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Intraday Trading Behavior around Interim Earnings Announcements on the Helsinki Stock Exchange

ABSTRACT

The article finds evidence from the Helsinki Stock Exchange that the widely documented U-shape pattern in trading activity – namely heavy trading in the beginning and at the end of the trading day and relatively light trading in the middle of the day – is affected by an anticipated information event (i.e. interim earnings announcement). Before the announcement day, trading is more concentrated at the close. This is consistent with investors' heterogeneous willingness to bear expected overnight risk, which is especially prevalent before an announcement. Moreover, a slight increase on the open is evident after the announcement day. Evidence is also provided that the change in intraday trading behavior is associated with announcement-related factors, such as the range of analysts' earnings forecasts, the magnitude of unexpected earnings and firm size. Furthermore, this association is evident to some extent during the transition between trading and non-trading regimes.

JEL Classification code: D82; G14; M41

Keywords: *volume, interim earnings announcement, intraday trading, asymmetric information*

I am grateful to Juha-Pekka Kallunki, Markku Rahiala, Jukka Perttunen and Hannu Schadewitz for their helpful comments and suggestions. I am also grateful for comments by Steven Thorley and other participants at the European Finance Association Meeting, Helsinki, August 1999. I would like to thank Startel/Taloussanomat for providing the analysts' earnings forecast data, Helsinki Stock Exchange for providing the intraday trading data, and Andrew Lightfoot for proof-reading the text and providing helpful suggestions. Any remaining errors are mine alone. I am also grateful for the financial support of Suomen Arvopaperimarkkinoiden Edistämissäätiö, Liikesivistysrahasto, Jenny & Antti Wihurin rahasto, and Oulun yliopiston tukisäätiö.

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1. INTRODUCTION

Traditionally, the informational role of earnings announcements has been evaluated by considering the price reaction. Much knowledge has been gained on the way in which prices respond to new information. However, as Beaver (1968) points out, the price reaction only reflects the aggregate market reaction, in that the reaction of individual investors' change in beliefs is 'cancelled out', whereas trading volume reflects the revision in beliefs of individual investors. Recently, an increasing number of trading volume studies and studies on intraday trading behavior have been published. This has been facilitated by the recent availability of transaction data from stock exchanges around the world in the last decade. Several new anomalies have been reported and predictive models have been proposed.[1] One of these anomalies is a U-shape pattern in trading activity during the trading day. [2]

The purpose of the present study is to investigate whether and how an anticipated information event such as an interim earnings announcement affects intraday trading on the Helsinki Stock Exchange, the HSE. Accordingly, if anticipated disclosures have an *ex ante* information content, traders will time their transactions in response to the anticipated informational event. This may also affect the timing of trades during the trading day. Thus the widely documented U-shape pattern in trades may be affected by the information event. The theoretical background for the intraday trading activity pattern in this study is based on Admati and Pfleiderer (1988), and Brock and Kleidon (1992). These models consistently assume that the existence of heterogeneous investors combined with periodic market closure affects trading behavior during the trading day.

This study contributes to existing literature in the following respects. Firstly, there is only limited empirical verification of the theoretical models of investors' intraday trading behavior around an anticipated information event. Secondly, this study extends Brock and Kleidon's (1992) model and Gerety and Mulherin's (1992) empirical insights by connecting the intraday trading pattern to the anticipated information event. In addition, the Finnish stock market, with its special characteristics[3], provides a suitable forum to study the robustness of previous findings produced in more developed stock markets (e.g. the US). Thirdly, financial analysts' earnings forecasts have hardly been studied in Finland, partly because of the difficulty in obtaining the data. Data on the dispersion and/or range of analysts' earnings forecasts are especially

1 The most widely quoted are the asymmetric information hypothesis of Admati and Pfleiderer (1988) and Brock and Kleidon's (1992) increased demand hypothesis.

2 Other anomalies include seasonalities in intraday returns and volatility, as reported by Wood, McInish and Ord (1985), and Foster and Viswanathan (1993). Handa (1992) also found a U-shaped intraday pattern in bid/ask spreads.

3 Among these characteristics are the institutional setting, with short-selling restrictions, the thin and unequally distributed trading volumes and the lack of designated market makers in the LOB trading system on the HSE.

crucial for volume studies since they facilitate measurement of the dispersion in beliefs before the announcement event.

The rest of the paper is organized in the following way. Section 2 briefly reviews the existing literature on intraday trading patterns and predicted behavior around an anticipated announcement event. In section 3 the research design is presented. Section 4 describes the trading system of the HSE and presents the data. In section 5 the empirical results concerning the change in intraday trading pattern around interim earnings announcements are presented. Finally, section 6 concludes the study.

2. INTRADAY TRADING BEHAVIOR AND ANTICIPATED INFORMATION EVENT

Research into intraday patterns in stock market trading volume falls into two groups – studies that develop models to predict trading patterns and studies that document observed patterns. Among the studies in the first group are Admati and Pfleiderer (1988), and Brock and Kleidon (1992). These related studies provide models to explain time-dependent patterns in security trading. Among the studies in the second group are Harris (1986), Jain and Joh (1988), Foster and Viswanathan (1990), and Gerety and Mulherin (1992), who detected a U-shape to intraday trading in the US markets. A similar pattern has also been found in France (Biais, Hilloin, and Spatt, 1992), Sweden (Niemeyer and Sandås, 1993) and recently also in Finland (Hedvall 1994).

Admati and Pfleiderer's (1988) model proposes that the intraday trading pattern is a result of the interaction between investors in possession of different information and an ability to choose their trading point during the trading day. The possibility of obtaining intraday trading regularities exists at certain times during the trading day when both informed and discretionary investors (who have some ability to choose when to trade during the day on the basis of trading costs) are in the market. The result is a clustering of volume that can occur at arbitrage times in the trading day, although their concluding remarks (p. 34) suggest that the open and close possibly represent unique clustering points. These propositions are more explicitly developed by Brock and Kleidon (1992). They argue that much of the trading at the open and close stems from the inability to trade when the market is closed. Since the market is inaccessible during the evening the volume on the opening reflects trades that would have been made earlier if the market had been open. The closing volume reflects differences in optimal portfolios between the overnight non-trading period and the trading period. These insights were followed up and extended by Gerety and Mulherin (1992). They focus on the assumption that investors differ in their willingness and/or ability to hold positions overnight. Accordingly, some market participants, so-called day traders, might specialize in arbitrage activities (or marketmaking) in individual stocks during the day, but may not desire to hold their positions overnight. Arbitrageurs exchange their specialized positions at the end of the day for a more diversified portfolio. Some legal restrictions or capital constraints might also induce heterogeneity in their ability to bear overnight risk. Accordingly, they argue that if investors transfer the risk of holding a position while the market is closed, then the volume at the end of the day should be directly related to the volatility expected to occur overnight. Correspondingly, when investors reacquire their specialized positions on the next day's open the expected *and unexpected* overnight information should be directly related to the volume at the next day's open.

The theoretical models above propose that an anticipated information event such as an interim report announcement affects the intraday trading pattern before and after the announcement event. These propositions give a straightforward testable hypothesis related to the anticipated information event. Before an anticipated information event, it is expected that trading activity at the end of the day increases, reflecting the volatility expected to occur overnight. Likewise, if slow information dissemination is assumed after an announcement, a relatively large amount of unexpected overnight information results in excess portfolio rebalancing activities on the open.

In addition, an anticipated information event may affect not only the trading pattern during the transition between trading and non-trading regimes, but also during other periods in the trading day. According to Kim and Verrecchia (1991a, 1991b), this takes place before the announcement event if the anticipated public announcement stimulates private information gathering and trading. They suggest that the anticipation of a public announcement stimulates private information gathering even if it is costly. Traders acquire private information of differing precision before an announcement. When the announcement is released, they form posterior beliefs and trade on their private information and market prices[4]. After the announcement, given slow dissemination of earnings information, excess portfolio rebalancing activities may result during other periods of the trading day.[5]

3. RESEARCH DESIGN

The change (or shift) in the intraday trading activity pattern around an announcement is tested by dividing the trading day into trading deciles. Each decile represents ten per cent of the free

4 For related empirical findings see e.g. Atiase and Bamber (1994), Utama and Cready (1997) and Bamber, Barron and Stober (1997).

5 Livne (1997) endorsed Kim and Verrecchia's notion (1994) of the dual role of public announcements. Firstly, public announcements eliminate the information asymmetry that prevailed in the pre-announcement period between informed and uninformed traders. The second informational role is to create new information asymmetry in the market since firms' published reports offer a rich set of data that can be better processed by some investors.

trading time in a trading day. This makes it possible to study shifts in the intraday trading activity pattern from the open to the close. Firstly, dummy regression models are used to test whether an anticipated information event changes the intraday trading pattern in a particular decile. Secondly, it is tested whether the aggregated absolute change is associated with announcement-related factors (range of analysts' earnings forecasts and the absolute difference in mean analysts' earnings forecasts and reported earnings). Finally, the association is tested during the transition periods between trading and non-trading regimes.

3.1 Tests for change by deciles

In order to study changes in intraday trading behavior, several proxies have to be specified. Firstly, the intraday trading pattern around the announcement is specified. Secondly, the 'normal' intraday trading pattern prevailing during non-event periods was specified. The shift in the trading pattern is denoted by the difference between these two patterns. More specifically, ACT_{Di}^{T} is the proportion of intraday trading activity in period T during decile D *(D=1,…,10,* where *D=1* is the first trading decile, and *D=10* is the last trading decile) of the overall trading activity in the sample firms in the corresponding trading period. All the sample stocks and all the deciles were aggregated in the denominator. Since the denominator comprises the aggregated trading activity over the entire sample (1992–1996) it is rather stable and thus relatively insensitive to market fluctuations[6]. The log-transformed measure[7] takes the following form:

$$(1) \qquad ACT_{Di}^{T} = \ln\left(\frac{\sum_{t=t_0}^{t_1} VOL_{Dti}}{\sum_{i}\sum_{t=t_0}^{t_1} VOL_{ti}} + 1\right),$$

where VOL_{Dti} refers to trading activity (number of shares traded, and number of transactions) on day t relative to the announcement date during decile D for announcement i. To approximate normality, log transformations were used. A small constant, 1, was added to eliminate problems associated with zero volumes (transactions) in log transformations. In order to provide deeper insight into the intraday trading pattern, the length of the pre- and post-announcement periods was varied. These periods are referred to by (t_0, t_1) in Eq. (1) above. Three pre-announcement periods were specified. The longest covers the five-day trading period preceding the announcement date, referred to as t_0=–5, t_1=–1. The middle period covers the three-

6 In volume studies, the number of outstanding shares has frequently been used as a scaling variable (see e.g. Gerety and Mulherin 1992). Since announcements affect daily trading, the use of such a scaling variable in this research setting would have resulted in increased trading activity figures in the trading deciles. Since the aim is to eliminate trading level fluctuations around the announcement, aggregated sample trading was used.

7 The change metric was also specified without log transformation. The results were about the same.

day trading period preceding the announcement date, referred to as t_0=–3, t_1=–1, and the shortest period covers the one-day trading period preceding the announcement date, referred to as t_0=t_1=–1. Three corresponding periods were specified for the post-announcement period [t_0=t_1=1; t_0=1, t_1=3; and t_0=1, t_1=5]. The announcement date is referred to as t_0=t_1=0. The corresponding relative stock trading activity during the non-announcement period, ACT^N_{Di}, is

$$(2)\qquad ACT^N_{Di} = \ln\left(\frac{\sum_{t=-30}^{-6} VOL_{Dti} + \sum_{t=6}^{30} VOL_{Dti}}{\sum_i \sum_{t=-30}^{-6} VOL_{ti} + \sum_i \sum_{t=6}^{30} VOL_{ti}} + 1\right).$$

The normal trading activity pattern covers the 25-day trading period preceding the announcement date, referred to as t_0=–30, t_1=–6, and the 25-day trading period subsequent to the announcement date, referred to as t_0=6, t_1=30, totalling 50 trading days. Hence, the change in trading activity pattern associated with announcement *i* during period *T* and decile *D* is specified thus:

$$(3)\qquad ACTDIFF^T_{Di} = ACT^T_{Di} - ACT^N_{Di}.$$

The change in intraday concentration pattern by deciles was tested using a dummy regression model. The basic form is as follows:

$$(4)\qquad ACTDIFF^T_{Di} = b_1 D1_i + b_2 D2_i +,\ldots,+ b_{10} D10_i + e^T_{Di},$$

where

$D1_i,\ldots,D10_i$ = $D1_i=1$ if the trade is in the first decile, otherwise 0,
$D2_i=1$ if the trade is in the second decile, otherwise 0,
...
$D10_i=1$ if the trade is in the tenth decile, otherwise 0,
$b_1,\ldots,b_{10}$ = estimated parameters,
e^T_{Di} = error term

In order to avoid the dummy variable trap (Greene 1991:243) there is no overall constant in the model. In addition, the parameters are restricted since $b_1+,\ldots,+b_{10}=0$. This results from the scaling variable in model (1). In order to produce an unrestricted model, b_5 was solved using other parameters. This resulted in the following regression model, where $D5_i$ is subtracted from the dummies[8]:

8 This subtraction decreases the estimated error variances somewhat. The estimated parameters remain unchanged.

(5) $ACTDIFF^{T}_{Di} = b_1(D1_i - D5_i) + b_2(D2_i - D5_i) +,...,+ b_{10}(D10_i - D5_i) + e^{T}_{Di}$.

The estimated parameters can be interpreted as the average deviation of the trading activity pattern in a given decile around the announcement from a corresponding trading activity pattern during the non-announcement period. Intraday trading activity models provide several predictions as to how investors time their trades around an anticipated announcement. During the pre-announcement period, $T<0$, trading ought to be more concentrated at the close compared to the non-event period. Thus b_{10} ought be significantly positive during the pre-announcement periods. During the post-announcement periods, $T>0$, the opening volume, b_1, ought to be significantly positive.

3.2 Association tests for change over deciles

Changes in the intraday trading pattern around an impending announcement may be associated with announcement-related factors. According to Brock and Kleidon (1992) and Gerety and Mulherin (1992), if investors expect large overnight risk, more rebalancing activities are also to be expected. Pre-disclosure information asymmetry obviously indicates to investors the magnitude of the expected overnight volatility. Kim and Verrecchia (1991a, 1991b) also suggest that an anticipated public announcement stimulates private information-gathering and trading before an announcement. This may lead to information-related trading throughout the trading day. After the announcement, given investors' heterogeneous ability to process firms' published reports and/or slow information dissemination, excess portfolio rebalancing activities may be seen throughout the trading day on the days immediately following the announcement. These insights assist us in specifying announcement-related proxies for expected overnight volatility and unexpected overnight information.

In the literature the range and dispersion of analysts' earnings forecasts are frequently employed as a proxy for pre-disclosure information asymmetry (see e.g. Ziebart 1990, Atiase and Bamber 1994, Lobo and Tung 1997, Vieru 1998)[9]. In Finland, there has been a distinct lack of databases covering analysts' earnings forecasts for research purposes. However, Startel/Taloussanomat, the leading Finnish provider of financial information services, agreed to make its database available to mitigate this lack. The metric for the magnitude of pre-disclosure information asymmetry proxied by the range of analysts' earnings per share forecasts, *RANGE*, takes the following form[10]:

9 For the deficiency of this proxy see Atiase and Bamber (1994:316).
10 Observations with mean forecasts from FIM –20,000 to FIM 20,000 were omitted (two observations), due to the metric's sensitivity to small denominators (similar cut-off rules are also used in Atiase and Bamber 1994 and Pincus 1983). The file containing the variation (or dispersion) of analysts' earnings forecasts was not available.

(6) $RANGE = (highest\ EPS\ forecast - lowest\ EPS\ forecast) / |mean\ EPS\ forecast|$.

The information content metric used here is the absolute difference between the mean of analysts' earning forecasts, *FORE,* and reported earnings, *REPO,* scaled by the number of outstanding shares, *OUT* (see Vieru 1998). This metric is an example of a more timely proxy for expected earnings than the previous year's earnings (see e.g. Easton and Harris 1991; Hayn 1995; Martikainen, Kallunki, and Perttunen 1997). Thus,

(7) $UE = |FORE - REPO| / OUT.$

The magnitude of the total change in the trading concentration pattern was obtained by aggregating the absolute changes in trading activity (number of shares traded and number of transactions) over the deciles. The magnitude of the total absolute change in the trading activity pattern specified for announcement event *i* , $CUMDIFF^T_i$, takes the following form:

(8) $$CUMDIFF^T_i = \sum_{D=1}^{10} |ACTDIFF^T_{Di}|,$$

where $CUMDIFF^T_i$ refers to the total absolute change in the trading activity pattern during announcement event *i* in period *T* relative to the announcement date (*T<0* refers to the pre-announcement days, *T=0* refers to the announcement day, and *T>0* refers to the post-announcement days). The same periods were used as in Section 3.1.

Based on the above analysis and in conjunction with prior empirical models of trading responses found in Atiase and Bamber (1994), and Bamber, Barron and Stober (1997), the hypothesized relationship was studied using both additive (Model 1) and multiplicative (Model 2) functional forms. The additive model was:

(9) $$\text{Model 1:} \quad CUMDIFF^T_i = a + b_1 UE_i + b_2 RANGE_i + b_3 lnSIZE_i + e^T_i,$$

where

UE_i = absolute difference between the mean analysts' earnings forecast and the reported earnings scaled by the number of outstanding shares;

$RANGE_i$ = absolute difference in maximum and minimum analysts' EPS forecasts scaled by the absolute mean of analysts' EPS forecasts;

$lnSIZE_i$ = natural log of the market value of the equity measured at the end of the pre-announcement year;

a and *b*s = OLS regression coefficients; and

e^T_i = error term.

The results' sensitivity to alternative specifications of the functional form of the relations was assessed using corresponding multiplicative models (see e.g. Atiase and Bamber 1994), where all the variables are log-transformed:

(10) *Model 2:* $ln\ CUMDIFF_i^T = a + b_1 lnUE_i + b_2 lnRANGE_i + b_3 lnSIZE_i + e_i^T.$

In all the periods the independent variables were the same. Before the announcement ($T<0$), *RANGE,* which proxies expected overnight volatility, was predicted to be positively associated with *CUMDIFF,* whereas after the announcement this association was predicted to be insignificant. After the announcement ($T>0$), given the slow dissemination of information, *UE,* which proxies unexpected overnight information, was predicted to be positively associated with *CUMDIFF.* If *UE* is positively associated with *CUMDIFF* before the announcement, this may imply that the magnitude of the information content is anticipated and some traders are taking positions accordingly. The same prediction is also valid for the multiplicative models. On the announcement day the crucial question is the time when the announcement is due to be released[11]. Thus, for example, if an announcement is released in the middle of the trading day, a larger change in the intraday pattern is to be expected compared to an announcement released in the last trading decile, given the U-shape pattern in intraday trading activity. Thus timing differences may violate the association, which suggests that *UE* and *RANGE* may be insignificantly associated with *CUMDIFF* on the announcement day.

The reason for adding firm size to the regression was based on Gerety and Mulherin (1992), and Stoll and Whaley (1990). For example, Stoll and Whaley (1990) note that low-volume stocks have a relatively greater ratio of overnight to daytime volatility than actively traded stocks. In addition, small firms are less closely monitored, indicating that small firms' announcements ought to be more informative (see e.g. Bamber 1987:513). Hedvall (1994) has also found a higher trade concentration for small firms in Finland. For these reasons, it was expected that *SIZE* would be negatively associated with *CUMDIFF.*

3.3 Association tests for change during transition periods

In the previous section the association between trading pattern changes across all the deciles and the independent variables was studied. The independent variables were constructed to measure the magnitude of the change in trading activity pattern across deciles without paying special attention to the timing or sign of these changes. Since theoretical propositions suggest

11 Casual observations suggest that earnings announcements are released throughout the day. Some firms announce even before the market open or near the market close.

that the concentration pattern may change, especially during transition periods, closer attention was paid to these extreme deciles.

Investors' rebalancing activities caused by expected overnight volatility may cause excess portfolio rebalancing activity before an impending announcement, especially during the last trading decile when the market close is approaching. After an announcement, unexpected overnight information resulting from the slow dissemination of knowledge and/or investors' heterogeneous ability to process the firm's published report may speed up trading during the first trading decile after the market open. The change in trading activity during the last trading decile was measured as follows:

$$(11) \qquad PREDIFF^{T}_{10i} = \ln\left(\frac{\sum_{t=t_0}^{t_1} VOL_{ti10}}{\sum_{i}\sum_{t=t_0}^{t_1} VOL_{ti}} + 1\right) - \ln\left(\frac{\sum_{t=30}^{-6} VOL_{10ti} + \sum_{t=6}^{30} VOL_{10ti}}{\sum_{i}\sum_{t=-30}^{-6} VOL_{ti} + \sum_{i}\sum_{t=6}^{30} VOL_{ti}} + 1\right).$$

Correspondingly, the change in trading activity during the first trading decile was measured as follows:

$$(12) \qquad POSTDIFF^{T}_{1i} = \ln\left(\frac{\sum_{t=t_0}^{t_1} VOL_{ti1}}{\sum_{i}\sum_{t=t_0}^{t_1} VOL_{ti}} + 1\right) - \ln\left(\frac{\sum_{t=30}^{-6} VOL_{1ti} + \sum_{t=6}^{30} VOL_{1ti}}{\sum_{i}\sum_{t=-30}^{-6} VOL_{ti} + \sum_{i}\sum_{t=6}^{30} VOL_{ti}} + 1\right).$$

The hypothesized relationship between the change in trading activity and various announcement-related factors during the transition periods was studied using the following regression models[12]:

(13) Pre-announcement period: $PREDIFF^{T}_{10i} = a + b_1 UE_i + b_2 RANGE_i + b_3 lnSIZE_i + e^{T}_{10i}$,

(14) Post-announcement period: $POSTDIFF^{T}_{1i} = a + b_1 UE_i + b_2 RANGE_i + b_3 lnSIZE_i + e^{T}_{1i}$,

where

$PREDIFF^{T}_{10i}$ = estimated change in the trading concentration pattern during the last decile *(D=10)* of the pre-announcement period;

$POSTDIFF^{T}_{1i}$ = estimated change in the trading concentration pattern during the first decile *(D=1)* of the post-announcement period;

UE_i = absolute difference between the mean analysts' earnings forecast and the reported earnings scaled by the number of outstanding shares;

12 The log-transformed model was also regressed, but the results were similar.

$RANGE_i$ = absolute difference in maximum and minimum analysts' EPS forecasts scaled by the absolute mean of analysts' EPS forecasts;
$lnSIZE_i$ = natural log of the market value of the equity measured at the end of the pre-announcement year;
a and *b*s = OLS regression coefficients; and
e^T_{10i} and e^T_{1i} = error terms.

Again, the independent variables were the same in all the periods. Before the announcement, *RANGE* was expected to be positively associated with *PREDIFF.* After the announcement, *UE* was predicted to be positively associated with *POSTDIFF.* If *UE* is positively associated with *PREDIFF* before the announcement, this may imply that the magnitude of the information content is anticipated and some traders are taking positions accordingly during the last trading decile.

As with Models 1 and 2, firm size was expected to be negatively associated with *PREDIFF.* After an announcement, the association between firm size and *POSTDIFF* is not straightforward since at least two opposite factors are involved: i) the magnitude of the information content, and ii) the precision of disclosure (see e.g. Schadewitz and Blevins 1997). If small firms' announcements are more informative, resulting in larger (and lagged) price changes, some of these price changes might also run into subsequent trading days as a result of overnight information dissemination. On the other hand, the average precision (or quality) of disclosure is lower for small firms, thus lessening the consensus among investors, possibly resulting in a reluctance to trade from the first moment at the open. Thus no normative relationship between firm size and *POSTDIFF* was expressed. In order to verify the presence of a non-linear association between the dependent and independent variables, squared values of *UE* and *RANGE* were also included in the independent variables.

4. TRADING ON THE HSE AND THE SAMPLE

4.1 Trading system on the HSE and descriptive statistics

The Helsinki Stock Exchange trading system[13], HETI (Helsinki Stock Exchange Automated Trading and Information System[14]), is a decentralized, fully-automated order-driven system. It replaced the old sequential open outcry system in 1989 and 1990. When the HETI system was

13 A good description of the HSE's trading system is presented by Hedvall (1994).
14 The official terminology of the HETI system and the entire set of trading rules can be found in Regulations on the Automated Trading of Shares, The Helsinki Stock Exchange, 1996.

introduced, off-book trading dominated, as described by Hedvall (1994: 54–55)[15]. One explanation for this might be the relatively short free trading period (from 10 am to 2:30 pm) and relatively long after-market trading period at that time. Since then, the trading hours during the trading day on the HSE have been extended several times. The free trading period has been lengthened and it now begins later than in the first subperiod. The changes were made to make the regular trading hours coincide more closely with trading in the European and US markets. As a result, average LOB trading during the sample period accounts for about 40 per cent of the number of shares traded and about 70 per cent of the transactions during the sample period. This means that the role of LOB trading has increased markedly since Hedvall (1994).

The free trading period is divided into deciles. Since the regular trading hours vary in length over the sample period, the length of each decile is not constant[16]. Jain and Joh (1988), and Foster and Viswanathan (1993) in the US market, Niemeyer and Sandås (1993) in the Swedish market and Hedvall (1994) in the Finnish market have reported a U-shape pattern in trading volume. They all report a high trading volume period on the open and toward the close. During the trading day, the trading volume decreases and toward the close it increases again[17].

4.2 Sample

The data used in the sample comprise all the interim earnings announcements with available analysts' interim earnings forecasts made between 1992 and 1996 for HSE-listed firms. Analysts' earnings forecasts are typically available for firms with the most actively traded stocks. The database with the analysts' interim earnings forecasts was provided by Startel/Taloussanomat[18]. In addition, the sample observations had to have an available daily trading volume in the HSE's intraday trade history file from 30 days preceding, to 30 days following, the date of each interim report announcement. The HSE data consist of all intraday time-stamped transac-

15 According to Hedvall (1994) limit order book trading (LOB trading) accounted for only 25 per cent of the trading volume in FIM. Off-LOB trades were large in size, since LOB trading accounted for about 60 per cent of the number of transactions.

16 In the first subperiod (1 January 1992 to 30 October 1993), the length of the regular trading period is 4 hours 30 minutes, thus each decile is 27 minutes long; in the second subperiod (1 November 1993 to 31 December 1995), the length of the regular trading period is 6 hours, thus each decile is 36 minutes long; in the third subperiod (1 January 1996 to 30 June 1996), the length of the regular trading period is longest (7 hours), and each decile is 42 minutes long; in the fourth subperiod (1 July 1996 to 31 December 1996) the length of the regular trading period is 6 hours and 30 minutes, thus each decile is 39 minutes long.

17 During the sample period 1.1. 1992 – 31.12.1996 a similar pattern was found for the number of transactions and trading volume. The figures are available upon request.

18 Analysts' interim earnings forecasting activity has increased considerably during the sample period. For example, in the Startel/Taloussanomat database the number of forecasters per interim earnings announcement has also increased considerably (in 1992 there were on average 5.6 forecasters, whereas in 1996 there were 8.9 forecasters). The average time span from a forecast release to the actual earnings announcement date has increased from one day to three days, producing greater consciousness of the level of pre-disclosure information asymmetry and more time for investors to rebalance their portfolios in response to analysts' forecasts.

tions[19]. The sampling criteria resulted in a total of 118 firm-year announcements released by the 21 firms presented in Vieru (1998). Usually firms release two sets of interim earnings per year, in the middle of June and the middle of October. Firms that only release one set of interim earnings usually report in August. There is evidence of clustering, i.e. firms tend to announce their interim earnings on the same day. Information is probably transferred from one firm to another firm, especially within the same industry, which may cause cross-sectional volume dependencies. However, the firms in the sample represent quite a wide spread of industries, which reduces the problems associated with announcement-time clustering[20].

During the sample period, LOB trading accounted for over 30 per cent of the number of shares traded and almost 80 per cent of the transactions in the stocks of the interim report announcement day. This suggests that on the announcement day relatively small trades will be executed via LOB. In addition average after-market trading accounted for over 50 per cent of the number of shares traded and 8 per cent of the transactions on the announcement date. This indicates that large trades in particular are executed after the market close on an announcement day. This may result from the HETI trading rule, which stipulates that an LOB order is only good for up to 10 lots. In addition, since prearranged trades must be executed within the spread during regular trading hours, any delay in execution increases the risk that the quote will move and the trade either has to be re-negotiated or that it is only reported when after-market trading begins. Since on average there are more quote changes on an announcement day than on a non-announcement day, more re-negotiations and delays are to be expected. On an interim report announcement day, the pattern in the volume and number of transactions seems to deviate from the regular U-shape. During the trading day, trading activity seems to increase almost continuously. This is to be expected since investors respond to interim earnings announcements immediately, which in turn increases trading activity[21].

Table 1 gives descriptive statistics on the independent and dependent variables. Only LOB traders are included in the analysis since in previous studies upstairs (i.e. prearranged) trading has been found to be less informative than downstairs (i.e. LOB) trading (see e.g. Booth, Lin, Martikainen, and Tse 1998). Hedvall (1994) also found that upstairs trading does not increase prior to the close of regular trading, suggesting that the upstairs trading environment changes much less when LOB trading closes and after-hours trading begins. The mean aggregated shift in the trading volume pattern compared to the event day (T=0), 0.9177, is almost twice as

19 Earlier studies where such intraday data have been used include Hedvall (1994), Hedvall and Liljeblom (1994), and Booth, Lin, Martikainen, and Tse (1998).
20 Enso-Gutzeit Corp., Kymmene Corp., Metsä-Serla Corp. and Repola Corp. all come under SIC code 21 (integrated pulp and paper product manufacture). When all those firms that did not announce their results first were eliminated from the sample, the results were unaltered.
21 Descriptive figures are available upon request.

TABLE 1. Descriptive statistics.

	Mean	Std.dev.	Min	Max
Independent variables, *$CUMDIFF_i^T$*				
VOLUME				
Pre-announcement period, *T<0*				
[–5,...,–1]	0.5767	0.2093	0.1452	1.3164
[–3,...,–1]	0.6549	0.2418	0.1861	1.3443
[–1]	0.9161	0.2952	0.2642	1.5781
Announcement date, T=0				
[0]	0.9177	0.2584	0.3479	1.5887
Post-announcement period, T>0				
[1]	0.8764	0.2800	0.2138	1.5291
[1,...,3]	0.6569	0.2462	0.1431	1.2959
[1,...,5]	0.5411	0.2049	0.1252	1.2372
TRANSACTION				
Pre-announcement period, *T<0*				
[–5,...,–1]	0.4714	0.1981	0.1087	1.3128
[–3,...,–1]	0.5668	0.2387	0.1543	1.3725
[–1]	0.8559	0.3210	0.2259	1.5656
Announcement date, T=0				
[0]	0.8080	0.2850	0.3401	1.5887
Post-announcement period, T>0				
[1]	0.7707	0.2900	0.2795	1.4917
[1,...,3]	0.5471	0.2225	0.0995	1.1667
[1,...,5]	0.4359	0.1741	0.0973	1.0755
Dependent variables				
UE	0.0026	0.0033	0.0000	0.0153
RANGE	0.6796	0.8276	0.0529	6.0000
lnSIZE	22.27	0.8374	20.82	25.10

$CUMDIFF_i^T$ = total absolute change in trading activity (volume and transaction) pattern during announcement event *i* in period *T* relative to the announcement (*T<0* refers to the pre-announcement periods, *T=0* refers to the announcement day, and *T>0* refers to the post-announcement periods);

UE = information content of the announcement measured as the absolute difference of the mean analysts' earnings forecast and reported earnings scaled by the number of outstanding shares;

RANGE = absolute difference in maximum and minimum analysts' EPS forecasts scaled by the absolute mean of analysts' EPS forecasts;

lnSIZE = natural log of the market value of the equity measured at the end of the pre-announcement year.

high as that in the five-day period prior to the announcement (T=–5,…,–1), 0.5767. After the announcement (T>0), the shift decreases and is about the same as in the corresponding five-day period before the announcement, 0.5411. An impending announcement appears to have a considerable effect on the trading pattern since the aggregated shift in the trading volume pattern on the day preceding the announcement, 0.9161, is at the same level as that on the announcement day. The results based on the number of transactions are similar.

Table 2 shows the correlations between the variables employed in the first association test. Panel A (Panel B) presents the correlations between the independent variables and *CUMDIFF* based on trading volume (transactions). During the pre-announcement periods the correlations between the trading volume shift and unexpected earnings range from 0.1528 to 0.2322. The corresponding correlations based on transactions range from 0.2076 to 0.2296. Each of the correlations is significantly greater than zero at $p<0.05$. During the post-announcement periods the correlations are usually significantly greater than zero at $p<0.1$. The lowest correlation is found on the announcement day, deviating insignificantly from zero.

The results in Table 2 also show that in the pre-announcement periods there is a slightly positive correlation between the shift in the trading activity concentration pattern and the range of analysts' earnings forecasts. During the post-announcement periods this correlation seems to disappear. In summary, these tentative findings are consistent with the hypothesis that the change in the trading activity pattern is associated with the expected and unexpected volatility related to an announcement. The correlations between the independent variables and *SIZE* strongly ($p<0.0001$) support the assumption that the trading shift around an announcement is negatively correlated with firm size.

5. EMPIRICAL RESULTS

Prior research suggests quite strongly that (interim) earnings announcements contain useful information for the market. This finding, along with the fact that investors represent a heterogeneous group and the existence of regular trading hours, suggests that the observed U-shape trading pattern is affected by the anticipated (interim) earnings announcement. In this section the empirical results concerning the intraday pattern around the interim report announcement are studied. The rest of this section is organized in the following way. Subsection 5.1 highlights the change in the intraday concentration pattern in trading activity (number of shares traded and number of transactions) for the sample firms around the interim earnings announcement for each trading decile. Subsection 5.2 studies the association of the aggregate (or overall) change in the intraday trading activity pattern with the expected overnight volatility as measured by the range of analysts' earnings forecasts and the unexpected overnight informa-

TABLE 2. Correlations between variables employed in the regression analysis.

Panel A. Trading volume	UE	RANGE	lnSIZE
Independent variables, *CUMDIFF*$_i^T$			
Pre-announcement period, *T<0*			
[–5,…,–1]			
	0.1528	0.2100	–0.5202
	(0.0985)	(0.0225)	(0.0001)
[–3,…,–1]	0.2053	0.1770	–0.4914
	(0.0257)	(0.0551)	(0.0001)
[–1]	0.2322	0.1270	–0.5433
	(0.0129)	(0.1780)	(0.0001)
Announcement date, T=0			
[0]	0.0262	0.0816	–0.4121
	(0.7792)	(0.3820)	(0.0001)
Post-announcement period, T>0			
[1]	0.1743	0.0869	–0.5156
	(0.0601)	(0.3516)	(0.0001)
[1,…,3]	0.1935	0.0886	–0.4754
	(0.0358)	(0.3399)	(0.0001)
[1,…,5]	0.2170	0.0785	–0.4933
	(0.0183)	(0.3980)	(0.0001)

Panel B. Transactions	UE	RANGE	InSIZE
Independent variables, *CUMDIFF*$_i^T$			
Pre-announcement period, *T<0*			
[–5,…,–1]	0.2143	0.1644	–0.4877
	(0.0198)	(0.0753)	(0.0001)
[–3,…,–1]	0.2296	0.1183	–0.4867
	(0.0124)	(0.2019)	(0.0001)
[–1]	0.2076	0.1530	–0.5468
	(0.0267)	(0.1042)	(0.0001)
Announcement date, T=0			
[0]	0.0266	0.1259	–0.4018
	(0.7756)	(0.1761)	(0.0001)
Post-announcement period, T>0			
[1]	0.1572	0.0441	–0.5310
	(0.0906)	(0.6367)	(0.0001)
[1,…,3]	0.1392	0.0708	–0.4684
	(0.1328)	(0.4463)	(0.0001)
[1,…,5]	0.1563	0.0311	–0.3939
	(0.0910)	(0.7381)	(0.0001)

CUMDIFF$_i^T$ = total absolute change in trading activity (volume and transaction) pattern during announcement event *i* in period *T* relative to the announcement (*T<0* refers to the pre-announcement periods, *T=0* refers to the announcement day, and *T>0* refers to the post-announcement periods);

UE = information content of the announcement measured as the absolute difference of the mean analysts' earnings forecast and reported earnings scaled by the number of outstanding shares;

RANGE = absolute difference in maximum and minimum analysts' EPS forecasts scaled by the absolute mean of analysts' EPS forecasts;

lnSIZE = natural log of the market value of the equity measured at the end of the pre-announcement year.

p-values in parantheses.

tion as measured by the absolute difference in mean analysts' earnings forecasts and reported earnings. In subsection 5.3 the same association tests are applied to the transition periods.

5.1 Change in concentration pattern by deciles

In Table 3 a significance test is applied for the change in trading pattern using three pre-announcement periods. Panel A refers to trading volume and Panel B to the number of transactions. This test is based on a dummy variable OLS regression with trading decile dummies (Eq. (5) above). The first row in Panel A tests whether the intraday trading volume pattern over the five-day period prior to the announcement, [–5,…,–1], deviates from the pattern prevailing during the non-announcement period. The second row tests whether the intraday trading volume pattern over the three-day period pattern prior to the announcement [–3,…,–1], deviates from the pattern prevailing during the non-announcement period. The third row tests whether the trading volume pattern on the day preceding the announcement date, [–1], deviates from the pattern prevailing during the non-announcement period. The fourth row in Table 3 in Panel A tests whether the trading volume pattern on the announcement day, *[T=0],* deviates from the pattern prevailing during the non-announcement period. The corresponding results based on transactions are given in Panel B. The fifth, sixth and seventh rows in Table 3 in Panel A test whether the intraday trading volume pattern during the post-announcement periods [day (1), days (1,…,3), and days (1,…,5)], deviates from the pattern prevailing during the non-announcement period. The corresponding test results based on transactions are presented in Panel B. Finally, the last three rows in Table 3 in Panel A (Panel B) test whether the intraday trading volume (transaction) pattern during the pre-announcement periods deviates from the pattern prevailing during the corresponding post-announcement periods.

Table 3 suggests that the trading activity pattern before the announcement date deviates from the pattern prevailing during the non-event period[22]. A statistically significant shift was detected during the close, especially for the trading volume pattern. For transactions the shift is less prominent. Thus trading volume during the last decile (close) proved to be higher before interim earnings announcement days than that prevailing during the non-event period. This is consistent with the propositions of Brock and Kleidon (1992) and Gerethy and Mulherin (1992).

22 The regular trading hours vary in length over the sample period, as described in footnote 16. This variation in length might affect investors' intraday trading behavior, which is not captured when data are pooled. The first sub-period differs most notably in length from the other sub-periods. The possible impact of pooling on the results was investigated by studying whether in the first sub-period the regression coefficients of model (5) differ from the other sub-periods. This was done by including dummy variables in the model to indicate whether the interim report was released at a time other than the first sub-period. Since this approach did not produce any significantly ($p<0.05$) differential slope coefficients, it appears that pooling does not materially affect the conclusions drawn here.

TABLE 3. Significance test for the change in intraday trading pattern. The following regression model was estimated both for trading volume and the number of transactions.

$$ACTDIFF^T_{Di} = b_1(D1_i - D5_i) + b_2(D2_i - D5_i) + ,\ldots, + b_{10}(D10_i - D5_i) + e^T_{Di}$$

where

$D1_i,\ldots,D10_i$ = $D1_i = 1$ if the trade is in the first decile, otherwise 0,
$D2_i = 1$ if the trade is in the second decile, otherwise 0,
...
$D10_i = 1$ if the trade is in the tenth decile, otherwise 0,

$b_1,\ldots,b_{10}$ = estimated parameters,

e^T_{Di} = error term

Panel A. Number of shares traded*100,000

	D1	D2	D3	D4	D6	D7	D8	D9	D10	R2
Pre-announcement period versus non-announcement period, T<0										
[−5 – −1]	0.00	−2.75	2.52	0.64	−8.54*	−7.76	−0.70	−12.7**	25.0*	0.0102
[−3 – −1]	−3.89	−5.49	7.57	−1.31	−9.09*	−4.44	0.80	−15.8**	31.7**	0.0119
[−1]	0.76	−12.1	−3.30	−14.0*	−13.7*	3.61	−9.77	−12.5	65.3***	0.0225
Announcement date versus non-announcement period, T=0										
0	−18.8*	−31.2***	−2.32	−3.08	27.9	3.87	22.5	14.4	−23.7	0.0057
Post-announcement period versus non-announcement period, T>0										
[1]	34.3	12.0	−4.59	4.24	−13.4	−22.0***	22.3	3.21	−26.0	0.0082
[1 – 3]	19.5	−1.82	−5.10	0.08	−2.17	−5.98	3.06	10.7	−13.1	0.0041
[1 – 5]	12.3	−1.31	−5.15	2.20	1.32	−3.60	0.57	3.35	−8.53	0.0026
Pre-announcement period versus post-announcement period										
[−5 – −1], [1 – 5]	−12.3	−1.44	7.68	−1.56	−9.86	−4.17	−1.26	−16.0	33.5*	0.0096
[−3 – −1], [1 – 3]	−23.4*	−3.67	12.7	−1.22	−6.92	1.54	−2.26	−26.4*	44.8**	0.0124
[−1] , [1]	−33.5	−24.1	1.28	−18.2	0.32	−25.6*	−32.0*	−15.7	91.2***	0.0228

Panel B. Number of transactions*100,000

	D1	D2	D3	D4	D6	D7	D8	D9	D10	R2
Pre-announcement period versus non-announcement period, T<0										
[−5 – −1]	3.24	−0.98	3.38	−1.76	−2.32	−6.82**	−0.62	−1.39	7.61	0.0030
[−3 – −1]	6.64	−2.60	6.14	−0.91	−5.30	−7.27*	2.77	−3.18	8.32	0.0043
[−1]	11.1	−2.23	−7.22	−6.15	−5.55	−4.03	−5.34	4.17	18.8*	0.0065
Announcement date versus non-announcement period, T=0										
T=0	−25.6***	−26.4***	−2.01	−5.95	26.6	−0.15	25.7	12.6	−17.3	0.0075
Post-announcement period versus non-announcement period, T>0										
[1]	41.4*	12.9	4.36	−6.49	−12.6*	−23.7***	11.1	1.73	−22.6**	0.0133
[1 −3]	15.8*	4.64	4.16	−1.42	−2.90	−6.19	−1.10	3.37	−15.0*	0.0070
[1 −5]	10.7	3.91	0.88	−0.55	−1.05	−3.32	−1.65	−1.05	−9.06	0.0044
Pre-announcement period versus post-announcement period										
[−5 – −1], [1 – 5]	−7.43	−4.89	2.50	−1.21	−1.27	−3.50	1.04	0.35	16.7**	0.0059
[−3 – −1], [1 – 3]	−9.16	−7.24	1.98	0.51	−2.40	−1.08	3.87	−6.55	23.4**	0.0082
[−1] , [1]	−30.3	−15.1	−11.6	0.34	7.06	19.6	−16.4	2.44	41.4***	0.0128

*,**,*** denote significance levels of 10 percent, 5 percent and 1 percent, respectively. One-tail test based on White's adjusted standard errors.

After an announcement, trading also seems to be slightly more concentrated at the open of the trading day than during the non-announcement period. Investors react on the open the following day, resulting in volume produced by unexpected overnight information. However, compared to the trading pattern shift towards the close before an announcement, this shift seems to be less prominent. This indicates that there is only a slight need to trade quickly during the post-announcement period.

Table 3 also suggests that on the announcement day of an interim report, trading begins relatively slowly compared to trading before the announcement. This is to be expected since interim reports tend to be released later on in the trading day, which increases trading activity. Since much of the LOB trading demand is exhausted during the trading day of an interim report announcement, there does not seem to be an especially high trade concentration at the end of the free trading period.

5.2 Association tests across deciles

The first test of association in trading change was performed by regressing the total absolute change in the trading activity pattern on the expected overnight volatility and unexpected overnight information as measured by announcement-related factors. The shift in trading activity before the announcement event was predicted if i) the anticipated public announcement stimulates private information-gathering and trading, and ii) investors balance their portfolios to bear excess risk. A corresponding shift in trading activity after the announcement, given a slow dissemination of announcement-based information, was also predicted.

All the models were estimated using ordinary least squares (OLS). Tests were made to discover whether the residuals were homoscedastic. Applying White's test for heteroscedasticity to the trading volume indicated that the null hypothesis of homoscedasticity is slightly unrealistic only for Model 1 (additive model) on the announcement day and in the one-day post-announcement period, their respective *p*-values being 0.074 and 0.064. For Model 2 (multiplicative model) the null hypothesis seemed to be slightly unrealistic only on the announcement day, the *p*-value being 0.087. For transactions the null hypothesis was unrealistic only for Model 1 (additive model) in the three-day pre-announcement periods, its *p*-value being 0.021, as against the next lowest value of 0.107. For Model 2 (multiplicative model) the null hypothesis of homoscedasticity was unrealistic for the three-day and one-day pre-announcement periods, their respective *p*-values being 0.066 and 0.043. Thus, where appropriate, the test statistics were corrected for heteroscedasticity using White (1980).

The OLS results for the additive and multiplicative models based on trading volume are presented in Table 4. The corresponding results based on transactions are presented in Table 5. The Table 4 indicate that announcement-related factors are associated with the total change

TABLE 4. Change in trading volume concentration pattern regressed on the information content of the announcements and level of pre-disclosure information asymmetry.

	Model 1: $CUMDIFF_i^T = a_i + b_1 UE_i + b_2 RANGE_i + b_3 lnSIZE_i + e_i^T$				Model 2: $lnCUMDIFF_i^T = a_i + b_1 lnUE_i + b_2 lnRANGE_i + b_3 lnSIZE_i + e_i^T$				
	UE	*RANGE*	*lnSIZE*	*F*	R^2	*lnUE*	*lnRANGE*	*lnSIZE*	*F*	R^2
Pre-announcement periods, *T<0*										
[–5 – –1]	8.772	0.045	–0.124	17.60	0.32	0.046	0.061	–0.264	26.17	0.41
	(1.753)	*(2.285)*	*(–6.371)*	*(0.0001)*		*(2.251)*	*(1.724)*	*(–7.868)*	*(0.0001)*	
	(1.599)	*(3.112)*	*(–7.424)*			*(2.047)*	*(1.931)*	*(–7.528)*		
	(1.878)	*(2.625)*	*(–6.881)*			*(2.507)*	*(2.040)*	*(–8.366)*		
[–3 – –1]	14.01	0.044	–0.135	15.90	0.30	0.041	0.058	–0.254	21.13	0.36
	(2.387)	*(1.921)*	*(–5.897)*	*(0.0001)*		*(1.884)*	*(1.557)*	*(–7.109)*	*(0.0001)*	
	(2.169)	*(3.116)*	*(–6.795)*			*(1.937)*	*(2.265)*	*(–6.717)*		
	(2.504)	*(2.159)*	*(–6.628)*			*(2.154)*	*(1.916)*	*(–7.579)*		
[–1]	18.94	0.033	–0.181	19.17	0.34	0.037	0.033	–0.236	21.99	0.37
	(2.652)	*(1.240)*	*(–6.702)*	*(0.0001)*		*(1.868)*	*(0.997)*	*(–7.448)*	*(0.0001)*	
	(2.783)	*(1.554)*	*(–8.509)*			*(1.981)*	*(1.281)*	*(–7.956)*		
	(2.913)	*(1.277)*	*(–7.357)*			*(2.116)*	*(1.259)*	*(–8.302)*		
Announcement date, *T=0*										
	0.448	0.015	–0.126	15.19	0.17	0.009	0.024	–0.144	8.79	0.19
	(0.066)	*(0.543)*	*(–4.735)*	*(0.0001)*		*(0.485)*	*(0.767)*	*(–4.832)*	*(0.0001)*	
	(0.088)	*(0.769)*	*(–5.704)*			*(0.457)*	*(0.911)*	*(–4.968)*		
	(0.193)	*(0.674)*	*(–5.494)*			*(0.670)*	*(1.072)*	*(–5.610)*		
Post-announcement periods, *T>0*										
[1]	12.24	0.017	–0.168	15.19	0.29	0.027	0.045	–0.228	18.65	0.33
	(1.785)	*(0.647)*	*(–6.253)*	*(0.0001)*		*(1.318)*	*(1.282)*	*(–6.797)*	*(0.0001)*	
	(1.690)	*(1.065)*	*(–7.055)*			*(1.322)*	*(1.549)*	*(–6.107)*		
	(1.948)	*(0.831)*	*(–7.207)*			*(1.472)*	*(1.741)*	*(–8.241)*		
[1– 3]	12.86	0.019	–0.135	13.13	0.26	0.039	0.062	–0.248	17.63	0.32
	(2.095)	*(0.773)*	*(–5.654)*	*(0.0001)*		*(1.656)*	*(1.530)*	*(–6.473)*	*(0.0001)*	
	(2.362)	*(1.111)*	*(–7.927)*			*(1.883)*	*(1.762)*	*(–7.217)*		
	(2.158)	*(0.773)*	*(–6.511)*			*(1.711)*	*(1.730)*	*(–8.012)*		
[1 – 5]	12.06	0.013	–0.117	14.85	0.28	0.047	0.049	–0.255	19.50	0.34
	(2.400)	*(0.663)*	*(–5.968)*	*(0.0001)*		*(2.067)*	*(1.256)*	*(–6.831)*	*(0.0001)*	
	(3.152)	*(0.835)*	*(–8.251)*			*(2.325)*	*(1.373)*	*(–7.589)*		
	(2.637)	*(0.744)*	*(–6.779)*			*(2.172)*	*(1.561)*	*(–7.861)*		

$CUMDIFF_i^T$ = magnitude of total absolute change in trading activity pattern for announcement event *i*;
UE_i = information content of announcement *i* measured as the absolute difference between the mean analysts' earnings forecast and the reported earnings scaled by the number of outstanding shares;
$RANGE_i$ = absolute difference of maximum and minimum analysts' EPS forecasts scaled by the absolute mean of analysts' EPS forecasts;
$lnSIZE_i$ = natural log of the market value of the equity measured at the end of the pre-announcement year;
a and *b*s = OLS regression coefficients; and
e_i^T = error term.

The first values below the regression coefficients in parentheses are the ordinary t-values. The second values below the regression coefficients in parentheses are the t-values adjusted for an unknown type of heteroscedasticity using White (1980). The third values below the regression coefficients in parentheses are the bootstrap t-values based on resampling of residuals (see Efron and Tibshirani 1993).

Table 5. Change in transaction concentration pattern regressed on the information content of the announcements and level of pre-disclosure information asymmetry.

	Model 1: $CUMDIFF_i^T = a_i + b_1 UE_i + b_2 RANGE_i + b_3 lnSIZE_i + e_i^T$					Model 2: $lnCUMDIFF_i^T = a_i + b_1 lnUE_i + b_2 lnRANGE_i + b_3 lnSIZE_i + e_i^T$				
	UE	*RANGE*	*lnSIZE*	*F*	R^2	*lnUE*	*lnRANGE*	*lnSIZE*	*F*	R^2
Pre-announcement periods, *T<0*										
[–5 – –1]	11.98	0.034	–0.110	15.61	0.29	0.069	0.086	–0.265	23.40	0.38
	(2.484)	*(1.768)*	*(–5.840)*	*(0.0001)*		*(2.954)*	*(2.157)*	*(–6.932)*	*(0.0001)*	
	(2.290)	*(2.781)*	*(–6.127)*			*(2.778)*	*(2.523)*	*(–6.775)*		
	(2.390)	*(2.042)*	*(–6.252)*			*(2.992)*	*(2.487)*	*(–7.298)*		
[–3 – –1]	15.27	0.0274	–0.133	15.20	0.29	0.053	0.067	–0.272	23.29	0.38
	(2.618)	*(1.193)*	*(–5.846)*	*(0.0001)*		*(2.347)*	*(1.712)*	*(–7.319)*	*(0.0001)*	
	(2.062)	*(2.060)*	*(–6.475)*			*(2.201)*	*(2.226)*	*(–7.425)*		
	(2.630)	*(1.408)*	*(–6.502)*			*(2.506)*	*(2.097)*	*(–8.372)*		
[–1]	18.30	0.046	–0.198	19.14	0.34	0.037	0.066	–0.289	25.91	0.41
	(2.356)	*(1.546)*	*(–6.737)*	*(0.0001)*		*(1.632)*	*(1.736)*	*(–7.979)*	*(0.0001)*	
	(2.171)	*(2.262)*	*(–7.889)*			*(1.587)*	*(2.430)*	*(–7.482)*		
	(2.486)	*(1.604)*	*(–7.557)*			*(1.985)*	*(1.857)*	*(–9.048)*		
Announcement date, *T=0*										
	0.938	0.032	–0.134	7.71	0.17	0.008	0.065	–0.163	9.19	0.20
	(0.125)	*(1.075)*	*(–4.559)*	*(0.0001)*		*(0.390)*	*(1.733)*	*(–4.570)*	*(0.0001)*	
	(0.150)	*(1.527)*	*(–5.730)*			*(0.385)*	*(1.965)*	*(–5.433)*		
	(0.206)	*(1.227)*	*(–5.461)*			*(0.538)*	*(2.014)*	*(–5.538)*		
Post-announcement periods, *T>0*										
[1]	10.66	0.002	–0.1817	15.85	0.30	0.026	0.018	–0.263	19.73	0.34
	(1.511)	*(0.064)*	*(–6.562)*	*(0.0001)*		*(1.174)*	*(0.483)*	*(–7.275)*	*(0.0001)*	
	(1.445)	*(0.064)*	*(–8.627)*			*(1.200)*	*(0.547)*	*(–9.681)*		
	(1.639)	*(0.224)*	*(–7.122)*			*(1.281)*	*(0.937)*	*(–8.021)*		
[1 –3]	7.791	0.011	–0.122	11.56	0.23	0.029	0.042	–0.257	16.69	0.31
	(1.383)	*(0.491)*	*(–5.548)*	*(0.0001)*		*(1.208)*	*(1.026)*	*(–6.556)*	*(0.0001)*	
	(1.356)	*(0.492)*	*(–7.141)*			*(1.258)*	*(1.203)*	*(–6.482)*		
	(1.483)	*(0.563)*	*(–5.891)*			*(1.264)*	*(1.291)*	*(–7.117)*		
[1 –5]	7.112	0.002	–0.080	7.93	0.17	0.051	0.043	–0.202	12.56	0.25
	(1.553)	*(0.102)*	*(–4.489)*	*(0.0001)*		*(2.181)*	*(1.054)*	*(–5.272)*	*(0.0001)*	
	(1.889)	*(0.146)*	*(–6.171)*			*(2.496)*	*(1.238)*	*(–5.422)*		
	(1.919)	*(0.185)*	*(–5.021)*			*(2.419)*	*(1.297)*	*(–5.961)*		

$CUMDIFF_i^T$ = magnitude of total absolute change in trading activity pattern for announcement event *i*;
UE_i = information content of announcement *i* measured as the absolute difference between the mean analysts' earnings forecast and the reported earnings scaled by the number of outstanding shares;
$RANGE_i$ = absolute difference of maximum and minimum analysts' EPS forecasts scaled by the absolute mean of analysts' EPS forecasts;
$lnSIZE_i$ = natural log of the market value of the equity measured at the end of the pre-announcement year;
a and *b*s = OLS regression coefficients; and
e_i^T = error term.

The first values below the regression coefficients in parentheses are the ordinary t-values. The second values below the regression coefficients in parentheses are the t-values adjusted for an unknown type of heteroscedasticity using White (1980). The third values below the regression coefficients in parentheses are the bootstrap t-values based on resampling of residuals (see Efron and Tibshirani 1993).

in the trading volume concentration pattern. The results are similar in Table 5, where the total change in the transaction pattern is regressed on the same announcement-related factors. All the estimated parameters are of the expected sign in both tables. Before the announcement *(T<0),* both expected volatility as measured by the range of analysts' earnings forecasts, *RANGE,* and the unexpected information as measured by the absolute difference in mean analysts' earnings forecasts and reported earnings, *UE*, appears to be positively related to the shift in trading pattern[23]. The computed t-values in parentheses are predominantly statistically significant at the 5% risk level, as based on one-side tests. In addition, firm size appears to be negatively related to the shift. This relation is very strong since the t-values in parentheses are statistically significant at the 0.1% risk level, as based on one-side tests. The results are very similar for Model 1 (additive model) and for Model 2 (multiplicative model).

On the announcement day *(T=0), RANGE* and *lnRANGE* were insignificant based on volume. However, when the number of transactions was studied using the multiplicative model (Model 2), the t-values were statistically significant at the 5% risk level, as based on one-side tests. During the period subsequent to the interim report announcement day *(T>0), RANGE* was no longer associated with the change in intraday trading pattern, as indicated by the low t-values. This is in line with the prediction, since the asymmetry of the content of the announcement has practically vanished. However, part of the unexpected information may still be connected to the information content of the announcement after the announcement day. This may be the case if information dissemination and processing are slow, lasting for a couple of days after the announcement. This view is supported by the significantly positively associated *UE* after the announcement based on trading volume activity, as presented in Table 4.

In order to verify the presence of non-linear association between the dependent and independent variables, squared values of *UE* and *RANGE* were also included in the independent variables. These squared values were predominately insignificant, thus the results are not presented here. Tests were also made to discover whether the residuals were normally distributed. Shapiro-Wilk's test of normality indicated, in the case of trading volume, that the null hypothesis that the residuals are normally distributed in the trading volume study seems to be realistic for all of the regressions at $p<0.01$. However, in the transaction study, the hypothesis seems to be unrealistic for the one-day period preceding and following the announcement at $p<0.01$. Since the assumption of normality of the residuals was violated, a bootstrapping strat-

23 Dummy variables were also included in the model in order to indicate whether the interim report was released at a time other than the first sub-period described in footnote 16. The dummy models employed took the following form: $CUMDIFF_i^T = a + b_1 UE_i + b_2 D_1 UE_i + b_3 RANGE_i + b_4 D_1 RANGE_i + b_5 lnSIZE_i + e_i^T$, where D_1=1 if the announcement was made after 1 November 1993, otherwise 0. This approach results in insignificant ($p>0.05$) differential slope coefficients. These findings suggest that the length of the free trading period does not materially affect the conclusions drawn.

egy for estimating the standard error of the parameters was applied (see e.g. Efron and Tibshirani 1993). To ascertain the severity of this bias, a bootstrap regression model was conducted[24]. The t-statistics resulting from the bootstrap procedure are shown in Tables 4 and 5 below the regression coefficients in parentheses. These t-statistics are similar to those obtained with OLS methods and with White adjustments.

5.3 Association tests during transition deciles

A second set of association tests was performed on the shifts in the intraday trading pattern during the transition periods. In these regressions the extreme trading deciles of continuous trading hours were investigated more closely. The shift in the trading activity pattern during these periods was regressed on the same announcement-related factors as in the previous section. Each model was estimated using OLS. Tests were made to discover whether the residuals were homoscedastic. Applying White's test for heteroscedasticity indicated that for trading volume the null hypothesis of homoscedasticity is slightly unrealistic only for the one-day pre-announcement period, its *p*-value being 0.099. For the models with squared values of *UE* and *RANGE* the null hypothesis of homoscedasticity seemed to be realistic for all the periods. For transactions the null hypothesis seemed to be unrealistic during all the pre-announcement periods, their *p*-values being 0.045, 0.066, and 0.036. Again, for the models with squared values of *UE* and *RANGE* the null hypothesis of homoscedasticity seemed to be realistic for all the periods. Thus, where appropriate, the test statistics were corrected for heteroscedasticity using White (1980).

The results based on trading volume are presented in Table 6 below and the results based on transactions are presented in Table 7. The upper part of the tables presents the regression results as based on the pre-announcement periods and the lower part of the tables presents the results as based on the post-announcement periods. The announcement day is omitted since the timing of the announcement may violate the predictions. In order to verify the presence of the non-linear association between the dependent and independent variables, squared values of *UE* and *RANGE* were also included in the independent variables.

Tests were made to discover whether the residuals were normally distributed. Shapiro-Wilk's test of normality indicated that for trading volume the null hypothesis that the residuals

24 This approach began with the OLS estimates, with the independent variables unchanged. Pseudo data were generated using the fitted values (Y-hat) from the OLS regression and adding a randomly selected residual to each by drawing with replacement from the vector of 118 residuals. Then the pseudo data were regressed on the original independent variables, repeating this procedure 200 times for each of the independent variables for the corresponding period *T* relative to the announcement. For each model, the parameter estimate was the mean of the 200 bootstrap coefficients. The bootstrap standard error was the sample standard error for the 200 bootstrap parameter estimates. The code was based on information provided by SAS Institute Inc. available from http://www.sas.com/techsup/download/stat/jackboot.sas.

TABLE 6. Change in trading volume concentration pattern in the last and first deciles regressed on the information content of the announcements and range in analysts' earnings forecasts.

	UE	*UE²*	*RANGE*	*RANGE²*	*lnSIZE*	*R²*	*F*
Pre-announcement period, dependent variable $PREDIFF^{T}_{10i}$							
[−5 − −1]	−1.033		−0.000		−0.002	0.001	0.047
	(−0.350)		*(−0.011)*		*(−0.162)*		*(0.986)*
	(−0.356)		*(−0.011)*		*(−0.188)*		
	(−0.389)		*(−0.067)*		*(−0.094)*		
	−7.525	594.0	−0.043	0.009	−0.002	0.024	0.560
	(−0.827)	*(0.772)*	*(−1.403)*	*(1.491)*	*(−0.185)*		*(0.730)*
	(−0.887)	*(0.888)*	*(−1.709)*	*(2.098)*	*(−0.223)*		
	(−0.653)	*(0.576)*	*(−1.133)*	*(1.167)*	*(−0.091)*		
[−3 − −1]	−0.950		0.004		−0.004	0.002	0.081
	(−0.265)		*(0.295)*		*(−0.256)*		*(0.971)*
	(−0.287)		*(0.418)*		*(−0.298)*		
	(−0.310)		*(0.289)*		*(−0.186)*		
	−5.819	435.1	0.003	0.000	−0.004	0.004	0.090
	(−0.521)	*(0.460)*	*(0.068)*	*(0.031)*	*(−0.253)*		*(0.994)*
	(−0.602)	*(0.590)*	*(0.077)*	*(0.042)*	*(−0.296)*		
	(−0.515)	*(0.411)*	*(0.167)*	*(−0.000)*	*(−0.154)*		
[−1]	−5.881		0.038		0.006	0.053	2.033
	(−1.199)		*(2.036)*		*(0.341)*		*(0.113)*
	(−1.143)		*(1.344)*		*(0.380)*		
	(−1.278)		*(2.094)*		*(0.345)*		
	−29.12	2077	−0.049	0.018	0.006	0.101	2.429
	(−1.948)	*(1.662)*	*(−1.004)*	*(1.881)*	*(0.320)*		*(0.040)*
	(−1.861)	*(1.540)*	*(−1.059)*	*(1.781)*	*(0.318)*		
	(−1.501)	*(1.107)*	*(−0.489)*	*(1.634)*	*(0.402)*		
Post-announcement period, dependent variable $POSTDIFF^{T}_{1i}$							
[1]	−0.035		−0.003		0.015	0.020	0.759
	(−0.014)		*(−0.246)*		*(1.453)*		*(0.519)*
	(−0.016)		*(−0.150)*		*(1.550)*		
	(0.045)		*(−0.329)*		*(1.496)*		
	−6.148	569.6	−0.089	0.018	0.014	0.125	3.177
	(−0.806)	*(0.885)*	*(−3.456)*	*(3.609)*	*(1.423)*		*(0.010)*
	(−0.852)	*(0.737)*	*(−4.334)*	*(4.725)*	*(1.530)*		
	(−0.507)	*(0.609)*	*(−1.690)*	*(1.875)*	*(1.556)*		
[1 − 3]	0.045		−0.007		0.016	0.053	2.122
	(0.025)		*(−0.942)*		*(2.244)*		*(0.1013)*
	(0.028)		*(−0.817)*		*(2.613)*		
	(−0.022)		*(−1.031)*		*(2.379)*		
	−8.384	764.4	−0.043	0.008	0.016	0.105	2.620
	(−1.535)	*(1.656)*	*(−2.311)*	*(2.055)*	*(2.259)*		*(0.028)*
	(−1.291)	*(1.400)*	*(−2.659)*	*(2.585)*	*(2.642)*		
	(−1.078)	*(1.206)*	*(−1.667)*	*(1.345)*	*(2.490)*		
[1 − 5]	2.707		−0.004		0.006	0.035	1.375
	(1.658)		*(−0.656)*		*(0.895)*		*(0.2540)*
	(1.341)		*(−1.162)*		*(0.989)*		
	(1.711)		*(−0.752)*		*(0.900)*		
	−10.78	1202	−0.003	−0.001	0.006	0.104	2.589
	(−2.197)	*(2.900)*	*(−0.172)*	*(−0.187)*	*(0.938)*		*(0.0296)*
	(−2.077)	*(2.743)*	*(−0.178)*	*(−0.231)*	*(1.079)*		
	(−1.221)	*(2.115)*	*(−0.102)*	*(−0.383)*	*(1.012)*		

$PREDIFF^{T}_{10i}$ = change in trading activity pattern for announcement event *i* during last trading decile of pre-announcement period *T*;

$POSTDIFF^{T}_{1i}$ = change in trading activity pattern for announcement event *i* during first trading decile of post-announcement period *T*;

All other variables are defined in table 4.

The first values below the regression coefficients in parentheses are the ordinary t-values. The second values below the regression coefficients in parentheses are the t-values adjusted for an unknown type of heteroscedasticity using White (1980). The third values below the regression coefficients in parentheses are the bootstrap t-values based on resampling of residuals (see Efron and Tibshirani 1993).

are normally distributed in the trading volume study is realistic for the five-day and three-day pre-announcement periods at $p<0.01$. For all the other periods non-normality was detected. In the transaction study, the hypothesis seemed to be unrealistic for the one-day period preceding and following the announcement at $p<0.01$. The results were the same for the models with squared values of *UE* and *RANGE.* Since the assumption of normality of the residuals was violated, a bootstrapping strategy for estimating the standard error of the parameters was again applied. The t-statistics resulting from the bootstrap procedure are shown in Tables 6 and 7 below the regression coefficients in parentheses.

In both tables the significance levels are much lower than in Tables 4 and 5, where the aggregate shifts were used as the dependent variable. However, during the one-day pre-announcement period, the expected overnight volatility as measured by the range of analysts' forecasts appears to explain to some extent the shift in trading to the last continuous trading decile, $p<0.1$. This shift seems to be somewhat more emphatic when the number of transactions is used as the dependent variable, and this is also slightly evident in the other pre-announcement periods, predominantly $p<0.1$. However, trading based on unexpected earnings, *UE*, is insignificant. Keeping in mind the results based on aggregate change reported in Tables 4 and 5, this suggests that trading based on private information acquisition is executed in earlier trading deciles. However, to a slight extent during the five-day post-announcement period, *UE* seems to be associated with the change in the trading volume pattern on the market open[25].

A significant non-linear association was detected for various periods. Non-linearity seemed to be most prominent for *RANGE*, especially during the one-day post-announcement periods for volume and for transactions, being significant at $p<0.05$. This indicates that in particular large pre-disclosure information asymmetry as measured by *RANGE* attracts traders at the open immediately after the announcement date. Trading based on especially large unexpected earnings, *UE,* also seems to attract investors at the open, but this effect seems to be more prominent later after the announcement, being significant during the five-day post-announcement period at $p<0.01$.

Due to the lack of competing information sources and close monitoring, the announcements of small firms may contain relatively more surprises than the announcements of large firms. This would lead one to expect higher expected overnight volatility preceding an an-

25 Dummy variables were also included in the models to indicate whether the interim report was released at a time other than the first sub-period. Significant ($p<0.05$) positive differential slope coefficients were found for *UE* in the three-day and the five-day post-announcement periods. This might be related to the long after-market I mode (2 hours 25 minutes) associated with the first sub-period. In other periods the after-market I mode is less than one hour. More prominent *UE*-based trading was possibly executed during after-market I mode in the first sub-period than in the following sub-periods.

TABLE 7. Change in trading transaction concentration pattern in the last and first deciles regressed on the information content of the announcements and range of analysts' earnings forecasts.

	UE	*UE²*	*RANGE*	*RANGE²*	*lnSIZE*	*R²*	*F*
Pre-announcement period, dependent variable $PREDIFF^T_{10i}$							
[–5 – –1]	–1.177		0.017		–0.014	0.050	2.001
	(–0.480)		*(1.784)*		*(–1.419)*		*(0.1179)*
	(–0.476)		*(1.268)*		*(–1.529)*		
	(–0.524)		*(1.694)*		*(–1.464)*		
	–0.137	–80.45	–0.019	0.008	–0.014	0.071	1.701
	(–0.018)	*(–0.126)*	*(–0.754)*	*(1.555)*	*(–1.450)*		*(0.1401)*
	(–0.002)	*(–0.137)*	*(–0.907)*	*(1.676)*	*(–1.617)*		
	(–0.018)	*(–0.177)*	*(–0.412)*	*(1.412)*	*(–1.454)*		
[–3 – –1]	–1.101		0.020		–0.011	0.042	1.653
	(–0.395)		*(1.803)*		*(–1.045)*		*(0.1811)*
	(–0.432)		*(1.980)*		*(–1.151)*		
	(–0.056)		*(1.748)*		*(–1.164)*		
	–0.039	–93.65	0.165	0.001	–0.011	0.042	0.982
	(–0.004)	*(–0.128)*	*(0.562)*	*(0.129)*	*(–1.039)*		*(0.4321)*
	(–0.005)	*(–0.146)*	*(0.599)*	*(0.145)*	*(–1.155)*		
	(–0.056)	*(–0.139)*	*(0.703)*	*(0.164)*	*(–1.086)*		
[–1]	–5.309		0.042		–0.009	0.0707	2.789
	(–1.190)		*(2.442)*		*(–0.514)*		*(0.0440)*
	(–1.399)		*(1.469)*		*(–0.600)*		
	(–1.258)		*(2.446)*		*(–0.568)*		
	–16.18	983.4	–0.036	0.016	–0.009	0.1031	2.482
	(–1.180)	*(0.858)*	*(–0.795)*	*(1.842)*	*(–0.548)*		*(0.0361)*
	(–1.236)	*(0.923)*	*(–0.853)*	*(1.649)*	*(–0.649)*		
	(–1.090)	*(0.639)*	*(–0.306)*	*(1.663)*	*(–0.534)*		
Post-announcement period, dependent variable $POSTDIFF^T_{1i}$							
[1]	–0.501		–0.007		0.014	0.024	0.907
	(–0.192)		*(–0.669)*		*(1.413)*		*(0.4403)*
	(–0.214)		*(–0.473)*		*(1.654)*		
	(–0.143)		*(–0.733)*		*(1.525)*		
	–6.565	562.6	–0.084	0.016	0.0136	0.107	2.660
	(–0.844)	*(0.857)*	*(–3.210)*	*(3.165)*	*(1.375)*		*(0.0260)*
	(–0.802)	*(0.884)*	*(–3.737)*	*(4.222)*	*(1.663)*		
	(–0.532)	*(0.558)*	*(–1.745)*	*(1.714)*	*(1.525)*		
[1 – 3]	0.372		–0.003		0.014	0.038	1.518
	(0.217)		*(–0.451)*		*(2.032)*		*(0.2136)*
	(0.218)		*(–0.324)*		*(2.337)*		
	(0.128)		*(–0.592)*		*(2.135)*		
	–6.105	591.8	–0.043	0.009	0.013	0.0981	2.438
	(–1.179)	*(1.351)*	*(–2.487)*	*(2.461)*	*(2.042)*		*(0.0388)*
	(–1.068)	*(1.208)*	*(–2.604)*	*(2.704)*	*(2.307)*		
	(–0.855)	*(1.059)*	*(–1.648)*	*(1.602)*	*(2.217)*		
[1 – 5]	1.590		–0.035		0.009	0.042	1.662
	(1.194)		*(–0.672)*		*(1.724)*		*(0.1792)*
	(1.077)		*(–1.011)*		*(1.950)*		
	(1.122)		*(–0.830)*		*(1.850)*		
	–6.483	720.0	–0.002	–0.001	0.009	0.0789	1.918
	(–1.592)	*(2.092)*	*(–0.151)*	*(–0.184)*	*(1.756)*		*(0.0969)*
	(–1.665)	*(2.361)*	*(–0.144)*	*(–0.204)*	*(2.028)*		
	(–1.052)	*(1.715)*	*(–0.076)*	*(–0.410)*	*(1.923)*		

$PREDIFF^T_{10i}$ = change in trading activity pattern for announcement event *i* during last trading decile of pre-announcement period *T*;
$POSTDIFF^T_{1i}$ = change in trading activity pattern for announcement event *i* during first trading decile of post-announcement period *T*;

All other variables are defined in table 4.
The first values below the regression coefficients in parentheses are the ordinary t-values. The second values below the regression coefficients in parentheses are the t-values adjusted for an unknown type of heteroscedasticity using White (1980). The third values below the regression coefficients in parentheses are the bootstrap t-values based on resampling of residuals (see Efron and Tibshirani 1993).

nouncement and a negative association between firm size and the change in concentration at the close. Evidence is provided that during the pre-announcement periods firm size seems to be negatively but mostly insignificantly associated with the trading concentration at the close. After the announcement, trading activity, as measured by the number of transactions, is more concentrated at the open, especially for large firms, being predominantly significant at $p<0.01$. This result might be associated with the fact that the precision of disclosure is higher for large firms, creating additional consensus among investors and leading to increased liquidity in the firm's stock, as evidenced by Healy, Palepu and Sweeney (1995:46). Schadewitz (1997) also found that the level of disclosure is associated with firm size in Finland.

6. CONCLUDING REMARKS

This paper provides empirical evidence on the informational role of interim earnings announcements in investors' intraday trading behavior in Finland. The results suggest that interim earnings announcements affect the intraday timing of trades. Thus the widely documented U-shape pattern in trading activity is affected by an anticipated information event. The findings are in line with the theoretical propositions. Before the announcement day, on average, trading is slightly more concentrated at the close than during the non-announcement period. This is consistent with investors' heterogeneous ability to bear expected overnight volatility, which is especially prevalent before an announcement. Moreover, a somewhat greater concentration of trading on the open is evident after the announcement day, indicating unexpected overnight information. The results of the paper further indicate that the change in the trading concentration pattern is associated with announcement-related factors, such as the range of analysts' earnings forecasts, the magnitude of unexpected earnings and firm size. This association is evident for the overall change in the trading pattern and to some extent during the transition between trading and non-trading regimes. ■

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