

High Frequency Trading firms, order book participation and liquidity supply during periods of heightened adverse selection risk: Evidence from LSE, BATS and Chi-X

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Abstract

This paper analyses the effect of exogenous volatility driven by the announcement of US macroeconomic data on High Frequency Trading (HFT) participation in the combined London Stock Exchange, Chi-X and BATS equity markets. This study uses a proprietary dataset provided by the UK Financial Services Authority that contains trade data and order book data from LSE, Chi-X Europe and BATS Europe for all constituents stocks in the FTSE 100 for 30 trading days in 2010 which is anonymised at the platform level and aggregates traders as either HFT or OT. This study finds that HFT are considerably more resilient in the order book surrounding the announcement of US macroeconomic figures. Further, HFT participation in trades significantly increases after the release of US macroeconomic data, with HFT supplying significantly greater levels of liquidity to Other Traders. This study highlights that HFT are able to mitigate the risk of information shocks through their speed, rather than through a reduced presence in the order book and trades.

Keywords: Market Microstructure, Market Quality, High Frequency Trading

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1. Introduction

High Frequency Trading (HFT) has emerged in the last decade to dominate trading volumes across the world's largest trading venues. From being virtually non-existent as a participant in markets at the turn of the millennium, HFT now constitute the vast majority of trading volume in the majority of developed markets. With the growth of these market participants, a questioning of the impact of their trading on market quality, particularly in periods of information asymmetry and exogenous volatility, has emerged. In a recent Bank of England press release (Haldane, 8 July 2011) the potential for HFT to exacerbate volatility is discussed. This study contributes to the regulatory and academic debate regarding the effect of HFT on market quality by analysing HFT activity, and its impact on liquidity, during a particular event: the sudden increase in information flow into the market driven by macroeconomic announcements. Using a unique dataset provided by the UK Financial Services Authority containing trade data and order book data from the LSE, Chi-X Europe and BATS Europe for all constituents stocks in the FTSE 100 for 30 trading days in 2010, HFT behaviour is studied on the combined LSE, Chi-X and BATS national order book surrounding these announcements. The data has been anonymised at the platform level and aggregated into two categories of trading firms: HFT – Other Trader.

High Frequency Traders, a subset of Algorithmic Trading (AT) participants, use computer algorithms and low latency infrastructure to generate and execute trading decisions for the purpose of generating returns on proprietary capital. Their primary strategies are statistical arbitrage, market-making and directional trading. Their main advantage lies in their ability to react to changing market conditions much faster than traditional market participants. Several reasons have emerged for their ascendancy in financial markets, including the reduction in minimum price increments on financial markets (i.e. reduced tick sizes), the move away from open outcry markets to automated electronic market interfaces, and the introduction in the US and Europe of market fragmentation, allowing trading of listed securities on various platforms. The recent drive to reduce latency (i.e., the time it takes to submit an order and receive confirmation that the order has entered the market) is also seen as presenting a new plane for competition among market participants.

Studies of low-latency trading primarily employ event-study analyses of market quality around reductions in latency on exchanges. Riordan and Storckenmaier (2009) analyse market quality on the Xetra platform of the Deutsche Bourse after a decrease in platform latency, and find an increase in liquidity after the systematic change, coinciding with lower price impact of trades and increased trading volume. Hendershott, Jones and Menkveld (2010) analyse algorithmic trading after the introduction of autoquote on the NYSE. They proxy the level of algorithmic trading with the

normalised level of message traffic, and their findings suggest a relationship between increased algorithmic trading, lower trading costs and increased quote information.

Hendershott and Riordan (2009) examine the role of algorithmic trading in the price discovery process. Algorithmic traders supply and demand liquidity at approximately equal levels, although their provision of liquidity increases as it becomes more expensive. Focusing specifically on high frequency traders (HFT), which are viewed as entities using proprietary capital in conjunction with low-latency algorithms to generate a return on capital, Brogaard (2010) conducts a study on NasdaqOMX. Trade and order book data identifies high frequency traders. He finds that HFT demand and supply liquidity in equal proportions, with HFT more likely to trade in higher capitalisation stocks, with lower spreads and greater depth. HFT post quotes at the best prices approximately 50% of the time, and HFT liquidity supply is shown to smooth volatility, while HFT liquidity demand does not exacerbate volatility. The author finds that HFT trades and quotes contribute more to price discovery than non-HFT trades.

The literature focuses on the time-series variation of HFT and AT. This study focuses on analysing HFT participation and liquidity supply and demand surrounding periods of increased information asymmetry. This paper analyses one source of information asymmetry – US macroeconomic announcements (namely, US Non-farm Payrolls and the Consumer Price Index) – and examines the effect on HFT participation in the order book, trade participation and liquidity demand and supply during continuous trading on the FTSE 100, across the LSE, Chi-X and BATS. The combination of these three platforms allows for an analysis of the vast majority of activity in the FTSE 100, while prior analysis of HFT and AT in the US and Europe only captures a fraction of HFT activity in a given sample of securities.

Classical models of information asymmetry, such as those put forward by Copeland and Galai (1983) and Glosten and Milgrom (1985), outline the relationship between informed and liquidity traders surrounding periods of heightened information asymmetry. They note that traditional market participants (including market makers) widen their spreads to offset losses to informed investors surrounding periods of heightened information asymmetry. Similarly, Lee, Mucklow and Ready (1993) show that liquidity providers widen their spreads and lower their order book depth surrounding periods of higher information asymmetry to manage their risk exposure.

The primary difference between HFT and traditional market participants during periods of information asymmetry is the ability of HFT to manage their risk exposure at finer time intervals. The ability to react faster to news announcements allows for an adjustment in latent liquidity supply in the order book, liquidity supply and liquidity demand. Therefore, while the traditional market participant reduces their risk exposure by exiting the limit order book, HFT have the potential to

manage their exposure by constantly adjusting their latent liquidity supply and trading participation, which could lead to resilience in supplying liquidity at the best quotes, and faster reversion of latent liquidity supply. Further, their ability to constantly manage their trading positions may result in HFT trading participation being resilient (if not increasing) during periods of information asymmetry and exogenous volatility (as shown in Brogaard, 2010). This study examines the effect of information asymmetry on HFT order book activity, trading and liquidity supply and demand.

Analysis of HFT in the order book surrounding US macroeconomic announcements documents that average HFT time at the best bid and ask does not change significantly from approximately 50%, while Other Traders (OT) significantly reduce their time at the best bid and ask quotes surrounding US macroeconomic announcements from approximately 85 – 90% to 50% after the announcement. Further, while HFT depth (in shares and value) experiences a reduction surrounding macroeconomic announcements, HFT depth reversion occurs much faster than OT. HFT are able to mitigate risk through their speed, and are shown to retain their presence at the best bid and ask quotes, while reverting to normal depth levels significantly faster than OT.

An analysis of trading participation reveals that HFT participation increases surrounding US macroeconomic announcements, while OT participation is lower. HFT liquidity demand increases in the intervals immediately surrounding the announcement, while HFT liquidity supply is significantly higher in the interval prior, and intervals after, the macroeconomic announcement. OT liquidity demand and supply is lower in the intervals immediately surrounding macroeconomic announcements. Finally, an analysis of trading pairs shows that HFT interaction with OT is increased surrounding US macroeconomic announcements, with HFT providing significantly more liquidity to OT in the periods surrounding the information announcement.

The rest of the paper is structured as follows. Section 2 presents the data used in this study, with the methodology outlined in Section 3. Section 4 presents results of the order book analysis, Section 5 discusses the results of the trade-level analysis, and Section 6 concludes.

2. Data

The data used for this study is provided by the UK Financial Services Authority and contains trade data and order book data from the London Stock Exchange (LSE), Chi-X Europe and BATS Europe for all constituents stocks in the FTSE 100 for 30 trading days in 2010. The data has been anonymised at the platform level and aggregated into two categories of trading firms: HFT – Other Trader. Prior studies, including Hendershott, Jones and Menkveld (2010) and Brogaard (2010) focus on a single platform in a fragmented market. The three platforms examined in this study account for

the vast majority² of volume executed in the UK, presenting a unique opportunity to analyse the trading and order book behaviour of HFT in a consolidated market.

This study analyses the effect of HFT activity in the FTSE 100 of the release of US economic announcements. As in Chaboud, Chiquoine, Hjalmarsson and Vega (2009), this paper samples 15 Non-farm Payrolls and Consumer Price Index announcements, and 15 non-announcement days in the following week of each announcement. The announcements are published at 8:30am Eastern Standard Time in the US, one hour prior to the commencement of trading. These announcements coincide with continuous trading at 1:30pm Greenwich Mean Time (British Summer Time in the months of March to September). Therefore, the effects of the macroeconomic announcement on HFT in a continuous trading environment can be studied.

The platform-level order book reconstruction uses time-stamped (nearest millisecond) order, trade, cancellation and amendment data to reconstruct the top three levels of the platform-level order book at each new event. Each message is classed by the platform as being submitted by either HFT or OT based on the above definition of HFT, and is further anonymised in-house to prevent identification of the actual participant. At each price level of the order book, the total HFT and Other Trader (OT) volumes are displayed. The combined order book is then constructed by sampling price and volume levels at the platform level at each new event. The final order book contains the 'national best' bid and ask prices, together with HFT and OT volumes. The consolidated trade data is an amalgamation of all platform-level trades, with the liquidity supplier and liquidity provider classified as either HFT or OT in-house, based on the definition of HFT provided above. Each trade message contains the date, time (to the nearest millisecond), price, volume, buyer type, seller type and initiator type.

To classify a trader as either HFT or OT, the platform and the FSA co-operate to classify all participants in each platform as either HFT or OT, based on the platform's understanding of the business of the participant, with reference to the provided definition of HFT. The FSA provides the platform with a list of all participants and their trader type mapping, and the data is anonymised at the platform level to ensure confidentiality of participants. Of a total of 1452 unique identifiers, 363 are classified as HFT, consisting of 52 unique firms.

An inherent limitation of the data is that HFT desks within firms whose trading contains a mixture of proprietary and agency trading cannot be segregated. The result of this is a possible underestimation of total HFT activity, as HFT arms within investment banks and other financial institutions are classified as OT. However, in light of the significant levels of HFT evident in the

²According to Thompson Reuters Market Share Report, LSE, Chi-X and BATS account for 86% of total lit volume in the UK in 2010.

sample, and at the risk of introducing a subjective view as to what constitutes HFT in the remaining OT orderflow, this paper adopts the approach of Brogaard (2010).

To examine the characteristics of HFT surrounding the commencement of US trading, the study focuses on the constituents of the FTSE 100 index, as Hendershott, Jones and Menkveld (2010) find that the majority of HFT occurs in large capitalisation, liquid stocks. Analysis is conducted on a stock-by-stock basis, and averaged across the full sample.

3. Methodology

3.1 Univariate Analysis

The release of macroeconomic data at 8:30am EST coincides with continuous trading in London at 1:30pm GMT (BST in the months of March to September – for simplicity referred to a London time). This provides a unique opportunity to analyse the effect of cross-Atlantic information flow on HFT in the UK market. This study focuses on the period 12:30- 2:30pm London time, with descriptive statistics calculated at one-minute intervals across the sample. HFT participation in the order book is examined to determine latent HFT liquidity supply, while HFT participation in trading is examined to determine the changes in HFT participation, liquidity supply and liquidity demand. The same analysis is conducted for OT. Announcement days and non-announcement days are compared for both trader types to determine the impact of macroeconomic announcements on trading and liquidity provision and demand.

Order book analysis focuses on latent HFT liquidity supply in the order book, examining HFT depth at the best bid and ask prices, and the time spent at the best quotes. Depth at the best bid and ask prices is calculated as the time-weighted depth at the national best prices for HFT and OT per second, and averaged per minute across all stocks in the FTSE 100 across announcement and non-announcement days. Depth is calculated as volume in shares and value. Time at the best bid and ask prices is calculated as the sum of milliseconds per second that HFT and OT are at the best bid and ask prices, and is averaged both across stocks and announcement and non-announcement days.

Participation in trading is calculated as the percentage of total volume in which a HFT (OT) is one or both sides of the trade. For each stock, the average is taken for each interval, and then averaged across all stocks on announcement and non-announcement days. Participation is calculated on a trade, volume and value basis. HFT (OT) liquidity supply is calculated as the total volume of liquidity supplied by HFT (OT) divided by total liquidity supplied, per minute, per stock. HFT (OT) liquidity demand is calculated similarly.

Trading pairs are analysed, with the four trading pairs (HFT-HFT, HFT-OT, OT-HFT, OT-OT) examined in the period surrounding the release of US macroeconomic announcements. The study

aims to determine HFT liquidity supply/demand, and their interaction with other market participants in a continuous trading environment, surrounding information announcements.

3.2 Multivariate Analysis

To isolate the effects of the announcement on HFT (OT) order book dynamics, the following regressions are estimated for each one-minute interval during the 10 minutes before and after the 1:30pm announcement:

$$\frac{TimeAtBest_{i,t}}{TimeAtBest_{i,b}} = \alpha + \beta_1 \Delta Volume_{i,t} + \beta_2 \Delta Volatility_{i,t} + \beta_3 Announcement_{i,t} + \varepsilon_i \quad (1)$$

$$\frac{Depth_{i,t}}{Depth_{i,b}} = \alpha + \beta_1 \Delta Volume_{i,t} + \beta_2 \Delta Volatility_{i,t} + \beta_3 Announcement_{i,t} + \varepsilon_i \quad (2)$$

where, for stock i , the dependent variable is taken as the liquidity proxy at time interval t divided by the benchmark liquidity proxy, $\Delta Volume_i$ is the change in total volume traded in stock i in period t (measured as stock turnover and value turnover for stock depth and value depth, respectively), $\Delta Volatility_t$ is the change in the natural logarithm of high divided by low prices for stock i in time interval t , $Announcement$ is a binary variable taking the value of one on announcement days, zero otherwise, and ε_i is an error term. The regressions are estimated for both HFT and OT.

To isolate the effects of the announcement on HFT (OT) trading participation, the following regressions are estimated for each one-minute interval during the 10 minutes before and after the 1:30pm announcement:

$$PartRate_{i,t} = \alpha + \beta_1 \Delta Volume_{i,t} + \beta_2 \Delta Volatility_{i,t} + \beta_3 Announcement_{i,t} + \varepsilon_i \quad (3)$$

where for stock i , the dependent variable is the percentage of volume in which the trader type participates as liquidity maker, taker, or both at time interval t , divided by the benchmark percentage of volume in which the trader type participates as liquidity maker, taker, or both. Independent variables are as described above. Participation is studied across trades, volume and value.

To examine the impact of US macroeconomic announcements on the proportion of liquidity demanded and supplied by HFT and OT, the following two regressions are estimated:

$$PropLiqD_{i,t} = \alpha + \beta_1 \Delta Volume_{i,t} + \beta_2 \Delta Volatility_{i,t} + \beta_3 Announcement_{i,t} + \varepsilon_i \quad (4)$$

$$PropLiqS_{i,t} = \alpha + \beta_1 \Delta Volume_{i,t} + \beta_2 \Delta Volatility_{i,t} + \beta_3 Announcement_{i,t} + \varepsilon_i \quad (5)$$

where for stock i , $PropLiqD$ is the proportion of liquidity demanded by a trader type in interval t , divided by the proportion of liquidity demanded by the trader type during the benchmark period. $PropLiqS$ is the proportion of liquidity supplied by a trader type in interval t , divided by the proportion of liquidity supplied by the trader type during the benchmark period. Regressions 4 and 5 are estimated on a trade, volume and value basis for both HFT and OT.

To examine the change in trading pairs surrounding US macroeconomic announcements, the following regression is estimated:

$$LT_LM_{i,t} = \alpha + \beta_1 \Delta Volume_{i,t} + \beta_2 \Delta Volatility_{i,t} + \beta_3 Announcement_{i,t} + \varepsilon_i \quad (6)$$

where for stock i , LT_LM is the proportion of total trading volume executed by a trading pair (taker-maker), divided by the benchmark proportion of total trading volume executed by that trading pair. This regression allows for a more robust understanding of the trading dynamics surrounding US macroeconomic announcements between HFT and OT.

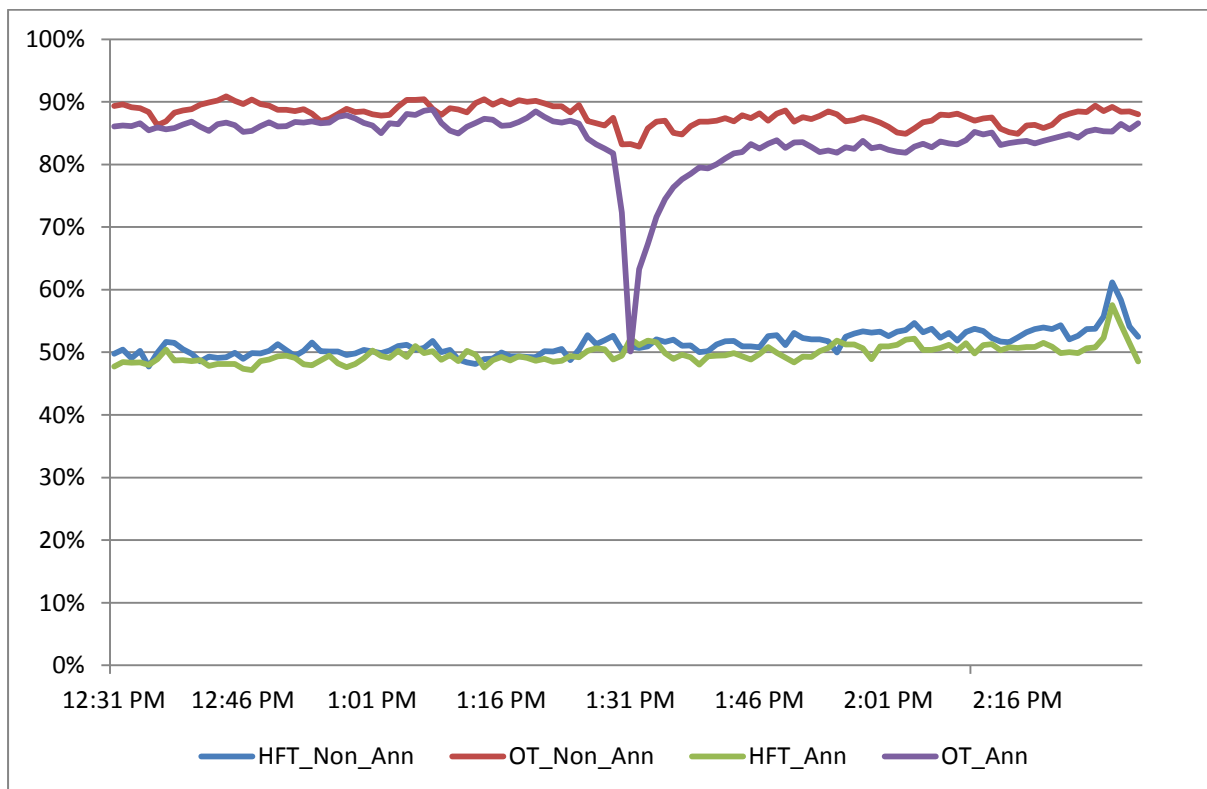
4. Order Book Results

4.1 Univariate Results

Figure 1 presents the results of the analysis of the percentage of time that HFT and OT are at the best bid and ask quotes during announcement and non-announcement days in the one hour prior to, and after, the US economic announcement. HFT average time at the best bid and ask does not change significantly on announcement days, relative to non-announcement days, while OT are at the best quotes less often on announcement days. HFT average time at the best bid and ask in the one minute interval before the announcement falls from 50.41% during the non-announcement sample to 49.44% in the announcement sample. For the same interval, average OT time at the best bid and ask falls from 83.19% to 72.30%, a reduction of 10.89%. In the one minute interval immediately following the economic news release, average HFT time at the best quotes rises from 50.96% on non-announcement days, to 52.15% on announcement days, an increase of 1.19%, while average OT time at the best quotes falls from 83.25% to 50.15%, a substantial drop of 33.10%. There appears to be no effect on HFT presence at the best bid and ask prices, while OT retreat from the best quotes, with average time at the best bid and ask prices falling significantly from the 85.00-

90.00% range in the 12:30 – 1:00pm period, to as low as 50.41% immediately after the announcement, and taking approximately 15 minutes to return to normal levels.

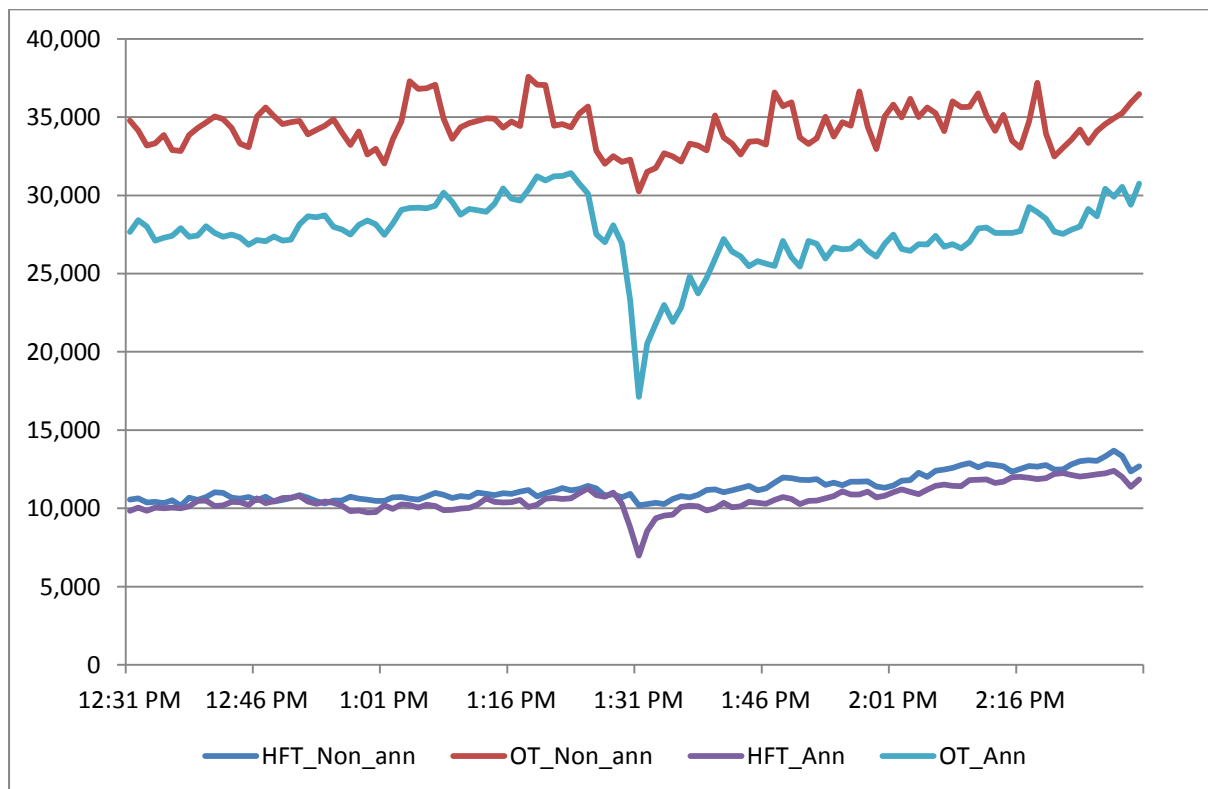
Figure 1 – Time at Best Bid and Ask Quotes



HFT and OT depth at the best bid and ask quotes in the period 12:30 – 2:30pm for announcement and non-announcement days is presented in Figure 2. On announcement days, HFT exhibit a significant drop in depth at the best bid and ask quotes in the period surrounding the US macroeconomic announcement. In the interval prior to the release of US economic data, average HFT depth falls from 10,940 shares on non-announcement days to 8,791 shares on announcement days, a decrease of 2,149 shares. In the interval after the US economic release, average HFT depth declines from 10,198 shares on non-announcement days to 6,976 shares, a fall of 3,222 shares. Average OT depth at the best bid and ask is lower throughout announcement days. However, surrounding US macroeconomic announcements, OT exhibit significantly lower depth for an

extended period. In the interval immediately prior to the economic announcement, average OT depth experiences a decrease from 32,282 shares on non-announcement days to 23,287 shares on announcement days, a reduction of 8,995 shares. After the announcement, average OT depth falls from 30,252 shares to 17,132 shares, a reduction of 13,120 shares. OT depth at the best bid and ask quotes does not return to pre-announcement levels until 45 minutes after the release of US economic information, while HFT revert within 5 minutes.

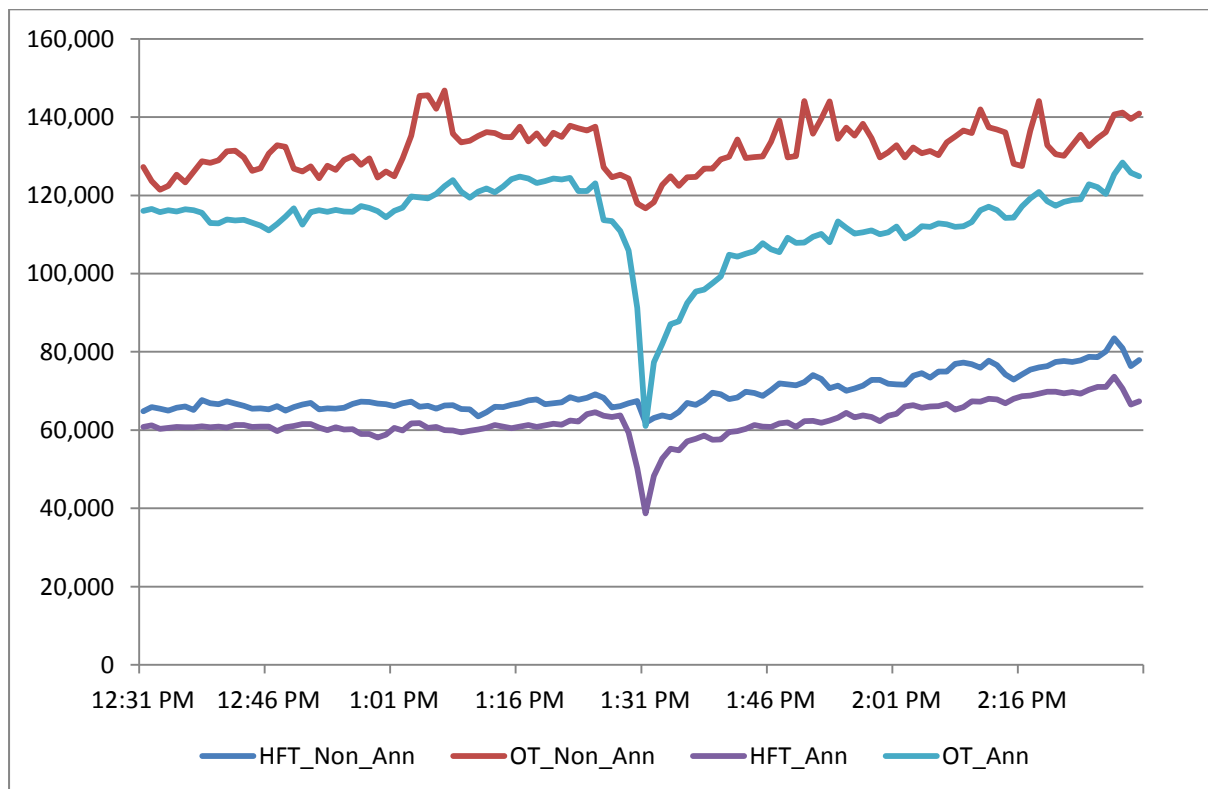
Figure 2 – Depth at Best Bid and Ask Quotes (Shares)



The average value of latent liquidity at the best bid and ask prices by HFT and OT on announcement and non-announcement days is presented in Figure 3. Similar to the analysis of depth in shares, HFT exhibit a significant fall in average depth at the best bid and ask quotes in the period immediately prior to the release of US economic data, with average HFT depth at the best bid and ask quotes reverting to pre-announcement levels 6 minutes after the release. Average OT depth at the best bid and ask quotes falls significantly in the interval prior to the release of US macroeconomic information, with average OT depth taking 45 minutes to revert to pre-announcement levels. HFT are able to manage their risk position through their speed and depth levels. They do not alter their average percentage of time at the best bid and ask quotes and,

although their depth at the best bid and ask prices falls in the period immediately before the announcement, the average HFT depth at the best bid and ask reverts to normal levels approximately 5 – 6 minutes after the announcement. OT exhibit significant falls in time at the best bid and ask quotes and depth, and take significantly longer to revert to normal levels.

Figure 3 – Depth at Best Bid and Ask Quotes (Value)



4.2 Multivariate Results

To control for the effects of volume and volatility on HFT and OT time at the best bid and ask quotes, regressions are estimated to isolate the effect of the announcement on HFT and OT time at the best bid and ask. The results are presented in Table 1. In the period surrounding the US economic announcement, HFT do not exhibit any statistically significant change in average time at the best bid and ask quotes, when changes in volume and volatility are controlled. OT time at the best bid and ask quotes is significantly lower at the 1% level on announcement days, beginning in the interval 2 minutes prior to the macroeconomic announcement, and remaining significantly lower in the 10 minutes after the announcement.

Table 1 – Time at best quotes

Trader Type	HFT	OT	HFT	OT	HFT	OT	HFT	OT
Interval	Intercept		Δ Volume		Δ Volatility		Announcement Dummy	
1:21pm	1.2231***	0.9943***	0.0009	-0.0010	-0.0009	0.0003	-0.1821	0.0066
1:22 pm	1.2527***	1.0094***	0.0022	-0.0005	-0.0006	0.0002	-0.0516	-0.0343
1:23 pm	1.4748***	0.9974***	-0.0073	0.0048**	0.0008	0.0004	-0.3780**	0.0058
1:24 pm	3.0375***	0.9971***	-0.0103	0.0004	-0.0043	0.0004	-1.7670	-0.0069
1:25 pm	1.2800***	1.0193***	-0.0074	-0.0023*	-0.0015	0.0000	0.0660	-0.0500**
1:26 pm	1.3126***	0.9427***	-0.0005	0.0001	0.0002	-0.0002	0.0124	-0.0119
1:27 pm	1.2159***	0.9539***	0.0012	0.0008	0.0054**	0.0003	0.0001	-0.0285
1:28 pm	1.5554***	0.9201***	-0.0190	0.0012	-0.0026	0.0005	-0.1509	-0.0089
1:29 pm	1.4790***	0.9783***	-0.0105	-0.0015	-0.0026	0.0001	0.4008	-0.0061***
1:30 pm	1.5929***	0.9046***	-0.0078	0.0008	0.1913***	-0.0001	0.0632	-0.1367***
1:31 pm	0.7101	0.8627***	0.1191	-0.0004	0.3456***	0.0001	2.1906	-0.1212***
1:32 pm	2.0790	0.8755***	-0.2896	-0.0004	-0.0038	0.0000	5.2319	-0.0831***
1:33 pm	1.6943	0.9119***	-0.0571	0.0039**	0.4414	-0.0005	16.1780	-0.0994***
1:34 pm	1.5572	0.9024***	0.1333	0.0012	-0.0011	0.0001	13.6742	-0.0739***
1:35 pm	6.2197***	0.9070***	-0.1074	0.0031	-0.0157	0.0001	-4.4964	-0.0408**
1:36 pm	1.2351***	0.9161***	-0.0193	0.0032	-0.0018	-0.003	0.3831	-0.0847***
1:37 pm	1.2215***	0.9060***	0.0018	0.0000	-0.0003	-0.0001	0.1401	-0.0544***
1:38 pm	1.3465***	0.9594***	-0.0038	0.0001	0.0005	-0.0001	0.1159	-0.1004***
1:39 pm	2.6000***	0.9421***	-0.0188	0.0014	-0.0060	0.0004	-1.0899	-0.0595***
1:40 pm	1.5843***	0.9388***	0.0206	0.0002	-0.0001	0.0003	-0.0783	-0.0520***

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the time at the best bid and ask quotes divided by the daily benchmark time at best bid and ask quotes. The benchmark period is 12:30 – 1:00 pm. The Δ Volume variable is the relative change in volume (shares) in the given interval, the Δ Volatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*. Significant at the .10 level, **. Significant at the .05 level, ***. Significant at the .01 level

Table 2 – Depth at best quotes(shares)

Trader Type	HFT	OT	HFT	OT	HFT	OT	HFT	OT
Interval	Intercept		Δ Volume		Δ Volatility		Announcement Dummy	
1:21pm	1.0520***	1.1733***	0.0000	0.0126	-0.0007	-0.0001	0.0393	0.0778
1:22 pm	1.0988***	1.3283***	-0.0033	0.0000	-0.0009	-0.0010	0.0404	-0.2284
1:23 pm	1.1165***	1.3314***	0.0009	0.0127	-0.0017	-0.0012	-0.0003	-0.1267
1:24 pm	1.0568***	1.1867***	-0.0004	-0.0006	-0.0008	-0.0003	0.0085**	-0.1081
1:25 pm	1.1070***	1.2388***	-0.0011	-0.0035	-0.0010	-0.0011	0.0816	-0.0557
1:26 pm	1.1604***	0.9285***	0.0000	0.0036*	-0.0011	0.0019	-0.0337	0.0701
1:27 pm	1.0881***	1.0239***	-0.0002	0.0099**	0.0003	-0.0005	0.0832*	-0.0807
1:28 pm	1.0762***	1.0153***	-0.0053	0.0032	0.0001	0.0001	0.0970**	-0.0262
1:29 pm	1.1013***	1.0086***	-0.0026	0.0000	-0.0004	-0.0004	0.0073	-0.0688
1:30 pm	1.1200***	1.2559***	-0.0018	0.0050	0.0001	-0.0018	-0.0841	-0.4684**
1:31 pm	0.9278***	0.9097***	-0.0012	-0.0012	0.0011	-0.0020	-0.1020***	-0.3570**
1:32 pm	1.0347***	0.8732***	-0.0017	0.0028	-0.0018	-0.0018	0.0181	-0.1480**
1:33 pm	1.0439***	0.9763***	0.0072	0.0060	0.0013	0.0036	0.0215	-0.1743
1:34 pm	1.0497***	0.9521***	-0.0054	0.0090	-0.0025	-0.0031	0.0684	-0.0900
1:35 pm	1.1295***	0.9910***	-0.0105**	0.0084	-0.0010	-0.0007	-0.0429	-0.1510
1:36 pm	1.1541***	0.9603***	-0.0050	0.0042	0.0001	-0.0011	-0.0171	-0.1007
1:37 pm	1.1405***	0.9725***	0.0014	-0.0012	-0.0002	-0.0004	-0.0023	-0.0232
1:38 pm	1.0310***	1.0410***	0.0084	0.0005	0.0179***	-0.0006	0.1469	-0.1543**
1:39 pm	1.1147***	1.0002***	-0.0022	0.0030	-0.0008	0.0001	-0.0741*	-0.0364
1:40 pm	1.1180***	1.0182***	0.0006	0.0158	0.0039*	-0.0008	-0.0117	-0.0809

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the depth at the best bid and ask quotes divided by the daily benchmark depth at best bid and ask quotes. The benchmark period is 12:30 – 1:00 pm. The Δ Volume variable is the relative change in volume (shares) in the given interval, the Δ Volatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 3 – Depth at best quotes(value)

Trader Type	HFT	OT	HFT	OT	HFT	OT	HFT	OT
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy	
1:21pm	1.0520***	1.1732***	0.0000	0.0126	-0.0008	-0.0002	0.0390	0.0786
1:22 pm	1.0990***	1.3270***	-0.0033	0.0000	-0.0009	-0.0011	0.0402	-0.2269
1:23 pm	1.1164***	1.3300***	0.0010	0.0127	-0.0017	-0.0012	-0.0006	-0.1246
1:24 pm	1.0567***	1.1868***	-0.0004	-0.0006	-0.0008	-0.0003	0.0880**	-0.1080
1:25 pm	1.1068***	1.2386***	-0.0010	-0.0036	-0.0010	-0.0011	0.0807	-0.0545
1:26 pm	1.1609***	0.9293***	0.0000	0.0036*	-0.0011	0.0019	-0.0348	0.0697
1:27 pm	1.0912***	1.0233***	0.0000	0.0099**	0.0003	-0.0005	0.0796	-0.0796
1:28 pm	1.0762***	1.0146***	-0.0053	0.0032	0.0001	0.0001	0.0966**	-0.0246
1:29 pm	1.1014***	1.0081***	-0.0026	0.0000	-0.0004	-0.0004	0.0062	-0.0681
1:30 pm	1.0622***	1.1865***	-0.0017	0.0055	0.0003	-0.0016	-0.0584	-0.4408***
1:31 pm	0.8912***	0.8426***	-0.0009	-0.0013	0.0009	-0.0017	-0.0361	-0.3150***
1:32 pm	1.0305***	0.8387***	0.0001	0.0057	-0.0011	-0.0005	0.0105	-0.1552***
1:33 pm	1.0421***	0.9358***	0.0048	0.0074	0.0008	0.0038	0.0805	-0.1784
1:34 pm	1.0445***	0.9129***	-0.0038	0.0092	-0.0009	-0.0005	0.0566	-0.0893
1:35 pm	1.1211***	0.9437***	-0.0103**	0.0105	-0.0010	-0.0007	-0.0427	-0.1379
1:36 pm	1.1532***	0.9584***	-0.0048	0.0041	0.0001	-0.0011	-0.0186	-0.0980
1:37 pm	1.1391***	0.9722***	0.0014	-0.0012	-0.0002	-0.0004	-0.0022	-0.0231
1:38 pm	1.0328***	1.0401***	0.0082	0.0005	0.0172***	-0.0006	0.1411	-0.1533**
1:39 pm	1.1140***	0.9999***	-0.0022	0.0031	-0.0008	0.0001	-0.0746*	-0.0357
1:40 pm	1.1175***	1.0177***	0.0005	0.0157	0.0039*	-0.0007	-0.0116	-0.0799

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the depth at the best bid and ask quotes divided by the daily benchmark depth at best bid and ask quotes. The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (value) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

To isolate the effect of the release of US macroeconomic data on HFT and OT depth at the best bid and ask quotes, after controlling for changes in volume and volatility, the regression in Equation 2 is estimated. The results are presented in Table 2. HFT exhibit a decrease in depth at the best bid and ask quotes in the interval immediately after the release of the US macroeconomic announcement, significant at the 1% level. In all other intervals surrounding the release, the coefficient of the announcement dummy variable does not exhibit any statistical significance. When the regression is estimated for OT, the announcement dummy variable coefficient is significantly negative at the 1% level, in the interval prior to the US economic release, and the two periods immediately following the announcement. Table 3 presents results from a similar analysis of the value of depth at the best bid and ask, and finds no relationship between HFT depth and US macroeconomic announcements. OT depth at the best bid and ask exhibits a qualitatively similar relationship with the release of US macroeconomic data.

5. Trading Results

5.1 Univariate Results

HFT and OT participation across trades, volume and value are analysed to determine the effect of the release of US economic data on the proportion of total trading that involves HFT/OT on at least one side of a transaction. Figure 4 presents results of the trade-level participation for HFT and OT on announcement and non-announcement days. Average OT participation exhibits a decrease from 90.97% on non-announcement days, to 84.92% on announcement days, in the interval immediately following the economic data release. Conversely, average HFT participation exhibits an increase from 52.54% on non-announcement days to 66.25% on announcement days, in the corresponding interval.

Figure 5 illustrates the results of the volume-level participation for HFT and OT on non-announcement and announcement days. Average OT participation exhibits a decrease from 92.86% on non-announcement days to 87.95% on announcement days, in the interval following the announcement of US macroeconomic figures. Conversely, average HFT participation exhibits an increase from 47.38% on non-announcement days, to 59.83% on announcement days, in the corresponding interval.³

³Similar analysis on value participation yields similar results to the volume participation, and is thus not included for brevity.

Figure 4 – Trade Participation

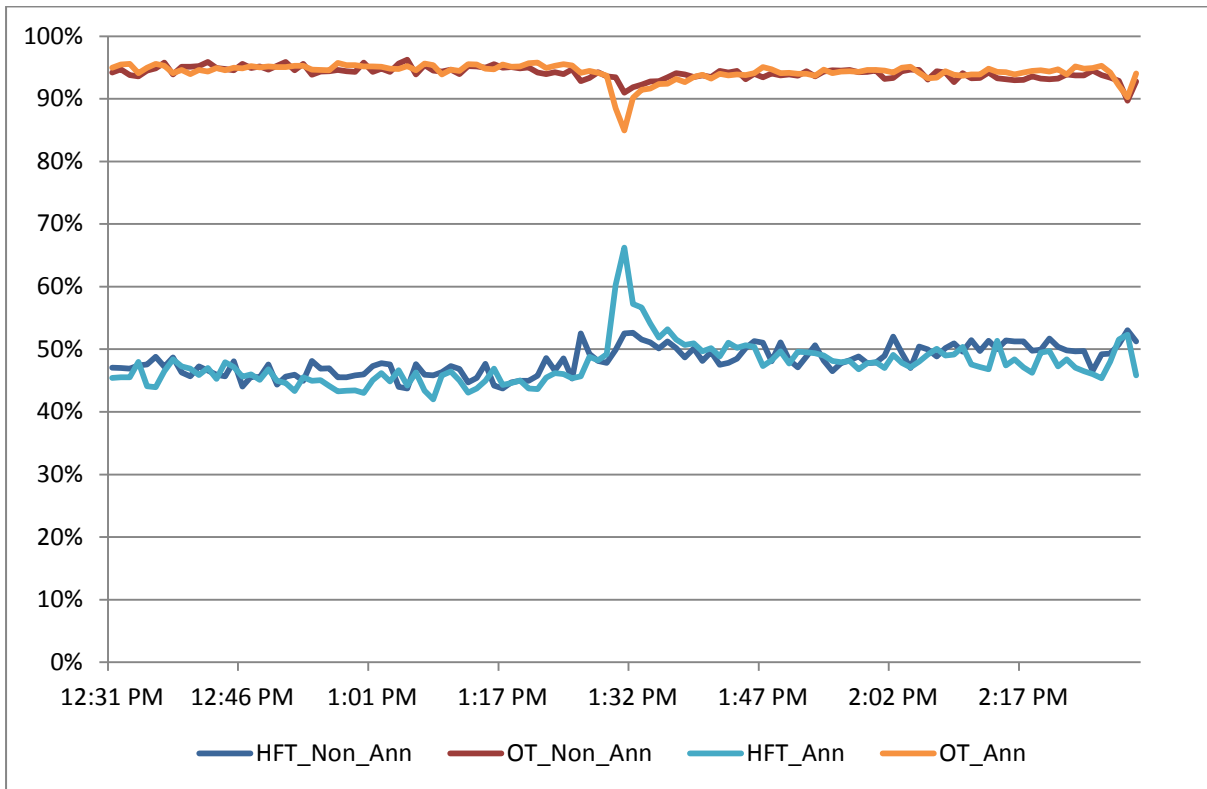
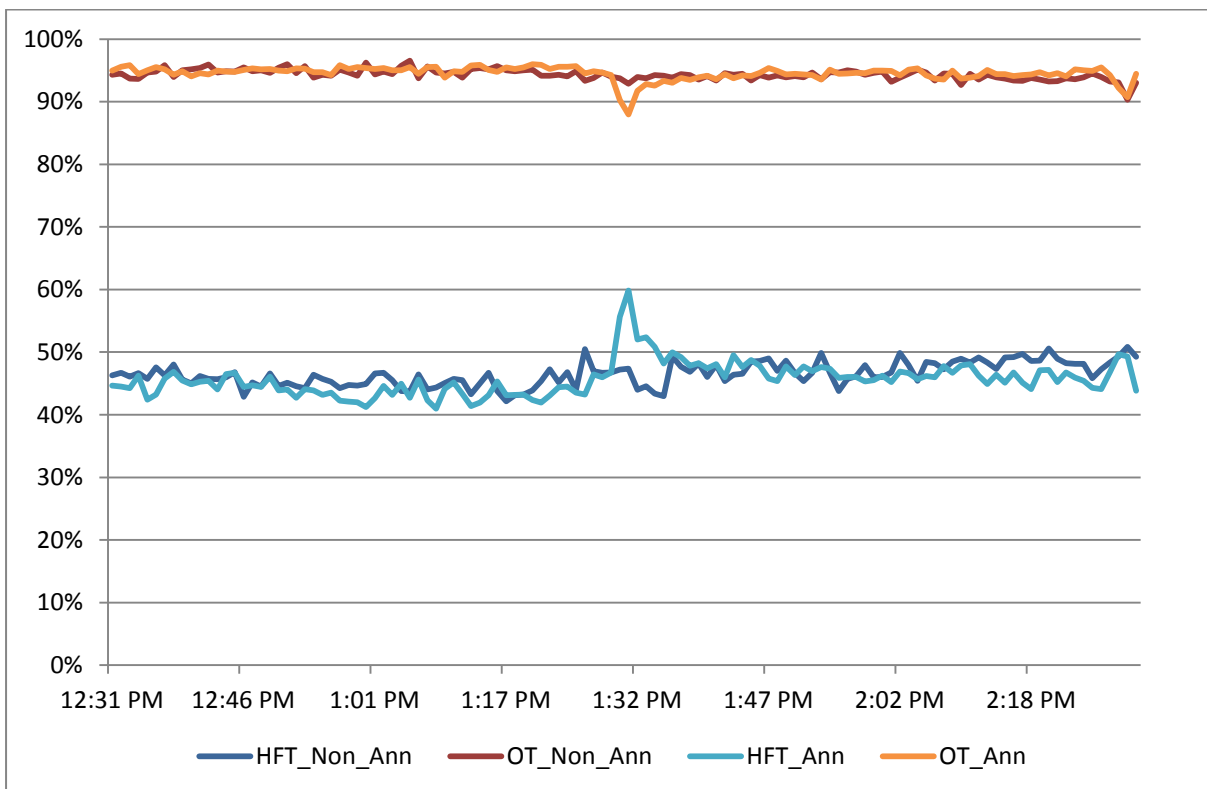


Figure 5 – Volume Participation



HFT and OT proportional liquidity demand and supply are also analysed to determine if there is an asymmetric driver in the changes in participation rates. Figure 6 presents the results of the trade-level proportional liquidity demand analysis. Surrounding 1:30pm in London trading, OT exhibit a reduction in proportional liquidity demanded. OT liquidity demand is approximately 70 – 80% of the total liquidity demand in the hour ending 1:30pm; 70.53% on non-announcement days, and falling to 61.03% on announcement days. Conversely, the proportion of liquidity demanded by HFT is approximately 20 – 30% of the total liquidity demanded in the hour prior to the announcement; 29.47% on non-announcement days, and 38.97% on announcement days in the 1:31pm interval.

Figure 6 – Trade Liquidity Demand

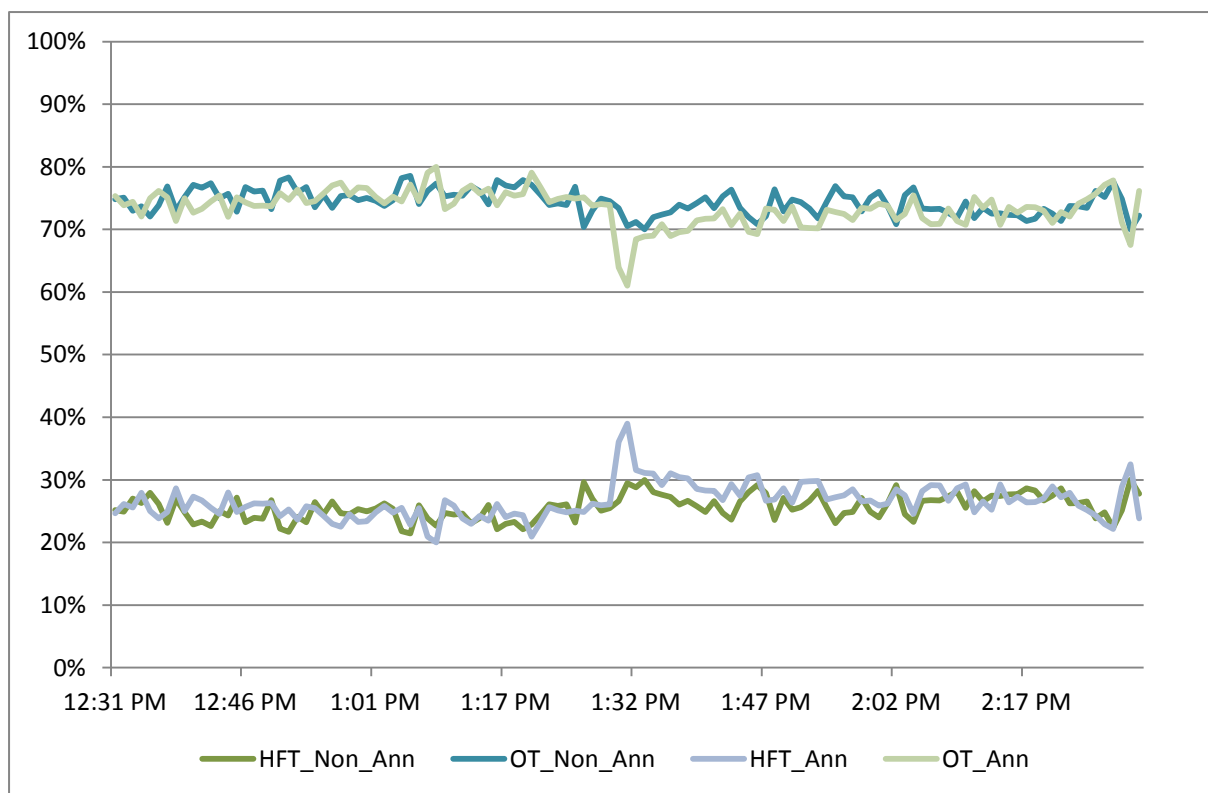
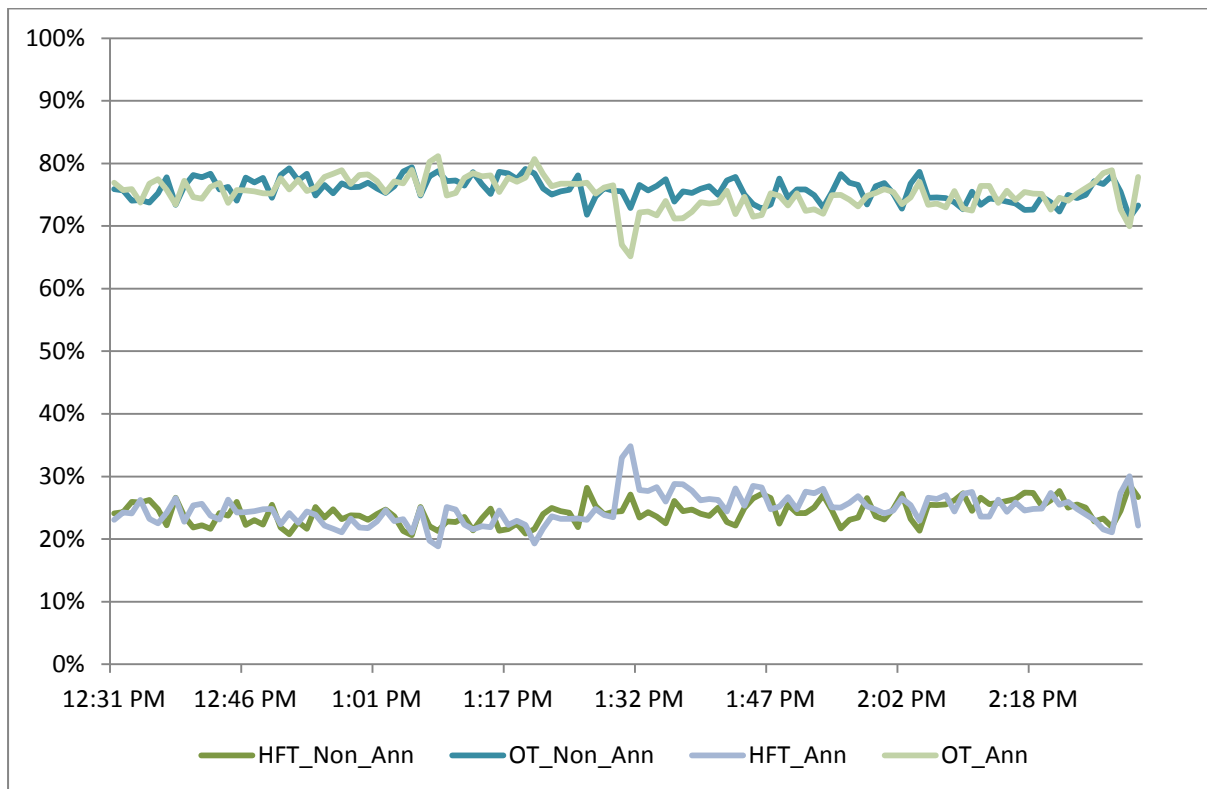


Figure 7 illustrates the results of the analysis of proportional demand of shares by HFT and OT. Similar to the trade-level analysis above, OT proportional volume demand falls, from an approximate level of 75 – 80% in the first hour of analysis, to 72.89% on non-announcement days, and 65.17% on announcement days. HFT proportional demand increases from approximately 20 – 25% to 27.11% on non-announcement days, and 34.83% on announcement days, in the period surrounding US macroeconomic releases.⁴

⁴An identical analysis on proportional demand in value yields quantitatively similar results to the volume demand, and is not included for brevity.

Figure 7 – Volume Liquidity Demand



HFT appear to maintain their presence at the best bid and ask quotes in the order book surrounding US macroeconomic data releases. To determine whether this translates into firm liquidity supply, and to determine if HFT and OT participation rate changes are driven by both changes in the levels of liquidity demand and supply, proportion of total liquidity supply across trades, volume and value are analysed. Figure 8 displays the result of the trade-level proportional liquidity supply analysis for OT and HFT on non-announcement and announcement days. OT proportional liquidity supply experiences a significant reduction, from approximately 70 – 80% in the first hour analysed, to 67.91% in the 1:31pm interval on non-announcement days, and 57.65% on announcement days. HFT proportional liquidity supply increases from approximately 20 – 25% in the first hour analysed, to 32.09% on non-announcement days, and 42.35% on announcement days, in the interval immediately after the announcement. A volume-level analysis of proportional liquidity supply by HFT and OT produces similar results, as presented in Figure 9. OT exhibit a reduction in proportional liquidity supply, falling from 72.58% on non-announcement days, to 62.96% on announcement days. Conversely, the proportion of liquidity supplied by HFT increases from 27.42% on non-announcement days, to 37.04% on announcement days.⁵

Figure 8 – Trade Liquidity Supply

⁵ Volume-weighted analysis is excluded as the results are very similar to the value-level analysis.

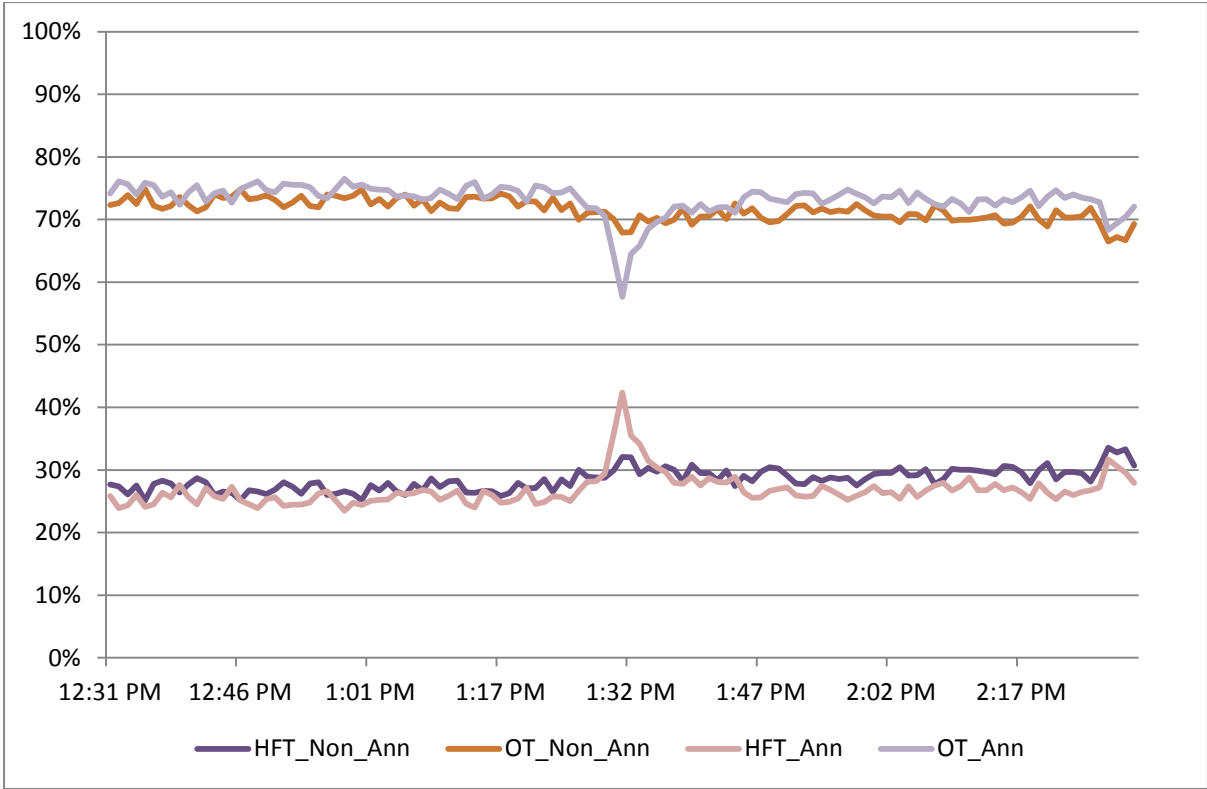
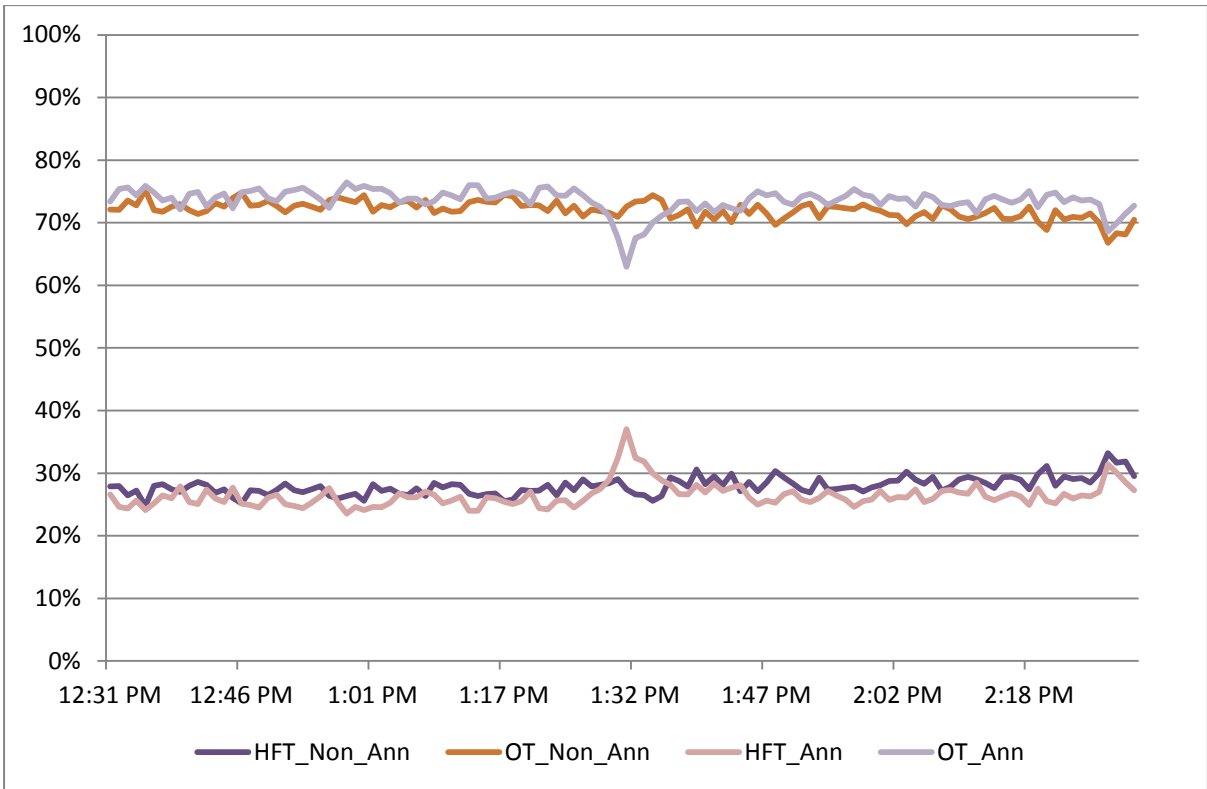
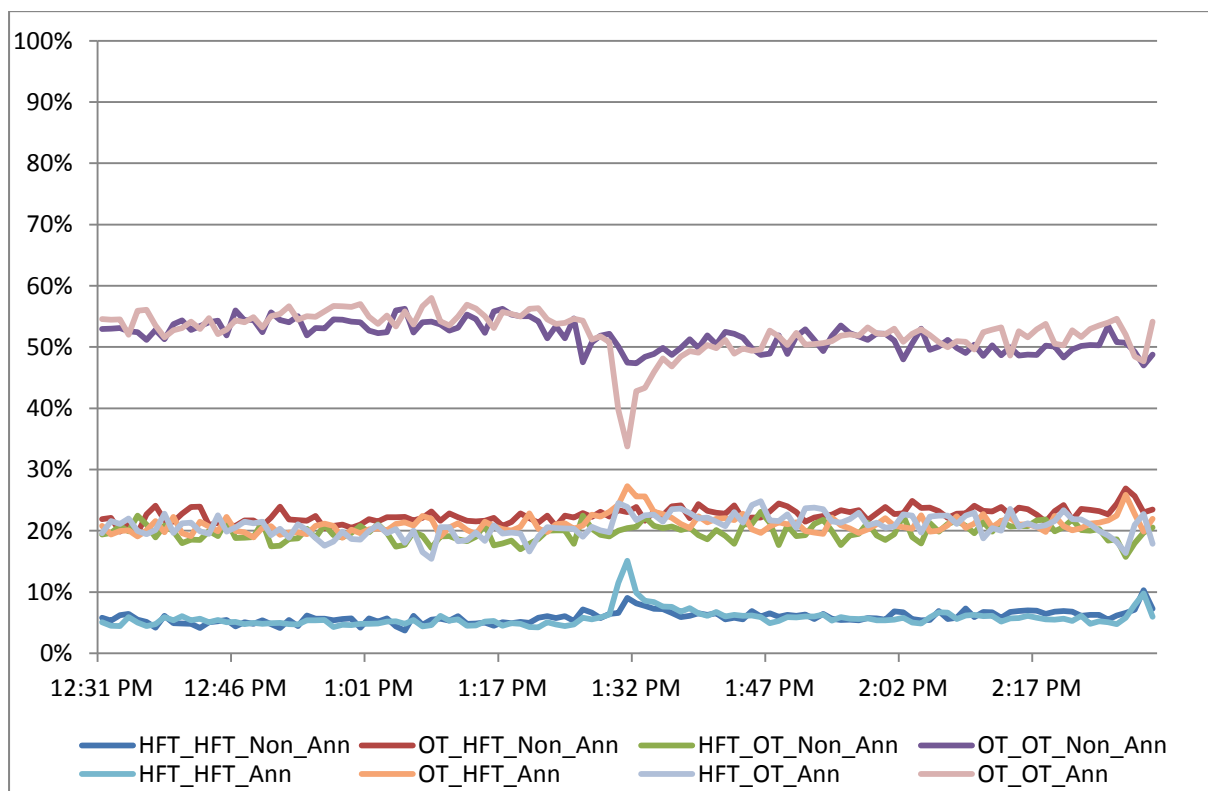


Figure 9 – Volume Liquidity Supply



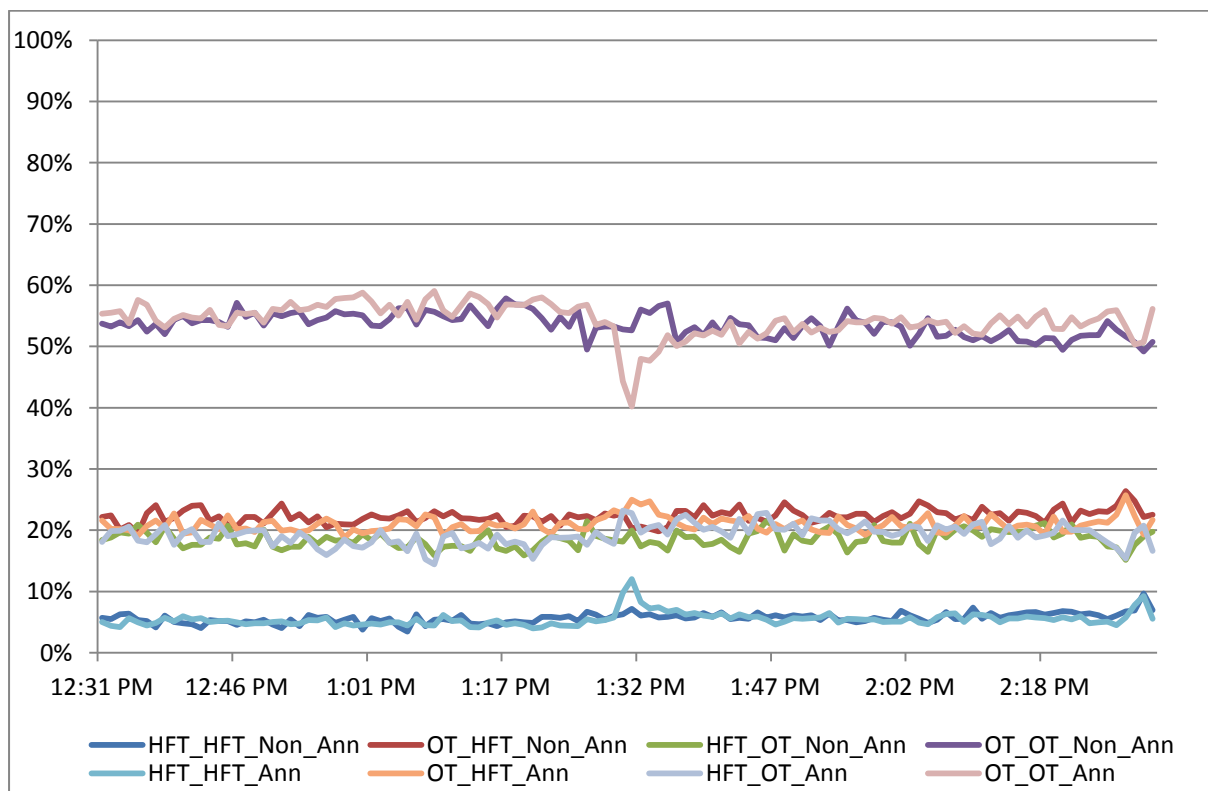
To determine the proportional net liquidity position between HFT and OT, an analysis of trade-level interaction is conducted for the four trading pairs. The results are presented in Figure 10. First, the proportion of total trades that are executed with HFT as the liquidity supplier and the liquidity demander are a small proportion in the first hour of the analysis, with HFT-HFT trades constituting approximately 5% of the total, while OT-OT trades comprise 50 – 60% of the total. Trades in which HFT supply liquidity to OT and vice versa, both account for approximately 20% of total trading. However, in the intervals immediately surrounding 1:30pm, OT-OT trades fall from 47.47% on non-announcement days, to 35.91% on announcement days, while HFT-HFT trades rise from 9.03% on non-announcement days, to 15.08% on announcement days. The proportion of trades in which OT supply liquidity to HFT in the interval following the announcement of US macroeconomic data increases from 20.44% on non-announcement days, to 23.76% on announcement days, while the proportion of trades in which HFT supply liquidity to OT in the one-minute interval following the announcement increases from 23.06% on non-announcement days, to 26.36% on announcement days. HFT provide proportionately more liquidity to OT on both announcement and non-announcement days in the period surrounding 1:30pm.

Figure 10 – Trade Pairs



A volume-level analysis of trading pairs is presented in Figure 11. Similar to above, HFT-HFT trades constitute approximately 5% of the total, while OT-OT trades comprise 55 – 60% of the total, in the first hour of the analysis. HFT-OT and OT-HFT account for approximately 20% of total volume each. However, in the intervals immediately surrounding 1:30pm, OT-OT trades fall from 52.62% on non-announcement days, to 40.17% on announcement days, while HFT-HFT trades rise from 7.14% on non-announcement days, to 12.05% on announcement days. The proportion of volume in which OT supply liquidity to HFT in the interval following the announcement of US macroeconomic data increases from 19.96% on non-announcement days, to 22.79% on announcement days, while the proportion of trades in which HFT supply liquidity to OT in the one-minute interval following the announcement increases from 20.23% on non-announcement days, to 25.00% on announcement days. HFT provide proportionately more liquidity to OT on both announcement and non-announcement days in the period surrounding 1:30pm. Value-weighted analysis produces qualitatively similar results.

Figure 11 – Volume Pairs



5.2. Multivariate Results

To control for the effects of volume and volatility on HFT and OT participation in trading, regressions are estimated to isolate the effect of the announcement on HFT and OT time at the best bid and ask. Results are presented in Table 4. Trade-level analysis shows that in the intervals 1:30 - 1:34pm, OT participation is significantly lower on announcement days than on non-announcement days. HFT participation is significantly greater in the intervals immediately before and after the announcement, with higher participation on announcement days in intervals 1:30pm (5% level of significance), 1:31pm (1% level of significance), 1:32pm (1% level of significance), 1:33pm (1% level) and 1:34pm (5% level). HFT do not reduce their participation during periods of information asymmetry caused by macroeconomic announcements, while OT participation is significantly lower on announcement days. Multivariate analysis for volume and value traded shows that HFT participation does not change in the intervals immediately before and after the information release, and increases in the intervals that follow. HFT participation increases significantly between announcement and non-announcement days surrounding the release of US economic data, while OT participation exhibits a fall in both the interval immediately prior to, and after, announcement release, significant at the 1% level. Value-based analysis yields quantitatively similar results.

Table 5 presents results for the multivariate analysis of liquidity taker determinants for HFT and OT. Across trades, volume and value, OT proportion of liquidity demand is lower in the interval immediately preceding and following the data release on announcement days, significant at the 1% level. The proportion of trades in which HFT demand liquidity is significantly higher in the interval prior to the information announcement, and the interval after the information announcement, at the 1% level. In the second interval after the announcement, HFT liquidity demand on a trade-level is higher at the 5% level of significance. On a volume and value basis, HFT liquidity demand is higher in the interval prior to the information announcement, at the 10% level of significance. However, after the interval immediately following the information release, HFT liquidity demand on announcement days is not significantly different to that of non-announcement days.

Table 4 – Participant determinants

Trades								
Trader Type	HFT	OT	HFT	OT	HFT	OT	HFT	OT
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy	
1:21pm	1.0024***	1.0054***	0.0045	-0.0015***	-0.0006	0.0002	-0.0454	0.0082
1:22 pm	1.0384***	1.0047***	0.0017	-0.0007	-0.0002	0.0001	-0.0123	0.0040
1:23 pm	1.0292***	0.9960***	-0.0032	0.0005	0.0015	-0.0001	0.0051	0.0103
1:24 pm	1.0371***	1.0019***	-0.0014	-0.0002	0.0014	-0.0004	0.0144	0.0111
1:25 pm	0.9784***	1.0063***	0.0000	0.0000	-0.0002	0.0000	0.0572	0.0021
1:26 pm	1.1593***	0.9833***	0.0004	0.0000	-0.0009	0.0000	-0.1390***	0.0133*
1:27 pm	1.0558***	0.9921***	-0.0003	0.0000	-0.0015	0.0000	0.0456	0.0086
1:28 pm	1.0509***	0.9983***	0.0003	-0.0019**	-0.0005	0.0002	0.0760	0.0030
1:29 pm	1.0830***	0.9961***	-0.0015	-0.0009	-0.0011	0.0001	0.0004	0.0008
1:30 pm	1.2324***	0.9894***	0.0034	-0.0006**	0.0033	-0.0002	0.1980**	-0.0592***
1:31 pm	1.4429***	0.9558***	-0.0028	-0.0004	0.0004	0.0001	0.1553***	-0.0648***
1:32 pm	1.2349***	0.9706***	0.0027	-0.0004	-0.0003	0.0000	0.1349***	-0.0160**
1:33 pm	1.1739***	0.9811***	-0.0024	0.0002	0.0013	-0.0002	0.1879***	-0.0142**
1:34 pm	1.1409***	0.9878***	0.0057	-0.0002	0.0003	0.0000	0.0901**	-0.0203***
1:35 pm	1.1527***	0.9844***	0.0020	-0.0002	0.0000	0.0000	0.0359	-0.0101
1:36 pm	1.1286***	0.9937***	0.0009	0.0010	-0.0005	0.0001	0.1107***	-0.0185**
1:37 pm	1.0842***	1.0032***	0.0013	0.0000	-0.0003	0.0001	0.0992**	-0.0194***
1:38 pm	1.0993***	0.9897***	-0.0004	0.0000	0.0010	0.0000	0.0713*	-0.0134*
1:39 pm	1.0832***	0.9987***	-0.0037	0.0006*	-0.0005	0.0000	0.0744*	-0.0121*
1:40 pm	1.1300***	0.9919***	-0.0023	0.0004	-0.0029	0.0000	0.0019	-0.0013

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all trades divided by the daily benchmark percentage of trades. The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (shares) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 4 (cont) – Participant determinants

Volume (shares)									
Trader Type	HFT	OT	HFT	OT	HFT	OT	HFT	OT	
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy		
1:21pm	1.0757***	1.0005***	0.0048	-0.0015**	-0.0013	0.0002	-0.0619	0.0079	
1:22 pm	1.1204***	1.0002***	0.0002	0.0000	0.0002	0.0000	-0.0338	0.0080	
1:23 pm	1.0973***	0.9903***	-0.0064	0.0007	0.0021	0.0000	0.0264	0.0144*	
1:24 pm	1.0888***	0.9989***	-0.0028	-0.0001	0.0008	-0.0004	0.0490	0.0096	
1:25 pm	1.0571***	1.0025***	0.0001	0.0000	-0.0001	0.0000	0.0450	0.0054	
1:26 pm	1.2388***	0.9830***	-0.0024	0.0002	-0.0019	0.0000	-0.1465***	0.0109	
1:27 pm	1.1170***	0.9940***	-0.0032	0.0003	-0.0019	-0.0001	0.0521	0.0086	
1:28 pm	1.1190***	0.9999***	-0.0055	-0.0014	-0.0002	0.0001	0.0539	0.0015	
1:29 pm	1.1833***	0.9940***	-0.0039	-0.0007	-0.0011	0.0002	-0.0363	0.0039	
1:30 pm	1.4931***	0.9885***	0.0020	-0.0004	0.0063	-0.0001	-0.0047	-0.0449***	
1:31 pm	1.4550***	0.9718***	-0.0019	-0.0002	0.0001	0.0000	0.1359	-0.0505***	
1:32 pm	1.1511***	0.9874***	-0.0002	0.0000	0.0002	0.0000	0.2204***	-0.0203***	
1:33 pm	1.1433***	0.9889***	-0.0043	0.0008	0.0014	-0.0002	0.2788***	-0.0113*	
1:34 pm	1.1166***	0.9920***	0.0020	-0.0001	0.0009	-0.0001	0.1673***	-0.0181***	
1:35 pm	1.1070***	0.9946***	0.0012	0.0000	-0.0011	0.0000	0.1133**	-0.0130*	
1:36 pm	1.1839***	0.9945***	-0.0039	0.0021	-0.0004	0.0001	0.0825*	-0.0183**	
1:37 pm	1.1036***	0.9982***	0.0013	0.0001	0.0000	0.0000	0.1482***	-0.0095	
1:38 pm	1.1751***	0.9887***	-0.0015	0.0000	0.0000	0.0001	0.0585	-0.0061	
1:39 pm	1.1039***	0.9938***	-0.0029	0.0006	0.0001	0.0000	0.0405	-0.0074	
1:40 pm	1.1580***	0.9914***	-0.0051	0.0005	-0.0003	0.0001	0.0305	-0.0020	

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all volume (shares) divided by the daily benchmark percentage of volume (shares). The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (shares) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 4 (cont) – Participant determinants

Volume (value)										
Trader Type	HFT		OT		HFT		OT		HFT	
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy		OT	
1:21pm	1.0783***	1.0004***	0.0048	-0.0015**	-0.0013	0.0002	-0.0644	0.0079		
1:22 pm	1.1200***	1.1199***	0.0002	0.0002	0.0005	0.0005	-0.0332	-0.0332		
1:23 pm	1.0971***	0.9904***	-0.0065	0.0007	0.0021	0.0000	0.0266	0.0143*		
1:24 pm	1.0883***	0.9989***	-0.0028	-0.0001	0.0009	-0.0004	0.0494	0.0096		
1:25 pm	1.0565***	1.0025***	0.0001	0.0000	-0.0001	0.0000	0.0457	0.0054		
1:26 pm	1.2379***	0.9830***	-0.0023	0.0002	-0.0019	0.0000	-0.1453***	0.0109		
1:27 pm	1.1173***	0.9939***	-0.0032	0.0003	-0.0018	-0.0001	0.0519	0.0086		
1:28 pm	1.1190***	0.9999***	-0.0055	-0.0014	-0.0004	0.0002	0.0538	0.0016		
1:29 pm	1.1839***	0.9940***	-0.0039	-0.0007	-0.0011	0.0002	-0.0369	0.0039		
1:30 pm	1.4927***	0.9886***	0.0019	-0.0004	0.0063	-0.0001	-0.0046	-0.0449***		
1:31 pm	1.4558***	0.9716***	-0.0020	-0.0002	0.0000	0.0000	0.1354	-0.0504***		
1:32 pm	1.1672***	0.9837***	-0.0010	0.0002	0.0002	0.0000	0.2038***	-0.0164***		
1:33 pm	1.1695***	0.9872***	-0.0049	0.0008	0.0013	-0.0002	0.2531***	-0.0098		
1:34 pm	1.1298***	0.9912***	0.0015	-0.0001	0.0009	-0.0001	0.1545***	-0.0173***		
1:35 pm	1.1209***	0.9926***	0.0012	0.0000	-0.0011	0.0001	0.0996*	-0.0109		
1:36 pm	1.1835***	0.9945***	-0.0039	0.0021**	-0.0004	0.0001	0.0830*	-0.0183**		
1:37 pm	1.1033***	0.9982***	0.0013	0.0001	0.0000	0.0000	0.1485***	-0.0095		
1:38 pm	1.1746***	0.9888***	-0.0015	0.0000	-0.0001	0.0001	0.0591	-0.0062		
1:39 pm	1.1025***	0.9941***	-0.0029	0.0006*	0.0002	0.0000	0.0821	-0.0076		
1:40 pm	1.1563***	0.9914***	-0.0051	0.0005	-0.0013	0.0001	0.0319	-0.0020		

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all volume (value) divided by the daily benchmark percentage of volume (value). The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (value) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 5 – Liquidity taker determinants

Trades								
Trader Type	HFT	OT	HFT	OT	HFT	OT	HFT	OT
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy	
1:21pm	1.0334***	1.0457***	0.0055	-0.0026*	-0.0007	0.0001	-0.0571	0.0098
1:22 pm	0.9846***	1.0330***	0.0057	-0.0014	0.0009	-0.0004	0.0991	-0.0182
1:23 pm	1.1845***	0.9997***	0.0002	0.0003	0.0001	-0.0002	-0.1800	0.0325
1:24 pm	1.0329***	1.0206***	-0.0017	0.0005	0.0035	-0.0013	-0.0676	0.0208
1:25 pm	0.9580***	1.0600***	-0.0002	0.0000	-0.0002	0.0001	0.1037	-0.0383*
1:26 pm	1.1900***	0.9584***	0.0005	-0.0002	0.0001	-0.0003	-0.1153	0.0859***
1:27 pm	1.0330***	1.0254***	0.0009	-0.0003	-0.0002	-0.0001	0.0270	-0.0044
1:28 pm	1.0197***	1.0343***	0.0062	-0.0038	-0.0020	0.0007	0.1005	-0.0053
1:29 pm	1.1188***	1.0368***	-0.0005	-0.0002	-0.0015	0.0006	-0.0305	0.0081
1:30 pm	1.2399***	1.0215***	0.0051	-0.0016**	0.0025	-0.0005	0.4317***	-0.1375***
1:31 pm	1.5314***	0.9448***	-0.0019	-0.0006	0.0007	-0.0004	0.3582***	-0.1085***
1:32 pm	1.2708***	0.9692***	0.0026	-0.0026	-0.0006	0.0002	0.2605**	-0.0263*
1:33 pm	1.2651***	0.9590***	-0.0028	0.0012	0.0031	-0.0009	0.1389*	-0.0149
1:34 pm	1.1650***	0.9920***	0.0023	-0.0003	0.0006	-0.0002	0.1812**	-0.0438**
1:35 pm	1.1974***	0.9781***	0.0024	-0.0004	0.0006	-0.0003	0.0863	-0.0069
1:36 pm	1.1202***	0.9965***	0.0014	0.0002	-0.0016	0.0003	0.2466***	-0.0476***
1:37 pm	1.0733***	1.0238***	0.0018	-0.0009	0.0005	0.0002	0.2238***	-0.0736***
1:38 pm	1.1683***	0.9915***	-0.0008	0.0012	0.0012	0.0000	0.1631**	-0.0329*
1:39 pm	1.0900***	1.0124***	-0.0046	0.0012	-0.0005	0.0001	0.1501	-0.0206
1:40 pm	1.2330***	1.0147***	-0.0077	0.0012	-0.0050	0.0005	0.0826	-0.0389*

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all trades divided by the daily benchmark percentage of trades. The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (shares) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 5 (cont) – Liquidity taker determinants

Volume (shares)												
Trader Type	HFT		OT		HFT		OT		HFT		OT	
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy		HFT		OT	
1:21pm	1.1538***	1.0199***	0.0068	-0.0033**	-0.0019	0.0003	-0.0305	0.0111				
1:22 pm	1.0733***	1.0117***	0.0022	-0.0010	0.0011	-0.0004	0.1402	-0.0038				
1:23 pm	1.2700***	0.9909***	0.0014	0.0004	0.0027	-0.0006	-0.1519	0.0310				
1:24 pm	1.0529***	1.0193***	-0.0026	0.0005	0.0022	-0.0010	0.0551	0.0108				
1:25 pm	1.0128***	1.0431***	-0.0002	0.0000	-0.0005	-0.0001	0.3397	-0.0310				
1:26 pm	1.3307***	0.9435***	-0.0033	0.0006	-0.0022	0.0006	-0.0708	0.0749***				
1:27 pm	1.1033*	1.0149***	-0.0057	0.0004	0.0013	0.0000	0.8030	-0.0153				
1:28 pm	1.0977***	1.0195***	0.0509*	-0.0040	-0.0005	-0.0003	0.2818	0.0044				
1:29 pm	1.3689***	1.0242***	0.0073	-0.0008	-0.0021	0.0004	0.2660	0.0170				
1:30 pm	1.4143***	1.0195***	-0.0030	-0.0017***	0.0028	-0.0003	1.1249*	-0.1246***				
1:31 pm	1.6361***	0.9549***	-0.0061	-0.0006	0.0001	-0.0004	0.8345**	-0.0916***				
1:32 pm	1.2519***	1.0135***	-0.0037	-0.0033	-0.0004	-0.0001	0.8148	-0.0572***				
1:33 pm	1.2511***	1.0080***	-0.0270	0.0013	0.0054	-0.0010	0.8697	-0.0553***				
1:34 pm	1.1867***	1.0140***	0.0053	-0.0012	0.0012	-0.0004	0.2642**	-0.0570***				
1:35 pm	1.1967***	1.0058***	0.0009	-0.0005	-0.0020	0.0003	0.1772*	-0.0245				
1:36 pm	1.2618***	0.9813***	-0.0095	0.0017	-0.0034	0.0005	0.3120*	-0.0326*				
1:37 pm	1.1594***	1.0142***	0.0005	-0.0006	0.0015	0.0001	0.3030***	-0.0752***				
1:38 pm	1.2903***	0.9827***	0.0014	0.0016*	0.0026	0.0004	0.2769	-0.0237				
1:39 pm	1.1583***	1.0086***	-0.0043	0.0008	-0.0005	0.0001	0.2063	-0.0189				
1:40 pm	1.4015*	0.9967***	-0.0283	0.0024	-0.0078	0.0001	0.8435	-0.0285				

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all volume (shares) divided by the daily benchmark percentage of volume (shares). The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (shares) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 5 (cont) – Liquidity taker determinants

Volume (value)								
Trader Type	HFT	OT	HFT	OT	HFT	OT	HFT	OT
Interval	Intercept		Δ Volume		Δ Volatility		Announcement Dummy	
1:21pm	1.1559***	1.0198***	0.0068	-0.0033**	-0.0019	0.0003	-0.0328	0.0113
1:22 pm	1.0717***	1.0122***	0.0222	-0.0010	0.0015	-0.0004	0.1413	-0.0042
1:23 pm	1.2775***	0.9915***	0.0010	0.0004	0.0026	-0.0006	-0.1594	0.0305
1:24 pm	1.0531***	1.0197***	-0.0026	0.0005	0.0023	-0.0010	0.0548	0.0104
1:25 pm	1.0105***	1.0436***	-0.0002	0.0000	-0.0005	-0.0001	0.3421	-0.0315
1:26 pm	1.3307***	0.9434***	-0.0033	0.0006	-0.0022	0.0006	-0.0707	0.0749***
1:27 pm	1.1038*	1.0150***	-0.0057	0.0003	0.0014	0.0000	0.8020	-0.0154
1:28 pm	1.0971***	1.0197***	0.0506*	-0.0039	-0.0009	-0.0003	0.2825	0.0042
1:29 pm	1.3673**	1.0246***	0.0073	-0.0008	-0.0021	0.0004	0.2671	0.0166
1:30 pm	1.4139***	1.0196***	-0.0030	-0.0017***	0.0029	-0.0003	1.1242**	-0.1247***
1:31 pm	1.6371***	0.9547***	-0.0062	-0.0006	0.0002	-0.0004	0.8332**	-0.0914***
1:32 pm	1.2742***	1.0037***	-0.0047	-0.0029	-0.0006	0.0000	0.7917	-0.0471***
1:33 pm	1.2794***	1.0016***	-0.0276	0.0015	0.0053	-0.0010	0.8414	-0.0490***
1:34 pm	1.1919***	1.0113***	0.0051	-0.0011	0.0012	-0.0004	0.2589**	-0.0543***
1:35 pm	1.2018***	1.0049***	0.0009	-0.0005	-0.0020	0.0003	0.1723*	-0.0237
1:36 pm	1.2617***	0.9813***	-0.0094	0.0017	-0.0034	0.0005	0.3121*	-0.0326*
1:37 pm	1.1599***	1.0143***	0.0005	-0.0006	0.0014	0.0001	0.3017***	-0.0753***
1:38 pm	1.2902***	0.9831***	0.0014	0.0016*	0.0027	0.0004	0.2771	-0.0241
1:39 pm	1.1555***	1.0093***	-0.0043	0.0008	-0.0005	0.0001	0.2092	-0.0195
1:40 pm	1.3997*	0.9971***	-0.0283	0.0024	-0.0078	0.0001	0.8442	-0.0288

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all volume (value) divided by the daily benchmark percentage of volume (value). The benchmark period is 12:30 – 1:00 pm. The Δ Volume variable is the relative change in volume (value) in the given interval, the Δ Volatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Results of the multivariate analysis, after controlling for the effects of volume and volatility on HFT and OT proportionate liquidity supply, are presented in Table 6. On a trade level, during the 1:30- 1:36pm intervals, the proportion of liquidity provided by HFT is higher on announcement days (significant at the 1% level, with the exception of 1:35pm, which is higher at the 5% level of significance). Conversely, the proportion of liquidity provided by OT is lower, at the 1% level of significance, during the 1:30 – 1:35pm intervals. HFT exhibit a statistically significant increase in the proportion of liquidity they provide on announcement days, with OT providing significantly less liquidity on announcement days. Analysing the proportion of volume- and value-level liquidity provision, HFT exhibit a statistically significant rise in the proportion of liquidity they provide on announcement and non-announcement days during the 1:31 – 1:36pm intervals, while the proportion of liquidity provision by OT is significantly lower on announcement days from the interval prior to the information release, until the 1:36pm interval. These results indicate that HFT increase their presence as liquidity providers surrounding announcement periods, while OT reduce their presence as liquidity providers.

The results of the multivariate analyses presented in Tables 4 – 6 indicate that HFT participation, both as a liquidity taker and a liquidity supplier, does not decrease on announcement days relative to non-announcement days. Relative HFT liquidity demand on a trade, volume and value basis increases in the interval prior to, and after, 1:30pm on announcement days, while relative HFT liquidity supply on a trade, volume and value basis is significantly higher surrounding announcements. Conversely, OT participation declines on announcement days, with OT liquidity demand and supply significantly lower in the intervals immediately preceding and following information announcements. HFT appear to be enter the market during this period of information asymmetry.

To determine the effect of the increase in HFT participation on other participants, multivariate analysis of trading pairs is undertaken, with the results presented in Table 7. Results at the trade level indicate that OT liquidity provision to HFT on announcement days is marginally increased on announcement days in the intervals immediately surrounding the announcement, while liquidity provision by HFT to OT on announcement days is significantly higher on announcement days, during the 1:29 – 1:34pm intervals. On a volume and value level, OT liquidity provision to HFT is higher on announcement days in the interval immediately following the economic news release (at the 10% level of significance). Provision of liquidity by HFT to OT is significantly higher during the 1:30 – 1:35pm intervals (at varying levels of significance). These results suggest that while HFT take liquidity from OT in the interval immediately after the information announcement, they also provide liquidity to OT in the intervals immediately before, and for a longer period after, the information release.

Table 6 – Liquidity maker determinants

Trades										
Trader Type	HFT		OT		HFT		OT		HFT	
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy		OT	
1:21pm	1.0483***	1.0212***	0.0062	-0.0029**	-0.0012	0.0003	-0.0186	0.0029		
1:22 pm	1.1082***	1.0047***	0.0023	-0.0009	-0.0016	0.0006	-0.0646	0.0202		
1:23 pm	1.1404***	1.0194***	-0.0080	0.0024	0.0018	-0.0006	0.0032	-0.0360		
1:24 pm	1.1554***	1.0043***	0.0001	-0.0004	-0.0004	-0.0004	-0.0179	-0.0114		
1:25 pm	1.0965***	0.9917***	0.0001	-0.0001	-0.0006	-0.0001	0.0099	0.0117		
1:26 pm	1.2346***	0.9666***	-0.0003	-0.0002	-0.0021	0.0004	-0.0795	0.0174		
1:27 pm	1.1991***	0.9716***	0.0087	0.0000	-0.0032	0.0005	0.1380	-0.0120		
1:28 pm	1.2176***	0.9767***	0.0025	-0.0005	0.0003	-0.0001	0.1210	-0.0145		
1:29 pm	1.1952***	0.9880***	0.0007	-0.0006	-0.0012	0.0002	0.1127	-0.0403*		
1:30 pm	1.3179***	0.9538***	0.0017	-0.0009	0.0041	-0.0008*	0.5602***	-0.1138***		
1:31 pm	1.6249***	0.9046***	-0.0044	0.0002	0.0016	0.0000	0.5092***	-0.1495***		
1:32 pm	1.4450***	0.9393***	0.0190	-0.0012	0.0006	-0.0001	0.3382***	-0.0600***		
1:33 pm	1.2941***	0.9868***	0.0091	0.0000	0.0015	0.0000	0.4258***	-0.1035***		
1:34 pm	1.2355***	0.9588***	0.0100	-0.0016	0.0005	0.0000	0.2104***	-0.0431***		
1:35 pm	1.2253***	0.9840***	0.0016	-0.0003	0.0000	0.0000	0.2500**	-0.0479***		
1:36 pm	1.9961***	0.9772***	-0.0023	0.0000	0.0014	0.0000	0.2067***	-0.0363*		
1:37 pm	1.1780***	0.9789***	-0.0003	-0.0001	-0.0003	0.0000	0.1161	-0.0171		
1:38 pm	1.2947***	0.9952***	-0.0002	-0.0010	0.0006	-0.0001	0.0323	-0.0343*		
1:39 pm	1.2015***	0.9781***	-0.0055	0.0017*	-0.0001	-0.0001	0.1558*	-0.0244		
1:40 pm	1.2563***	0.9731***	-0.0019	0.0003	-0.0019	0.0004	0.0561	0.0120		

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all trades divided by the daily benchmark percentage of trades. The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (shares) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 6 (cont) – Liquidity maker determinants

Volume (shares)												
Trader Type	HFT		OT		HFT		OT		HFT		OT	
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy		HFT		OT	
1:21pm	1.2101***	1.0073***	0.0052	-0.0020	-0.0019	0.0003	-0.1324	0.0038				
1:22 pm	1.3438***	0.9946***	-0.0010	-0.0001	-0.0012	0.0003	-0.2138	0.0413				
1:23 pm	1.2615***	1.0016***	-0.0148	0.0036	-0.0042	0.0007	-0.0047	-0.0292				
1:24 pm	1.2568***	0.9908***	-0.0024	0.0002	-0.0004	-0.0006	-0.0607	-0.0037				
1:25 pm	1.1903***	1.0354***	0.0001	-0.0002	-0.0006	-0.0002	-0.0214	-0.0389				
1:26 pm	1.3576***	0.9552***	-0.0032	0.0007	-0.0018	0.0002	-0.1761**	0.0340				
1:27 pm	1.2593***	0.9717***	0.0082	0.0011	-0.0028	0.0004	0.1199	-0.0050				
1:28 pm	1.2819***	0.9748***	-0.0053	0.0018	-0.0021	0.0004	0.0920	-0.0125				
1:29 pm	1.2958***	0.9753***	-0.0067	0.0007	-0.0013	0.0000	0.1210	-0.0337				
1:30 pm	1.5664***	0.9534***	-0.0016	0.0001	0.0056	-0.0007	0.2665	-0.0883***				
1:31 pm	1.5033***	0.9555***	-0.0066	0.0015*	0.0010	0.0000	0.4758***	-0.1342***				
1:32 pm	1.3737***	0.9952***	0.0043	-0.0004	0.0008	-0.0001	0.4035***	-0.0801***				
1:33 pm	1.3635***	0.9973***	0.0028	0.0007	-0.0017	0.0000	0.4374***	-0.0807***				
1:34 pm	1.1919***	0.9951***	0.0050	0.0014	0.0016	-0.0002	0.4015***	-0.0682***				
1:35 pm	1.1919***	1.0181***	-0.0006	0.0000	-0.0006	-0.0001	0.4136**	-0.0657***				
1:36 pm	1.2646***	0.9907***	-0.0128	0.0027	0.0022	-0.0002	0.2008**	-0.0420*				
1:37 pm	1.2162***	0.9918***	-0.0001	-0.0001	-0.0001	-0.0001	0.0940	-0.0165				
1:38 pm	2.0819***	0.9802***	-0.0082	-0.0008	-0.0062	0.0002	-0.6198	-0.0078				
1:39 pm	1.2328***	0.9770***	-0.0063	0.0014	0.0034	-0.0002	0.1773*	-0.0252				
1:40 pm	1.2742***	0.9828***	-0.0061	0.0017	0.0014	0.0000	0.0954	0.0047				

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all volume (shares) divided by the daily benchmark percentage of trades. The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (shares) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 6 (cont) – Liquidity maker determinants

Volume (value)												
Trader Type	HFT		OT		HFT		OT		HFT		OT	
Interval	Intercept		Δ Volume		Δ Volatility		Announcement Dummy		HFT		OT	
1:21pm	1.2169***	1.0070***	0.0052	-0.0020	-0.0019	0.0003	-0.1384	0.0041				
1:22 pm	1.3439***	0.9948***	-0.0010	-0.0001	-0.0012	0.0003	-0.2139	0.0411				
1:23 pm	1.2649***	1.0018***	-0.0148	0.0036	-0.0042	0.0000	-0.0082	-0.0294				
1:24 pm	1.2547***	0.9908***	-0.0024	0.0002	-0.0004	-0.0006	-0.0586	-0.0038				
1:25 pm	1.1900***	1.0354***	0.0001	-0.0002	-0.0006	-0.0002	-0.0212	-0.0390				
1:26 pm	1.3562***	0.9554***	-0.0032	0.0007	-0.0018	0.0002	-0.1741**	0.0367				
1:27 pm	1.2597***	0.9717***	0.0081	0.0011	-0.0029	0.0004	0.1202	-0.0050				
1:28 pm	1.2814***	0.9747***	-0.0053	0.0018	-0.0021	0.0004	0.0925	-0.0124				
1:29 pm	1.3012***	0.9751***	-0.0069	0.0007	-0.0013	0.0001	0.1158	-0.0335				
1:30 pm	1.5639***	0.9535***	-0.0016	0.0001	0.0053	-0.0008	0.2693	-0.0884***				
1:31 pm	1.5062***	0.9553***	-0.0067	0.0015*	0.0009	0.0001	0.4731***	-0.1340***				
1:32 pm	1.3872***	0.9811***	0.0035	0.0004	0.0010	-0.0001	0.3898***	-0.0657***				
1:33 pm	1.3890***	0.9884***	0.0021	0.0010	-0.0020	0.0001	0.4126***	-0.0722***				
1:34 pm	1.2121***	0.9904***	0.0043	0.0015	0.0016	-0.0002	0.3822***	-0.0637***				
1:35 pm	1.1964***	1.0165***	-0.0006	0.0000	-0.0006	-0.0001	0.4091**	-0.0641***				
1:36 pm	1.2630***	0.9908***	-0.0128	0.0027	0.0021	-0.0002	0.2050**	-0.0421*				
1:37 pm	1.2164***	0.9920***	-0.0001	-0.0001	-0.0001	-0.0001	0.0937	-0.0168				
1:38 pm	2.0806***	0.9805***	-0.0082	-0.0008	-0.0061	0.0002	-0.6182	-0.0081				
1:39 pm	1.2311***	0.9775***	-0.0063	0.0014	0.0036	-0.0002	0.1790*	-0.0258				
1:40 pm	1.2719***	0.9830***	-0.0061	0.0017	0.0013	0.0000	0.0975	0.0044				

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all volume (value) divided by the daily benchmark percentage of trades. The benchmark period is 12:30 – 1:00 pm. The Δ Volume variable is the relative change in volume (value) in the given interval, the Δ Volatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 7 – Pairs Determinants

Trades								
Pair	HFT_HFT	HFT_OT	HFT_HFT	HFT_OT	HFT_HFT	HFT_OT	HFT_HFT	HFT_OT
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy	
1:21pm	1.3159***	1.0086***	0.0477*	0.0018	-0.0039	0.0006	-0.3773*	-0.0597
1:22 pm	1.3082***	1.0243***	0.0087	0.0034	-0.0027	0.0013	-0.1143	0.0577
1:23 pm	1.5227***	1.3996***	-0.0108	-0.0018	-0.0052	-0.0007	-0.4172**	-0.3866*
1:24 pm	1.5096***	1.0797***	-0.0001	-0.0026	0.0031	0.0024	-0.5036**	-0.0873
1:25 pm	1.1783***	0.9306***	-0.0002	-0.0002	-0.0021	-0.0007	-0.1396	0.1878**
1:26 pm	1.6304***	1.2004***	-0.0001	0.0000	-0.0015	0.0005	-0.2221	-0.1815**
1:27 pm	1.5724***	1.0323***	-0.0025	0.0002	-0.0026	-0.0005	-0.2383	0.0036
1:28 pm	1.4435***	0.9955	0.0263	0.0066	-0.0034	-0.0017	-0.0339	-0.0204
1:29 pm	1.5960***	0.9405***	0.0021	0.0016	-0.0033	-0.0009	0.1550	0.0490
1:30 pm	1.8262***	1.1105***	0.0203*	0.0016	0.0146	0.0003	1.6639***	0.2543*
1:31 pm	2.7592***	1.2384***	0.0018	-0.0005	0.0000	0.0016	2.0940***	0.1256*
1:32 pm	1.9541***	1.2212***	0.0241	-0.0026	-0.0009	0.0007	0.9141***	-0.0053
1:33 pm	1.8652***	1.1898***	-0.0023	-0.0024	0.0291**	0.0022	0.5286**	0.0723
1:34 pm	1.8974***	1.1501***	0.0031	0.0105	0.0012	0.0004	0.2854	0.0690
1:35 pm	1.6495***	1.0939***	0.0060	0.0003	0.0027	0.0008	0.4558*	0.0933
1:36 pm	1.3884***	1.0698***	-0.0216	0.0037	-0.0052	-0.0013	0.7720***	0.1632**
1:37 pm	1.3341***	1.1111***	-0.0010	0.0017	-0.0014	-0.0007	0.4859*	0.1563
1:38 pm	1.5875***	1.1345***	-0.0057	0.0001	-0.0017	0.0013	0.3934	0.0920
1:39 pm	1.1681***	1.0575***	-0.0089	-0.0028	-0.0018	-0.0006	0.7175***	0.1120
1:40 pm	1.3327***	1.0175***	0.0027	-0.0026	-0.0055	-0.0030	0.2798	0.1695
Pair	OT_HFT	OT_OT	OT_HFT	OT_OT	OT_HFT	OT_OT	OT_HFT	OT_OT
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy	
1:21pm	1.0900***	1.0629***	0.0010	-0.0052**	-0.0006	0.0001	0.0936	0.0324
1:22 pm	1.1285***	1.0555***	0.0012	-0.0023	-0.0022	0.0001	-0.0520	-0.0108
1:23 pm	1.0954***	1.0054***	-0.0085	0.0043	0.0025	-0.0009	0.1259	-0.0147
1:24 pm	1.1835***	1.0155***	-0.0021	0.0007	-0.0009	-0.0016	-0.0037	0.0178
1:25 pm	1.1872***	1.0595***	0.0001	-0.0001	0.0002	0.0000	-0.0477	-0.0430
1:26 pm	1.1827***	0.9188***	-0.0001	-0.0003	-0.0019	0.0000	0.0152	0.1141***
1:27 pm	1.2252***	1.0096***	-0.0031	-0.0004	-0.0038	0.0006	0.1469	-0.0424
1:28 pm	1.2582***	1.0160***	0.0010	-0.0044	0.0016	0.0004	0.0380	0.0120
1:29 pm	1.1677***	1.0548***	-0.0023	0.0001	-0.0007	0.0007	0.1464*	-0.0632
1:30 pm	1.2538***	1.0007***	0.0009	-0.0024**	0.0023	-0.0018*	0.2640***	-0.2610
1:31 pm	1.4669***	0.8711***	-0.0054	0.0001	0.0022	-0.0007	0.2184***	-0.2584***
1:32 pm	1.3021***	0.9145***	0.0056	-0.0041	0.0011	0.0001	0.1948***	-0.0629
1:33 pm	1.1630***	0.9478***	-0.0100	0.0034	0.0020	-0.0013	0.3805***	-0.1346***
1:34 pm	1.1725***	0.9463***	0.0100	-0.0001	0.0000	-0.0002	0.2139***	-0.1014***
1:35 pm	1.1925***	0.9848***	0.0002	-0.0005	0.0007	-0.0007	0.1414	-0.0734**
1:36 pm	1.2360***	0.9655***	0.0041	-0.0007	0.0020	0.0002	0.1041	-0.0817***
1:37 pm	1.2293***	1.0012***	-0.0004	-0.0013	0.0005	0.0002	-0.0070	-0.0964***
1:38 pm	1.0874***	1.0020***	0.0036	0.0002	0.0017	-0.0003	0.1310*	-0.0750**
1:39 pm	1.1717***	1.0011***	-0.0034	0.0029	0.0004	-0.0001	0.0891	-0.0474
1:40 pm	1.2320***	1.0114***	-0.0006	0.0013	-0.0017	0.0010	0.0520	-0.0475

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all trades taking place between a given trading pair divided by the daily benchmark percentage of trades executed by that same trading pair. The pair is structured as *Taker_Maker*. The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (shares) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 7 (cont) – Pairs Determinants

Volume (shares)								
Pair	HFT_HFT	HFT_OT	HFT_HFT	HFT_OT	HFT_HFT	HFT_OT	HFT_HFT	HFT_OT
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy	
1:21pm	2.7143***	1.1390***	0.0708	0.0030	-0.0094	-0.0007	-1.4040	-0.1198
1:22 pm	2.3124	1.1144***	0.0179	0.0037	-0.0074	0.0011	2.1880	0.0610
1:23 pm	2.0266***	1.3888***	-0.0176	0.0067	-0.0058	0.0023	-0.8776***	-0.2335
1:24 pm	1.9956***	1.0983***	-0.0056	-0.0028	0.0027	0.0005	-0.1594	0.0560
1:25 pm	1.6344***	0.9958***	-0.0003	-0.0002	-0.0031	-0.0002	-0.4287	-0.0400
1:26 pm	2.8691***	1.4510***	0.0492*	-0.0048	-0.0081	-0.0030	-1.2696*	-0.1893
1:27 pm	1.6194***	1.1249***	-0.0055	-0.0024	0.0012	-0.0011	-0.2828	0.1013
1:28 pm	1.6969	1.2256***	-0.1123	0.0037	0.0069	0.0003	4.9353	-0.2075*
1:29 pm	2.0758***	1.0306***	0.0087	0.0054	-0.0051	-0.0009	0.0538	-0.0068
1:30 pm	2.3786***	1.1922**	0.0010	-0.0048	0.0007	-0.0038	3.3540**	0.8500
1:31 pm	4.9206	1.3742***	-0.5821	0.0027	0.1128	0.0014	26.4394	0.4199*
1:32 pm	2.4624	1.2288	-0.0726	0.0146	-0.0008	-0.0002	3.1747	0.1164
1:33 pm	2.6719***	1.1098***	-0.0092	-0.0023	0.0214	0.0079	0.2738	0.5292
1:34 pm	2.3564***	1.1596***	0.0953*	0.0087	0.0030	0.0009	0.1872	0.2193*
1:35 pm	1.6797***	1.1312***	0.0205	0.0002	0.0002	-0.0025	0.7558*	0.2287*
1:36 pm	1.7598*	1.3198***	-0.0823	0.0092	-0.0085	-0.0043	2.2708*	0.1202
1:37 pm	2.0431***	1.2835***	-0.0056	0.0013	-0.0025	-0.0009	0.0778	0.1531
1:38 pm	2.1471	1.2274***	-0.0215	-0.0032	-0.0072	0.0025	1.5126	0.2392
1:39 pm	1.3593	1.1263***	-0.0350	-0.0037	-0.0099	-0.0007	2.8073	0.3706
1:40 pm	1.5176***	1.1490***	-0.0066	-0.0073	-0.0076	-0.0009	0.3829	0.2628
Pair	OT_HFT	OT_OT	OT_HFT	OT_OT	OT_HFT	OT_OT	OT_HFT	OT_OT
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy	
1:21pm	1.2163***	1.0069***	-0.0025	-0.0046	-0.0017	0.0005	0.1478	0.0416
1:22 pm	1.1761***	1.0009***	0.0029	-0.0016	-0.0022	-0.0001	-0.0229	0.0537
1:23 pm	1.2234***	0.9723***	-0.0219*	0.0064	-0.0040	-0.0006	0.1290	0.0004
1:24 pm	1.2943***	0.9983***	-0.0030	0.0008	-0.0007	-0.0014	-0.0184	0.0184
1:25 pm	1.2917***	1.0310***	0.0001	-0.0002	0.0003	-0.0003	-0.0959	-0.0336
1:26 pm	1.3130***	0.8865***	-0.0025	0.0016	-0.0012	0.0010	-0.1126	0.1365***
1:27 pm	1.3294***	0.9939***	-0.0051	0.0014	-0.0042	0.0004	0.0579	-0.0467
1:28 pm	1.3220***	0.9940***	-0.0122	-0.0022	-0.0018	-0.0001	0.2843	0.0055
1:29 pm	1.2931***	1.0219***	-0.0084	0.0004	-0.0007	0.0002	0.1283	-0.0404
1:30 pm	1.3582***	0.9965***	-0.0044	-0.0018*	0.0026	-0.0017	0.3521**	-0.2223***
1:31 pm	1.4019***	0.9341***	-0.0087*	0.0015	0.0011	-0.0009	0.2874***	-0.2404***
1:32 pm	1.2342***	1.0496***	0.1403*	-0.0054	0.0015	-0.0003	0.6333*	-0.1661***
1:33 pm	1.2259***	1.0237***	-0.0137	0.0034	-0.0006	-0.0012	0.3709***	-0.1740***
1:34 pm	1.1539***	1.0418***	0.0034	0.0030	0.0007	-0.0006	0.3623***	-0.1742***
1:35 pm	1.1330***	1.0684***	-0.0019	-0.0003	0.0019	0.0002	0.3583**	-0.1346***
1:36 pm	1.3172***	0.9658***	-0.0060	0.0025	0.0040	0.0004	0.3752	-0.0709**
1:37 pm	1.2434***	1.0216***	-0.0004	-0.0010	0.0011	-0.0001	0.4259	-0.1227***
1:38 pm	1.2231***	0.9809***	0.0014	0.0015	-0.0015	0.0004	0.1516	-0.0438
1:39 pm	1.2473***	0.9935***	-0.0038	0.0019	0.0051	-0.0004	0.0136	-0.0492
1:40 pm	1.3258***	0.9974***	-0.0173	0.0057	-0.0004	0.0000	0.7510	-0.0432

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all volume traded between a given trading pair divided by the daily benchmark percentage of volume traded by that same trading pair. The pair is structured as Taker_Maker The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (shares) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

Table 7(cont) – Pairs Determinants

Volume (value)								
Pair	HFT_HFT	HFT_OT	HFT_HFT	HFT_OT	HFT_HFT	HFT_OT	HFT_HFT	HFT_OT
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy	
1:21pm	2.5527***	1.1406***	0.0715	0.0030	-0.0088	-0.0007	-1.2446	-0.1216
1:22 pm	2.1282	1.1123***	0.0201	0.0037	-0.0069	0.0010	2.3707	0.0623
1:23 pm	1.9927***	1.3972***	-0.0186	0.0062	-0.0057	0.0023	-0.8434***	-0.2425
1:24 pm	1.9764***	1.0978***	-0.0056	-0.0028	0.0029	0.0005	-0.1409	0.0562
1:25 pm	1.6336***	0.9930***	-0.0003	-0.0002	-0.0031	-0.0001	-0.4277	0.2213**
1:26 pm	2.8551***	1.4514***	0.0496*	-0.0048	-0.0084	-0.0029	-1.2553*	-0.1898
1:27 pm	1.6208***	1.1253***	-0.0055	-0.0024	0.0013	-0.0010	-0.2837	0.1005
1:28 pm	1.6988	1.2250***	-0.1121	0.0036	0.0069	-0.0001	4.9329	-0.2070*
1:29 pm	2.0861***	1.0270***	0.0085	0.0055	-0.0051	-0.0009	0.0436	-0.0035
1:30 pm	2.3545*	1.1922**	0.0011	-0.0048	0.0009	-0.0038	3.3787**	0.8494
1:31 pm	4.9111	1.3745***	-0.5793	0.0026	0.1110	0.0015	26.4585	0.4199*
1:32 pm	2.4753	1.2424***	-0.0733	0.0142	-0.0008	-0.0003	3.1736	0.1025
1:33 pm	2.6481***	1.1281***	-0.0098	-0.0027	0.0212	0.0078	0.2967	0.5110
1:34 pm	2.3693***	1.1563***	0.0941*	0.0087	0.0033	0.0009	0.1758	0.2226**
1:35 pm	1.6736***	1.1363***	0.0200	0.0002	0.0000	-0.0026	0.7655*	0.2236*
1:36 pm	1.7568*	1.3201***	-0.0816	0.0093	-0.0085	-0.0043	2.2676*	0.1202
1:37 pm	2.0449***	1.2841***	-0.0056	0.0013	-0.0025	-0.0010	0.0759	0.1517
1:38 pm	2.1444	1.2276***	-0.0216	-0.0032	-0.0070	0.0026	1.5170	0.2392
1:39 pm	1.3499	1.1247***	-0.0352	-0.0038	-0.0099	-0.0007	2.8415	0.3724
1:40 pm	1.5688***	1.1468***	-0.0066	-0.0073	-0.0076	-0.0009	0.3856	0.2645
Pair	OT_HFT	OT_OT	OT_HFT	OT_OT	OT_HFT	OT_OT	OT_HFT	OT_OT
Interval	Intercept		ΔVolume		ΔVolatility		Announcement Dummy	
1:21pm	1.2194***	1.0063***	-0.0026	-0.0046*	-0.0016	0.0005	0.1460	0.0422
1:22 pm	1.1769***	1.0016***	0.0029	-0.0016	-0.0023	0.0000	-0.0236	0.0530
1:23 pm	1.2232***	0.9732***	-0.0219*	0.0064	-0.0039	-0.0006	0.1289	-0.0004
1:24 pm	1.2907***	0.9987***	-0.0030	0.0008	-0.0006	-0.0014	-0.0147	0.0179
1:25 pm	1.2910***	1.0317***	0.0001	-0.0002	0.0003	-0.0003	-0.0952	-0.0343
1:26 pm	1.3119***	0.8865***	-0.0025	0.0016	-0.0124	0.0010	-0.1108	0.1364***
1:27 pm	1.3296***	0.9942***	-0.0051	0.0013	-0.0042	0.0004	0.0585	-0.0469
1:28 pm	1.3208***	0.9942***	-0.0119	-0.0022	-0.0018	0.0000	0.2859	0.0053
1:29 pm	1.2901***	1.0224***	-0.0084	0.0004	-0.0007	0.0002	0.1315	-0.0408
1:30 pm	1.3567***	0.9967***	-0.0044	-0.0018*	0.0025	-0.0016	0.3537**	-0.2225***
1:31 pm	1.4016***	0.9335***	-0.0087*	0.0015	0.0010	-0.0009	0.2878***	-0.2398***
1:32 pm	1.2500***	1.0167***	0.1391*	-0.0037	0.0018	-0.0002	0.6174*	-0.1322***
1:33 pm	1.2465***	1.0042***	-0.0143	0.0039	-0.0008	-0.0012	0.3511***	-0.1548***
1:34 pm	1.1687***	1.0353***	0.0029	0.0032	0.0006	-0.0006	0.3482***	-0.1679***
1:35 pm	1.1380***	1.0653***	-0.0019	-0.0003	0.0020	0.0002	0.3531**	-0.1316***
1:36 pm	1.3157***	0.9658***	-0.0060	0.0025	0.0039	0.0004	0.3766	-0.0709**
1:37 pm	1.2430***	1.0222***	-0.0004	-0.0001	0.0010	0.0000	0.4266	-0.1233***
1:38 pm	1.2221***	0.9819***	0.0014	0.0015	-0.0015	0.0004	0.1528	-0.0447
1:39 pm	1.2456***	0.9948***	-0.0038	0.0019	0.0052	-0.0004	0.0143	-0.0505
1:40 pm	1.3238***	0.9979***	-0.0173	0.0056	-0.0005	0.0001	0.7528	-0.0436

This table reports results from the regression which isolates the difference in the dependant variable on 15 announcement and 15 non-announcement days throughout 2010 for High Frequency Traders (HFT) and Other Traders (OT) in the FTSE 100. For each time interval, the dependant variable is measured as the percentage of all value traded between a given trading pair divided by the daily benchmark percentage of value traded by that same trading pair. The pair is structured as Taker_Maker. The benchmark period is 12:30 – 1:00 pm. The ΔVolume variable is the relative change in volume (value) in the given interval, the ΔVolatility variable is the relative change in volatility, calculated as the natural logarithm of the price range in the interval and the Announcement Dummy takes the value of one on announcement days, zero otherwise. For each regression, coefficient estimates are reported. Adjusted R-squared values are omitted due to their lack of statistical inference.

*: Significant at the .10 level, **: Significant at the .05 level, ***: Significant at the .01 level

6. Conclusion

HFT's constitute a significant portion of volume in the FTSE 100. This study examines the effect of an exogenous volatility event, the announcement of US macroeconomic statistics, on HFT presence in the order book and their participation in trading, liquidity demand and liquidity supply. Combining order books and order-level data from the London Stock Exchange, Chi-X Europe and BATS Europe, constituting over 86% of the fragmented FTSE 100 volume, and identifying HFT at the firm-level, this study documents that HFT are a resilient and active participant in both the order book and trading.

Order book analysis indicates that HFT are able to manage their exposure during periods of exogenous volatility and information asymmetry, with HFT time at the best bid and ask unchanged surrounding US macroeconomic announcements, and HFT depth reverting to normal levels soon after announcements. OT, however, reduce their latent liquidity supply, with OT time at the best bid and ask falling from approximately 90% to 50% surrounding macroeconomic announcements, while OT depth at the best bid and ask falls significantly, taking longer to revert to normal levels. HFT continue to provide liquidity in the order book surrounding macroeconomic announcements, while OT mitigate their risk by withdrawing from the best quotes and reducing depth.

Trade analysis indicates that HFT participation increases from approximately 45% of all volume prior to announcements, to 60% surrounding macroeconomic announcements, with the proportion of liquidity supplied and demanded by HFT increasing significantly. OT appear to retreat from the market, with OT participation falling from approximately 95% to 85% surrounding announcements, with OT liquidity supply and demand decreasing surrounding announcements. HFT interaction with OT also increases, with HFT supplying liquidity to OT prior to, and for a significant period after, the announcement, while they take liquidity from OT during the period immediately after the announcement. HFT enter the market surrounding periods of information asymmetry and exogenous volatility, consistently supplying liquidity, while remaining constant or increasing their liquidity demand.

This study contrasts announcement and non-announcement days to determine the effect of information asymmetry on HFT behaviour. The response by HFT to this volatility indicates that HFT are able to manage their risk exposure through their speed in reacting to orderflow, increasing their participation as both liquidity suppliers and trade initiators, during periods of information asymmetry. Further avenues for research include the overlap between US and European markets, including the presence of HFT in European trading after US trading commences, and the effect of continuous trading in the US on HFT in Europe.

References

- Brogard, J.A. (2010). High Frequency Trading and its Impact on Market Quality. Working paper.
- Chaboud, A., Chioune, B., Hjalmarsson, E., Vega, C. (2009). Rise of the Machines: Algorithmic Trading in the Foreign Exchange Market. FRB International Finance Discussion Papers.
- Copeland, T. E., Galai, D. (1983). Information Effects on the Bid/Ask Spread. *Journal of Finance*, 38, 1457-1469.
- Glosten, L.R., Milgrom, P.R. (1985). Bid, ask and the transaction prices in a specialist market with heterogeneously informed traders. *The Journal of Financial Economics* 14, 71-100.
- Haldane, A. G. (2011). The Race to Zero. Bank of England.
- Hendershott, T., Riordan, R. (2009). Algorithmic Trading and Information. Working paper.
- Hendershott, T., Jones, C., Menkveld, A. (2008). Does Algorithmic Trading Improve Liquidity? *Journal of Finance*, forthcoming.
- Lee, C.M.C., Mucklow, B., Ready, M.J. (1993). Spreads, depth and the impact of earnings information: an intraday analysis. *The Review of Financial Studies* 6, 345-374.
- Riordan, R., Storkenmaier, A. (2009). Latency, Liquidity and Price Discovery. Working Paper.