High Frequency Trading in the US Treasury Market: Evidence Around Macroeconomic News Announcements

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Motivation

- High frequency (HF) trading has become prevalent in financial markets during the past decade

- Features of HF trades
  - React quickly to news and changes in market conditions
  - Able to process large amount of information

- Empirical literature: mostly focus on equity markets
  - Market liquidity: HF activity improve liquidity.
    - Hendershott *et al.*, 2011; Brogaard, 2011; 2012a; Hasbrouck and Saar, 2011; Chaboud *et al.*, 2009
  - Price efficiency: mixed evidence
    - Brogaard, 2010; Hendershott and Riordan, 2010; Chaboud *et al.*, 2011

This paper

- Investigates HF trading in the US Treasury market
  - Daily trading volume nearly 5 times that of the US equity market
  - Limit order market, no intervention from market maker

- Examine HF trading around the announcement of important macroeconomic news
  - Significant portion of price discovery occurs after macro news announcement (e.g. Fleming and Remolona, 1997)

- In addition, macroeconomic news release offers unique setting on studying how HF activity responds to information arrival
  - Pre- and post-announcement periods represent different informational environment.
  - Unique feature of HF trading is its quick response to information arrival

What we do

- We propose a new procedure to identify HF trades and orders
  - high frequency (HF) activities are identified on the basis of the reaction time of order placement/changes deemed beyond human capabilities
- We examine
  1. how HF activity evolves around news announcements
  2. the impact of HF activity on market liquidity and return volatility around information arrival
  3. the effect of HF activity on price discovery around information arrival

What we find

1. HF activities around announcements
   - Both HF trades and orders increase substantially following macroeconomic news announcements.

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2. HF activity and *subsequent* liquidity and volatility
   - ➤ ↑ volatility (Cartea and Panalva, 2011; Foucault *et al.*, 2012)
   - ➤ ↑ bid-ask spreads, ↓ depth at best quote (Foucault *et al.*, 2012)
   - ➤ ↑ overall depth

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3. HF activity and price discovery
   - ➤ Manual trades and orders are *more informative* (Chaboud *et al.*, 2011)
   - ➤ *No evidence* that HF activity helps price discovery

Data: Limit Order Book

- US Treasury 2-, 5-, and 10-year bond data from BrokerTec (60-65% on-the-run trading volume).

- Market closes at 5:30 PM EST and then reopen at 7:00 PM EST.

- Sample period: Jan 2nd, 2004 to Jun 30th, 2007

- Consists of over 700 million observations and about 17 million transactions.

Data: Pre-scheduled Announcement

- Expectations and realizations of 32 macroeconomic news announcements from Bloomberg

- Expectation measured by median of market participants survey (Balduzzi *et al.*, 2001)

- Standardized news surprise

$$SUR_{k,t} = \frac{A_{k,t} - E_{k,t}}{\sigma_k},$$

  - $A_{k,t}$ is the actual value of announcement k on day t,
  - $E_{k,t}$ is the median forecast of the announcement k on day t
  - σ_k is the time-series standard deviation of $A_{k,t} - E_{k,t}$.

Data: Macroeconomic variables

Building Permits	FOMC Meeting	Leading Indicators
Business Inventories	FOMC Minutes	New Home Sales
Capacity Utilization	GDP-Adv.	Nonfarm Payrolls
Construction Spending	GDP-Final	NY Empire State Index
Consumer Confidence	GDP-Prel.	Personal Spending
CPI	Housing Starts	PPI
Durable Orders	Industrial Production	Retail Sales
Existing Home Sales	Initial Claims	Trade Balance
Factory Orders	ISM Index	Treasury Budget
Fed's Beige Book	ISM Services	Unemployment Rate
Personal Income		

Data: Liquidity and volatility

- *30-minute window* around announcement

	15-min Pre-announcement			15-min Post-announcement		
	2-year	5-year	10-year	2-year	5-year	10-year
Spread (tick)	1.12	1.32	1.24	1.09	1.25	1.16
Trading volume ($ mln)	55.87	49.96	43	144.16	110.64	101.86
Depth at best quotes ($ mln)	438.5	88.04	86.97	522.83	99.85	101.55
Overall depth ($ mln)	3730.78	952.4	1165.29	4461.95	1179.27	1496.01
Volatility ($\times$ 1000)	2.1	5.5	9.47	4.61	12.07	19.78

Identification of HF Activity

- Each order has a reference number that
  - records submission timing and
  - subsequent alteration, cancellation or execution.

- We identify HF activity from reaction time to changes in market conditions
  - Order / Trades placed at a speed deemed beyond human reaction.

Identification of HF Activity (cont'd)

- HF orders / trades if
  - Market order placed within a second of change in best quote (HFMO)

  - Limit order at best quote modified in a second with
    - change in best quote on same side of the market (HFLO1)
    - changes in best quote on opposite side of the market (HFLO2)
  - Limit order at second best quote modified in a second with change in best quote on the same side of market (HFLO3)
  - Limit order cancelled or modified within one second of placement (HFLO4)

HF Activity and time-series seasonality

- *Abnormal HF activities*
  - Value of actual HF trades (orders) in excess of average HF trades (orders) during previous 30 minutes interval over past 5 non-announcement days

$$HF_{t,1M(i)}^{TRADE*} = HF_{t,1M(i)}^{TRADE} - \frac{1}{5}\sum_{k=1}^{5}\left[\frac{1}{30}\sum_{j=1}^{30} HF_{t-k,1M(i-j)}^{TRADE,NON}\right]$$

$$HF_{t,1M(i)}^{ORDER*} = HF_{t,1M(i)}^{ORDER} - \frac{1}{5}\sum_{k=1}^{5}\left[\frac{1}{30}\sum_{j=1}^{30} HF_{t-k,1M(i-j)}^{ORDER,NON}\right]$$

HF Orders and Trades

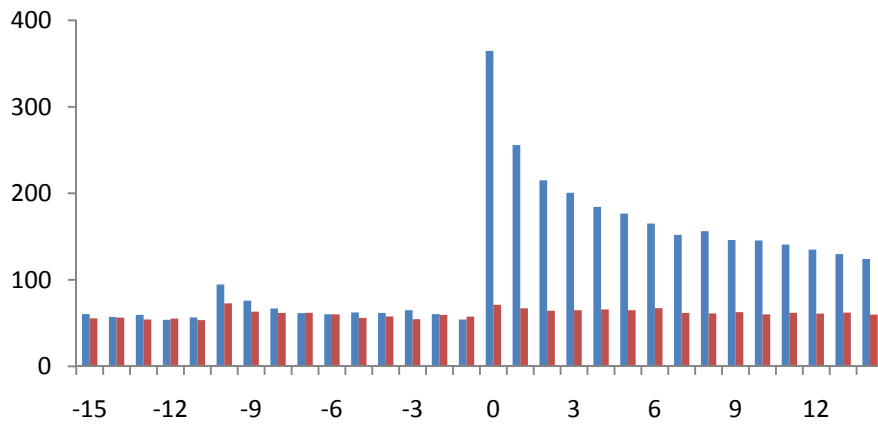|	2-year note		5-year note		10-year note	
	Pre-ann.	**Post-ann.**	**Pre-ann.**	**Post-ann.**	**Pre-ann.**	**Post-ann.**
Panel A: HF Trades						
	28.34	71.48	77.38	184.68	75.63	182.12
Panel B: HF Orders						
	561.57	1617.54	1371.56	3729.04	1631.19	4564.62
Panel C: Abnormal HF Trades and Orders						
Abnormal Trades	5.09	43.41	10.40	102.55	10.29	103.75
Abnormal Orders	51.95	931.34	44.43	2057.07	48.85	2611.88

HF Orders Around Announcements

2-year note
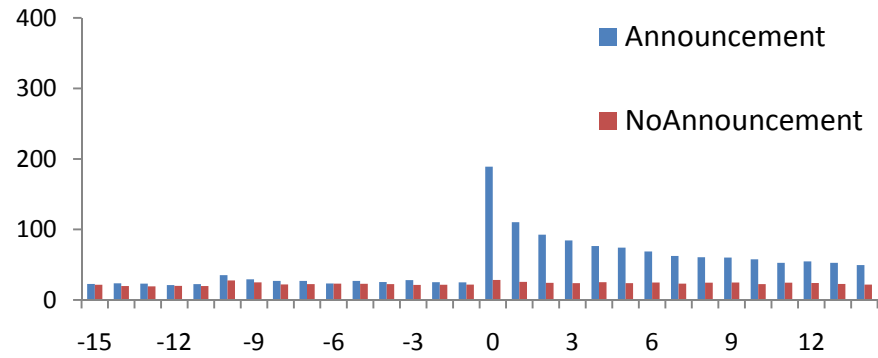
5-year note

10-year note
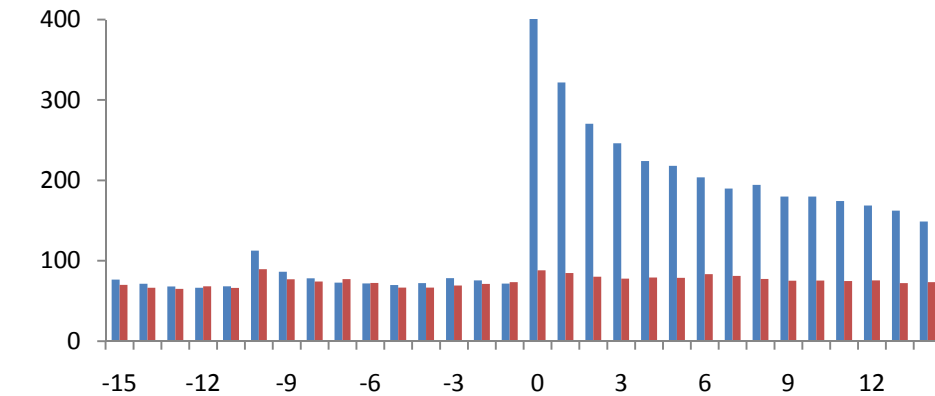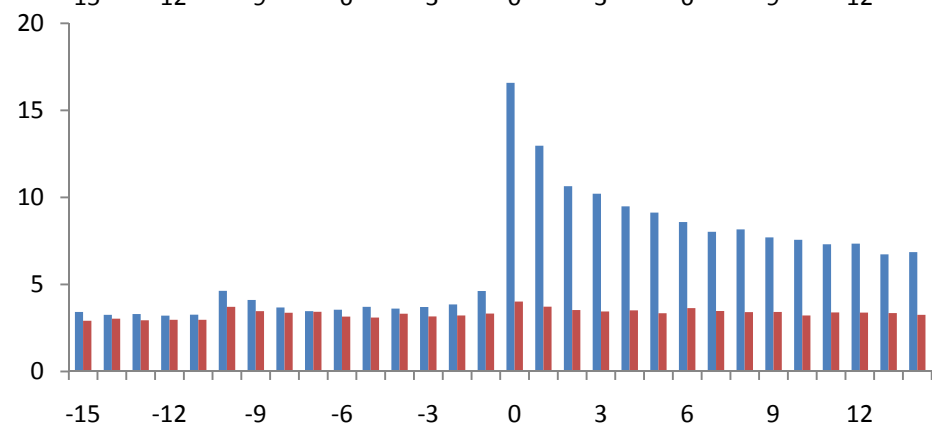
HF Trades Around Announcements
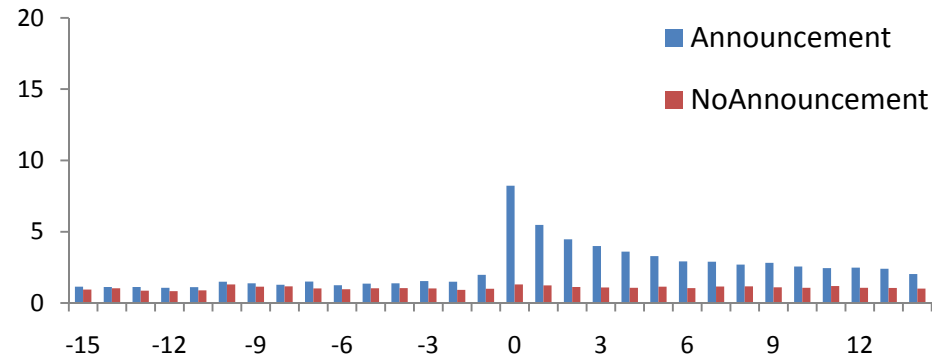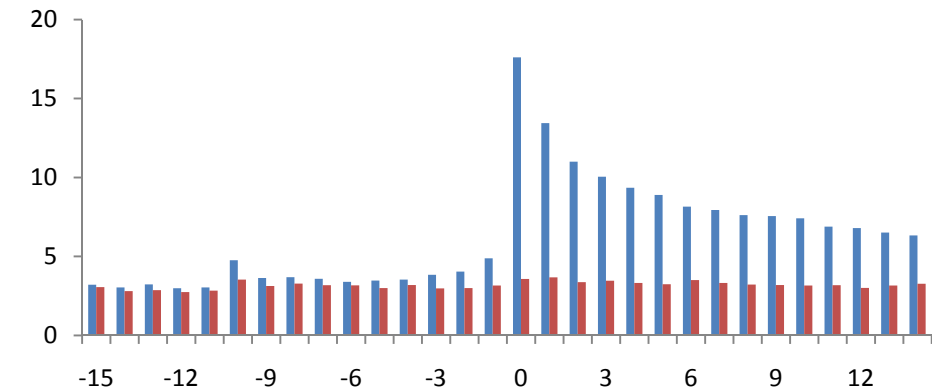
Impact on Subsequent Liquidity

- Impact of abnormal HF activities on subsequent abnormal market liquidity and volatility

➤ *Abnormal liquidity* in excess of its average during previous 30 minutes interval over past 5 non-announcement days

$$LIQ^*_{t,1M(l+1)} = \alpha + \varphi_0 HF^{ORDER*}_{t,1M(l)} + \gamma_0 HF^{TRADE*}_{t,1M(l)} + \varphi_1 NHF^{ORDER*}_{t,1M(l)} + \gamma_1 NHF^{TRADE*}_{t,1M(l)} + \beta LIQ^*_{t,1M(l)} + \varepsilon_{t,1m(l)}$$

where $LIQ^*_{t,1M(l+1)} = SPRD^*_{t,1M(l)}, DPTH^{BST*}_{t,1M(l)}, DPTH^{ALL*}_{t,1M(l)}$

➤ *Abnormal volatility* as $|\Delta mid|_{t,1M(l)}$ in excess of its average during previous 30 minutes interval over past 5 non-announcement days

$$VLTY^*_{t,1M(l+1)} = \alpha + \varphi_0 HF^{ORDER*}_{t,1M(l)} + \gamma_0 HF^{TRADE*}_{t,1M(l)} + \varphi_1 NHF^{ORDER*}_{t,1M(l)} + \gamma_1 NHF^{TRADE*}_{t,1M(l)} + \beta VLTY^*_{t,1M(l)} + \varepsilon_{t,1m(l)}$$

HF and Subsequent Liquidity I

Spread in tick

	Pre-announcement			Post-announcement		
	2-year	**5-year**	**10-year**	**2-year**	**5-year**	**10-year**
Intercept	0.5454***	1.2876***	1.9539***	0.1473***	0.4637***	0.2902***
SPRD*	0.1743***	0.2374***	0.1926***	0.2403***	0.2561***	0.1616***
NHF^{ORDER*}	-0.0061***	-0.0135***	-0.0102***	-0.0006*	-0.0019***	-0.0012**
NHF^{TRADE*}	0.0525***	0.0007	-0.0213	-0.0024	-0.0035	-0.0109
HF^{ORDER*}	**0.0055*****	**0.0117*****	**0.0088*****	0.0001	**0.0019*****	0.0002
HF^{TRADE*}	**0.0723*****	**0.1878*****	**0.1336*****	**0.0242****	0.0072	**0.0470*****
|SUR|				1.4541***	2.7772***	3.1298***
R^2	0.029	0.0496	0.0311	0.0795	0.0928	0.0368

➢ ↑ Spread with ↑ abnormal HF trades and orders
➢ Effect stronger pre-announcement

HF and Subsequent Liquidity II

Depth at best quote

	Pre-announcement			Post-announcement		
	2-year	5-year	10-year	2-year	5-year	10-year
Intercept	-63.05***	-11.27***	-11.27***	1.3012	-1.1456	-1.7314**
DPTH^{BST}*	0.5656***	0.3870***	0.4250***	0.2527***	0.1562***	0.2415***
NHF^{ORDER}*	0.4591***	0.0499***	0.0537***	-0.1027**	-0.0075*	0.0022
NHF^{TRADE}*	-3.8102***	-0.2882*	-0.3171**	0.1791	-0.0016	-0.092
HF^{ORDER}*	**-0.5593***	**-0.0426***	**-0.0238***	-0.0972	-0.0073	0.0012
HF^{TRADE}*	**-5.6650***	**-0.6329***	**-1.1712***	**-4.8691***	**-0.4790***	**-0.4480***
|SUR|				-167.66***	-22.86***	-27.81***
R^2	0.318	0.1517	0.1669	0.0876	0.0423	0.0754

➢ ↓ Depth at best quote with ↑ abnormal HF trades and orders
➢ Effect stronger pre announcement

HF and Subsequent Liquidity III

Overall Depth

	Pre-announcement			Post-announcement		
	2-year	**5-year**	**10-year**	**2-year**	**5-year**	**10-year**
Intercept	-152.54***	-44.37***	-47.10***	-4.1376	1.5167	0.9967
$DPTH^{ALL}*$	0.9513***	0.9658***	0.9732***	0.8656***	0.9150***	0.9367***
$NHF^{ORDER}*$	0.9319***	0.0342	-0.0286	0.2399***	-0.0213**	-0.0404***
$NHF^{TRADE}*$	-11.8166***	-1.7780***	-1.2330**	-1.4169	-0.5398**	-0.0448
$HF^{ORDER}*$	-0.7917	**0.1261*****	**0.1741*****	**0.1924***	**0.1556*****	**0.1553*****
$HF^{TRADE}*$	**21.3234*****	**4.2589*****	**4.7355*****	**5.6104*****	**1.0553*****	**1.9367*****
|SUR|				-874.86***	-240.36***	-285.34***
R^2	0.8168	0.8478	0.8677	0.7961	0.8702	0.9046

➢ ↑ overall depth with ↑ abnormal HF trades and orders

HF and Subsequent Volatility

Volatility

	Pre-announcement			Post-announcement		
	2-year	**5-year**	**10-year**	**2-year**	**5-year**	**10-year**
Intercept	0.3157***	0.6214***	0.8851***	0.9263***	2.2805***	4.0583***
VLTY*	0.1508***	0.1761***	0.1337***	0.2853***	0.3114***	0.2741***
NHF^{ORDER}*	0.0013	-0.0027***	-0.0017	-0.0012**	-0.0036***	-0.0050***
NHF^{TRADE}*	0.0679***	0.0255	0.0655**	0.0224	0.0438**	0.0836***
HF^{ORDER}*	**0.0045***	**0.0080***	**0.0059***	**0.0037***	**0.0059***	**0.0043**
HF^{TRADE}*	**0.1510***	**0.1842***	**0.3285***	**0.0915***	**0.0988***	**0.2238***
|SUR|				10.8967***	26.9838***	41.0709***
R^2	0.0769	0.0662	0.0514	0.2904	0.3298	0.2866

➤ ↑ volatility with ↑ abnormal HF trades and orders

HF Activity and Price Efficiency

- Informativeness of HF orders (trades) versus manual orders (trades)
  - *Manual orders:* orders (trades) submitted with a delay of 3 seconds or more following market changes
  - Kaniel and Liu test (2006)
    - *Null hypothesis:* HF orders (trades) and manual orders (trades) are equally informative

- Examine HF activities on subsequent mid-quotes serial correlation
  - Boehmer and Kelley (2010) and Boehmer *et al.* (2012).

HF Activity and Informativeness

- Kaniel and Liu (2006) test
  - assess informativeness of orders (trades) by comparing the actual percentages of orders (trades) on the 'correct' side of the market
  - compare percentages of buy (sell) order followed by higher (lower) mid-quote 30 minutes after announcement

$$\phi = 1 - N\left[\frac{n_{man} - nP_{man}}{\sqrt{n \cdot P_{man}(1 - P_{man})}}\right]$$

  where
  - P_{man} : probability a submitted order (trade) is a manual order (trade)
  - n : total number of times quote midpoint in the correct direction
  - n_{man}: correct direction following a submission of a manual order (trade)

HF Activity and Informativeness

- ## Kaniel and Liu (2006) test

  > 95% : informativeness of HF order (trade)

  < 5% : informativeness of manual orders (trades)

	Trades (Market Orders)				Orders (Limit Orders)			
Panel A: Pre-Announcement Period								
	All	Small	Medium	Large	All	Small	Medium	Large
2yr	**0.9929**	**0.984**	0.9242	0.721	**0.0089**	**1**	0.5764	**0**
5yr	0.6726	0.581	0.385	0.8096	**0**	**0.0083**	**0**	0.187
10y	0.0896	0.0281	0.4959	0.4478	**0.0131**	0.8725	**0.001**	**0.0028**
Panel B: Post-Announcement Period								
	All	Small	Medium	Large	All	Small	Medium	Large
2yr	**1**	**0.9997**	**1**	**0.9557**	**0**	**0.006**	**0.0029**	**0**
5yr	0.9467	0.8409	0.9174	0.6228	**0**	**0**	**0**	**0.002**
10y	0.9458	0.8982	0.7888	0.7504	**0**	**0.0119**	**0**	**0**

➢ Manual orders tend to be more informative, especially after announcement

HF Activity and Price Efficiency

- Mid-quote serial correlation Boehmer and Kelley (2010) and Boehmer *et al.* (2012)

- Prices follow random walk→ autocorrelation= 0

$$\left|AC_{t,5m(i)}\right| =$$
$$\alpha + \varphi_0 HF^{ORDER*}_{t,5m(i-1)} + \gamma_0 HF^{TRADE*}_{t,5m(i-1)} + \varphi_1 NHF^{ORDER*}_{t,5m(i-1)} +$$
$$\gamma_1 NHF^{TRADE*}_{t,5m(i-1)} + \beta_1 VLTY^*_{t,5m(i-1)} + \beta_2 DPTH^{BST*}_{t,5m(i-1)} +$$
$$\beta_3 DPTH^{ALL*}_{t,5m(i-1)} + \beta_4 SPRD^*_{t,5m(i-1)} + \gamma\left|SUR_t\right| + \varepsilon_{t,5m(i)}$$

HF Activity and Price Efficiency

Mid-quote autocorrelation regression

	Pre-announcement Period			Post-announcement Period		
	2-year	5-year	10-year	2-year	5-year	10-year
Intercept	0.6871***	0.7635***	0.6462***	0.3422***	0.3438***	0.4016***
NHF^{ORDER}*	-0.0004	-0.0066***	-0.0037**	0.0006	-0.0003	0.0001
NHF^{TRADE}*	0.1013**	0.0780*	0.1331***	-0.0056	-0.0037	0.0006
HF^{ORDER}*	0.0074*	0.0121***	0.0056**	-0.001	-0.0001	-0.0005
HF^{TRADE}*	-0.2661***	0.0594	0.024	-0.0059	0.0062	0.0076
VLTY*	-0.2519**	-0.2219***	-0.0543	0.0074	-0.0107	-0.0048
DPTH^{BST}*	-0.0696***	-0.1358*	0.0029	-0.006	-0.0143	-0.0041
DPTH^{ALL}*	-0.0078***	-0.0328***	-0.0449***	0.0011	0.0036	0.0051**
SPRD*	0.101	0.1177	0.0726	-0.0181**	-0.0038	-0.0069**
|SUR|				-0.0034	-0.0297**	-0.0269
R^2	0.0656	0.0407	0.0708	0.032	0.039	0.0453

➢ Significance of HF trades (orders) only recorded during the pre-announcement period.

Conclusions

- We examine HF activity in the U.S. Treasury market around macroeconomic news announcements
  - we introduce a new procedure to identify HF trades and orders
  - examine role of HF activity on liquidity, volatility and price discovery

- HF activity ↑ dramatically following news releases

- HF activity
  - ↑ subsequent bond return volatility
  - Mixed effect on market liquidity
  - Manual trades and orders tend to be more informative than the HF counterparts and HF does not seem to help the price discovery process

Work in progress

- Does HF help transmitting public information shocks?
  - ➢ Speed of price impact

- Robustness check
  - ➢ Impact of orders in different categories