The impact of UK macroeconomic announcements on the market for gilts

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Abstract

This paper extends previous research by documenting the impact of scheduled UK macroeconomic news announcements on the trading volume and price volatility of the gilt market. Our results suggest that return volatility does rise following a macroeconomic announcement. There is tentative evidence to suggest that the increase in volatility is associated with a rise in both the size of price changes and the average size of trades, but not an increase in the number of trades. Contrary to previous studies, we find that "good" news has a greater impact on the gilt market than "bad" news.

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1. Introduction

Most of the existing research on the adjustment process of bond markets to public information focuses on the behaviour of price volatility around macroeconomic announcements (Edderington and Lee (1993, 1995), Becker *et al*. (1993), amongst others). Recently, Fleming and Remolona (1998) (F&R) consider the behaviour of trading volume as well as price volatility around macroeconomic announcements in the US Treasury market. Their results suggest that in a brief first stage, price volatility rises and trading volume falls, whereas in a prolonged second stage, volume surges and price volatility persists. F&R's (1998) analysis, however, is limited to inter-dealer market data. Theoretical models explain inter-dealer trading as a "second-stage" process, reflecting dealers desire to trade with each other in order to unwind positions which they have acquired from dealing with customers at an earlier first stage.[1] To the extent that this is the case in practice, F&R's analysis can be viewed as an analysis of a bond market's response to information during the second, inter-dealer trading, stage.

This paper complements previous research, and in particular F&R's analysis, by documenting the impact of scheduled UK macroeconomic news announcements on the trading volume and price volatility of the gilt market. Importantly, and in contrast to F&R, our data set includes all transactions. This allows us to consider the reaction to public information of the bond market at large. In addition, the paper contributes to the slowly emerging market microstructure literature on government debt markets[2] by providing insights on the price formation process in the gilt market.

A number of related studies have assessed the impact of macroeconomic announcements upon the UK government bond market by investigating the reaction of the government bond futures contract around announcement times. Becket *et al.* (1993) analyse the intra-day shape of price volatility for the Long Gilt contract and find significant deviations from the familiar U-shape observed in equity markets, with price volatility spiking around releases of UK and US macroeconomic announcements. ap Gwylim *et al.* (1998) analyse the adjustment of the Short Sterling contract to UK announcements. Their finding suggest that price volatility spikes in the first 15 seconds following the announcement and remains elevated for approximately 5 minutes thereafter. ap Gwylim and Thomas (1998) find that RPI, producer prices and labour market data are the most important macroeconomic sources of volatility of the Long Gilt contract with producer prices and labour market data being the most important US announcements.

Our findings suggest that price volatility does rise following a macroeconomic announcement. There is tentative evidence to suggest that the increase in volatility is associated with a rise in both the size of price changes and the average size of trades, but not an increase in the number of trades. We also find that the increase in volatility is higher after favourable relative to unfavourable macroeconomic news. The rest of the paper is organised as follows: in Sections 2 and 3 we describe the structure of the gilt market and our data set respectively; in Section 4 we outline our methodology and present our results; and in Section 5 we conclude.

2. Gilt market structure

The U.K. gilt market is organised around the London Stock Exchange, where all gilts are listed. At the centre of the market, a number of competing Gilt-Edged Market Makers (GEMMs) stand ready to trade with investors. During our sample period (October 1995 – May 1996), 21 firms acted as GEMMs.[3] All GEMMs were required to quote continuous two-way prices in all gilt issues in return for

[1] For example, Naik et al. (1994), Lyons (1996, 1997), Vogler (1997), Saporta (1997), Werner (1997).

[2] For example, apart from F&R, Proudman (1995), Vitale (1996), Fleming (1997), Balduzzi *et al.* (1997), Scalia (1998), Scalia and Vacca (1998).

[3] Today, the number of GEMMs is 16.

certain benefits, such as direct bidding rights at gilt auctions and stock borrowing facilities.[4] In January 1996, a repo market open to all market participants (including intermediaries) was introduced. Trading was sluggish in the beginning, but picked up during the second half of 1996, and has been growing steadily since (Quarterly Bulletin, February, Bank of England).

The conventional quote size is £5m nominal value, and prices are quoted "clean", i.e. without accrued interest. There is no central quote dissemination system. Dealing takes place by telephone directly between GEMMs and their clients. GEMMs can trade with each other either directly, or through an active anonymous inter-dealer broker (IDB) system, to which non-GEMMs do not have access. During the sample period, only trades in value of up to £25,000 were published immediately; details of all other transactions were never made public, although the Bank of England published daily average prices for each gilt based on the GEMM's previous days closing price.[5] Until 1 November 1998, when gilts were decimalised, the minimum price change, or tick size, was 1/32nd of a £1.00. Normal trading hours are 8 a.m. to 5 p.m., but essentially the gilt market is open around the clock. The majority of transactions are settled (by book-entry) on the business day following the trade. During the sample period, GEMMs were separately capitalised from their parent firms and had to be registered with the Bank of England, which also acted as the supervisory authority. Separate capitalisation, however, ended in 1997. In April 1998, responsibility for the issuance and management of the UK's sterling debt passed from the Bank of England to the Debt Management Office.

3. Data

The data set records the universe of transactions in the gilt cash market between the 10 October 1995 and 31 May 1996, a total of 163 trading days. Each transaction record identifies: the parties to each bargain; the capacity in which they dealt, ie. as either agent, or principal; the quantity and value of the bargain; the date and time the bargain took place (time stamped to the minute); and a number of so called special bargain positions. Earlier samples of similar data have been analysed by Proudman (1995) and Vitale (1996).

The data were obtained from the London Stock Exchange's Transaction Data Service. The rules of the London Stock Exchange require every LSE member to submit a "transaction report" to the Exchange for every trade they execute in a LSE-listed security. The set of matched transaction reports constitutes the Exchange's Transaction Data Service (TDS). The Exchange uses the TDS for audit-trail, settlement and research purposes. The Exchange's process of matching the quantity and value details reported by every party to a transaction ensures the accuracy of the price and quantity data. Unfortunately, the accuracy of the transaction sequence is less certain because LSE members are allowed a maximum delay of 15 minutes before they submit a transaction report for trades of less than or equal to £100,000 nominal and a delay of 5 minutes for all other trades. However, as Proudman (1995) notes, most GEMMs are likely to have automated front-end reporting systems to book trades instantaneously, reducing the chance of time stamp inaccuracies.[6]

We deleted a number of observations where either the price or the traded quantity were recorded as zero. We also applied a filter which deleted all transactions that took place at a price more than 10% smaller or greater than those of adjacent transactions. Except for one month, our TDS data encrypt the

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[4] In September 1998, the requirement that all GEMMs should make markets in all gilts was lifted and a separate list of IG market makers was introduced: 8 GEMMs entered the list.

[5] Today, the retail trade size has doubled to £50,000. There are plans to publish some additional price and volume information (see Ganley et al. (1998) for more details on the transparency regime of the gilts market).

[6] In the small number of cases where the time stamp of the two parties reporting the same transaction differed, we used the time stamp reported by the GEMM. For more details about the LSE's TDS data see the Appendix in Reiss and Werner (1995) (in the context of equities) and the Data Section in Proudman (1995) (in the context of gilts).

identity of the reporting firms. To check the quality of our filtered data set, we matched Bank of England data on GEMM positions with the daily positions implied by the unencrypted part of our TDS data.[7] The fact that we were successful in matching all but a tiny minority of positions in infrequently traded gilts gave us further confidence in the quality of our data.

During the sample period, 368,164 transactions were observed in a total of 95 gilts. Since the power of our statistical tests increases with the number of observed trades around public announcement times, we focus our analysis on the gilt with the largest number of trades during the period. This is the 7% Treasury 2001, one of the two 5-year benchmark stocks over the sample period.[8] At the start of our sample period, at £7.5bn, the 7% Treasury 2001 had the highest nominal value outstanding of any stock (representing 3.2% of total gilt issuance). An additional £3bn nominal of the stock was auctioned in March 1996, and a further £250mn nominal was issued through a tap on 30 October. At £54.5bn, the stock recorded the third highest turnover during the sample period, surpassed only by the 8% Treasury 2000, with turnover of £93bn and the 7.25% Treasury 1998, with turnover of £60.9bn.

The total number of transactions in the sample stock is 29,289, of which 25,401 (86.7%) are customer trades and 3,888 (13.2%) are inter-dealer trades. The vast majority of inter-dealer trades (3,033 trades, 78% of the total) are conducted anonymously through one of the 3 Inter-dealer Brokers (IDBs). The remaining inter-dealer trades (22%) involve direct (non-anonymous) trading between dealers. In terms of sterling value, customer trades account for 55.40% of total business, with inter-dealer trading accounting for the rest (37% via an IDB, 7.60% directly between dealers). At £1.18mn, the average trade size for customer trades is substantially smaller than the average inter-dealer trade size of £8.02mn. The trade size distribution is highly left skewed. Median trade sizes for customer trades and inter-dealer trades stand at £11,818 and £3.9mn respectively. The modal quantity for customer transactions during the period is £10,000 nominal. The comparative figure for inter-dealer trades is £1mn nominal.

In terms of trade distribution amongst counterparties the sample stock is fairly representative of the market at large. In terms of trade size distribution, however, the stock is less representative. Whereas the average and median trade sizes for the market at large are £2.9mn and £39,000 respectively, the overall average and median trade sizes for the sample stock are substantially lower at £1.18mn and £11,814 respectively, suggesting that the sample stock is more actively traded by retail investors than the market at large.

We also collected data on key monthly macroeconomic announcements during the sample period. These were the announcements of average earnings, industrial production, producer price index, retail sales and the retail price index (RPIX) by the CSO (now the ONS), and unemployment figure announcements, which were released by the Department of Employment.[9] During our sample period and for our set of macroeconomic variables the ONS and the Department of Employment faxed the data to journalists and other interested parties at 9.30 a.m. Table 1 shows the list of announcements, the Reporting Agency, the time they were announced and the day of the week in which they occurred.

There were in total 130 days without announcements, leaving 33 days with announcements (we refer to these days as “non-announcement days” and “announcement days” respectively). When two announcements took place on the same day we excluded these days from our analysis to concentrate on days with only one announcement. The majority of UK announcement dates in our sample fall on a Wednesday or a Thursday, whereas Friday is the day with the least announcements (although a

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7 As mentioned in Section II, over our sample period the Bank of England acted as the prudential supervisor for GEMMs. As part of their responsibilities to the Bank, GEMMs were required to report their positions by gilt and derivative instrument on a daily basis.

8 The other 5-year benchmark during the period is the 8% Treasury 2000.

9 We choose this particular set of announcements because of the availability of market expectations data on these series. These announcements were also studied by ap Gwylim et al (1998) and ap Gwilym and Thomas (1998), who also use UK data.

number of important US announcements, including labour market data, fall on Fridays). Figure 1 plots the intra-week distribution of turnover (by value) revealing that Wednesday, the day on which the majority of UK announcements fall, is the busiest day. The least busy day of the week is Monday, indicating that the announcement of PPI figures did not induce a surge in trading volume across the day (in addition very few US announcements fall on Mondays).

To shed more light on the response of gilts prices to the release of macroeconomic announcements we subdivide the six macroeconomic announcements listed above into "good" and "bad" announcements as seen from the perspective of a bond holder, to ascertain whether there is an asymmetric response to news. We classify "good" and "bad" according to market expectations about the macroeconomic releases outlined in Section 3 above. The expectations data were obtained from Money Market Services International (MMS). MMS provide expectations of the relevant macroeconomic variable based upon a survey which they conduct of economists and analysts from financial institutions which they contact the week before the announcement. The expectation is the median of the forecast of the participants of the survey. The number of respondents to the survey varies between 20 to 25. The surprise is calculated as outturn minus expectation. In the case of the retail price index, the average earnings figures, the producer price index, retail sales and industrial production a positive (negative) surprise is defined as bad (good) news, whereas in the case of unemployment figures a positive (negative) surprise is defined as good (bad) news. The *raison d'être* for our classification of the surprises is that if the news is expected to have a positive (negative) effect on bond prices then it is deemed to be good (bad) news. For example, higher than expected retail sales, might be associated with expectations of higher future interest rates, therefore implying a fall in UK bond prices. The classification is summarised in Table 1.

4. Method and results

4.1 Method

We follow the generally accepted event study methodology for high frequency data by identifying the reaction of the variable of interest (volatility, volume, *etc*) around the announcement and comparing this reaction to the more "typical" behaviour of the variable over the same time of the day on days when announcements are not made. In other words, we split our sample into announcement and non-announcement days. The announcement days refer to all those days which have an announcement about six key macroeconomic indicators: the retail price index, average earnings figures, the producer price index, unemployment figures, retail sales and industrial production announcements. Due to the frequency of trades on 7% Treasury Stock 2001, we focus our attention on 30 minute intervals throughout the trading day. Edderington and Lee (1995) use a similar method. Using this approach we depict graphically the average reaction of the gilts market on the announcement and non-announcement days. From the raw gilt price series we calculate the following two variables and compare their announcement day behaviour with their non-announcement day behaviour: the standard deviation of half hourly gilt returns across the 30 minute windows for the announcement and non-announcement days and the average absolute return of the half hourly gilt returns for each 30 minute window. We also calculate the average *number of trades* and *trade volume* for each half hourly interval for the announcement and non-announcement days.

To test for the significance of differences in the mean of the announcement and non-announcement series, we use non-parametric tests. These have the advantage over standard parametric tests of not having to make assumptions about the distribution of the random variable in question. This is useful since, in our sample, preliminary investigation showed that the assumption of normality was violated. To test whether there is a higher and statistically significant difference between the means of absolute

returns, number of trades and trade volume on announcement and non-announcement days, we calculate the following non-parametric test statistic for each of the 30 minute windows during the standard trading day:[10]

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{j} \frac{S_j^2}{m_j} - 3(N+1) \quad (1)$$

where S_j is the rank sum for either the announcement, or non-announcement day series; m is the number of rankings given to each series ($J=2$); and N is the total number of rankings given across the j series. The test statistic is distributed as $\chi^2(J-1)$ under the null hypothesis that the j populations have identical medians. We also use a more familiar, and standard parametric test of the equality between two means and present this test alongside the non-parametric test.

To test whether there is higher volatility of returns on announcement versus non-announcement days we use another non-parametric test statistic for each of the 30 minute windows during the trading day:[11]

$$F = \left[\frac{\sum_{j=1}^{j} m_j (X_i - X)^2}{\sum_{j=1}^{j} \sum_{i=1}^{m_j} (X_{ij} - X_i)^2} \right] \times \left[\frac{N-J}{J-1} \right] \quad (2)$$

where $X_{ij} = \left| R_{ij} - \overline{R} \right|$, when R_{ij} is the return for day i interval j and $\overline{R}$ is the series median; $X_i = \sum_{i=1}^{m_j} \frac{X_{ij}}{m}$; $\overline{X} = \sum_{j=1}^{j} \sum_{i=1}^{m_j} \frac{X_{ij}}{N}$; and finally, $N = \sum_{j=1}^{j} m_j$. Under the null hypothesis of homoskedasticity across sample groups, the statistic is distributed as $F_{(J-1,\ N-j)}$. Once again, for the purposes of comparison and completeness, we also present a more familiar parametric F-test for the equality of the two measures of variance.

4.2 Results using all macroeconomic announcements

The average behaviour, over half-hourly windows, of the gilts market over announcement and non-announcement days in our sample is shown in Figures 2 to 5. The average standard deviation of gilt returns for the half hourly intervals is shown in Figure 2. In this figure we can see the familiar "U-shaped" pattern in volatility. Over the sample period, the standard deviation of returns on announcement days is higher in the half hour which follows the macro data releases at 9.30 a.m. Using the Brown-Forsythe modified Levene test, we can reject the hypothesis that volatility is constant at the 95% level.

ap Gwylim *et al* (1998) argue that increased volatility around an announcement period could be derived from two sources: either by the occurrence of larger price changes after the announcement, or the occurrence of a larger number of trades. To investigate whether this is the case for our sample we calculate the average absolute return and number of trades for the announcement and non-announcement days across the half hourly windows. In Figure 3 we plot the average absolute returns series. The Figure indicates that absolute returns are larger for announcement days for an hour after

[10] This statistic is the Kruskall-Wallis statistic.

[11] This statistic is the Brown-Forsythe modified Levene test.

the 9.30 a.m. announcement. However, both the parametric and non-parametric tests reject the significance of this difference at conventional significance levels.

In Figures 4 and 5 we plot the average number of trades and average trade volume for the two series respectively. Figure 4 shows that the average number of trades is generally higher in announcement days compared with the non-announcement days, but this difference is small and statistically insignificant. Interestingly, the number of trades Figure 5 indicates that around the macroeconomic announcement there is higher volume on the announcement day, between 9.30 a.m. and 10 a.m. However, the results in both Tables 2 and 3 indicate that this is not a statistically significant difference. There is also higher volume between 11.30 a.m. and 12 p.m., 2 p.m. and 3 p.m., and between 3.30 p.m. and 4 p.m. although again these are not statistically significant differences. Overall, Figures 3, 4 and 5 seem to suggest that higher volatility witnessed immediately after a macroeconomic news release is due to the occurrence of larger price changes with an associated increase in trading volumes, but with little difference in the number of trades executed.

To summarise, there is strong evidence to suggest that volatility in gilt returns is higher after a macroeconomic news announcement. Rather than being caused by an increase in the number of trades, it seems to be due to an increase in the size of price changes and an increase in trade volume.

4.3 Results after separating the good from the bad news

We now turn to the surprise data, as outlined in Section 3 and, from the point of view of the bondholder, differentiate between "good" and "bad" macroeconomic news announcements. These results are presented in Figures 6 to 9 and are the equivalents of Figures 2 to 5. The base series, ie. the non-announcement series, is the same for both sets of Figures and results. In Figure 6 we can see that the standard deviation of gilt returns after the release of favourable economic news is higher than for the non-announcement base case. The tests statistics in Tables 2 and 3 confirm that this result is strongly significant. The standard deviation of returns after favourable news rises from approximately 0.38% before the announcement to about 0.68% in the half hour interval which follows, and falls back slowly to the non-announcement day norm over the next 90 minutes. For the adverse news volatility series we find that volatility seems to be lower than on non-announcement days. This result suggests then that good rather than adverse news leads to higher volatility in the gilts market; a result which is in contrast to much of the finance literature (although the result does depend upon our admittedly subjective grouping of "good" and "bad" news). The results in Figure 6 are reinforced by the results calculated for the absolute returns series in Figure 7 where we can see an increase in volatility after the announcement on good news days, although the results are not statistically significant and are generally "noisier" than those presented in Figure 6.

We plot the average number of trades and trade volume for the half hour intervals in Figures 8 and 9. With respect to the number of trades, we find evidence, that the number of trades on "good" announcement days is higher than on non-announcement days, but not during the announcement half hour. The number of trades is higher on favourable news days between 11 a.m. and 11.30 a.m. (and at the 90% level between 10.30 a.m. and 11 a.m.) and between 4 p.m. and 4.30 p.m. The frequency of trades on adverse news days is always lower than for non-announcement days, but never statistically significantly so. However, with respect to the volume data we find graphical evidence to suggest that trade volume on adverse news days is significantly higher than for favourable news days, between 9.30 a.m. and 10 a.m., between 12 p.m. to 12.30 p.m. and between 2.30 p.m. to 3.30 p.m. However, these differences are never found to be statistically significant. Figure 9 also indicates that "good" news volumes significantly are strong between 10.30 a.m. to 11 a.m. and between 12.30 p.m. and 1 p.m., with the former period being statistically significant.

5. Conclusions

Our results here indicate that the volatility of gilt returns increases after a macroeconomic news announcement. We find graphical evidence to suggest that this increase in volatility is due to an increase in the size of price changes and an increase in trade volume, rather than by an increase in the number of trades at this time. By separating “good” news announcements from “bad” we are able to discern that the former has a greater impact upon the gilts market than the latter, which is contrast to other studies which have attempted to measure the impact of news on securities prices.

References

ap Gwilym, O, M J Buckle, A D Clare and S H Thomas, 1998: The transaction-by-transaction adjustment of interest rate and equity index futures markets to macro-economic adjustments, *Journal of Derivatives*, Vol. 6, No. 2, 7-17.

ap Gwilym O and S H Thomas, 1998: Which macroeconomic announcements have most impact on Long Gilt futures market volatility? *Derivatives Use, Trading & Regulation*, 4, 164–73.

Balduzzi, P, E J Elton, and T C Green, 1997: Economic news and the yield curve: evidence from the U.S. Treasury market, *New York University Working Paper*.

Becker, K G, Finnerty J E and Kopecky K J, 1993: Economic News and Intraday Volatility in International Bond Markets, *Financial Analysts Journal*, May-June, 81-5.

Edderington, L H and J H Lee, 1993: How Markets process Information: News releases and Volatility, *Journal of Finance*, 48, 1, 161-191.

Edderington, L H and J H Lee, 1995: The short run dynamics of the price adjustment to new information, *Journal of Financial and Quantitative Analysis*, 30, 117-34.

Fleming, M J, 1997: The round-the-clock market for US Treasury securities, *Federal Reserve Bank of New York Economic Policy Review* (December), 31-50.

Fleming, M J, and E M Remolona, 1998: Price Formation and Liquidity in the U.S. Treasury Securities Market: the Response to Public Information, *Journal of Finance*, forthcoming.

Ganley, J, Holland A and Saporta V, 1998: Transparency and the design of security markets, *Financial Stability Review*, 4, pp. 8-17.

Lyons, R K, 1996: Optimal transparency in a dealer market with an application to foreign exchange, *Journal of Financial Intermediation*, 5, 225–254.

Lyons, R K, 1997: A simultaneous trade model of the foreign exchange hot potato, *Journal of International Economics*, 42, 275– 298.

Naik N, A Neuberger and S Viswanathan, S, 1994: Disclosure regulation in competitive dealership markets: analysis of the London Stock Exchange, *IFA Working Paper* No 193, London Business School.

Proudman, J, 1995: The microstructure of the U.K. gilt market, *Bank of England Working Paper No 38.*

Reiss, P, and I Werner, 1995: Transaction costs in dealer markets: Evidence from the London Stock Exchange, in: Lo, Andrew, ed., *The Industrial Organization and Regulation of the Securities Industry*, University of Chicago Press.

Saporta, V, 1997: Which inter-dealer market prevails ? An analysis of inter-dealer trading in opaque markets, *Bank of England Working Paper No 59*.

Scalia, A, 1998: Periodic Information Asymmetry and Intraday Market Behaviour: an Empirical Analysis, *European Finance Review*, 1, pp. 307 – 335.

Scalia, A, and V Vacca, 1998: Market Transparency, Liquidity, and Price Discovery: A Case Study, *Banca d'Italia working paper.*

Vitale, P, 1996: Two Months in the Life of Two Market Makers on the London Stock Exchange, *unpublished*, Bank of England.

Vogler, K-H, 1997: Risk allocation and inter-dealer trading, *European Economic Review*, 41, pp. 1615 – 1634.

Werner, I, 1997: A Double Auction Model of Interdealer Trading, *Research Paper No 154*, Graduate School of Business, Stanford University.

Table 1

Public announcements (October 1995 – May 1996)

Time	Announcement	Impact	Source	Day of the week				
				Mo	Tu	We	Th	Fr
9.30 a.m.	Average Earnings	–	ONS	0	0	7	0	0
9.30 a.m.	Industrial Production	–	ONS	1	2	1	2	1
9.30 a.m.	PPI	–	ONS	7	0	0	0	0
9.30 a.m.	Retail Sales	–	ONS	0	0	5	3	0
9.30 a.m.	RPI	–	ONS	0	0	0	7	0
9.30 a.m.	RPIX	–	ONS	0	0	0	8	0
9.30 a.m.	Unemployment	+	Dept of Employment	0	0	7	0	0
Total				8	2	20	20	1

Notes: The column headed “impact” indicates our view of how a positive shock (actual - expected) would impact upon bond prices. For example, higher than expected retail sales, might be associated with expectations of higher future interest rates, therefore implying a fall in UK bond prices, denoted by “–” in the Table.

Table 2

Non-parametric test results

Time Interval	**S. Deviation of Return**			**Absolute Return**			**No. of Trades**			**Volume**		
	F-Statistic			χ^2-Statistic			χ^2-Statistic			χ^2-Statistic		
	All	Good	Bad	All	Good	Bad	All	Good	Bad	All	Good	Bad
8:30 - 9:00	0.0724	0.0524	0.2700	0.0387	0.1800	0.0030	0.1324	0.0525	0.0437	1.2974	0.4291	1.2623
9:00 - 9:30	0.0180	2.6968	0.2634	0.0602	0.4671	0.0001	1.9177	0.7095	0.1411	0.0243	0.0341	0.2814
9:30 - 10:00	***4.4853***	***8.9330***	2.1166	0.5541	0.5624	0.0558	0.4173	0.0428	0.5021	0.6015	2.5001	0.6301
10:00 - 10:30	0.1632	0.0756	0.7848	2.9476	0.1105	2.2456	1.1736	1.4063	0.0264	0.0131	0.1258	0.0043
10:30 - 11:00	0.9252	0.5185	0.4461	-0.1084	0.1592	2.1311	***4.4278***	3.6904	0.5527	***5.6484***	***7.7179***	0.9446
11:00 - 11:30	0.7620	1.5135	0.1721	0.6756	0.4228	0.2733	3.6673	***5.5031***	1.0371	2.3996	0.7220	0.4384
11:30 - 12:00	0.3568	0.5493	0.5106	0.5206	0.0177	0.9148	0.3788	0.8059	1.2437	0.5510	0.1057	0.3984
12:00 - 12:30	0.0450	2.4481	0.8623	2.6019	0.9000	0.0000	0.0441	0.9085	0.0000	3.4425	1.0058	2.8112
12:30 - 13:00	0.3549	1.0374	1.6713	0.0854	0.2191	1.5780	0.1267	0.0641	0.2013	0.0073	0.8333	0.5728
13:00 - 13:30	0.0582	0.3433	1.4898	0.0598	0.4219	0.2651	0.0728	0.2639	0.0247	0.0891	1.1776	0.0251
13:30 - 14:00	1.3933	0.3578	1.3974	0.2222	0.1215	1.3929	0.2604	0.9071	0.0030	0.0840	0.7454	0.0003
14:00 - 14:30	0.3788	0.0564	0.7409	1.3212	3.0642	0.0408	0.0086	0.9432	0.2337	0.2562	2.0327	0.0769
14:30 - 15:00	2.5394	1.8615	1.6581	3.6054	1.2373	1.4561	0.0528	2.0411	0.2858	0.0027	0.0026	0.7410
15:00 - 15:30	1.8584	1.8054	2.3929	0.1462	1.5919	0.9425	0.0810	0.0062	1.5623	0.0357	0.1514	0.0736
15:30 - 16:00	1.5370	2.2176	0.3448	1.0347	***5.2836***	0.0434	0.7657	0.7118	0.4005	0.1832	0.2304	0.3338
16:00 - 16:30	0.2750	0.0077	0.0247	0.4676	1.3541	0.0171	***4.3400***	***6.5784***	0.8825	3.2888	2.3529	1.7081

Notes: A bold statistic denotes significance at at least the 95% level of confidence.

Table 3

Parametric test results

Time Interval	**S. Deviation of Return**			**Absolute Return**			**No. of Trades**			**Volume**		
	F-Statistic			χ^2-Statistic			χ^2-Statistic			χ^2-Statistic		
	All	Good	Bad	All	Good	Bad	All	Good	Bad	All	Good	Bad
8:30 - 9:00	0.1500	0.1579	0.0817	-0.1601	0.2347	-0.9518	1.1015	0.4879	0.3454	0.2312	-1.4252	-1.4754
9:00 - 9:30	0.7441	0.1284	1.3625	0.5559	-0.9968	0.5019	1.1378	0.5710	0.5129	-0.3268	-0.6053	-0.4941
9:30 - 10:00	***3.6733***	***7.7429***	0.3769	1.2085	1.1491	-0.3427	0.3526	0.4124	0.3171	0.6766	0.7832	0.8666
10:00 - 10:30	0.5802	0.9512	0.4764	1.5188	-0.1293	1.0284	0.8624	1.0645	-0.0951	-1.3620	-0.5601	-1.1429
10:30 - 11:00	0.4091	0.5563	0.3659	0.0226	0.3237	1.1422	1.5753	***1.6689***	0.4788	1.0943	***1.7962***	0.2141
11:00 - 11:30	0.2948	0.1934	0.3904	0.6372	0.0927	0.3759	1.3427	1.5339	0.6491	0.5144	0.4632	-1.5888
11:30 - 12:00	0.2181	0.1766	0.1867	-1.4689	-0.9036	***-1.9527***	0.7926	0.1965	1.0690	1.2666	0.4940	0.7362
12:00 - 12:30	***2.2491***	0.5795	0.6028	***1.8433***	1.2561	0.2823	0.2317	0.8098	-0.0522	0.7809	-0.7406	1.1568
12:30 - 13:00	***2.3269***	0.7506	***4.8114***	0.7475	-0.0353	1.1271	0.7231	0.6905	0.5467	0.8175	1.0699	-0.0416
13:00 - 13:30	1.2525	0.2821	***3.2673***	-0.1482	-1.3191	-1.3509	-0.3476	-0.0471	0.0181	0.4601	0.8451	0.4009
13:30 - 14:00	0.1195	0.1800	0.0585	-1.5706	***-1.6763***	-0.3638	-0.3663	0.4695	-0.7338	-0.8664	0.1689	-0.8572
14:00 - 14:30	0.3954	0.5212	0.2198	1.3255	***1.8177***	-1.1587	-0.3803	0.4270	-0.7657	1.2432	0.7644	0.9886
14:30 - 15:00	0.4526	0.2991	0.4772	***1.7111***	0.9229	0.8951	-0.2226	0.6216	0.0160	0.8052	-0.0297	1.1595
15:00 - 15:30	0.4224	0.2906	0.2348	-0.5234	***-1.9820***	0.7979	-1.0756	-0.6547	***-1.6447***	0.0571	-0.9030	0.5591
15:30 - 16:00	0.3280	0.1684	0.4269	-1.1147	***-3.5541***	-0.2604	-0.8607	-0.8966	-0.4558	1.2058	0.6118	0.8646
16:00 - 16:30	0.5361	0.4572	1.0411	-0.3195	-0.5215	0.3374	1.5297	1.6011	0.6587	0.1313	1.0267	-0.7612

Notes: A bold statistic denotes significance at at least the 95% level of confidence.

Figure 1: Intra-week distribution of turnover

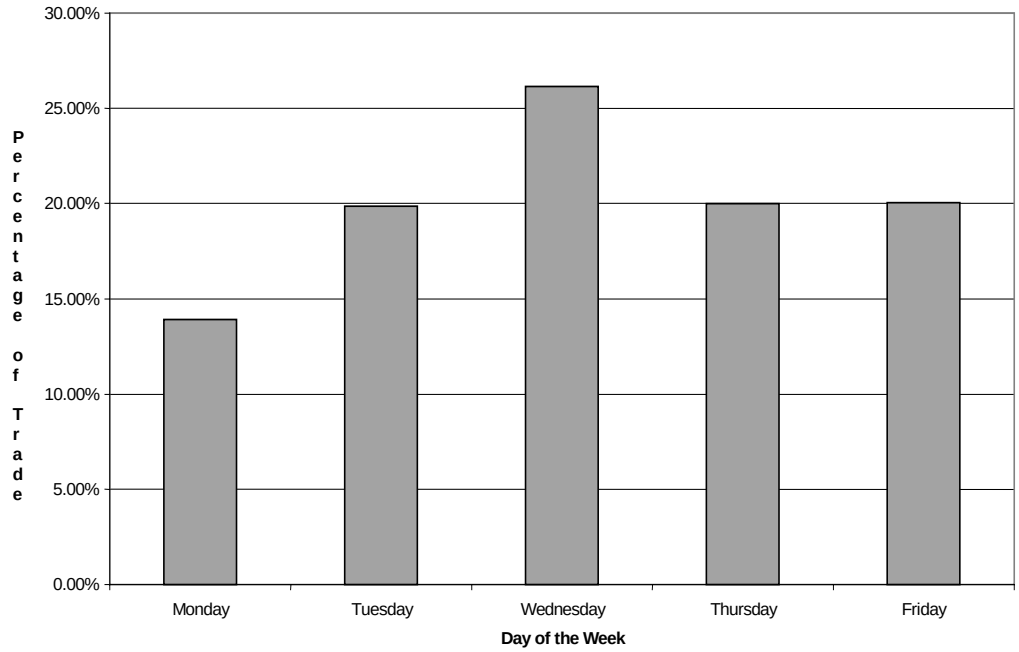

Figure 2: Standard Deviation

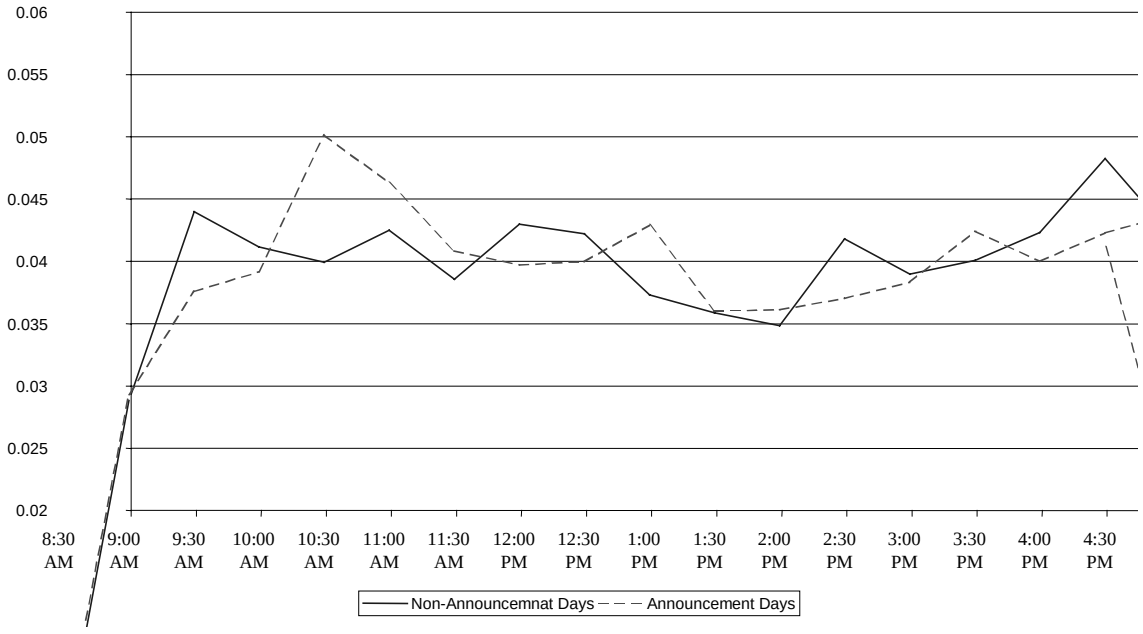

Figure 3: Absolute Returns

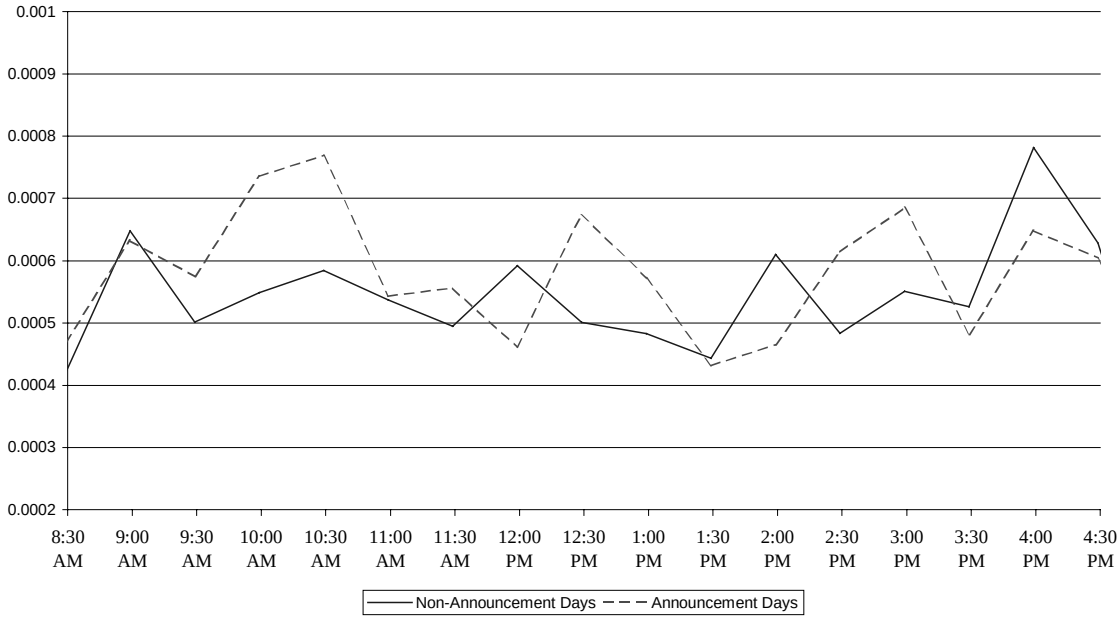

Figure 4: Number of Trades

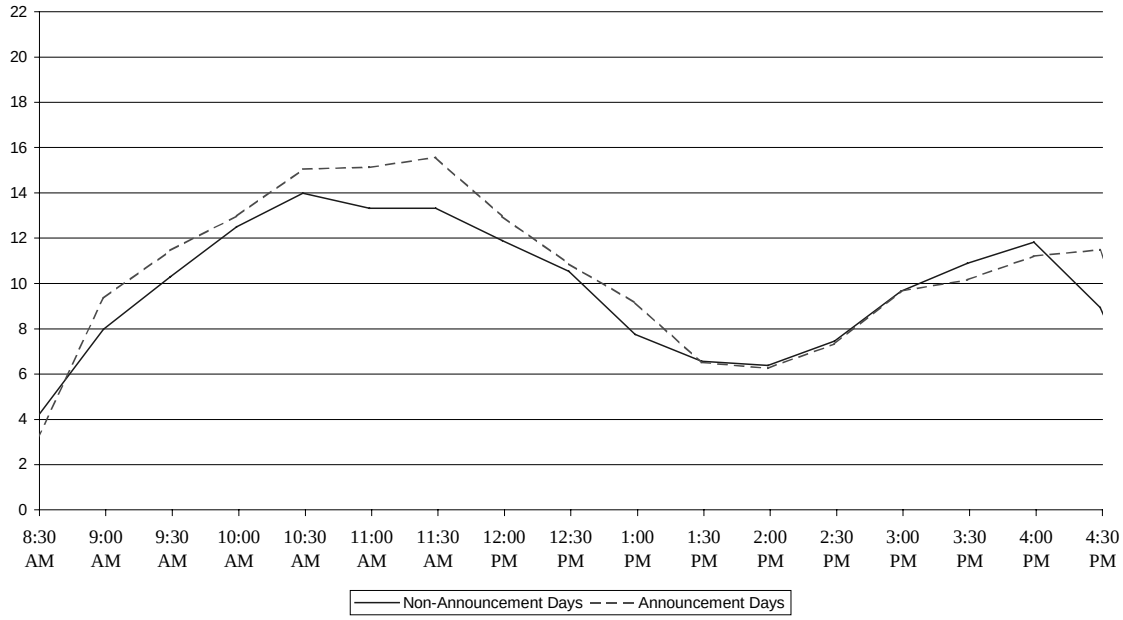

Figure 5: Total Volume

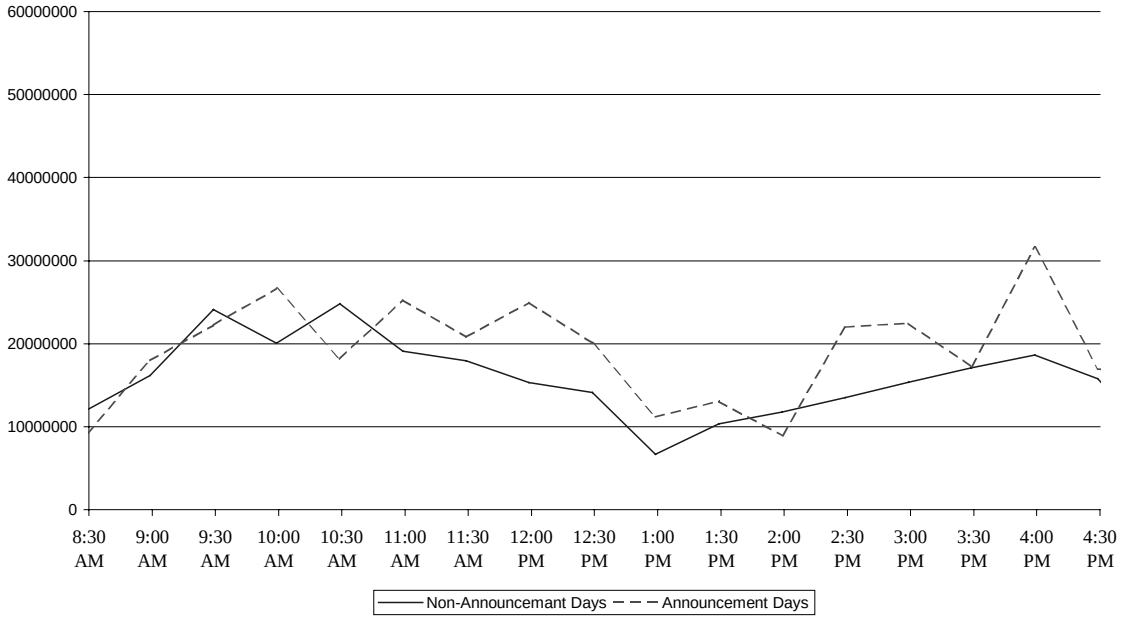

Figure 6: Standard Deviation

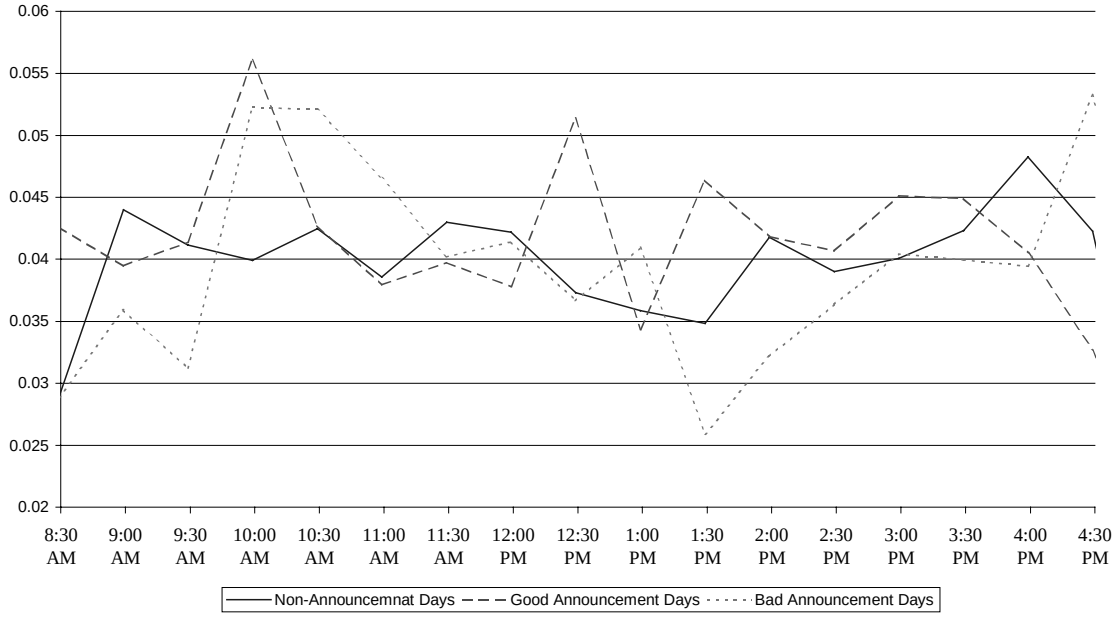

Figure 7: Absolute Returns

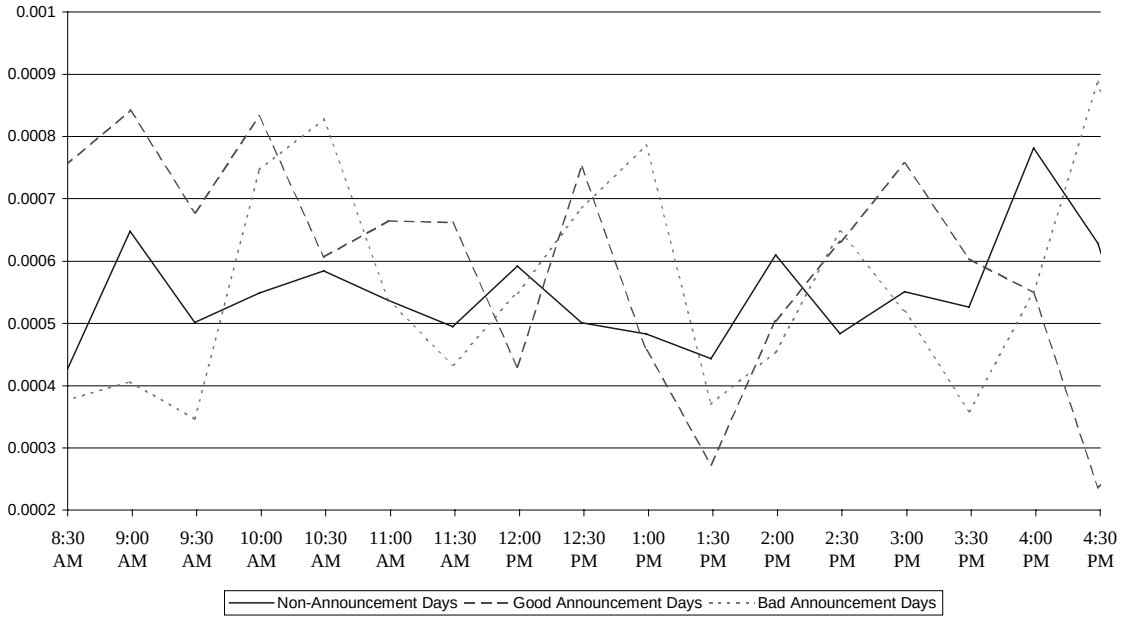

Figure 8: Number of Trades

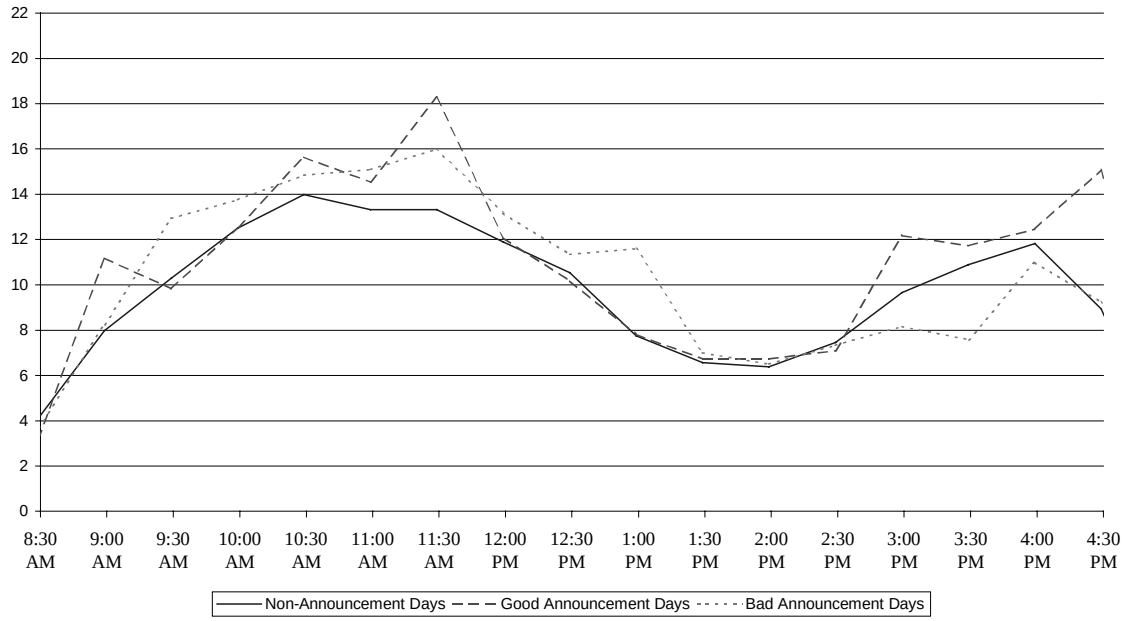

Figure 9: Total Volume