Interest Rate Futures

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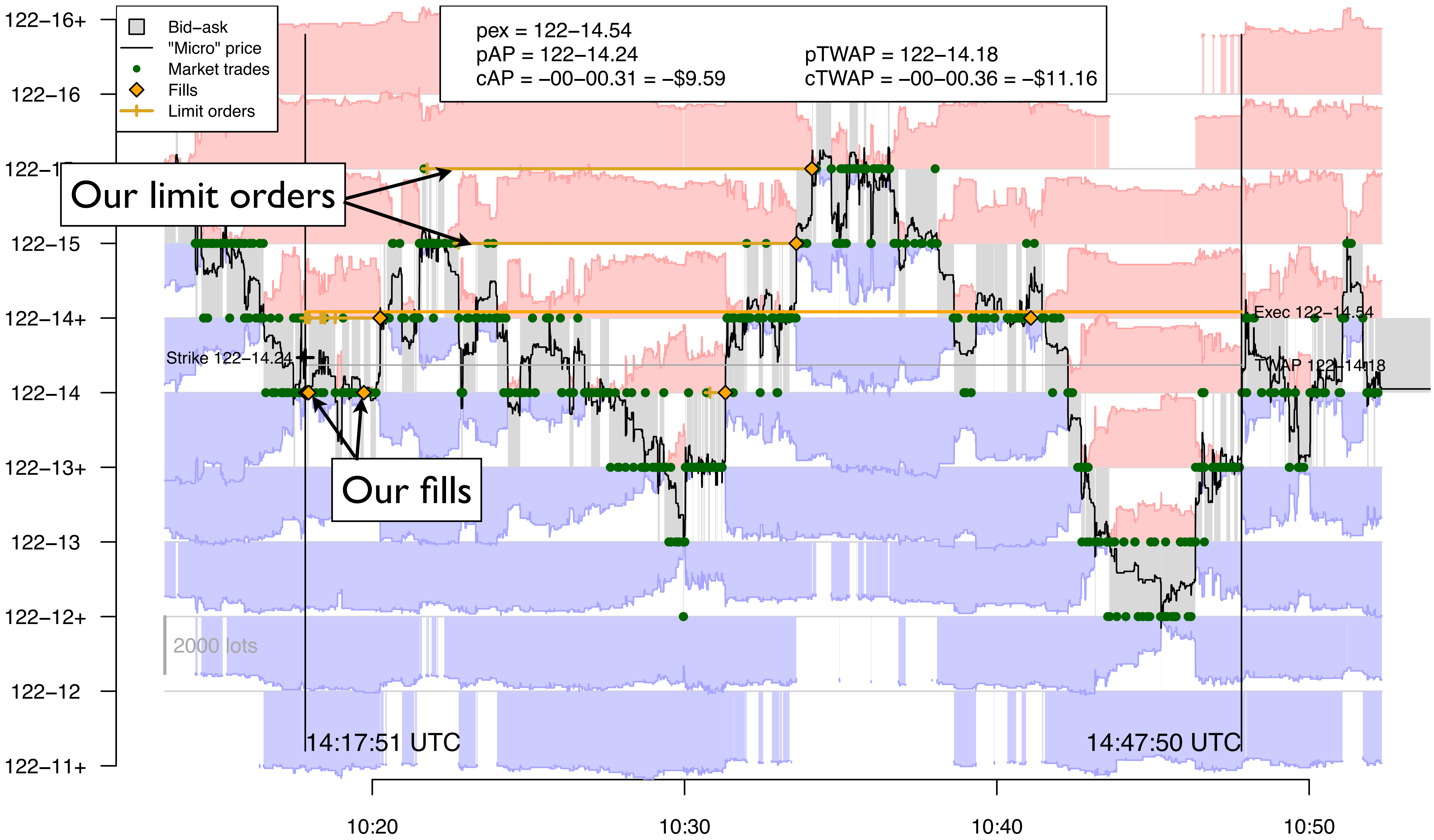
Market Microstructure
Dec 9, 2010

QB = Algorithmic Execution

SELL 179 ZNU0 (Sept 2010 10-yr Treasury)



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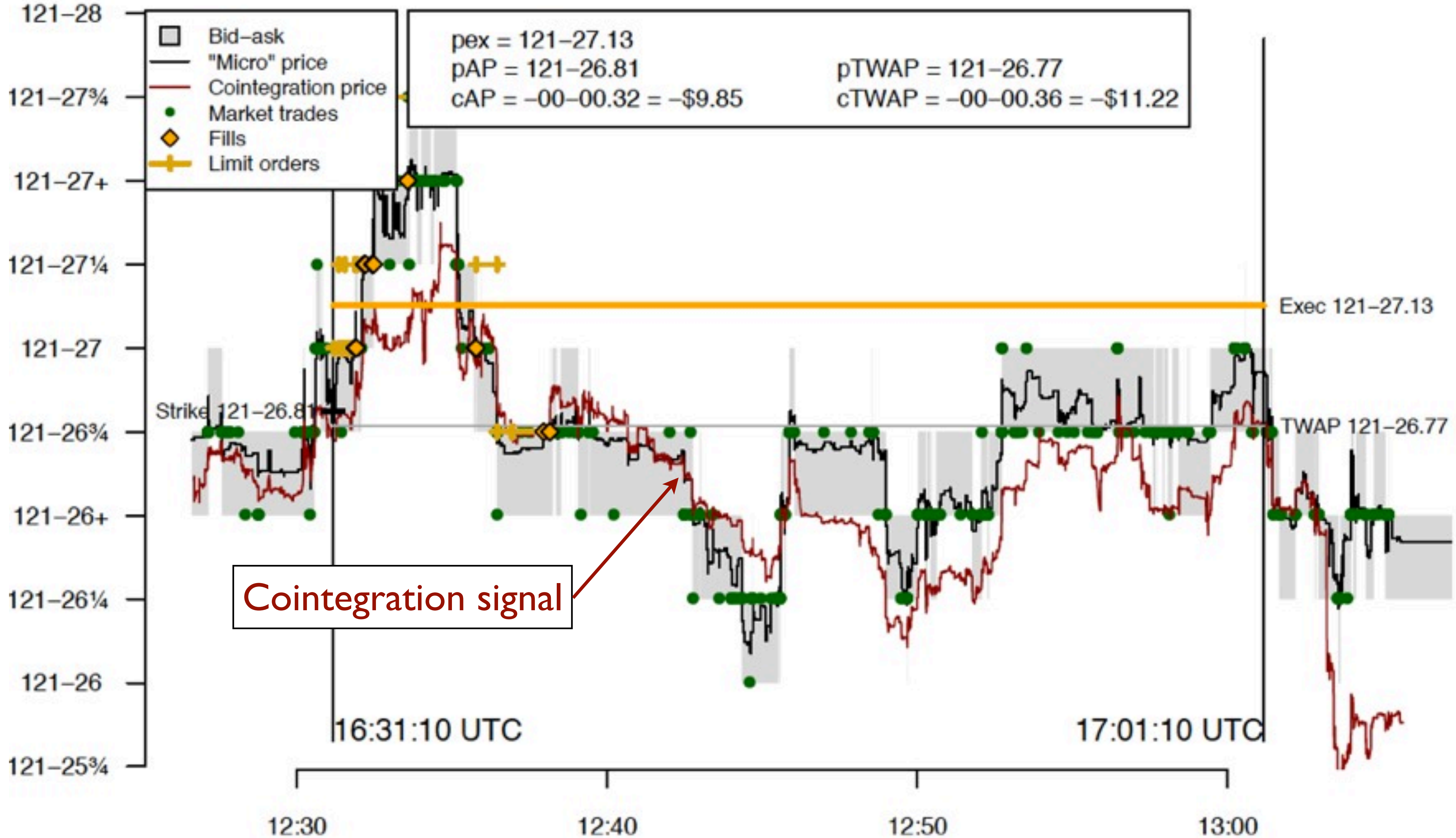
Produced by QB from CME and internal data

Algorithmic Execution + TCA (Example 2)

SELL 63 ZFZ0
(Dec 2010 5-yr Treasury)



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Algo execution and cost measurement

- No prop trading or market making

Interest rate products, starting with futures

- Equities already well served
- Currently live with futures on CME

Value add is microstructure expertise

1. The products
2. Pro rata matching algorithms
3. Treasury roll
4. LDB data set

1. Interest rate futures products

Chicago Mercantile Exchange (CME)

- US Treasury futures
- Eurodollar futures
- Fed Funds

London International Financial Futures (LIFFE)

- Euribor, Euroswiss, Euroyen, *etc*
- Short Sterling
- Gilt

Eurex

- Bund, Bobl, Schatz

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Futures are not securities

Regulated by CFTC not SEC (US)

- primary purpose is information dissemination

Defined and owned by exchanges

- no fragmentation (many attempts)
- exchanges have much more central role
- microstructure is much more important

Almost all trading is now electronic

- very good market data

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CME US Treasury futures

	Min deliv	Max deliv	ADV (`000)
2-yr note	1.9 yr	2 yr	342
3-yr note	2.9 yr	3 yr	0
5-yr note	4.2 yr	5.3 yr	741
10-yr note	6.6 yr	10 yr	1468
Bond (30 yr)	15 yr	25 yr	469
Ultra bond	25 yr	--	92

Short position has choice of security and date

- conversion factor to approximate 6% yield

Cheapest-to-deliver (CTD) embedded option

Treasury futures trading

Quarterly expirations (Mar, Jun, Sep, Dec)

front month is only liquid one (Roll event)

Price quotes relative to par, with 32nds

e.g. 118-15+ = \$118 + 15.5/32

Tick size 1/4, 1/2, or 1 32nd

Notional \$100k: 1/32 = \$31.25

(brokerage commissions ~\$1-2)

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CME Eurodollar futures

- Eurodollar = dollar deposit outside US (1956)
  - “Euro” = “foreign”
- Eurodollar futures on CME since 1981
  - first cash-settled futures contract
- Forward bet on changes in LIBOR rate
  - 9950 = 99.50 = LIBOR at 1.50%/yr
- Delivery amt is 3-month interest on $1MM
  - 9950 → 9951 (1 bp) = $25 gain
  - Tick size is 1/2 bp = $12.50

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Inherently multidimensional

Quarterly expirations to 10 yrs (+ serials)

- 40 contracts, 10-15 active
- All are short-term rates: very correlated

Spread contracts

- Calendar spreads: +1 Jun, -1 Dec
- Butterflies: +1 Jun, -2 Sep, +1 Dec
- Treasury inter-commodity: +8 5-yr, -5 10-yr

Additional modeling features

- implied liquidity
- cointegration

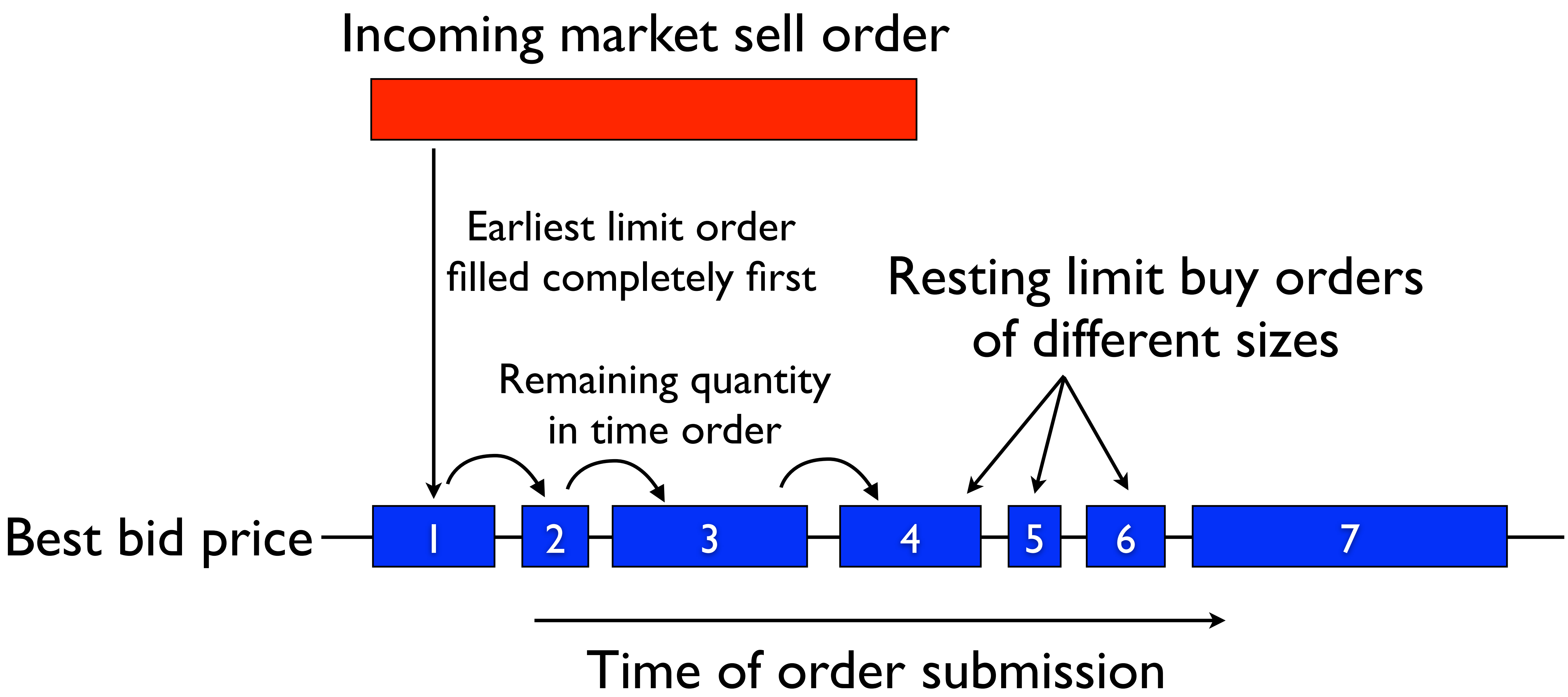
2. Pro rata matching

How market orders are matched to limit

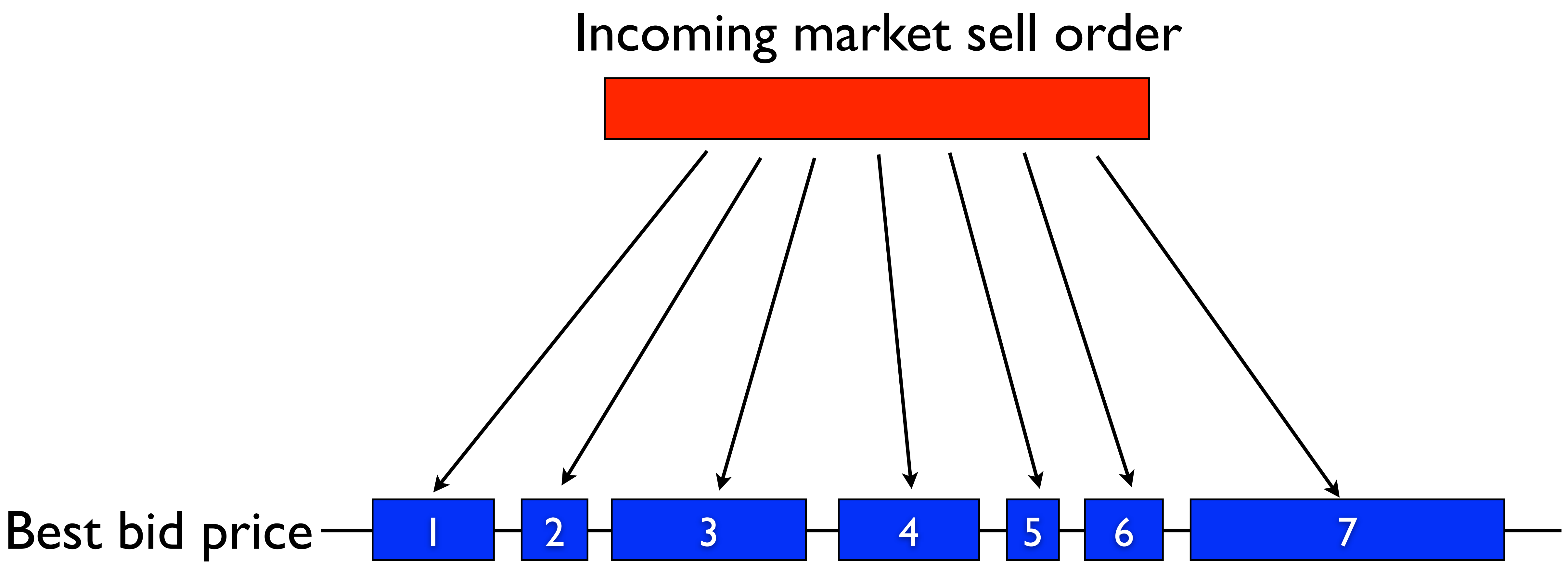
Algorithm fixed by exchange

- to attract more volume
- to attract correct mix of participants
- etc

First-in first-out (FIFO) order matching



Pro rata order matching



Incoming volume divided
among *all* resting orders
at best price

Reasons for pro rata matching:

- Historical tradition from pit trading
- Encourage submission of large limit orders
- Allow late entrants to participate

Characteristic of interest rate futures markets

- Eurodollar, Euribor, Treasury calendar spreads
- Short sterling

“Arms race” to oversize limit orders

- limited only by risk of overfilling
- Jonathan Field & Jeremy Large 2008

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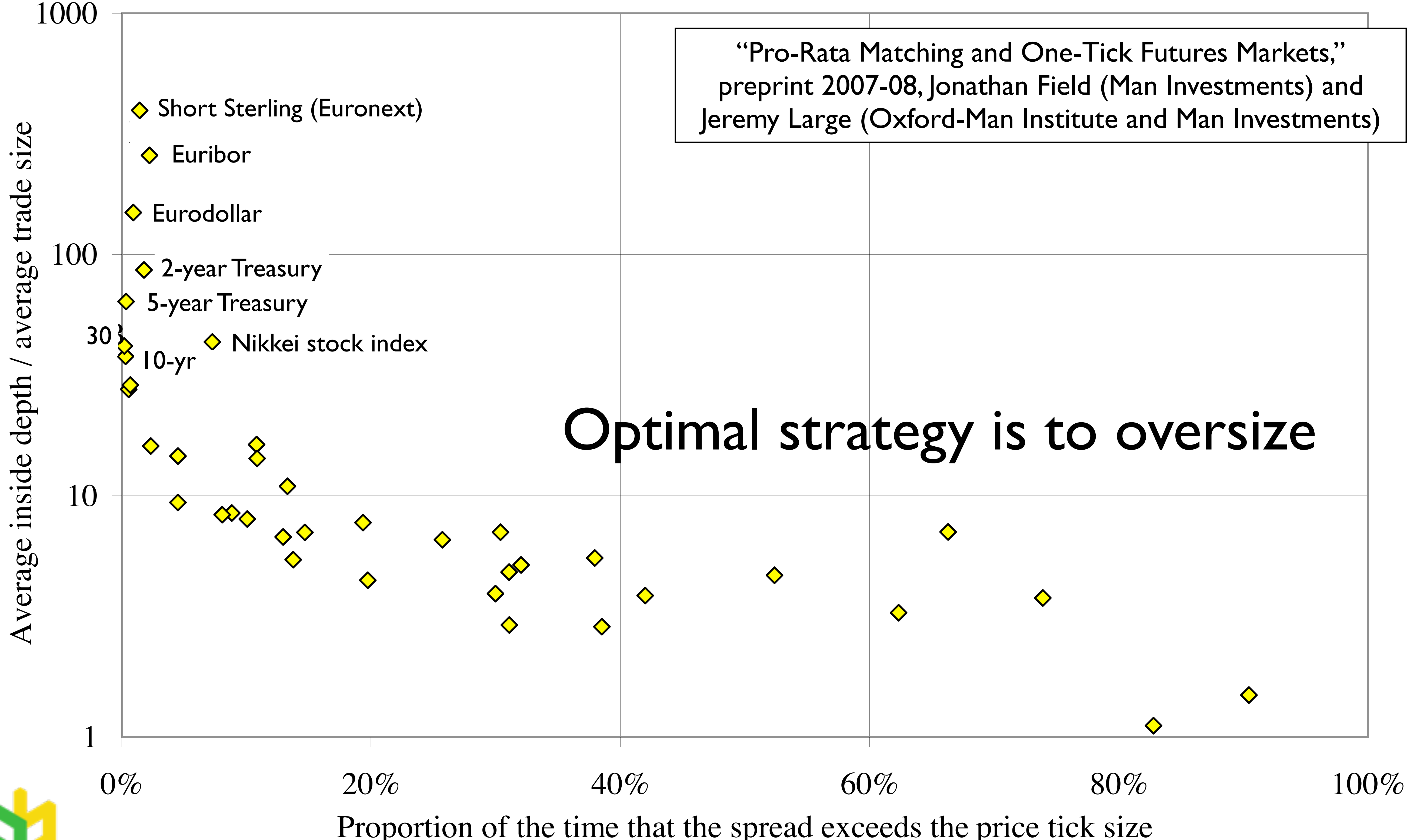
Interest rate futures typically have pro rata matching, large resting liquidity, and large tick size



CME Eurodollar pro rata

1. First order at new level is filled first
   when filled, no new order
2. Remaining volume is allocated pro rata
   volumes rounded down to integral trade size
   0-lots and 1-lots rounded down to zero
3. Remaining volume is allocated FIFO

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1. Orders placed during the “pre-opening” or at the indicative opening price (IOP) will be matched on a price and time priority basis. **Note that implied orders are not taken into consideration, as they are only active during the continuous trading session**.
2. Priority is assigned to an order that betters the market, i.e. a new buy order at 36 betters a 35 bid. Only one order per side of the market (buy side and sell side) can have this TOP order priority. There will be situations where a TOP order doesn’t exist for one or both sides of the market (for example, an order betters the market, but is then canceled). There will never be a situation that results in two orders on the same side of the market having TOP order status.
3. Only outright orders can be TOP orders, however the TOP orders of underlying orders that are creating implied orders will be taken into consideration during the matching process so as not to violate the TOP order rule in any market.
4. TOP orders are matched first, regardless of size.
5. After a TOP order is filled, Pro Rata Allocation is applied to the remainder of the resting orders at the applicable price levels until the incoming order is filled.
6. The Pro Rata algorithm allocates fills based upon each resting order’s percentage representation of total volume at a given price level. For example, an order that makes up 30% of the total volume resting at a price will receive approximately 30% of all executions that occur at that price. Approximate fill percentages may occur because allocated decimal quantities are always rounded down (i.e. a 10-lot order that receives an allocation of 7.89- lots will be rounded down to 7-lots).
7. The Pro Rata algorithm will only allocate to resting orders that will receive 2 or more contracts.
8. After percentage allocation, all remaining contracts not previously allocated due to rounding considerations are allocated to the remaining orders on a FIFO basis.

   - Outright orders will have priority over implied orders and will be allocated the remaining quantity according to their timestamps.
   - Implied orders will be then allocated by maturity, with the earliest expiration receiving the allocation before the later expiring contracts. If spread contracts have the same expiration (i.e., CONTRACT A-CONTRACT B and CONTRACT A-CONTRACT C), then the quantity will be allocated to the earliest maturing contracts making up that spread (i.e., the CONTRACT A-CONTRACT B will get the allocation before the CONTRACT A-CONTRACT C because the CONTRACT B expires before the CONTRACT C).

Consequences of pro rata matching

- Massive oversizing of limit orders
  - "arms race" in competition for liquidity
  - limited only by risk tolerance
- Incentive for marketable limit orders
  - become new TOP order
- Rapid variations on limit order size
  - no penalty for cancellation and resubmission

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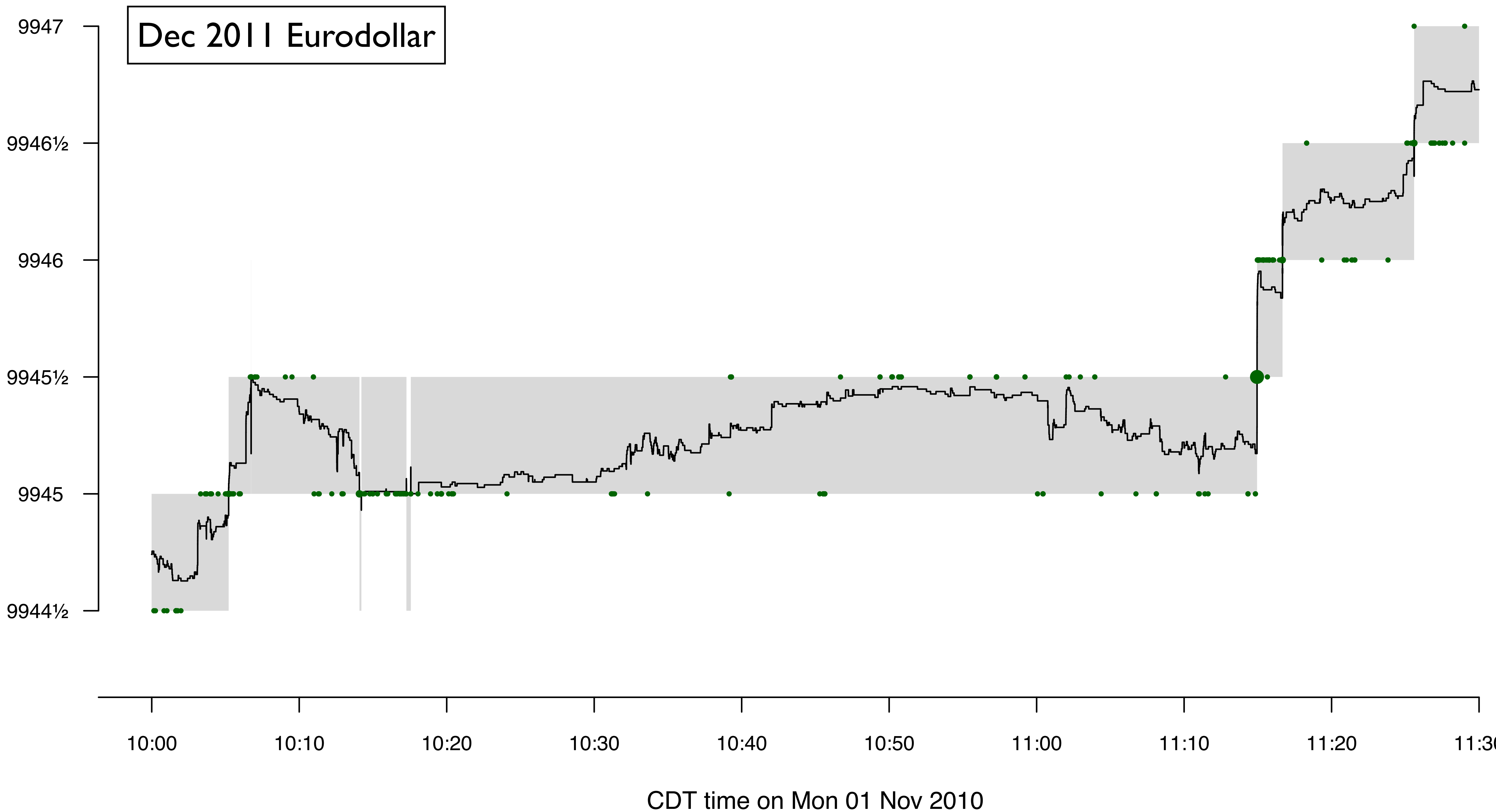
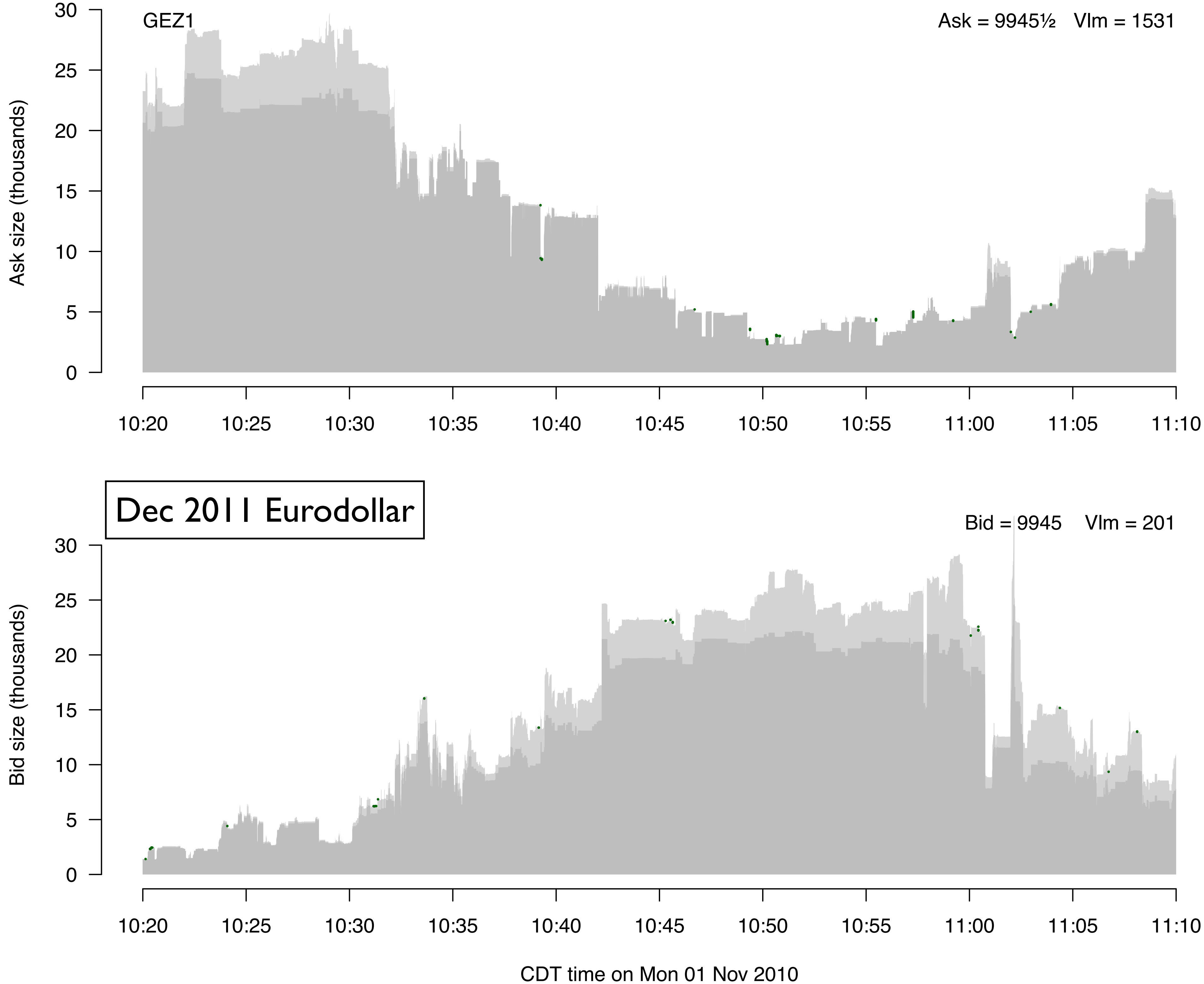
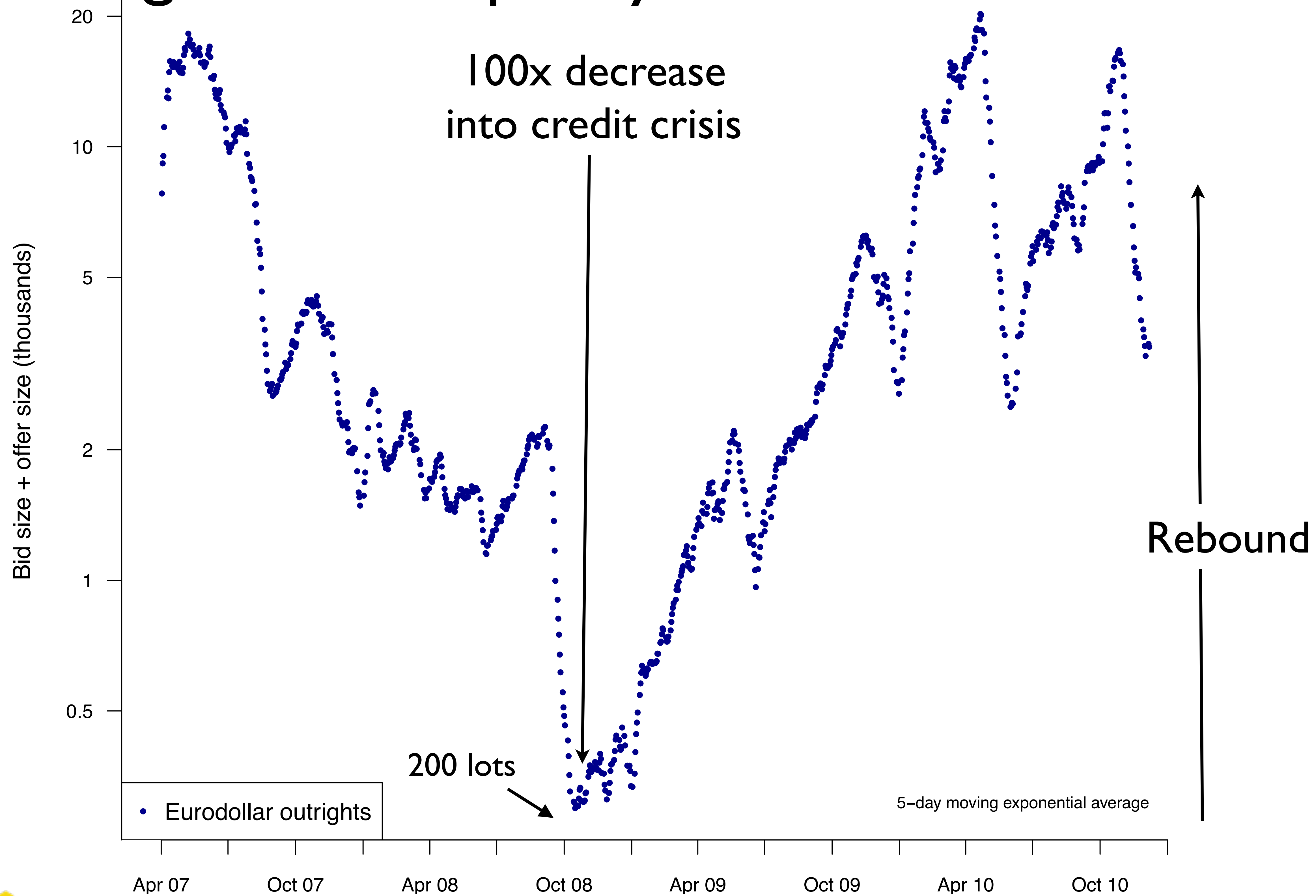
Eurodollar market data



Variations in quote size



Avg Posted Liquidity: Eurodollar Futures



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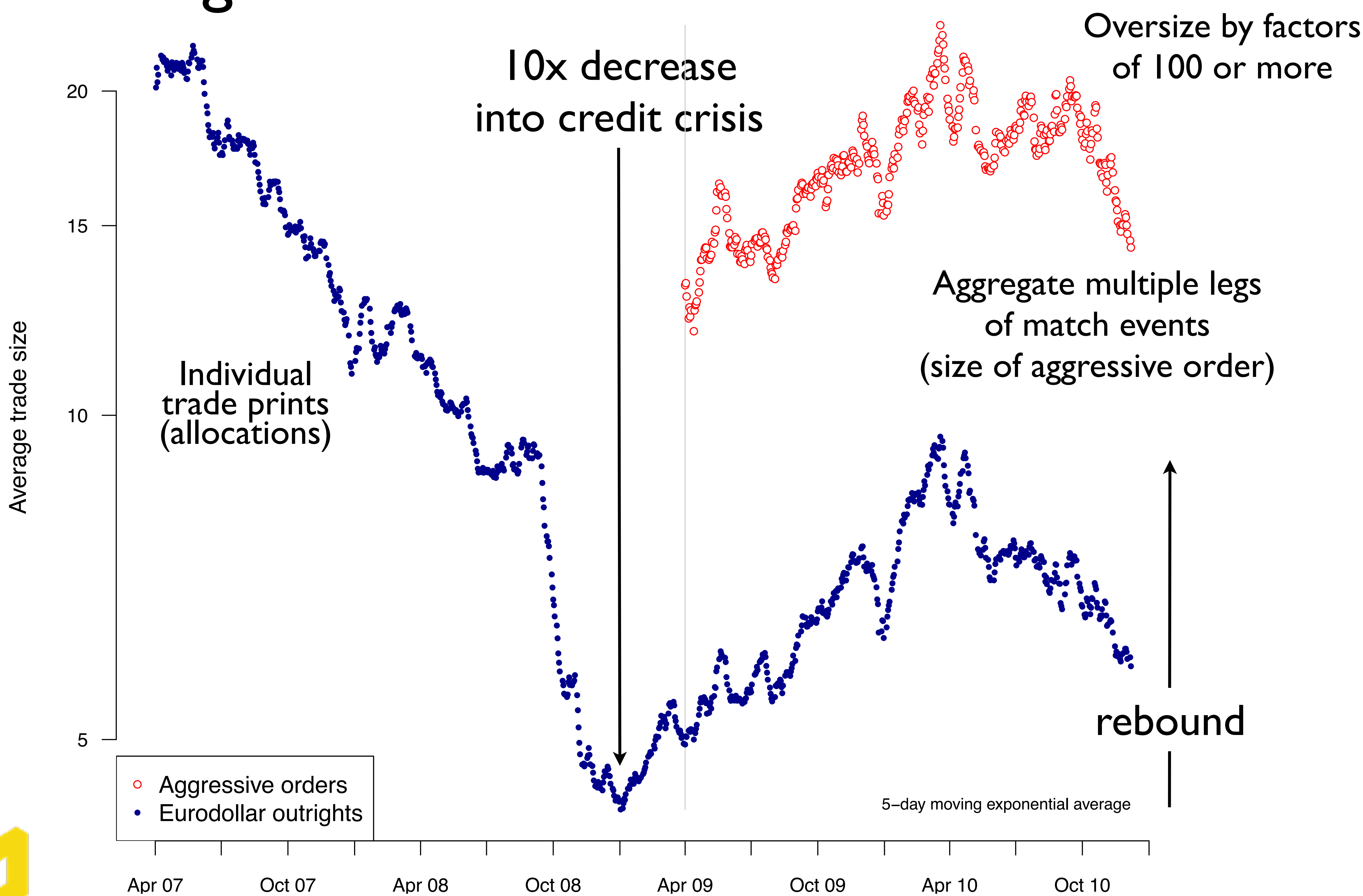
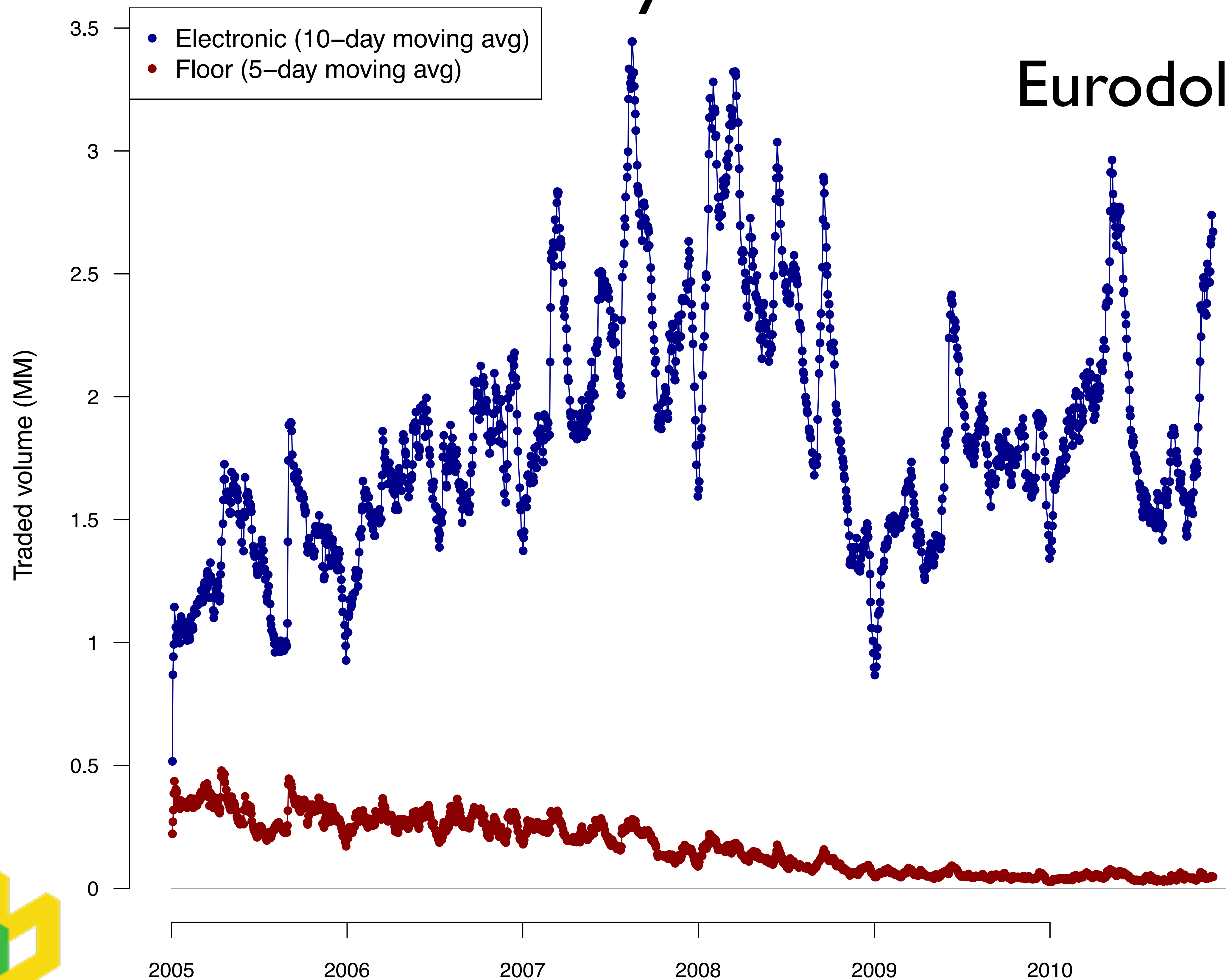
Average Trade Size: Eurodollars



Trade volumes vary much less



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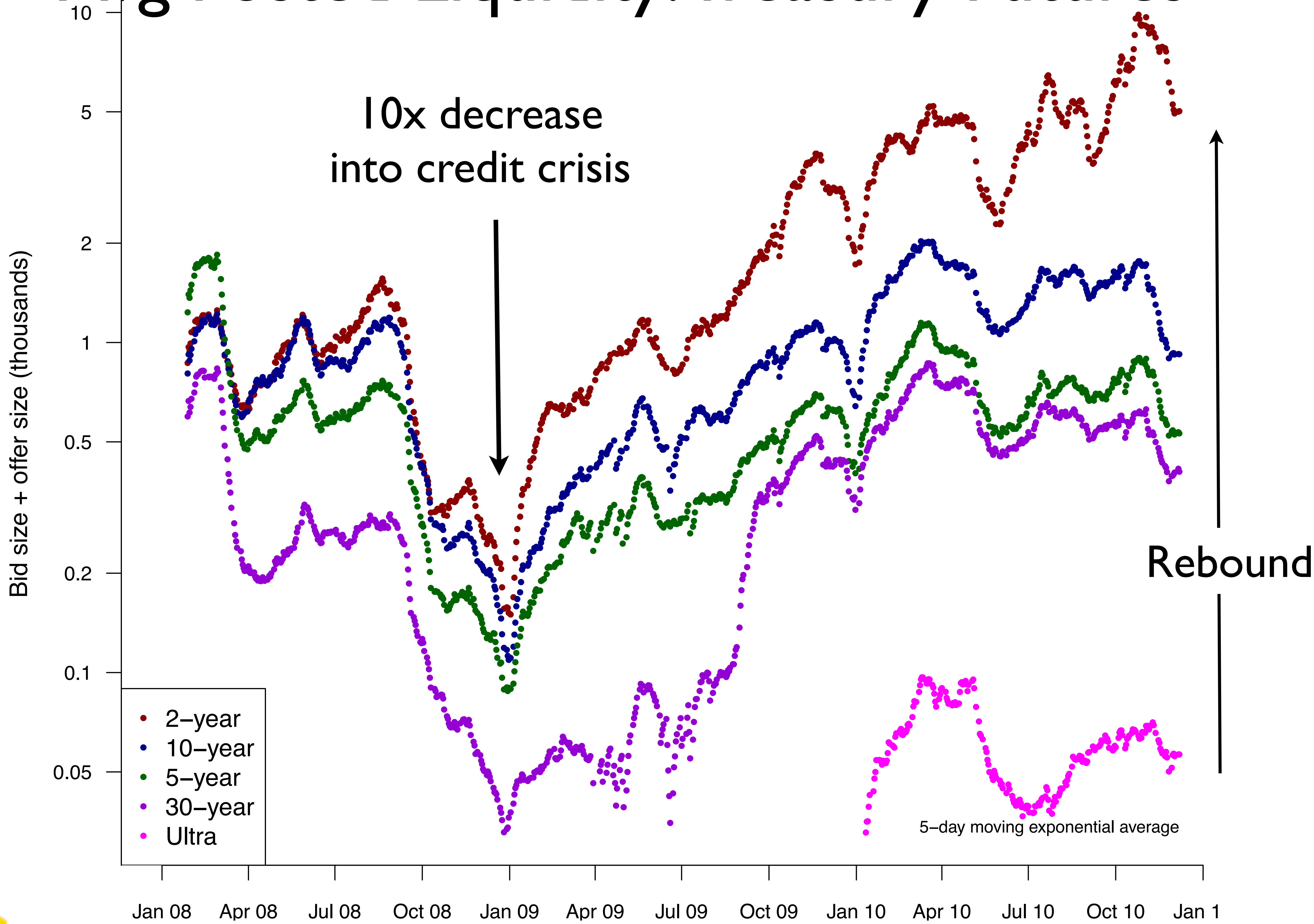
Avg Posted Liquidity: Treasury Futures



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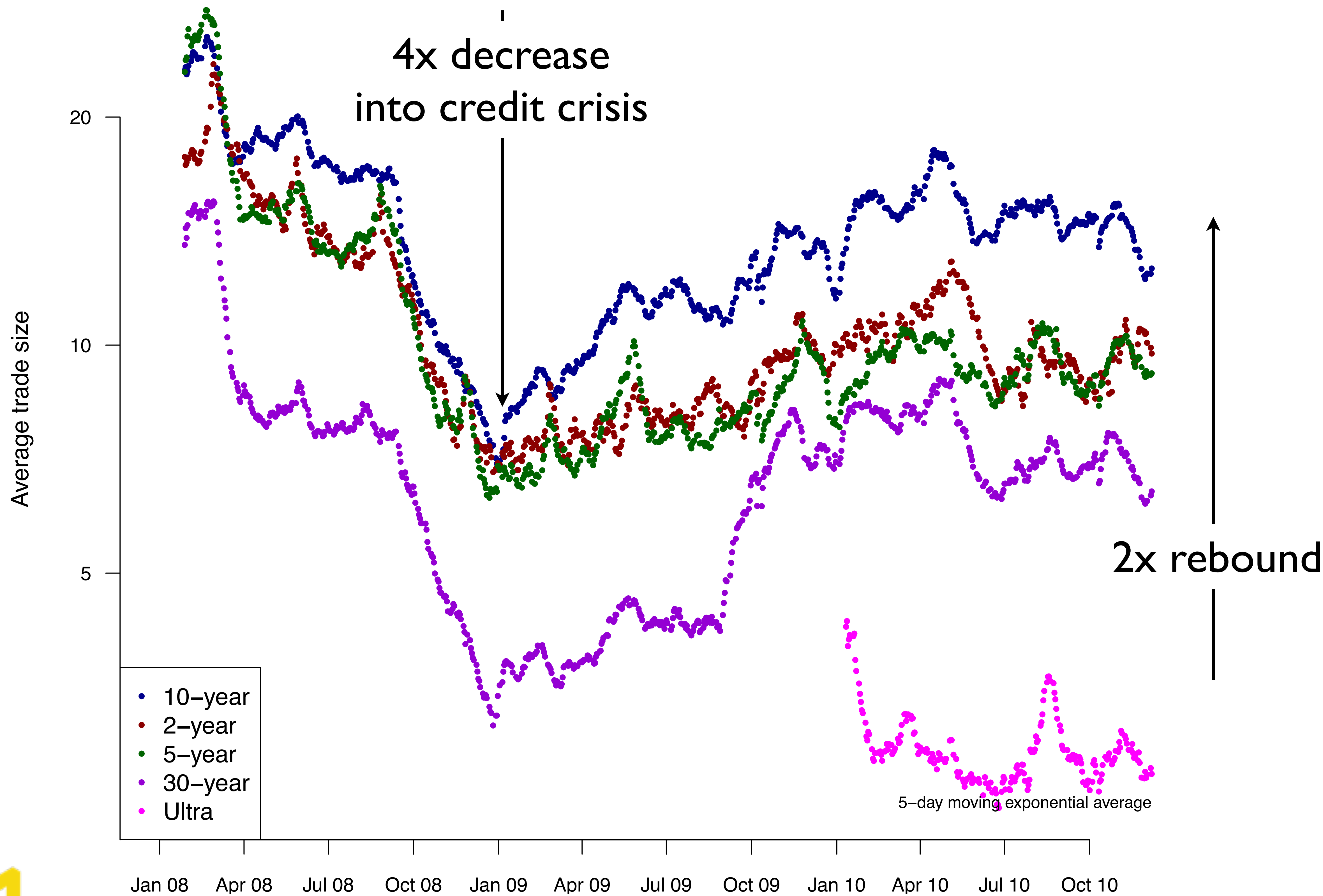
Average Trade Size: Treasuries



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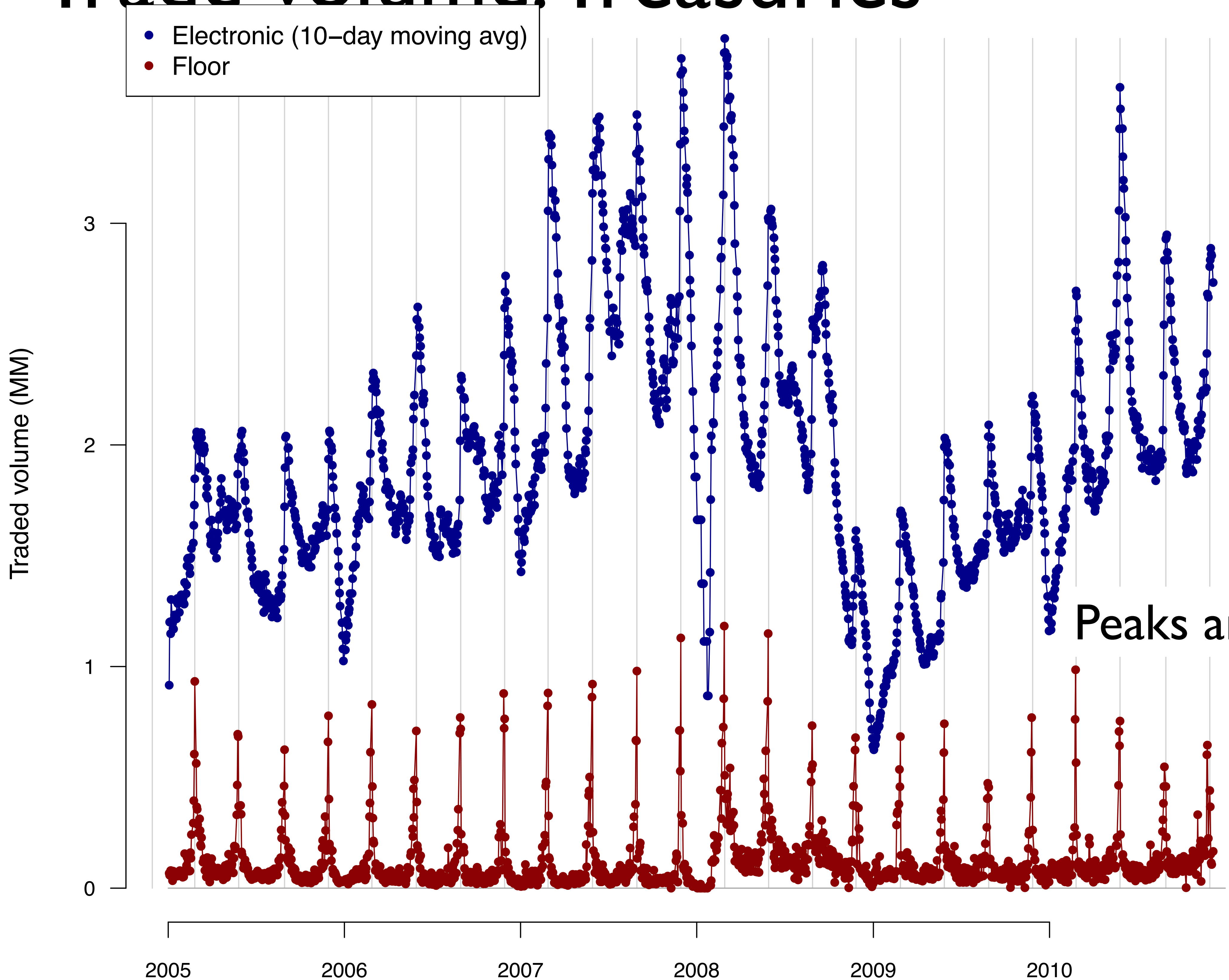
Trade volume: Treasuries



Peaks are roll events

How much pro rata, how much FIFO?

Jianhong Wang, NYU MMF 2010

Depends on limit order size distribution

- uniform order size: more FIFO volume
- large and small orders: more pro rata

LIFFE IR matching (pre July 2010)

Pro-rata, weighted by sequence number

Optimal strategy is to split limit order:

- one large order, plus
- many small 1-lot orders

If all traders are symmetric size,
optimal size is golden ratio

Karel Janeček and Martin Kabrhel (RSJ Invest)
"Matching algorithms of international exchanges"
preprint Dec 2007

LIFFE Euribor "time pro rata"

1. First order at new level is filled first
   when filled, no new order
2. Remaining volume is allocated
   by pro rata *weighted* by preceding volume
   volumes rounded down to integral trade size
   0-lots rounded *up* to one
3. Remaining volume is allocated

Purpose
encourage small traders
reduce transient quotes

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2. Treasury roll event

Who trades with whom?
Role of market makers

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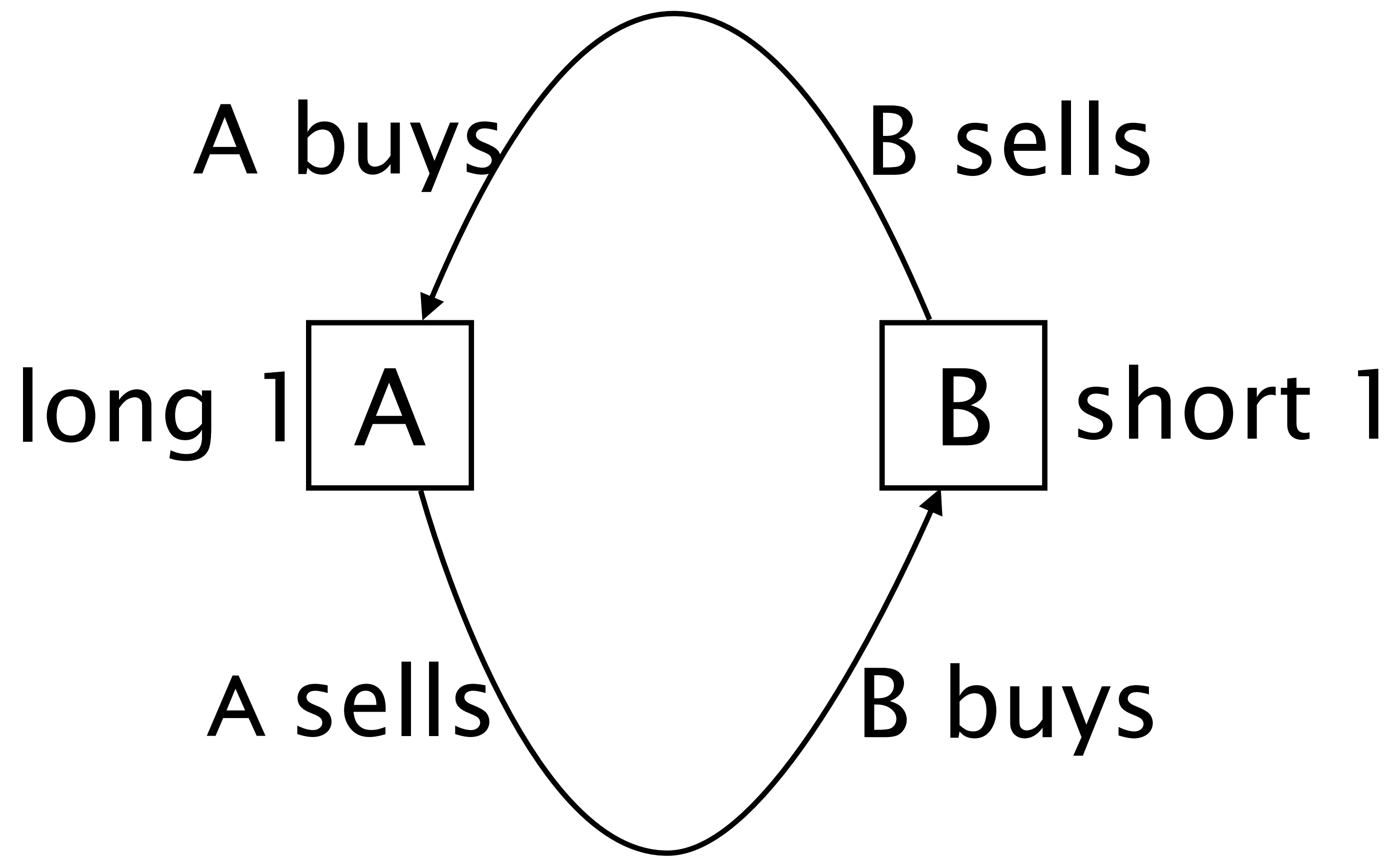
Futures open interest

time

Open interest = 0

Open interest = 1

Open interest = 0



Roll

		Open interest	
A	B	Dec	Mar
long 1 Dec	short 1 Dec	1	0
sell →	buy		
Dec-Mar calendar spread			
long 1 Mar	short 1 Mar	0	1

If position holder trades with position holder, then 1 spread prints for each 1 change in open interest

Roll 2: via market maker

A	MM	B
long 1 Dec	flat	short 1 Dec

sell → buy

Dec-Mar calendar spread

sell → buy

Dec-Mar calendar spread

A	MM	B
long 1 Mar	flat	short 1 Mar

If position holders trade with intermediaries, then 2 spreads print for each 1 change in open interest

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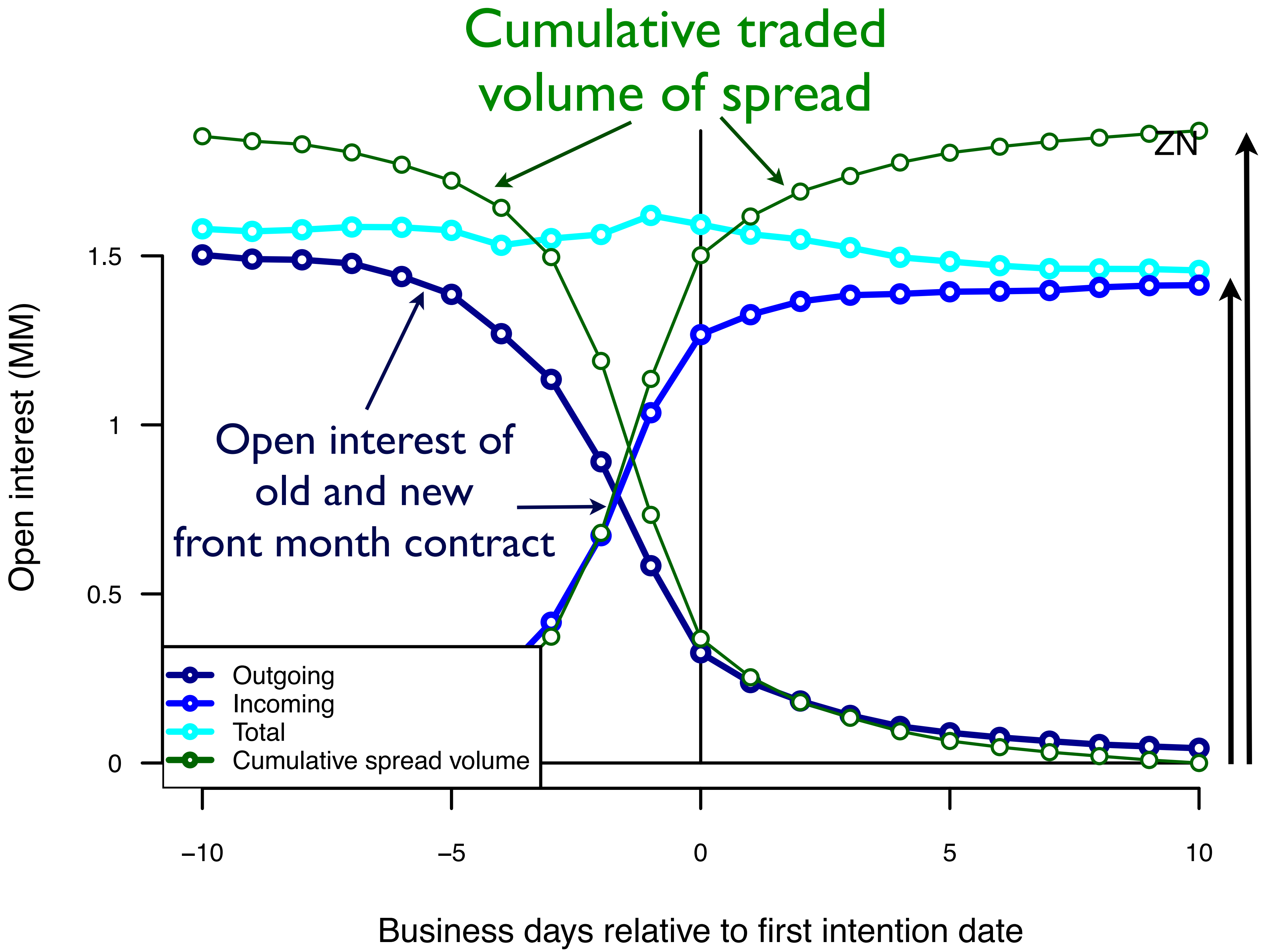
Transfer of open interest



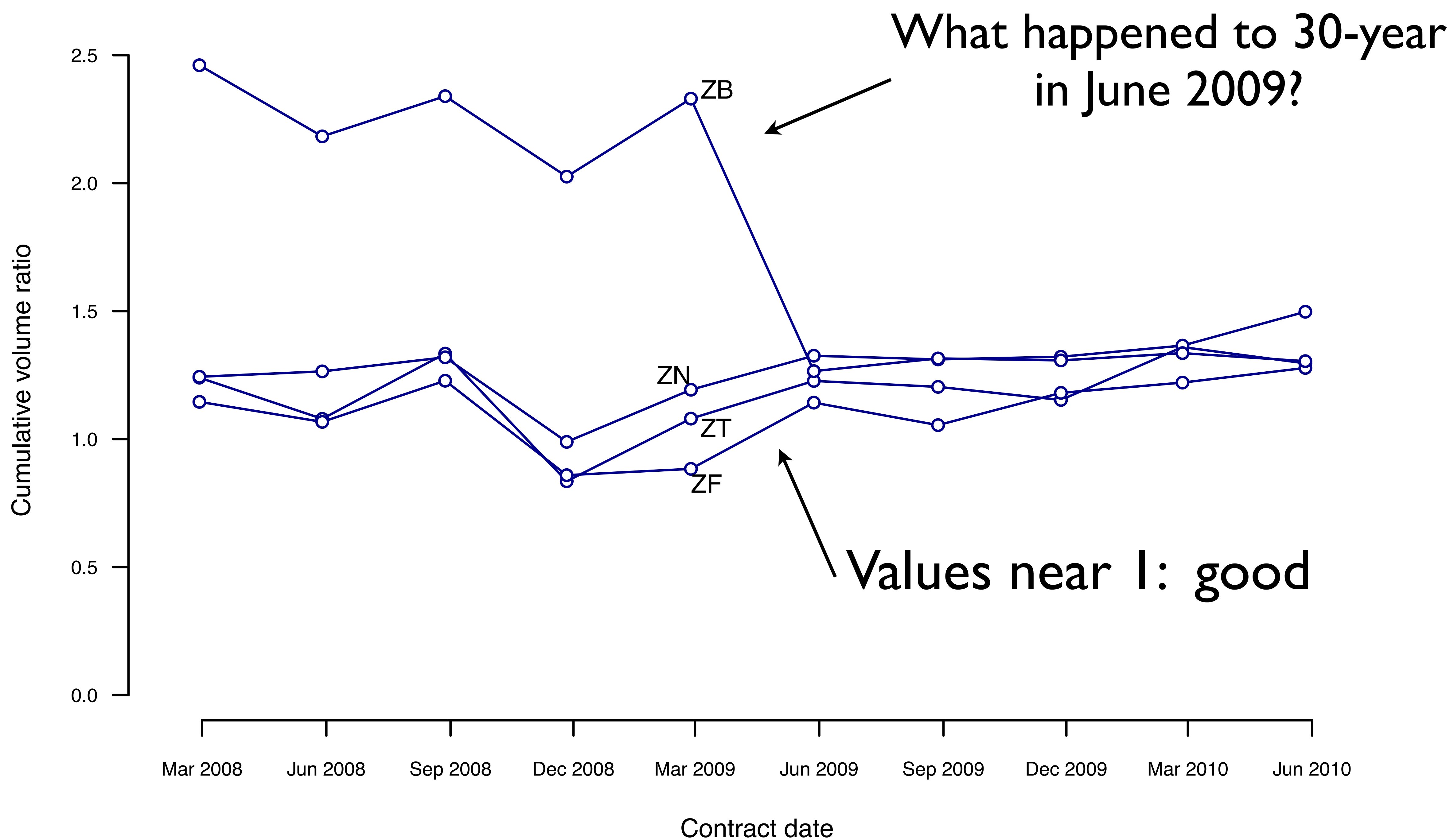
Ratio of spread volume to open interest measures efficiency

Ratio near 1: open interest moves via direct trades

Ratio near 2: open interest moves via intermediaries

ZN: Average across 10 rolls March 2008 to June 2010

Historical evolution of volume ratio



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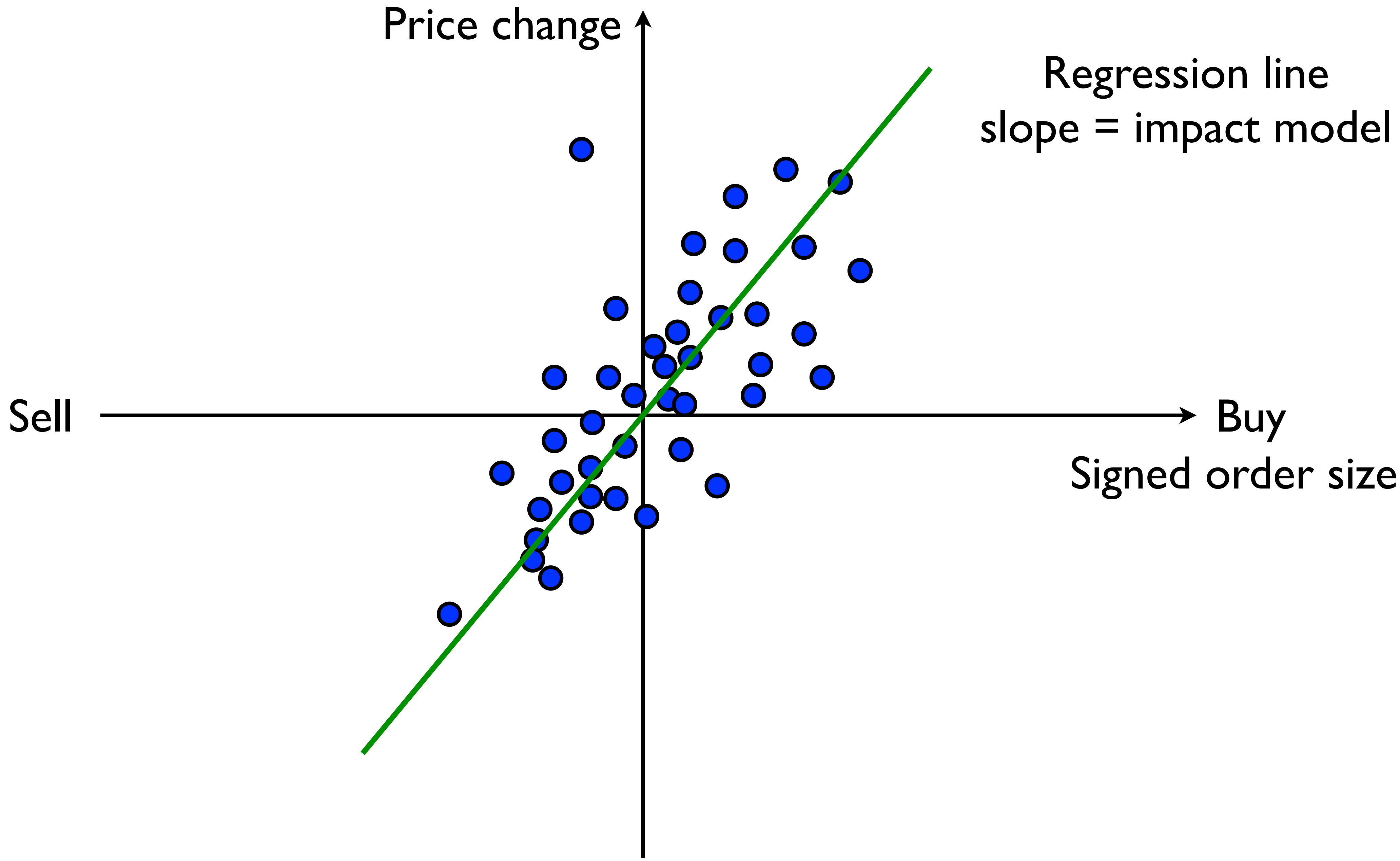
4. LDB data set

How to measure market impact of trades?



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What is a buy or a sell?

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   trade at ask = buy, at bid = sell
   liquidity demanders try to act like providers

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   market impact of our client population
   dependent on details of data set
   impossible for external analysts to replicate

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   impossible for external analysts to replicate
3. CME LDB:
   market participants labelled by type
   estimate temporary and permanent impact

Customer Trade Indicator (CTI) code

1. Exchange local trading for own account
   market maker
2. Member firm trading for own account
   bank proprietary trading desk
3. Local trading for other's account
   (almost no volume -- merge with CTI 1)
4. External firm
   liquidity demander

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CME Liquidity Data Bank (LDB)

For Treasury outrights since Jan 2009

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CME Liquidity Data Bank (LDB)

For Treasury outrights since Jan 2009

For each 15-minute interval

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CME Liquidity Data Bank (LDB)

For Treasury outrights since Jan 2009

For each 15-minute interval

For each trade price level

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CME Liquidity Data Bank (LDB)

For Treasury outrights since Jan 2009

For each 15-minute interval

For each trade price level

→Buy and sell volume for each CTI category

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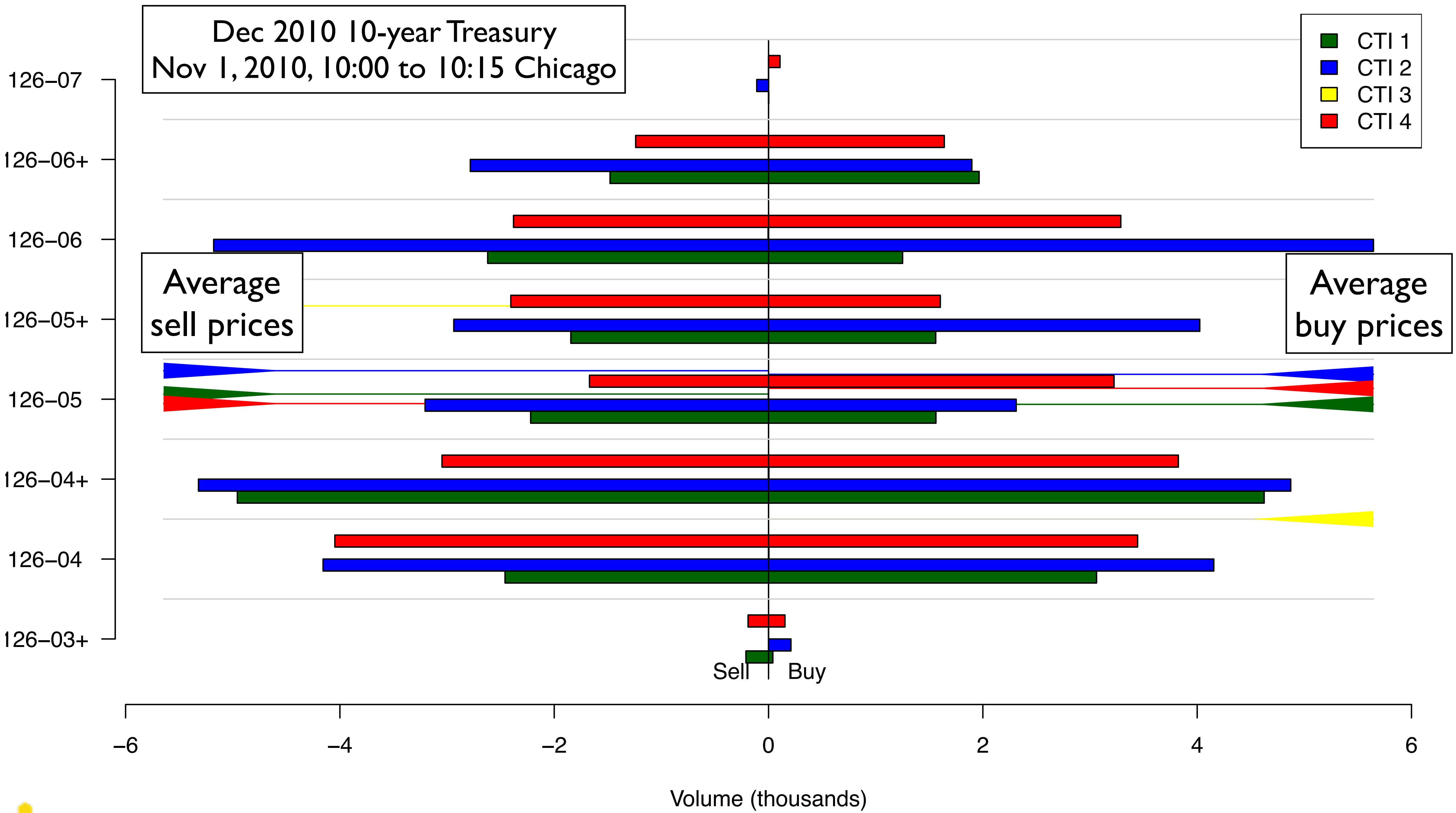
CTI example



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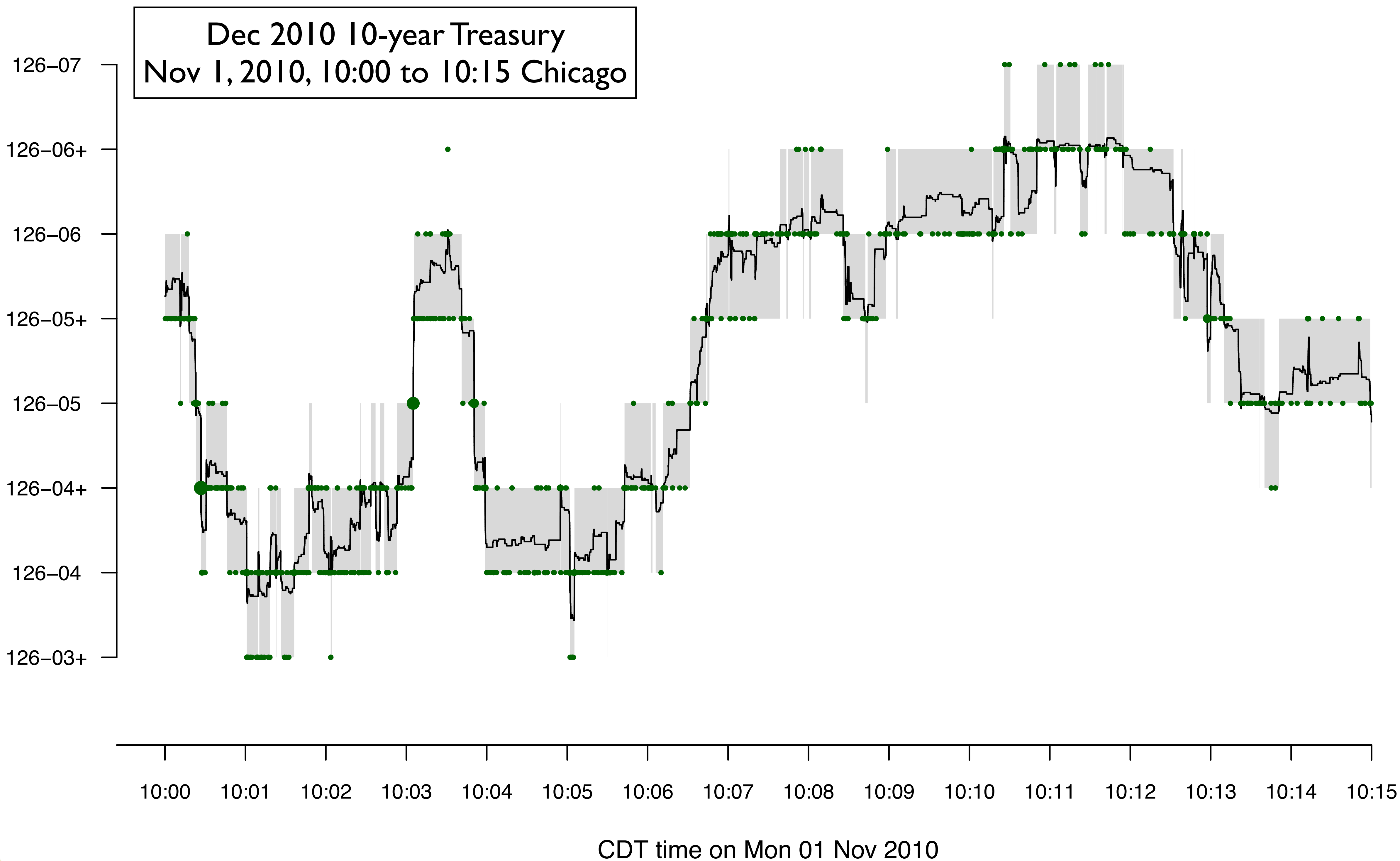
Produced by Quantitative Brokers from CME LDB Data

Market data



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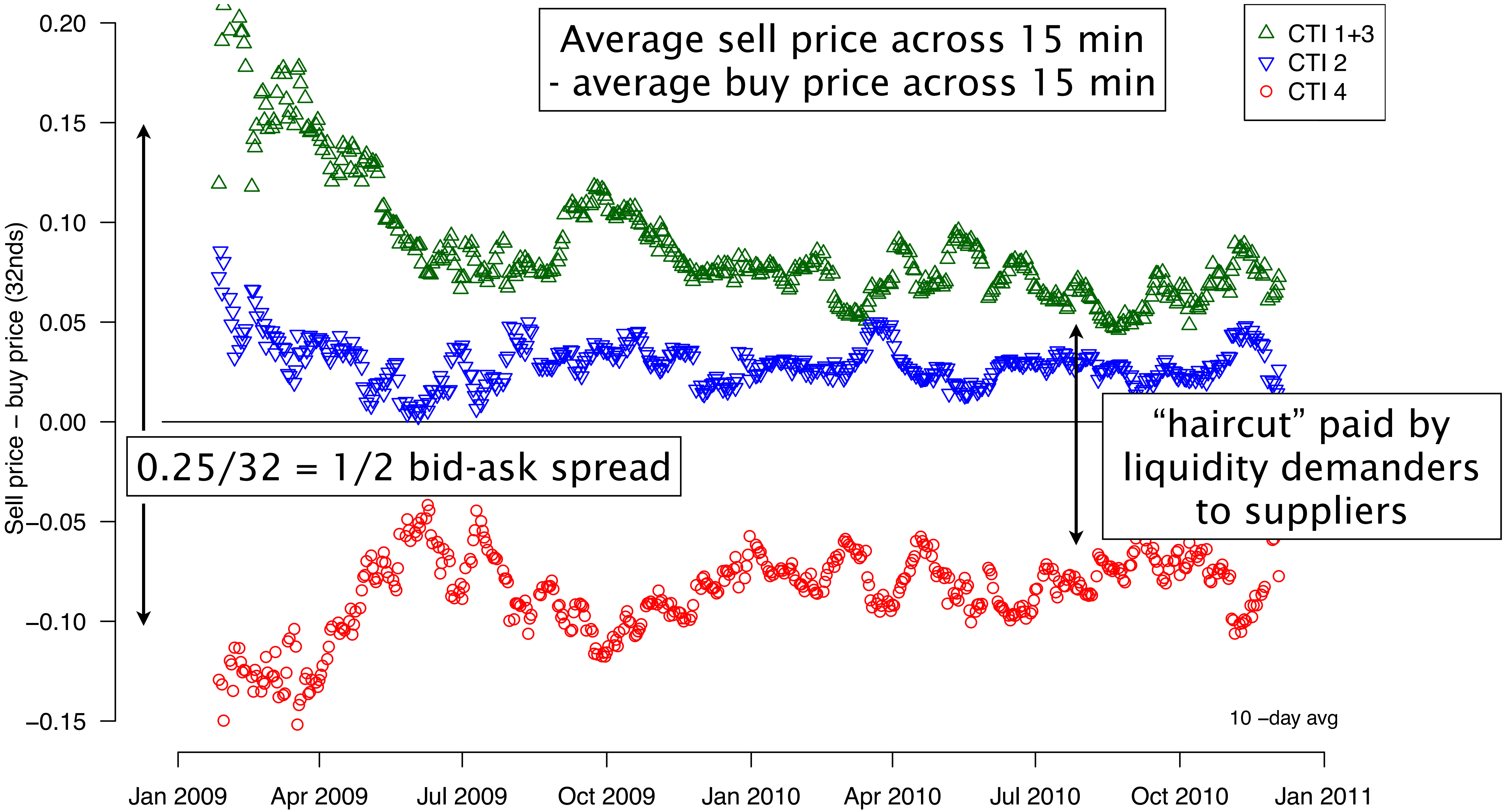
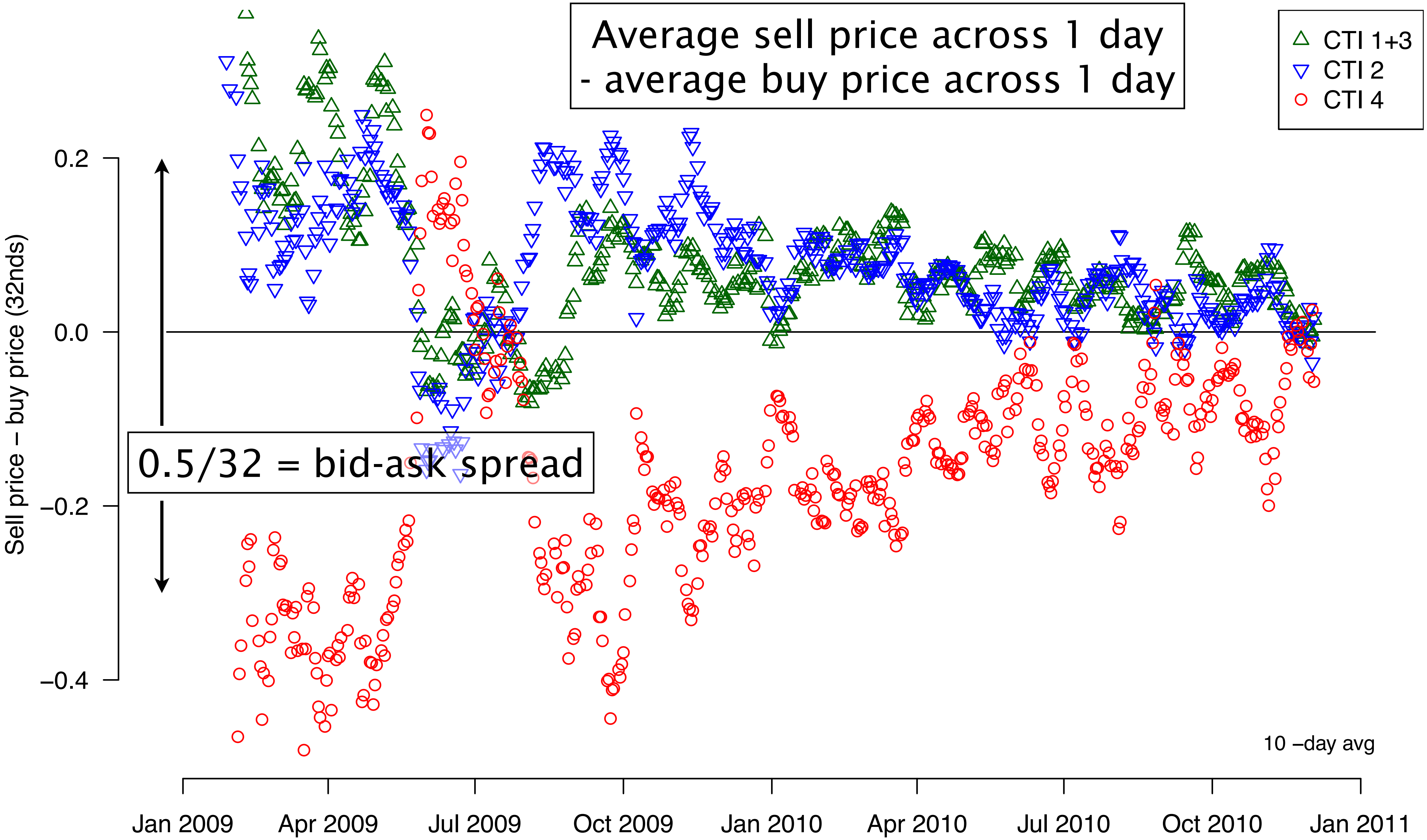
Produced by Quantitative Brokers from CME Market Data

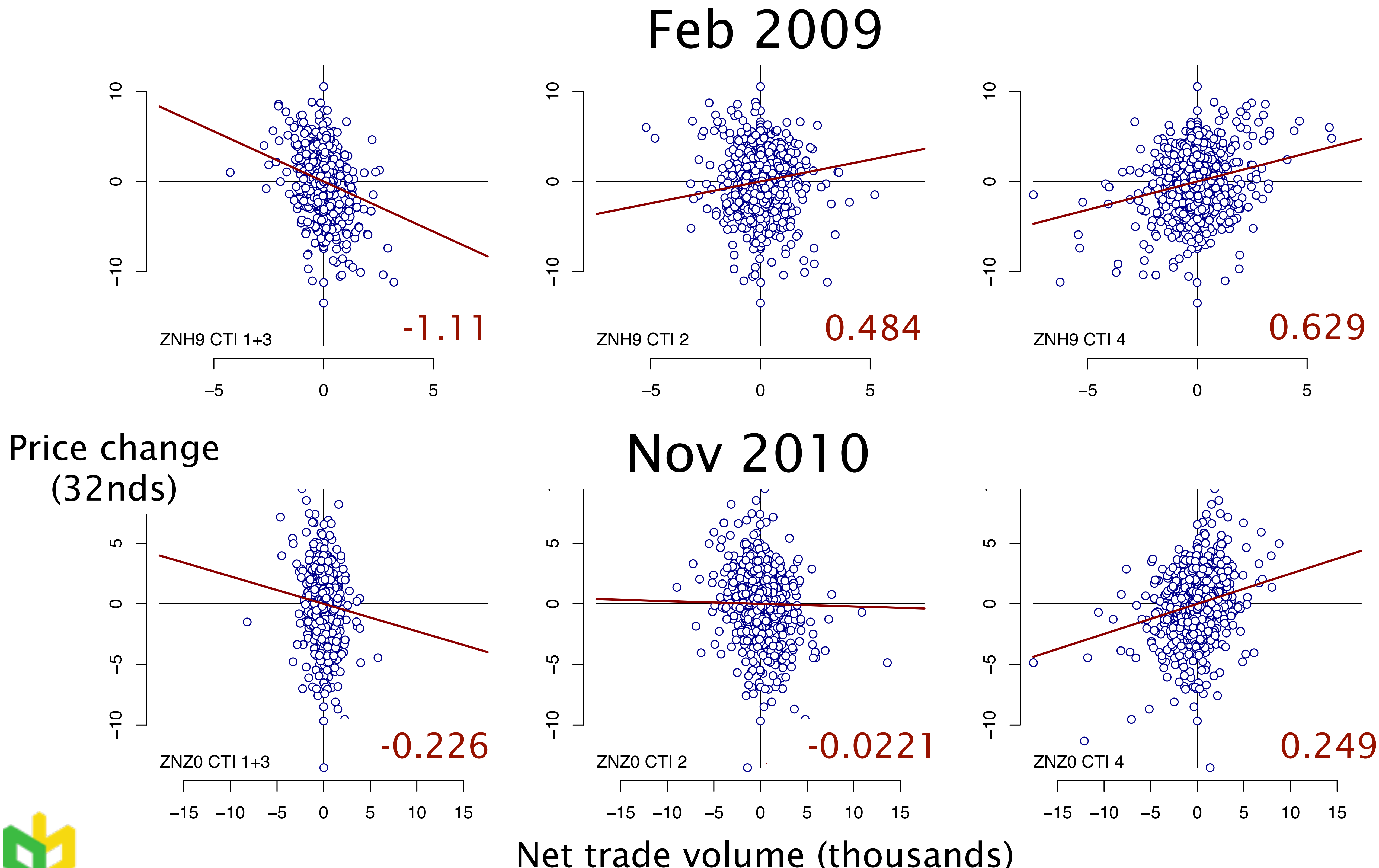
Average price difference -- 15 min



Average price difference -- daily



Market impact estimates



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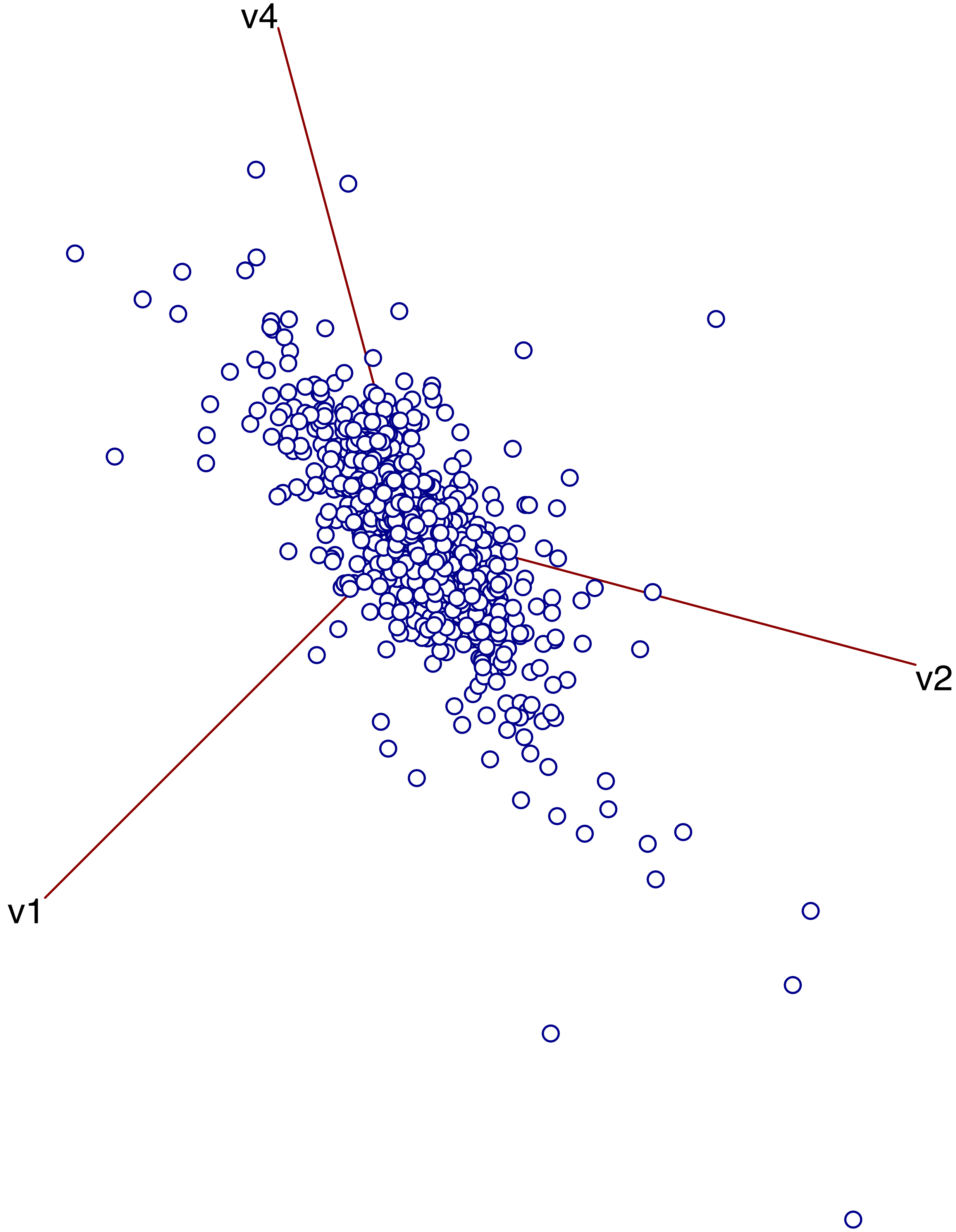
Correlation in order flow



Primary flow is CTI 4 ↔ CTI 2

Conclusions

1. Market details are important

2. Futures have different and interesting properties

3. Can get insight into market properties

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