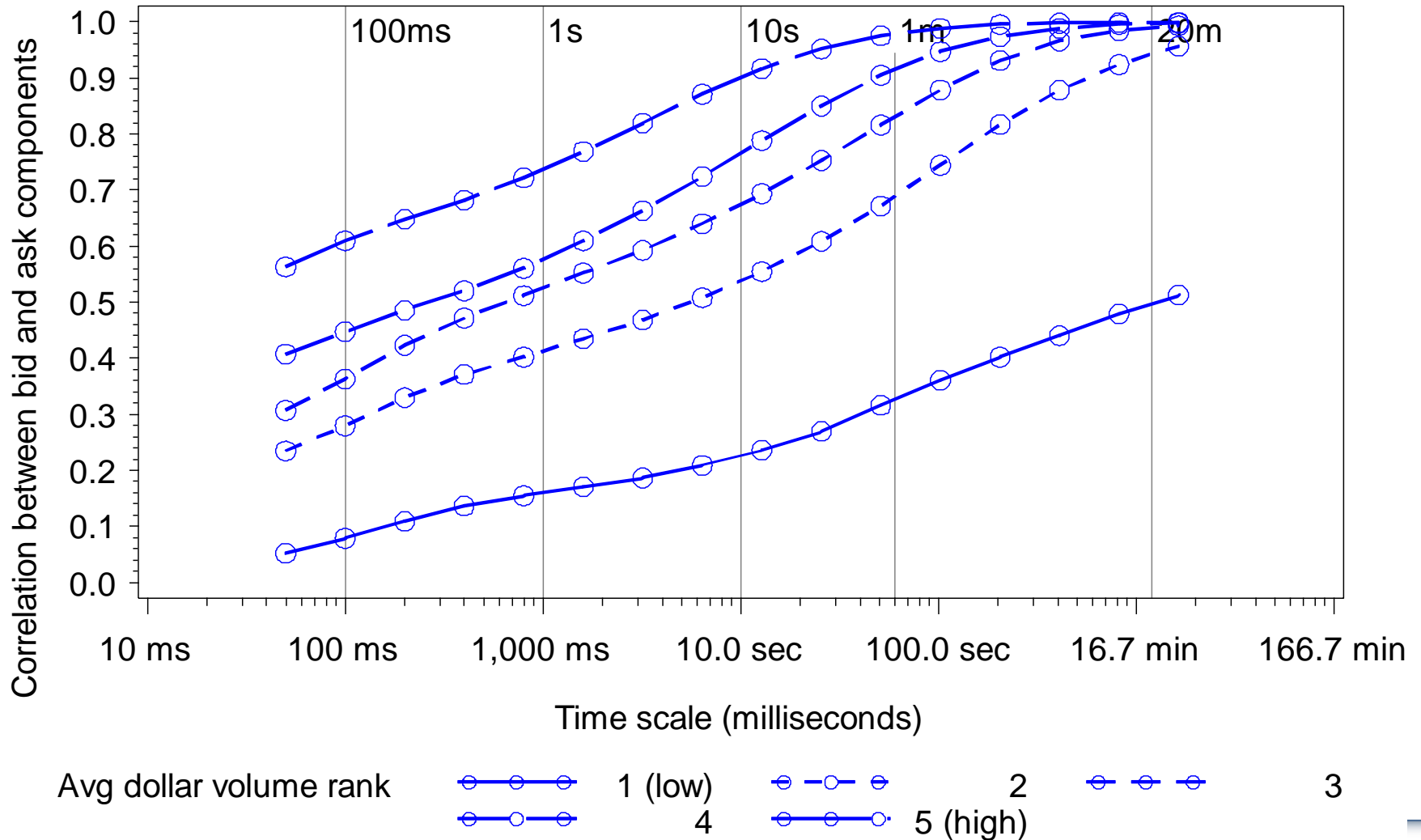
	1 (low)		2		3
	4		5 (high)		

Table 2. Time scale variance estimates, 2011

Time scale	Rough volatilities			Wavelet volatilities			Bid-Offer Corr
	(1) σ_j , mils	(2) σ_j , bp	(3) Variance ratio	(4) ν_j , mils	(5) ν_j , bp	(6) Variance ratio	
< 50 ms	0.29						
50 ms	0.40				0.16	3.76	0.32
100 ms	0.56				0.22	3.59	0.36
200 ms	0.77				0.30	3.27	0.41
400 ms	1.06	0.61	3.21	0.73	0.42	2.89	0.44
800 ms	1.47	0.84	2.90	1.02	0.58	2.60	0.48
1,600 ms	2.04	1.17	2.64	1.41	0.81	2.38	0.52
3.2 sec	2.84	1.61	2.40	1.97	1.11	2.16	0.55
6.4 sec	3.94	2.22	2.12	2.74	1.52	1.84	0.60
12.8 sec	5.48	3.04	1.88	3.80	2.08	1.65	0.65
25.6 sec	7.61	4.17	1.69	5.27	2.83	1.51	0.70
51.2 sec	10.57	5.70	1.54	7.31	3.88	1.39	0.75
102.4 sec	14.65	7.80	1.42	10.12	5.30	1.29	0.79
3.4 min	20.29	10.67	1.32	13.99	7.25	1.21	0.83
6.8 min	28.11	14.61	1.23	19.38	9.93	1.15	0.86
13.7 min	38.85	19.98	1.16	26.66	13.53	1.08	0.89
27.3 min	53.24	27.16	1.08	36.00	18.17	1.00	0.90

How closely do the bid and offer track at the indicated time scale?

Figure 3. Wavelet correlations between the National Best Bid and National Best Offer



The 2011 results: a summary

- Variance ratios: short term volatility is much higher than we'd expect relative to a random-walk.
- In mils per share or basis points, *average* short term volatility is economically meaningful, but small.

Historical analysis

CRSP Universe 2001-2011. (Share code = 10 or 11; average price \$2 to \$1,000; listing NYSE, Amex or NASDAQ)

In each year, chose 150 firms in a random sample stratified by dollar trading volume

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High-resolution analysis with low resolution data

- ❑ TAQ with millisecond time stamps only available from 2006 onwards
- ❑ TAQ with one second time stamps available back to 1993.
- ❑ Can we draw inferences about *subsecond* variation from second-stamped data?

The problem

Quote A	10:01:35
---------	----------

Quote B	10:01:35
---------	----------

Quote C	10:01:35
---------	----------

- Where within the second did these quotes actually occur?
- With a few simple assumptions, we know how they are distributed and how they may be simulated.

Recall the constant intensity Poisson process ...

- $N(t)$ = no. of events in an interval $(0, t)$
- s_i = arrival time of event i
- If $N(t) = n$, then s_1, s_2, \dots, s_n have the same distribution as the order statistics in a sample of n independent $U(0, t)$ random variables.
- This suggests a simple procedure...

Quote A	10:01:35
---------	----------

Quote B	10:01:35
---------	----------

Quote C	10:01:35
---------	----------

- Draw three $U(0,1)$ random numbers
- Sort them
- Assign them as the millisecond remainders

Quote A	10:01:35. 243
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Quote B	10:01:35. 347
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Quote C	10:01:35. 912
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- Compute variance estimates using the simulated time stamps.

Formalities

- Assume that
 - The quotes are correctly sequenced.
 - Arrivals within the second are Poisson with (unknown) constant intensity.
 - The bid and offer process is independent of the within-second arrival times.
- Then each calculated statistic constitutes a draw from the corresponding Bayesian posterior.

Does this really work?

2011 millisecond-stamped TAQ data

Strip the millisecond portions of the time-stamps

Simulate new ms stamps

Wavelet variance estimates using actual ms time-stamps

Wavelet variance estimates using simulated ms. time-stamps.

Correlation?

Table 4. Correlations between estimates based on actual vs. simulated millisecond time stamps.

Panel A: $Corr(v_{bid,j,i,d}^2, \tilde{v}_{bid,j,i,d}^2)$

Time scale	Full sample	Dollar trading volume quintiles				
		1 (low)	2	3	4	5 (high)
< 50 ms	0.952	0.948	0.960	0.958	0.916	0.979
50 ms	0.953	0.944	0.952	0.952	0.937	0.982
200 ms	0.975	0.965	0.969	0.975	0.977	0.988
800 ms	0.994	0.991	0.989	0.995	0.996	0.998
3.2 sec	0.999	0.999	0.999	1.000	1.000	1.000
25.6 sec	1.000	1.000	1.000	1.000	1.000	1.000
6.8 min	1.000	1.000	1.000	1.000	1.000	1.000
27.3 min	1.000	1.000	1.000	1.000	1.000	1.000

The correlations are terrific. *Why?*

- If observations are *sparse* in time, their exact location doesn't matter.
 - Suppose that there is one quote change in the hour ...
- If observations are *dense*, their exact location is known more precisely.
 - Consider the first order statistic (the minimum) in a sample of n Uniform(0,1) draws.
 - Sample of $n = 1$ vs. $n = 1,000$

Table 4. Correlations between estimates based on actual vs. simulated millisecond time stamps.

Panel B: $Corr(v_{bid,offer,j,i,d}^2, \tilde{v}_{bid,offer,j,i,d}^2)$, [the bid/offer covariances]

Time scale	Full sample	Dollar trading volume quintiles				
		1 (low)	2	3	4	5 (high)
< 50 ms	0.775	0.333	0.768	0.896	0.919	0.943
50 ms	0.900	0.662	0.926	0.965	0.972	0.978
200 ms	0.979	0.921	0.986	0.995	0.995	0.998
800 ms	0.999	0.998	0.999	1.000	1.000	1.000
3.2 sec	1.000	1.000	1.000	1.000	1.000	1.000
25.6 sec	1.000	1.000	1.000	1.000	1.000	1.000
6.8 min	1.000	1.000	1.000	1.000	1.000	1.000
27.3 min	1.000	1.000	1.000	1.000	1.000	1.000

Back to the 2001-2011 historical sample

- Variance estimations will be based on simulated millisecond timestamps.

Table 5. Summary statistics, historical sample, 2001-2011 (*only odd numbered years are shown*)

	2001	2003	2005	2007	2009	2011
No. firms	137	141	144	150	145	149
NYSE	106	51	48	55	56	47
Amex	16	10	8	14	5	6
NASDAQ	15	80	88	81	84	96
Avg. daily trades	167	231	448	970	1,993	1,346
Avg. daily quotes	1,525	1,470	6,004	12,521	41,571	24,053
Avg. daily NBB changes	128	210	611	772	1,787	1,225
Avg. daily NBO changes	127	226	729	789	1,789	1,146
Avg. price	\$20.57	\$14.41	\$16.10	\$15.81	\$11.25	\$15.77
Market equity cap \$ Million	\$976	\$205	\$348	\$480	\$382	\$690

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23% CAGR

32% CAGR

What statistics to consider?

- ❑ Long-term volatilities changed dramatically over the sample period.
- ❑ Variance ratios (normalized to long-term volatility) are the most reliable indicators of trends.

Table 6. Wavelet variance ratios for bids and offers, 2001-2011

Panel A: Computed from *unadjusted* bids and offers

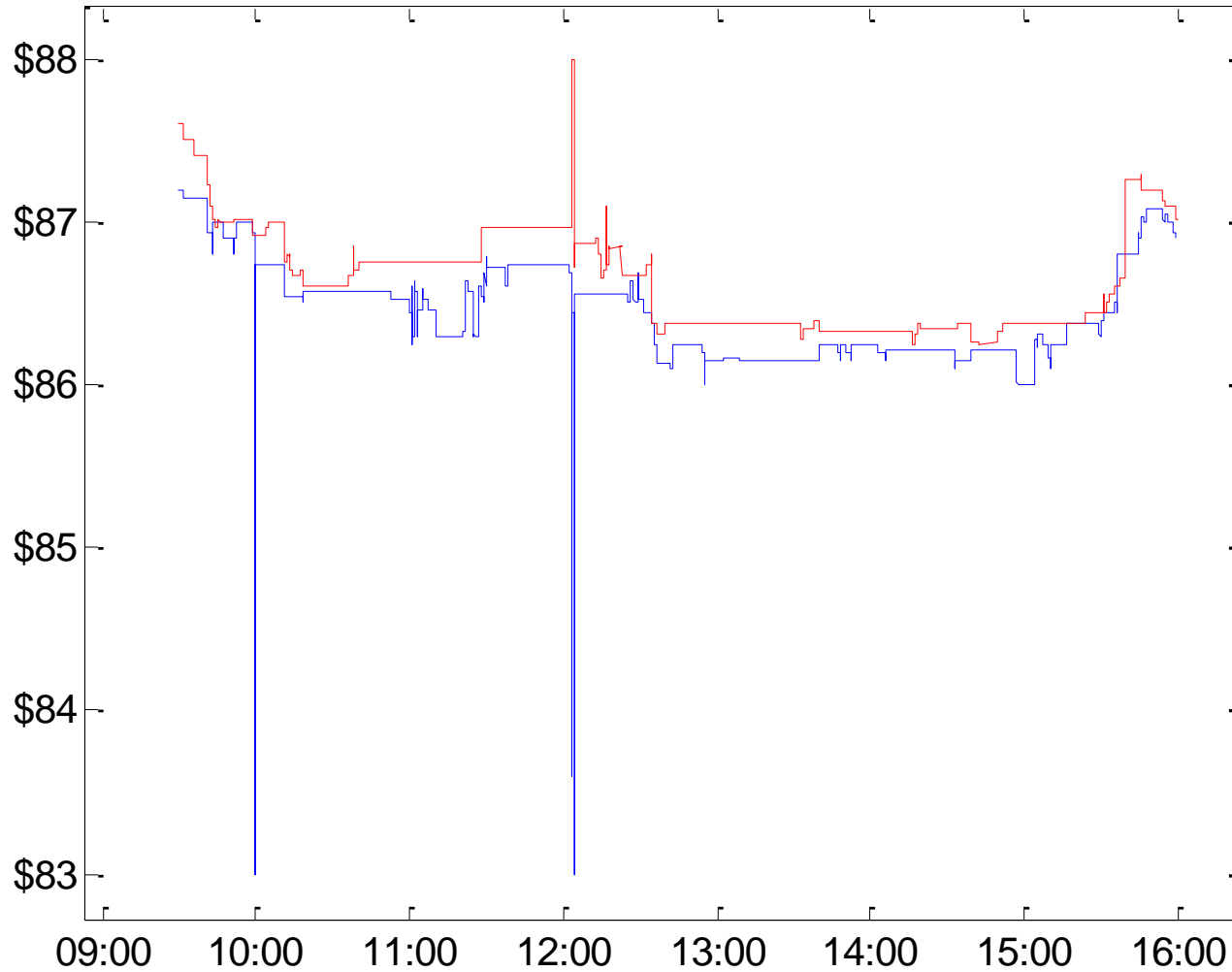
Time scale	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
50 ms	5.29	7.36	5.96	10.31	6.56	8.57	6.96	6.07	4.53	7.09	4.71
100 ms	5.52	6.75	5.20	9.71	6.38	8.07	6.27	5.39	4.12	6.27	4.33
200 ms	5.35	6.44	5.05	9.06	6.10	7.34	5.33	4.65	3.68	5.41	3.75
400 ms	4.65	5.35	4.92	8.18	5.64	6.30	4.25	3.84	3.21	4.54	3.07
800 ms	3.16	4.12	3.86	5.59	4.93	5.10	3.41	3.11	2.76	3.71	2.56
1,600 ms	2.13	2.56	3.19	4.11	4.06	4.05	2.89	2.59	2.42	3.04	2.23
3.2 sec	2.00	2.25	2.91	3.39	3.42	3.37	2.56	2.28	2.16	2.53	2.01
6.4 sec	1.95	2.12	2.61	2.91	2.88	2.92	2.35	2.08	1.94	2.16	1.82

No trend in quote volatilities?

- Maybe ...
 - “Flickering quotes” aren’t new.
 - Recent concerns about high frequency trading are all media hype.
 - The good old days weren’t really so great after all.

- What *did* quote volatility look like circa 2001?

Figure 4 Panel A. Bid and offer for PRK, April 6, 2001.



Compare

- PRK in 2001 vs. AEPI in 2011
 - PRK: large amplitude, no oscillation.
 - AEPI: low amplitude, intense oscillation.

Denoising (filtering) “pops”

- $bid = rough + smooth$
- Denoised $rough^*$
 - $= rough \text{ capped at } \pm 1.5 \times spread$
- Reconstruct a denoised bid as
 - $bid^* = rough^* + smooth$
- Form new variance estimates.

Figure 4 Panel B. PRK, April 6, 2001, Rough component of the bid

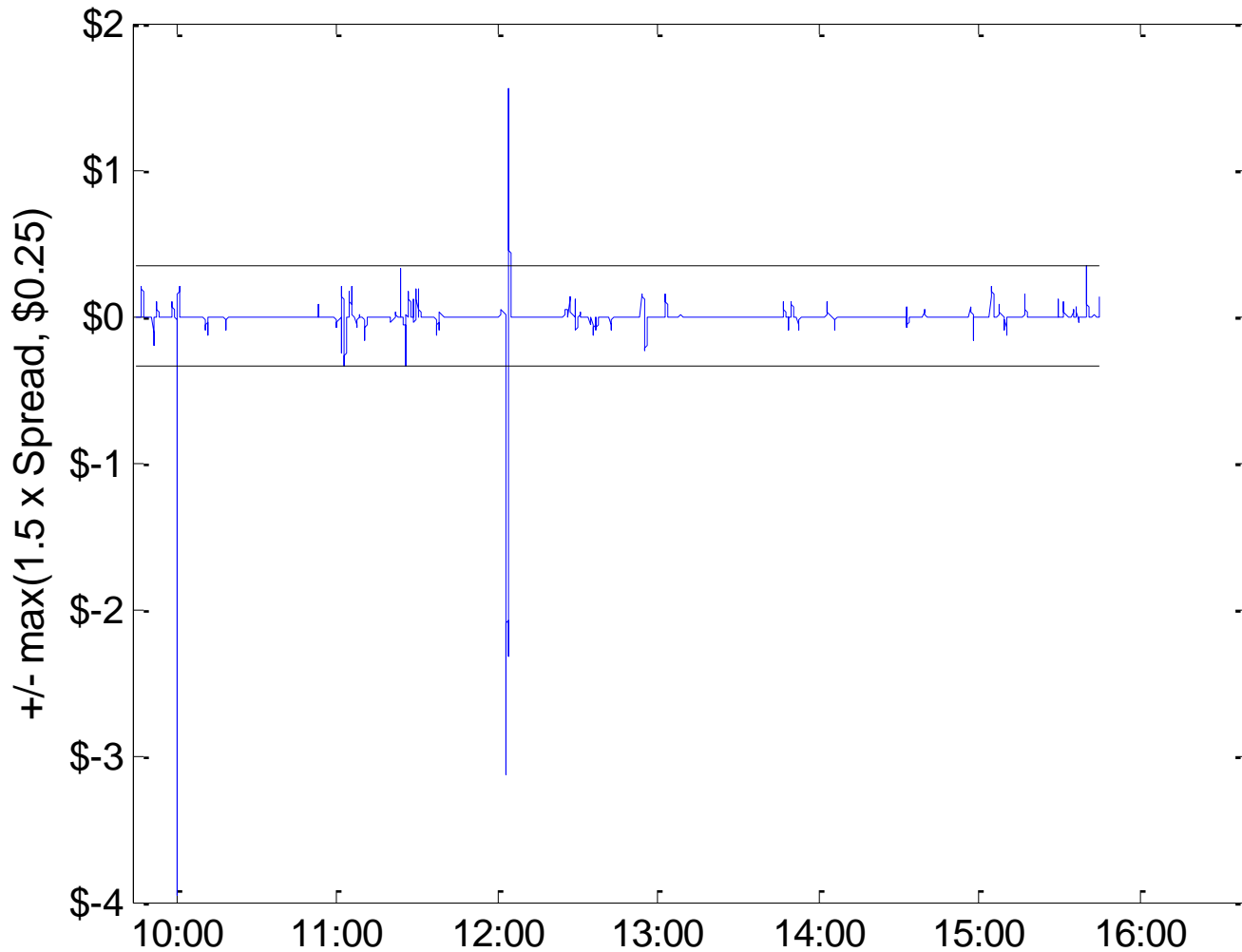


Table 6. Wavelet variance ratios for bids and offers, 2001-2011, *Detail*

Panel A: Computed from *unadjusted* bids and offers

Time scale	2001	...	2011
50 ms	5.29		4.71
100 ms	5.52		4.33
200 ms	5.35		3.75
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800 ms	3.16		2.56
1,600 ms	2.13		2.23
3.2 sec	2.00		2.01
6.4 sec	1.95		1.82

Panel B: Computed from *denoised* bids and offers

Time scale	2001	...	2011
50 ms	1.61		4.47
100 ms	1.58		4.08
200 ms	1.56		3.57
400 ms	1.56		3.01
800 ms	1.57		2.52
1,600 ms	1.64		2.20
3.2 sec	1.82		1.99
6.4 sec	2.12		1.82

Table 6. Wavelet variance ratios for bids and offers, 2001-2011

Panel B. Computed from *denoised* bids and offers

Time scale	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
50 ms	1.61	2.38	3.07	7.03	5.95	8.24	6.56	5.84	4.22	6.81	4.47
100 ms	1.58	2.33	3.02	6.84	5.76	7.76	5.89	5.18	3.85	6.01	4.08
200 ms	1.56	2.28	2.96	6.50	5.49	7.04	4.99	4.46	3.43	5.19	3.57
400 ms	1.56	2.24	2.88	5.92	5.05	6.02	3.96	3.68	2.99	4.37	3.01
800 ms	1.57	2.20	2.77	5.01	4.37	4.82	3.13	2.98	2.58	3.58	2.52
1,600 ms	1.64	2.21	2.68	4.00	3.52	3.79	2.63	2.51	2.28	2.94	2.20
3.2 sec	1.82	2.31	2.60	3.45	2.96	3.16	2.33	2.22	2.05	2.46	1.99
6.4 sec	2.12	2.54	2.58	3.20	2.60	2.75	2.15	2.04	1.86	2.11	1.82

Summary of the variance ratio evidence

- Without filtering: no trend in quote volatility.
- With filtering
 - Volatility in earlier years is lower
 - *Maybe* an increasing overall trend
 - But highest values are mostly in 2004-2006
- The effects of filtering suggest that
 - Early years: volatility due to spikes
 - Later years: volatility reflects oscillations
- What changed?

SEC's Reg NMS (“National Market System”)

- ❑ Proposed in 2004; adopted 2005; implemented in 2006.
- ❑ Defined the framework for competition among equity markets.
- ❑ Enhanced protection against trade-throughs
 - Example: market A is bidding \$10 and market B executes a trade at \$9.
- ❑ For a market's bid and offer to be protected, they have to be accessible instantly (electronically)
 - This requirement essentially forced all markets to become electronic.

Before and after

- Prior to Reg NMS
 - Trading dominated by slow, manual floor markets
 - Weak protection against trade-throughs
- Post Reg NMS
 - Bids and offers are firm and accessible.
 - Strong trade-through protection

So has quote volatility increased?

- Apples vs. oranges
 - The nature of quotes has changed.
- Quote volatility has changed
 - From infrequent large changes to frequent (and oscillatory) small changes.
- Possibly a overall small increase,
 - But nothing as strong as the trend implied by the growth in quote messaging rates.

Follow-up questions

- ❑ What strategies give rise to the episodic oscillations?
- ❑ Are the HFQ episodes unstable algos?
- ❑ Are they sensible strategies to detect and access liquidity?

Dark trades: internalized execution

- A broker receives a retail buy order.
 - The order is not sent to an exchange or any other venue.
 - The broker sells directly to the customer at the National Best Offer (NBO)
- Volatility in the NBO → volatility in execution price.

Dark trading

- “Dark” the market executing the order did not previously post a visible bid or offer at the execution price.
 - The trade itself is promptly reported.
- Dark mechanisms
 - Hidden (undisplayed) limit orders
 - Internalized executions
 - Dark pools

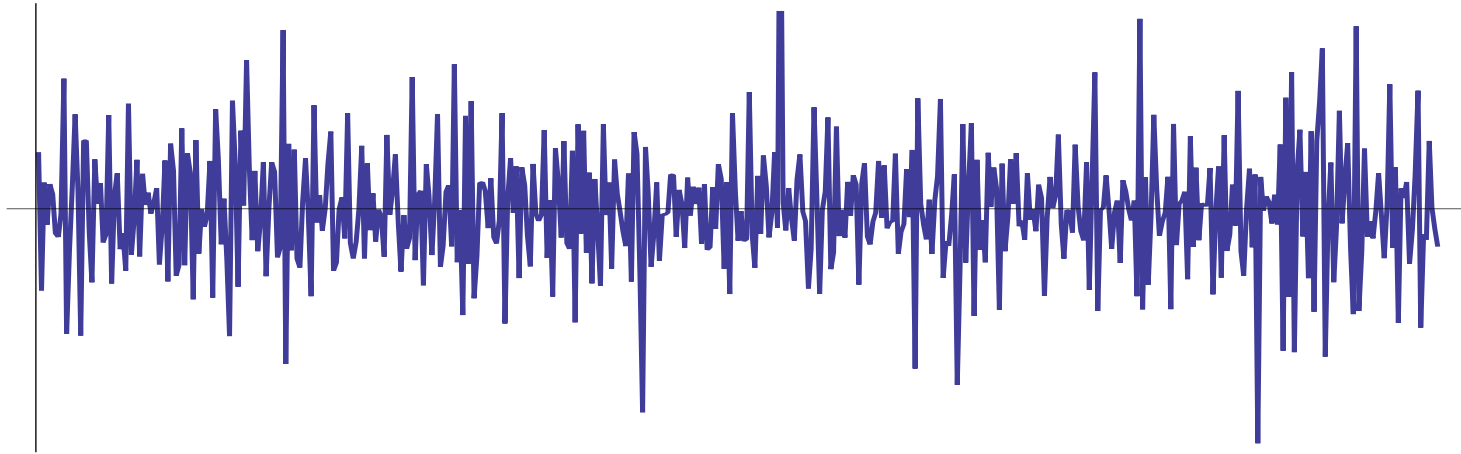
Dark trades: dark pools

- Mechanism
 - Traders send buy and sell orders to a computer.
 - The orders are not displayed.
 - If the computer finds a feasible match, a trade occurs.
- The trade is priced at the midpoint of the National Best Bid and Offer (NBBO)
- Volatility in the NBBO causes volatility in the execution price.

Look-back options

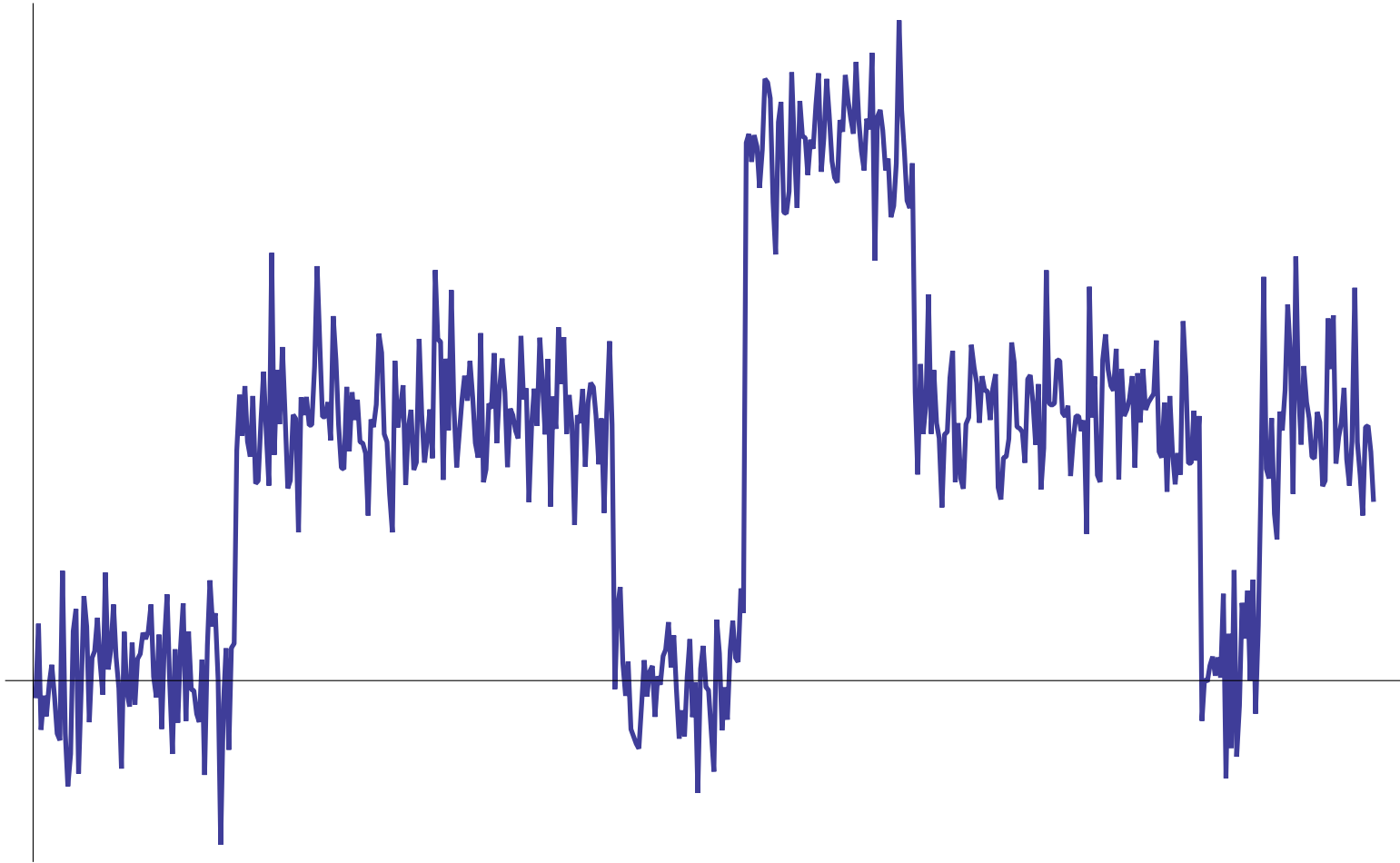
- Internalization: a broker receives a retail buy order and executes the order at the NBO.
- Problem: how does the customer know what the NBO is or was?
- Might the dealer take the highest price in the interval of indeterminacy?
 - Stoll and Schenzler (2002)

What's lost by first-differencing?



- First difference plot of a simulated series.

... and the integrated series



Analyzing quote volatility

- Usual approach
 - *parametric model* for variance of price changes (ARCH, GARCH, ...)
- This study
 - *Non-parametric* analysis of variances of price levels

Variance about a local mean of a random walk

