# Announcement Versus Nonannouncement: A Study of Intraday Transaction Price Paths of Deutsche Mark and Japanese Yen Futures

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## INTRODUCTION

It is widely recognized that the movement of the exchange rate is mainly driven by publicly available macroeconomic news from both countries. Harvey and Huang (1991) find higher U.S.–European and U.S.–Japanese exchange-rate volatility during U.S. trading hours. They hypothesize that the high volatility observed on the opening hours of Thursdays and Fridays is due to the release of U.S. macroeconomic news. Ederington and Lee (1993) find that the intraday and interday volatility patterns in three futures markets[1] are primarily affected by the scheduled monthly macroeconomic news announcements. They find that volatility usually soars in the five minutes immediately following major announcements,[2] then

[1]They are Treasury bond, Eurodollar, and Deutsche mark futures markets. Ederington and Lee (1994) find the similar regularities for Japanese yen futures.

[2]These are the announcements they identify to move the market. For Deutsche mark, the announcements are employment, merchandise trade deficit, gross national product, producer price index, durable goods orders, and retail sales.

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falls sharply over the next 10 to 15 minutes and stays higher than non-announcement days for several hours.

The first question one would ask is how exactly the transaction price movement is affected by the anticipated news announcements. The extensively studied volatility measure[3] reveals price variation over a period of time. However, a clear description on the movement of transaction price paths is not offered. Taking into account the facts that transaction price may be in disequilibrium and the trading is not frictionless, Amihud and Mendelson's (1987) partial price adjustment model suggests that when the market adjusts to the news without delay, the first-order autocorrelation of log price changes (FAC) is between $-1/2$ and 0. On the other hand, if the market underreacts or overreacts to the news, the FAC is greater or less than $-1/2$. The FAC can be positive especially when the variance of fundamental prices is large enough and the market adjusts to the news with a lag. The FAC is, thus, more informative concerning the market's reaction to the news than the volatility measure.

The second question is whether the releases of scheduled announcements enlarge the magnitude of successive price changes. With many floor traders (scalpers) continuously offering bids and asks to facilitate trading [Kuserk and Lock (1993); Siber (1984); Working (1954)] futures markets have a very competitive market-making environment. Thus, the successive price changes are usually minimized to 1 tick.[4] Unlike the stock market, futures markets do not record quoted bid–ask spreads. The widely available Time and Sales data, on the other hand, do not record the status of each transaction price. Therefore, the realize bid–ask spreads cannot be exactly measured. Thompson and Waller (1988) show that the average absolute value of price changes (AAC) is a better measure of liquidity costs for corn and oats futures. Thus, the AAC represents the average successive price changes during a certain period of time and can be treated as a proxy of realized bid–ask spreads.[5]

The third question is how the impact of news changes the price fluctuation range (PR). The PR which measures the maximal fluctuation range of prices over a period of time is an alternative measure of price volatility [Garman and Klass (1980); Parkinson (1980)]. It also indicates the maximal possible gross profit per contract that can be made during a

[3]Here, volatility is represented by either standard deviation or variance of prices; log price changes; or price changes.

[4]The contract size is DM125,000 for DM and ¥12,500,000 for JY. The size of one tick, which is \$0.0001/DM and \$0.000001/JY, is equal to \$12.5 per contract for both currencies.

[5]Realized bid–ask spread is the absolute value of the difference between the current transaction price, which is the scalpers' ask (bid) and the earlier transaction price which is the scalpers' bid (ask). See Stoll (1989) for a detailed explanation.

period of time [Webb and Smith (1994)]. This is the variable which gets most of the attention from practitioners. For example, the Money and Investing section of the *Wall Street Journal* reports the highs and lows of the day or of the year for the value of most of the financial assets.

The fourth question is whether the expected announcements enhance the intensity of the trading. The literature of the Mixture Distribution Hypothesis has demonstrated that the number of price changes is a proxy of information flows [Clark (1973); Harris (1986); Laux and Ng (1993)]. The number of prices (NP),[6] thus, represents the intensity of order arrival rates. The thing one should be aware of is that higher NP may be caused by more liquidity orders and/or information orders. This is another reason why the other three price statistics should be studied. High information trading is expected to increase the values of FAC, AAC, PR and NP. On the other hand, high liquidity trading is expected to increase only NP.

Even though the FAC, AAC, PR, and NP[7] convey useful information on intraday transaction price movements, transaction costs, maximal possible gross profits per contract, and information flows, few studies have paid attention to the intraday patterns of these four price variables. This article intends to fill this gap via studying the two most actively traded currency futures, Deutsche Mark (DM) and Japanese Yen (JY), and presenting a detailed picture of how the market reacts to anticipated U.S. macroeconomic announcements during U.S. trading hours.

## DATA AND STATISTICS

### Data

The data set consists of Time and Sales data of DM and JY futures from the Chicago Mercantile Exchange (CME), and announcement dates from the Money Market Services (MMS) International.[8] To be consistent with Ederington and Lee's work, the dates of 18 scheduled monthly announcements from November, 1988 to December, 1993 are used. These include the following announcements made at 7:30 Central Standard Time[9]: (1)

[6](The number of transaction prices) $- 1 =$ (the number of price changes) at the opening interval. This remains the same for the rest of the trading intervals.

[7]These four price variables are similar to the percentage of price reversals, the percentage of price changes exceeding one tick and median time between price changes reported in Ederington and Lee (1995) [Table 1]. However, they focus on the window of two minutes before and ten minutes after the announcements.

[8]All dates are verified with the "Commodity Alert" section of *Futures*, "The Week Ahead" section of *Business Week*, and "Tracking the Economy" section of the *Wall Street Journal*.

[9]Central Standard Time is hereafter assumed, unless otherwise noted.

consumer price index (CPI), (2) durable goods orders, (3) employment, (4) gross national product (GNP),[10] (5) housing starts, (6) leading indicators, (7) merchandise trade deficit, (8) producer price index, and (9) retail sales; at 8:15: (1) industrial production, (2) capacity utilization; at 9:00: (1) business inventories, (2) construction spending, (3) factory orders, (4) NAPM survey, (5) new home sales, and (6) personal income; and, at 13:00: federal budget. The Time and Sales data cover 1269 trading days from November 1, 1988, to November 5, 1993. During this five-year period, both DM and JY opened at 7:20 and closed at 14:00. The prices used are for the nearest contract except during an expiration month. For example, the prices of a March 1989 contract are used for trading days in December, 1988, January, 1989, and February, 1989; a June 1989 contract is used for the trading days in March, April, and May, 1989; and so on. All prices of bid, ask, and any transaction recorded after 14:00 are excluded from this study.

Contrary to prior studies which use only intraday transaction prices every five minutes, this study divides each day into 80 five-minute intervals and takes every transaction price into account. Building on Ederington and Lee's (1993) (1994) results, this article separates the whole sample into three subsamples: (1) the A-sample (major announcements[11]), including only those 369 days when figures on employment, merchandise trade deficits, PPI, durable goods orders, GNP (GDP), retail sales, or CPI were announced; and, (2) the B-sample (minor announcements), including 346 days when only one of the other 11 announcements was announced;[12] and, (3) the *N*-sample, including all trading days except those when any of the above macroeconomic statistics were announced. The *N*-sample totals 554 days.

## Statistics

The following are the notations and definitions of the FAC, AAC, NP, and PR.

$P_{i,j}^{d}$ = the $j$th transaction price in the $i$th trading interval of day, $d$,[13]

[10]The announcement dates of gross domestic product (GDP) are used since December, 1991.
[11]While CPI (CPI & retail sales) has no immediate impact on DM (JY), they do have an effect on transaction prices in the later time. See Ederington and Lee (1993) and Ederington and Lee (1994).
[12]There are 101 days with both major and minor announcements, which are included in the *A*-sample and excluded from the *B*-sample.
[13]$P_{i,j}^{d}$ = \$/per DM × 10000 or $P_{i,j}^{d}$ = \$/per JY × 1000000.

$$i = 1, 2, 3, \ldots, 80^{14}, j = 1, \ldots, NP_i^d, d = 1, \ldots, D,$$

$NP_i^d$ = the NP recorded for interval, $i$, of day, $d$,

$$D = \begin{cases} A & \text{the number of days of an announcement sample} \\ N & \text{the number of days of a nonannouncement sample,} \end{cases}$$

$$\Delta \ln P_{i,j+1}^d = \ln P_{i,j+1}^d - \ln P_{i,j}^d$$

$$\overline{\Delta \ln P_i^d} = \frac{\sum_{j=1}^{N_i^d} \Delta \ln P_{i,j+1}^d}{N_i^d - 1}$$

$FAC_i^d$ = the FAC for interval, $i$, of day, $d$

$$= \frac{\sum_{j=1}^{N_i^d} (\Delta \ln P_{i,j+2}^d - \overline{\Delta \ln P_i^d})(\Delta \ln P_{i,j+1}^d - \overline{\Delta \ln P_i^d})}{\sum_{j=1}^{N_i^d} (\Delta \ln P_{i,j+1}^d - \overline{\Delta \ln P_i^d})^2}$$

$AAC_i^d$ = the AAC over interval, $i$, of day, $d$

$$= \frac{\sum_{j=1}^{N_i^d} |P_{i,j+1}^d - P_{i,j}^d|}{N_i^d - 1}$$

$PR_i^d$ = PR over interval, $i$, of day, $d$ = $\underset{j}{\mathrm{Max}}(P_{i,j}^d) - \underset{j}{\mathrm{Min}}(P_{i,j}^d)$.

The following method is employed to get sample mean statistics for all three samples and to test whether they are significantly different. Each statistic is first calculated for each five-minute trading interval[15] of every day. Then, one regression for each five-minute interval is run for each statistic to get the mean statistics for the $A$-sample, $B$-sample, and the $N$-sample. Moreover, the covariance matrices are heteroskedasticity [White (1980)] and serial correlation [Newey and West (1992)] corrected. Take FAC, for example,

$$FAC_i^d = a_{1i} D_A^d + a_{2i} D_B^d + a_{3i} D_N^d + \varepsilon_i^d,$$

[14]Each trading day has 400 minutes, which is equal to 80 five-minute trading intervals.

[15]If the number of prices is less than 3 for any five-minute interval, then the FAC of this interval is treated as a missing value.

where $d$ eq $1, \ldots, 1269$; $D_A^d = 1$, when there is any of the 7 major announcements on day, $d$, and $D_A^d = 0$, otherwise; $D_B^d = 1$, only with any of the 11 minor announcements on day, $d$, and $D_B^d = 0$, otherwise; and, $D_N^d = 1$, when there is none of the 18 announcements on day, $d$, and $D_N^d = 0$, otherwise. Thus, for interval, $i$, $a_{1i}$, $a_{2i}$, and $a_{3i}$ are the average FAC of the $A$-sample, $B$-sample, and $N$-sample, respectively; and, $\varepsilon_i^d$ is the error term, where $i = 1, \ldots, 80$.

## MODEL AND EMPIRICAL RESULTS

### Partial Price Adjustment Model

The following is Amihud and Mendelson's (1987) model:

$$P_t - P_{t-1} = g(V_t - P_{t-1}) + e_t, \text{ where } e_t \sim \text{i.i.d. } (0, \sigma^2); \tag{1}$$

$$V_t = V_{t-1} + \varepsilon_t, \text{ where } \varepsilon_t \sim \text{i.i.d. } (0, \nu^2) \tag{2}$$

where $V_t$ and $P_t$ are in logarithms, $V_t$ is the unobservable fundamental price, and $P_t$ is the observed transaction price at time, $t$. The random variable $e_t$ is independent of $\varepsilon_t$. The random variable, $\varepsilon_t$, is the fundamental news shock and $e_t$ captures the noisy trading, price discreteness, and bid–ask spreads. The parameter, $g$, is the adjustment coefficient and $g \in (0,2)$, under the assumption that the return series is stationary. When $g = 1$, transaction prices adjust to a fundamental price instantaneously; when $0 < g < 1$, there is a lagged adjustment; and, when $1 < g < 2$, the market overreacts to the news shock. In the special case when $g = 0$, the transaction price process follows a random walk. Rearranging (1) and using $R_t = P_t - P_{t-1}$, one obtains:

$$R_t = g\varepsilon_t + (1 - g)R_{t-1} + e_t - e_{t-1} \tag{3}$$

$$\text{Var}(R_t) = (g/(2 - g))\nu^2 + (2/(2 - g))\sigma^2 \tag{4}$$

$$\text{Corr}(R_t, R_{t-1}) = ((1 - g)g\nu^2 - g\sigma^2)/(g\nu^2 + 2\sigma^2) \tag{5}$$

(1) When the market is efficient, i.e., $g = 1$,

$$-1/2 < \text{Corr}(R_t, R_{t-1}) = (-\sigma^2)/(\nu^2 + 2\sigma^2) < 0 \tag{6}$$

The negative autocorrelation is caused by noise and transaction friction. The higher the fundamental variance ($\nu^2$), the closer to 0 Corr $(R_t,R_{t-1})$ becomes. On the other hand, the larger the transaction friction ($\sigma^2$), the smaller Corr$(R_t, R_{t-1})$ becomes.

(2) When the market overreacts, i.e., $1 < g < 2$,

$$-1 < \mathrm{Corr}(R_t, R_{t-1}) = -((g-1)g\nu^2 + g\sigma^2)/(g\nu^2 + 2\sigma^2) < -1/2 \quad (7)$$

The oscillation of price movement is caused not only by noise and transaction friction but also by market participants' overreaction to a news shock. In other words, the overshooting of prices can enhance the negative autocorrelation. Thus, $\mathrm{Corr}(R_t,R_{t-1})$ is negatively correlated with both $\nu^2$ and $\sigma^2$.

(3) When the market undershoots, i.e., $0 < g < 1$

$$-1/2 < (-\sigma^2)/(\nu^2 + 2\sigma^2) < \mathrm{Corr}(R_t, R_{t-1})$$
$$= ((1-g)g\nu^2 - g\sigma^2)/(g\nu^2 + 2\sigma^2) \quad (8)$$

and when

$$\nu^2 \geq \sigma^2/(1-g),\ \mathrm{Corr}(R_t, R_{t-1}) \geq 0 \quad (9)$$

This demonstrates that $\mathrm{Corr}(R_t,R_{t-1})$ is positive only when a news shock is large enough and the market adjusts to the news with a lag. $\mathrm{Corr}(R_t,R_{t-1})$ is positively correlated with $\nu^2$ and negatively correlated with $\sigma^2$.

This model predicts that the FAC is between $-1/2$ and 0 at the normal time. When a news shock occurs, the FAC is either less than $-1/2$ when the market overreacts to the information, or greater than $-1/2$ when the market has partial price adjustment.

## Empirical Results

Since the major announcements are made at 7:30 and the other minor announcements are made at 8:15, 9:00, and 13:00, the transaction prices of *A*-sample and *B*-sample are expected to have the most distinctively different behavior from the N-sample at these times. Two questions naturally arise: (1) How long does this difference in the behavior of each mean statistic of each interval between the *A*-sample, *B*-sample, and *N*-sample last?; and, (2) Are the intraday patterns found in each mean statistic significant? The following sections will answer these two questions in detail.

### *The First-Order Autocorrelation of Log Price Changes*

The intraday patterns of the average FAC's for the *A*-sample ($\mathrm{FAC}_i^{A}$'s), *B*-sample ($\mathrm{FAC}_i^{B}$'s), and *N*-sample ($\mathrm{FAC}_i^{N}$'s) are depicted in Figures 1(A) and 1(B) for DM and JY, respectively. For both currencies, $\mathrm{FAC}_i^{A}$'s, $\mathrm{FAC}_i^{B}$'s, and $\mathrm{FAC}_i^{N}$'s, where $i = 1, \ldots, 80$, are different from 0 at the 1%

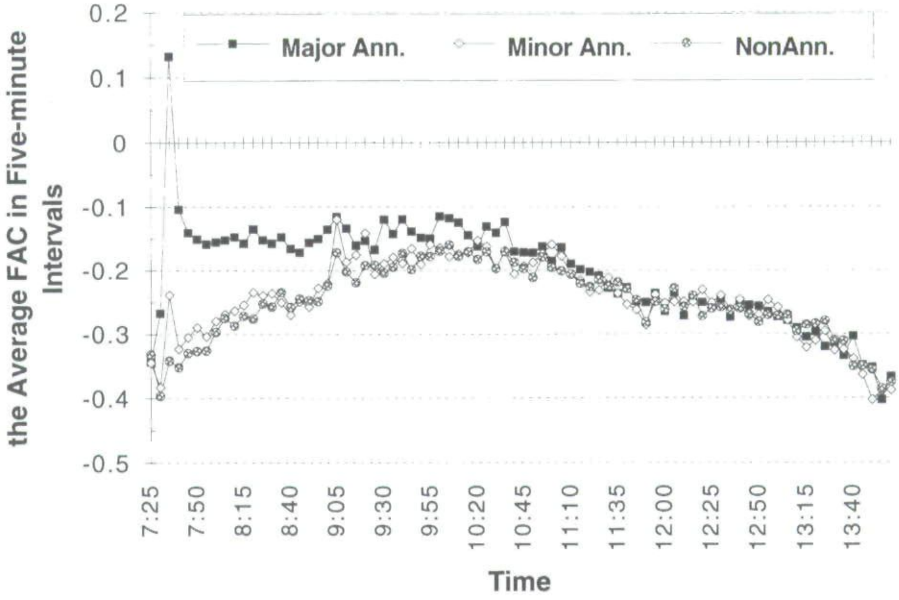


**FIGURE 1(A)**
Deutsche mark: 11/01/88–11/05/93.

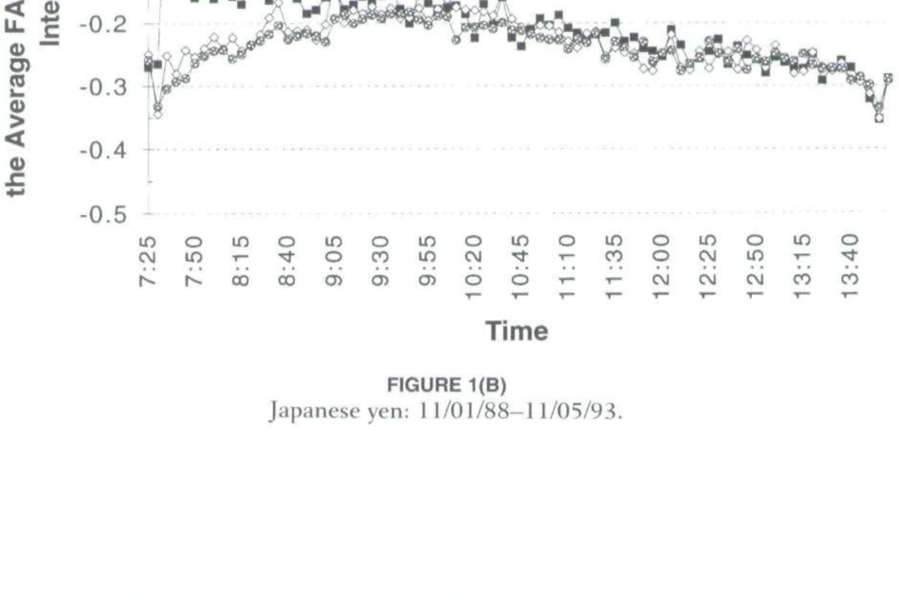


**FIGURE 1(B)**
Japanese yen: 11/01/88–11/05/93.

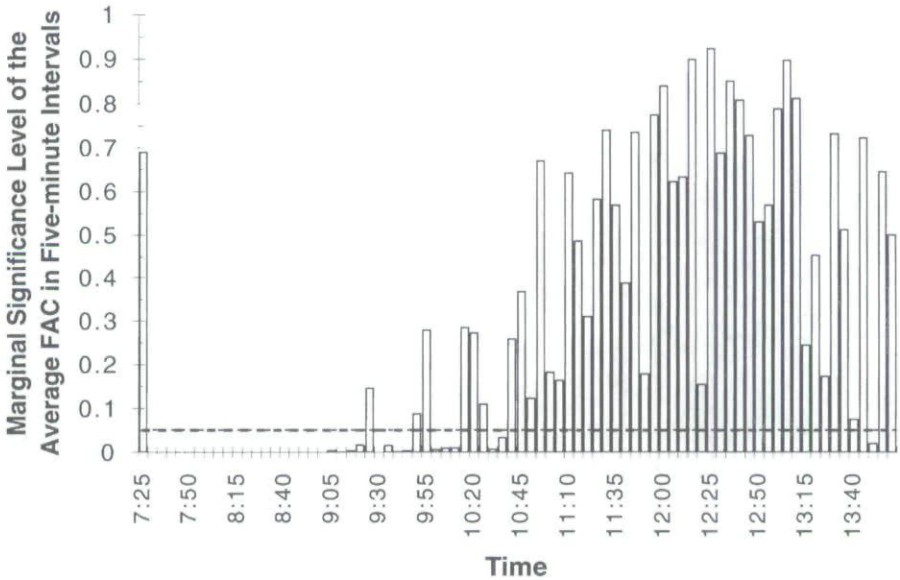


FIGURE 1(C)
Deutsche Mark. H0: Sample mean of major ann. = sample mean of minor ann. only = sample mean of nonann.

marginal significance level. As the partial price adjustment model predicts, $\text{FAC}_i^N$'s are between $-1/2$ and 0 for both currencies. Notice that $\text{FAC}_i^N$'s exhibit an inverse U-shaped pattern across five-minute trading intervals for both DM and JY. This suggests that the fundamental variances are higher during mid trading hours. In other words, the intraday patterns of information flows are inverse U-shaped.

It is obvious that the 7:30 and 9:00 announcements do cause the average FAC over the 7:30–7:35 interval ($\text{FAC}_3^A$, $\text{FAC}_3^B$) and 9:00–9:05 interval ($\text{FAC}_{21}^A$, $\text{FAC}_{21}^B$) to increase. Moreover, $\text{FAC}_3^A$ is the only one which is positive for both currencies. According to the partial price adjustment model, this indicates that the market tends to adjust to news with a lag and the major announcements cause larger shock to the market. For the 8:15 announcements, the impact on price paths is not as obvious as the 7:30 and 9:00 announcements. The possible reason is that there are 33 days of the *A*-sample and 27 days of the *B*-sample having the 8:15 announcements. Therefore, the impact is diluted. The 13:00 announcement—the federal budget—does not affect the transaction price paths for either DM or JY.

The test results for the null hypotheses, $\text{FAC}_i^A = \text{FAC}_i^B = \text{FAC}_i^N$, where $i = 1, \ldots, 80$, are presented in Figures 1(C) and 1(D) for DM and JY, respectively. For both currencies, $\text{FAC}_i^A$'s and $\text{FAC}_i^N$'s behave sig-

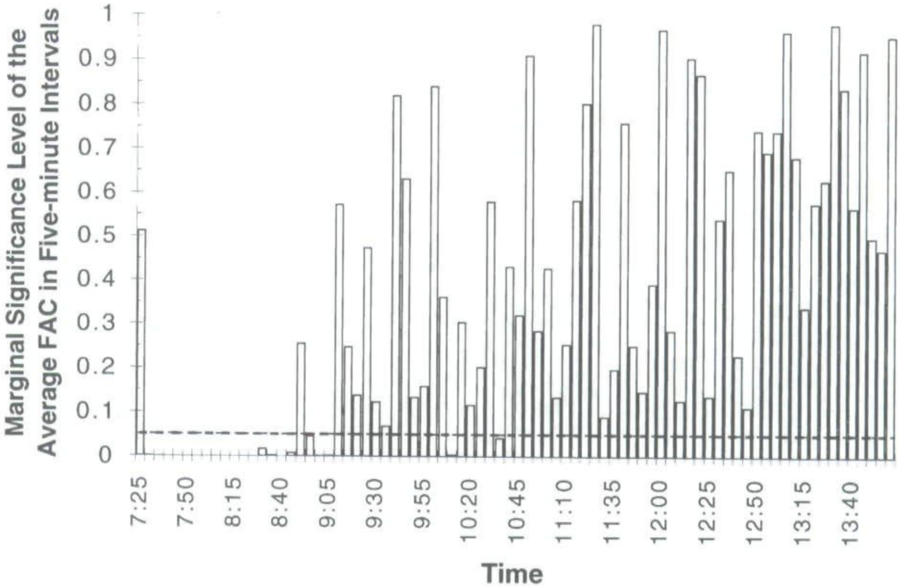


**FIGURE 1(D)**

Japanese yen. H0: Sample mean of major ann. = sample mean of minor ann. only = sample mean of nonann.

nificantly differently in the early trading intervals except during the opening interval (7:20–7:25). This suggests that the market starts to react to "news noise" five minutes before the major announcement. The significant differences between *A*-sample, *B*-sample and *N*-sample lasts till 9:10 for JY and 10:15 for DM. This implies that the market reaction caused by the announcements has receded by the lunch hour. Figures 1(E) and 1(F) show that $FAC_i^B$ is significantly different from $FAC_i^N$ only at the 5-minute interval following the minor announcements, and that it takes about 5 to 20 minutes for the market to adjust to the news. Since the major announcements are identified by Ederington and Lee (1993, 1994) to move the markets, it is not surprising to find that they have a greater and more lasting impact on the market than the minor announcements.

Figures 1(A) and 1(B) show the time-of-day patterns for $FAC_i^A$'s, $FAC_i^B$'s, and $FAC_i^N$'s. $FAC_i^N$'s exhibit an inverse U-shaped pattern across trading intervals of the day for both DM and JY. To determine whether the visible intraday patterns do exist, nine[16] trading intervals are selected for testing whether their mean statistics are equal. They are 7:20–7:25, 7:30–7:35, 8:15–8:20, 9:00–9:05, 10:00–10:05, 11:00–11:05, 12:00–

[16]By doing so, one is able to minimize computing time without losing generality.

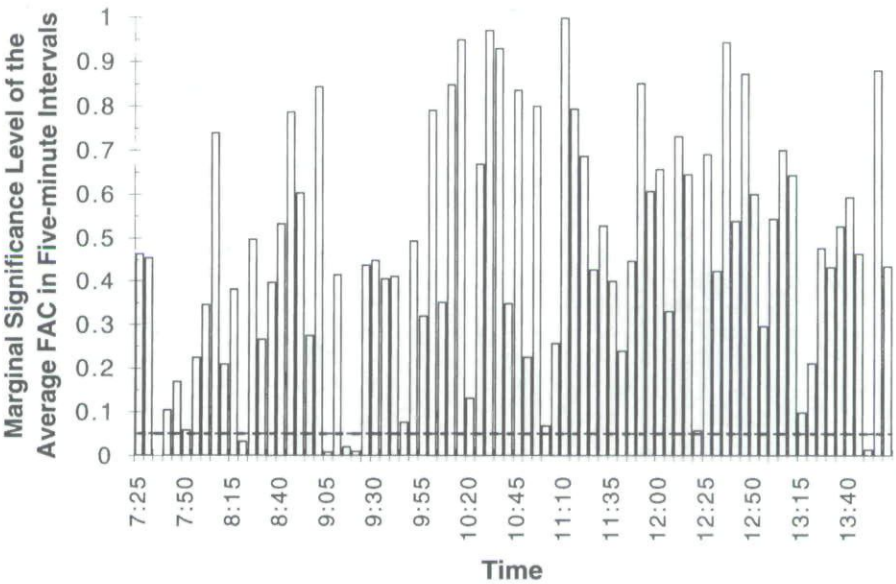


**FIGURE 1(E)**

Deutsche mark. H0: Sample mean of minor ann. only = sample mean of nonann.

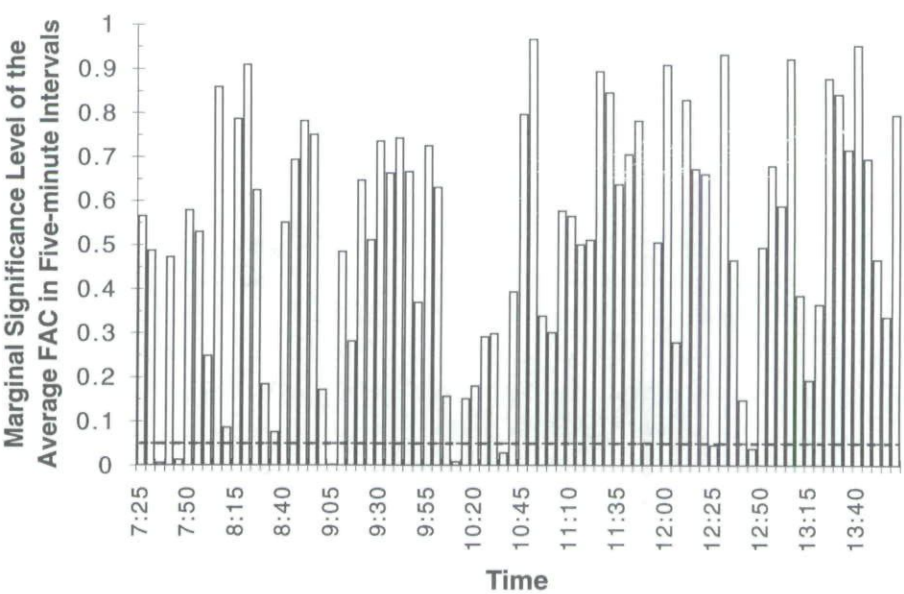


**FIGURE 1(F)**

Japanese yen. H0: Sample mean of minor ann. only = sample mean of nonann.

**TABLE I**

The Average FAC. H0: No Intraday Pattern[a]

| | Major Announcement A-Sample | | Minor Announcement B-Sample | | Nonannouncement N-Sample | |
|---|---|---|---|---|---|---|
| | $\chi^2(8)$ | P-Value | $\chi^2(8)$ | P-Value | $\chi^2(8)$ | P-Value |
| Deutsche mark | 1214.8436 | 0.0000 | 253.7086 | 0.0000 | 314.9809 | 0.0000 |
| Japanese yen | 496.5381 | 0.0000 | 88.9079 | 0.0000 | 84.4509 | 0.0000 |

[a]Nine intervals are used to test the null hypothesis. They are 7:20–7:25; 7:30–7:35; 8:15–8:20; 9:00–5:05; 10:00–10:05; 11:00–11:05; 12:00–12:05; 13:00–13:05; and 13:55–14:00.

12:05, 13:00–13:05, and 13:55–14:00. As shown in Table I, the null hypotheses of no intraday pattern for $FAC_i^A$'s, $FAC_i^B$, and $FAC_i^N$'s are rejected at the 1% marginal significance level. The distinctive intraday patterns of $FAC_i^A$'s are mainly caused by the major macroeconomic announcements. However, one of the factors which causes $FAC_i^N$'s to exhibit an inverse U-shaped pattern may be the overlapping trading hours between the U.S., London, and European markets [Ferguson, Mann and Schneck (1993) Harvey and Huang (1991)]. For the *B*-sample, both factors contribute to the intraday patterns of $FAC_i^B$'s. In any case, the inverse U-shaped $FAC_i^N$'s suggests that the intraday patterns of information flows are inverse U-shaped when none of the 18 scheduled macroeconomic news announcements are released.

### *The Average Absolute Value of Price Changes*

Copeland and Galai (1983) show that the presence of informed traders induces dealers to quote higher bid–ask spread to minimize the loss. Higher individual dealer's quoted bid–ask spread is likely to cause higher market spread, ceteris paribus, which, in turn, enlarges the successive transaction price changes. Therefore, the AAC is expected to be positively correlated with information trading. From the intraday patterns of the average FAC's, one expects that the average AAC's will increase after the announcements and exhibit an inverse U-shaped pattern for the days without announcements.

The intraday patterns of average AAC's for the *A*-sample ($AAC_i^A$'s), *B*-sample ($AAC_i^B$'s), and *N*-sample ($AAC_i^N$'s) are shown in Figures 2(A) and 2(B) for DM and JY, respectively. Notice that the 7:30 and 9:00

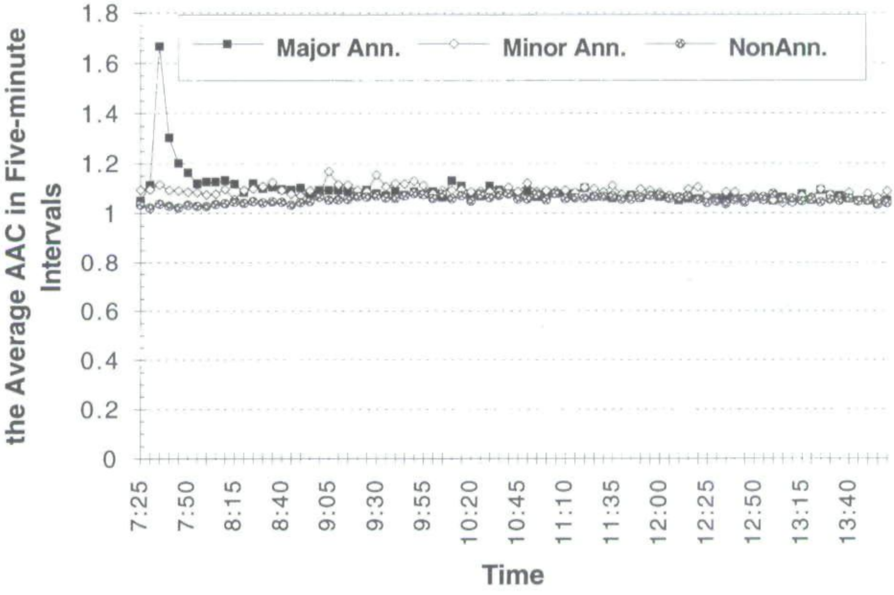


**FIGURE 2(A)**
Deutsche mark: 11/01/88–11/05/93.

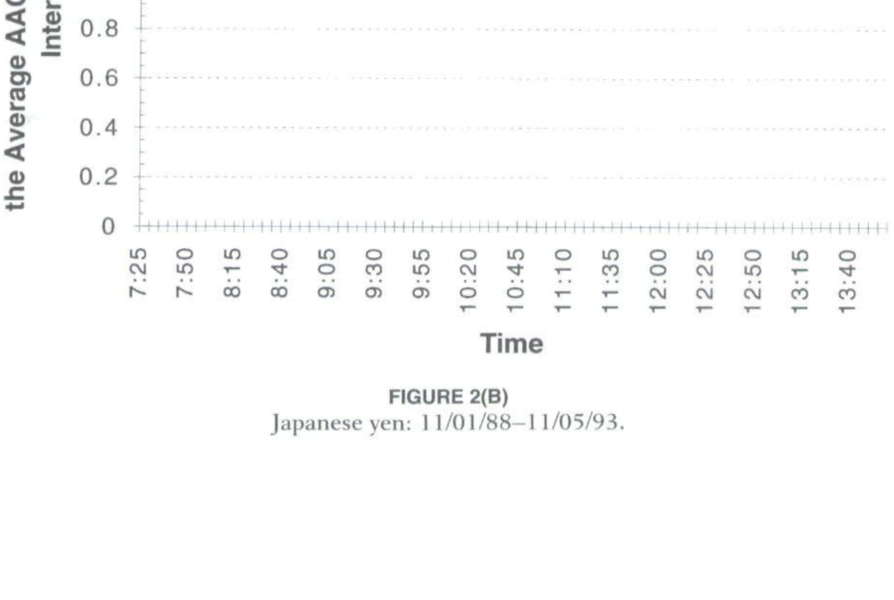


**FIGURE 2(B)**
Japanese yen: 11/01/88–11/05/93.

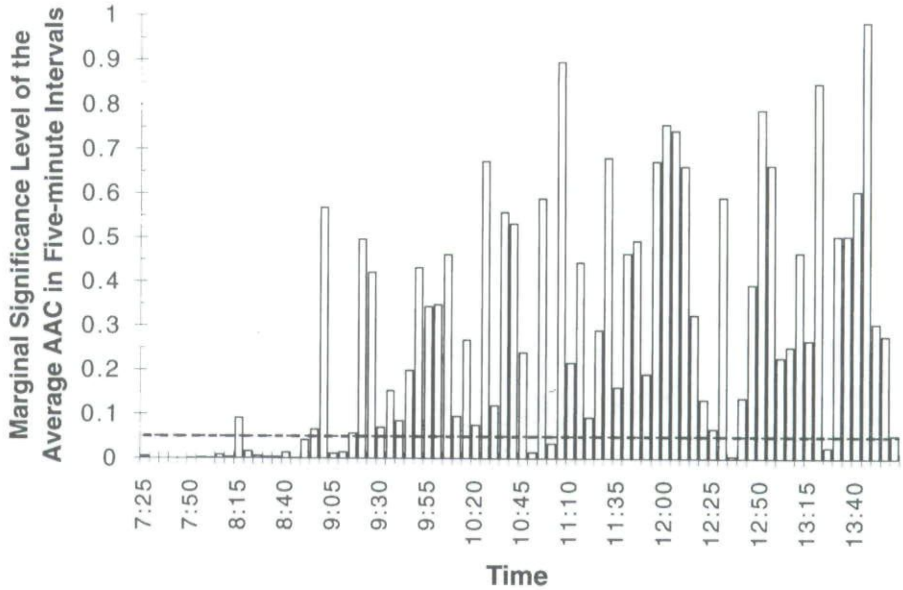


**FIGURE 2(C)**

Deutsche mark. H0: Sample mean of major ann. = sample mean of minor ann. only = sample mean of nonann.

announcements do enlarge the average AAC, especially, immediately following the major announcements, where $AAC_3^A$ is the largest for both currencies.

The test results for the null hypotheses, $AAC_i^A = AAC_i^B = AAC_i^N$, where $i = 1, \ldots, 80$, are presented in Figure 2(C) for DM and Figure 2(D) for JY. The null hypotheses are rejected mostly within two hours of trading at the 1% or 5% marginal significance level. From Figures 2(E) and 2(F), it is noteworthy that the differences between $AAC_i^B$'s and $AAC_i^N$'s are more pronounced and last longer for DM than for JY. This suggests that the change of dollar/mark exchange rate is more sensitive to U.S. macroeconomic news than to the dollar/yen exchange rate. Apparently, it takes a shorter time for $AAC_i^A$'s to converge to $AAC_i^N$'s than for $FAC_i^B$'s to converge to $FAC_i^N$'s. In other words, after one hour of trading, the enlarged transaction costs caused by a major announcement vanish. The transaction price path, however, is still noisy with trends. However, for the $B$-sample of DM, the opposite phenomena are observed. It takes longer for $AAC_i^B$'s to converge to $AAC_i^N$'s than for $FAC_i^B$'s to converge to $FAC_i^N$'s. This suggests that while the minor announcements do not affect the price path much, they do have a more lasting impact on transaction costs for DM. These findings suggest that information usually

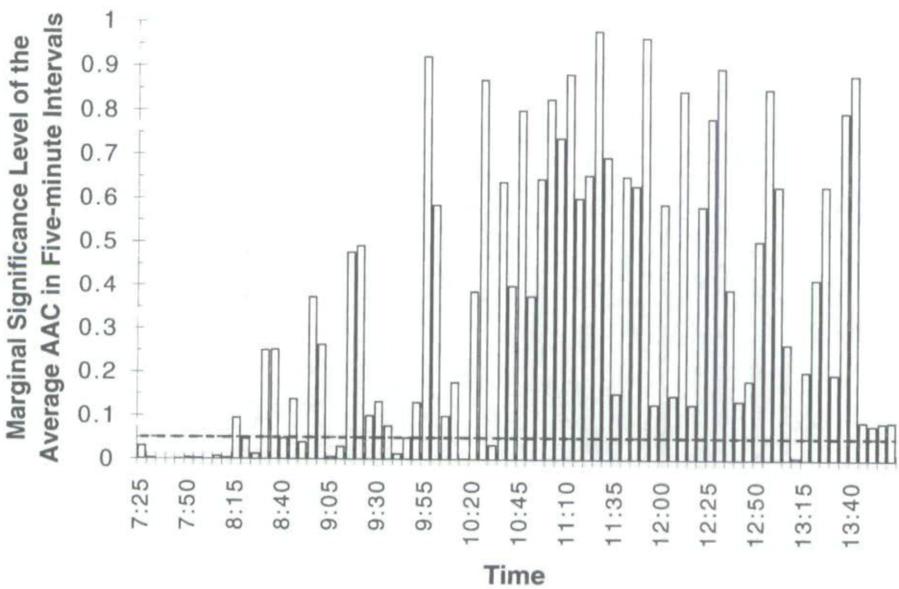


FIGURE 2(D)

Japanese yen. H0: sample mean of major ann. = sample mean of minor ann. only = sample mean of nonann.

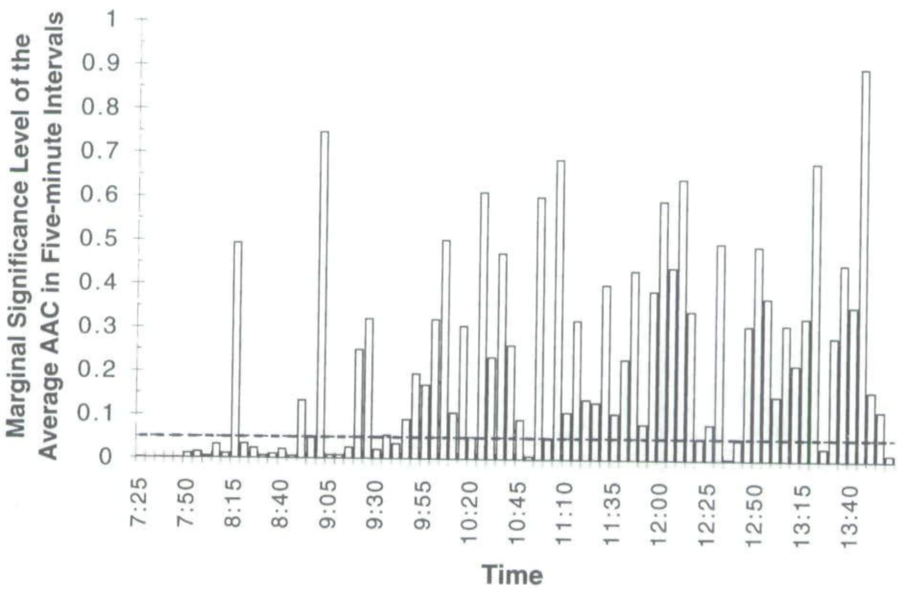


FIGURE 2(E)

Deutsche mark. H0: Sample mean of minor ann. only = sample mean of nonann.

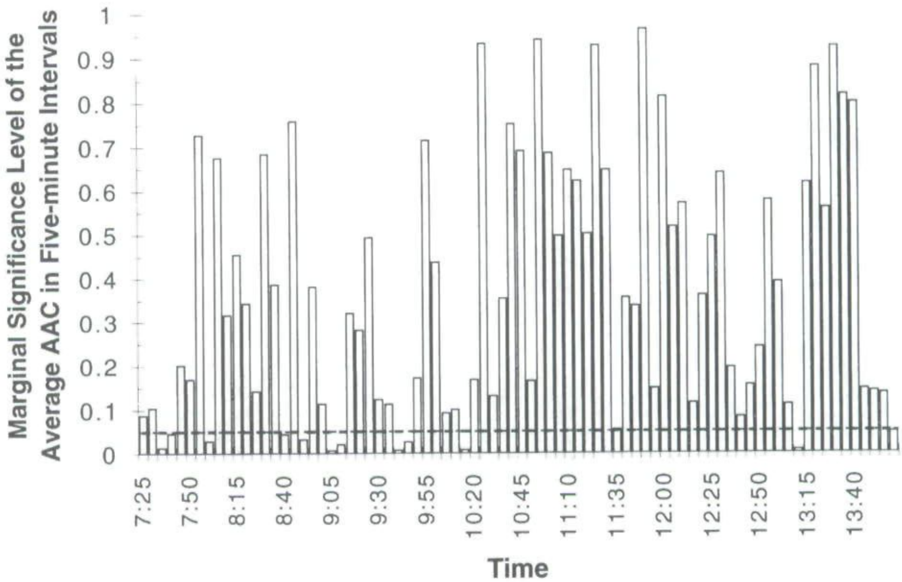


**FIGURE 2(F)**

Japanese yen. H0: Sample mean of minor ann. only = sample mean of nonann.

**TABLE II**

The Average AAC. H0: No Intraday Pattern

| | *Major Announcement A-Sample* | | *Minor Announcement B-Sample* | | *Nonannouncement N-Sample* | |
|---|---|---|---|---|---|---|
| | $\chi^2(8)$ | *P-Value* | $\chi^2(8)$ | *P-Value* | $\chi^2(8)$ | *P-Value* |
| Deutsche mark | 92.7503 | 0.0000 | 30.9011 | 0.0001 | 11.8383 | 0.1586 |
| Japanese yen | 123.4553 | 0.0000 | 42.8885 | 0.0000 | 42.9402 | 0.0000 |

affects both movement of transaction price and magnitude of successive price changes. But, sometimes, the news effect is only reflected by one of them.

Since the intraday patterns of the average AAC suggest the intraday patterns of transaction costs, it is important to know whether these patterns actually exist. Table II shows that the null hypothesis of equality of $AAC_i^A$'s and $AAC_i^B$ across the nine trading intervals is strongly rejected at the 1% marginal significance level for both DM and JY. For the $N$-sample, the intraday patterns of $AAC_i^N$'s are more significant for JY than for DM. In fact, for DM, the null hypothesis of no intraday patterns for $AAC_i^N$'s can not be rejected at the 10% marginal significance level. Figures 2(G)

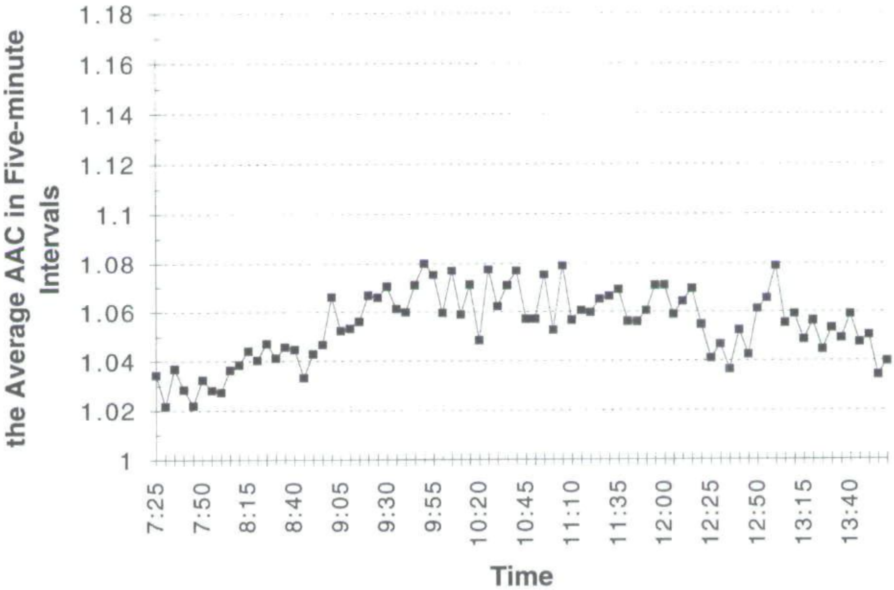


**FIGURE 2(G)**
Deutsche mark: 11/01/88–11/05/93 nonannouncement sample.

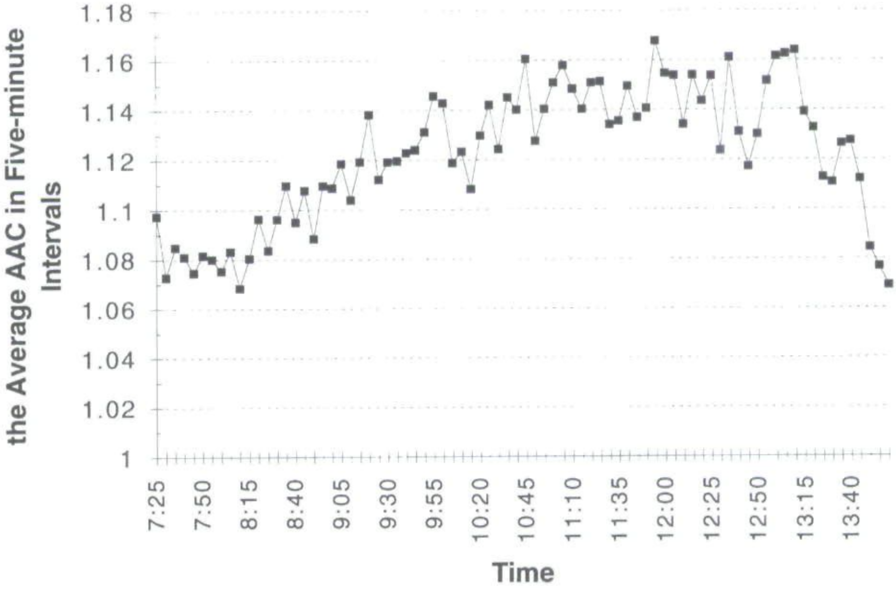


**FIGURE 2(H)**
Japanese yen: 11/01/88–11/05/93 nonannouncement sample.

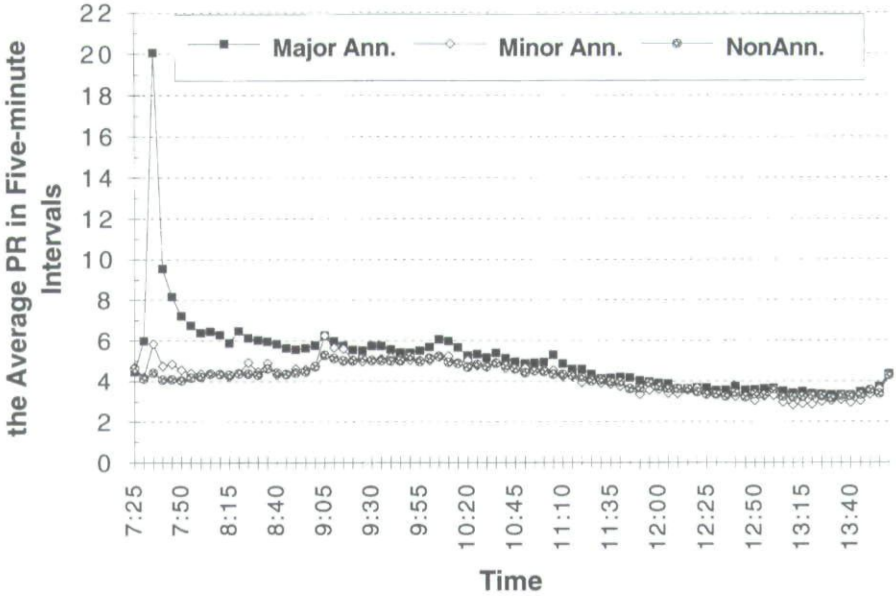


**FIGURE 3(A)**
Deutsche mark: 11/01/88–11/05/93.

and 2(H) present the replication (in different scale) of Figures 2(A) and 2(B) for the $N$-sample. Here, an inverse U-shaped pattern for $AAC_i^N$ is detected for both JY and (less obviously) for DM. This is further evidence that intraday information flows and transaction costs are also inversely U-shaped for the $N$-sample.

*The Price Ranges*

The PR is a measure of both volatility and maximal possible gross profit[17] over a five-minute trading interval. The intraday patterns of average PR's for the $A$-sample ($PR_i^A$'s), $B$-sample ($PR_i^B$'s), and $N$-sample ($PR_i^N$'s) are presented in Figures 3(A) and 3(B) for DM and JY, respectively. Notice that $PR_i^B$'s, $PR_i^N$'s are between 3 to 7 ticks, which indicates that off-floor traders generally hold positions longer than five minutes, because otherwise they could not make profits after subtracting transaction costs.[18] Similar to the intraday patterns of $FAC_i^N$'s and $AAC_i^N$'s, $PR_i^N$'s also exhibit an inverse U-shaped pattern.

For the A-sample, $PR_i^A$'s for DM are between 3 and 20 ticks, and for

[17]Maximal gross profit per contract for interval $i$, equals $PR_i^d \times \$12.5$.
[18]Kolb (1991) states that the transaction cost of a round turn for an off-the-floor trader is about \$25 (2 ticks) to \$80 (6.4 ticks) per contract. The transaction cost for a floor trader is probably less than \$1.

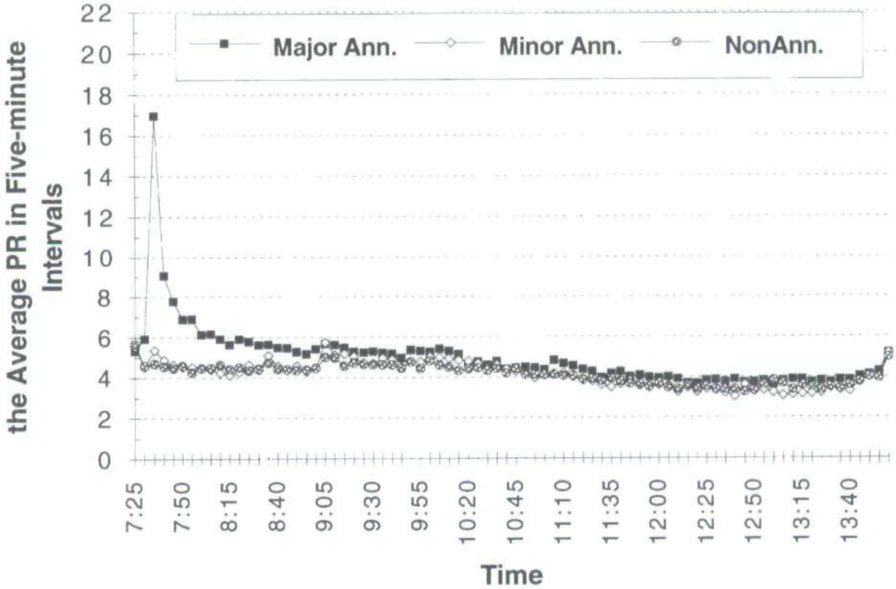


**FIGURE 3(B)**
Japanese yen: 11/01/88–11/05/93.

JY between 3 and 16 ticks. Maximal fluctuation for both currencies occurs at the 7:30–7:35 interval which is right after the 7:30 announcement time. The large $PR_i^A$'s give traders an incentive to try to predict macroeconomic statistics before they are announced. For example, a wise trader who buys one DM or JY contract at the five-minute low and sells it at the five-minute high (or vice versa), can, on average, make \$250 (for DM) or \$200 (for JY) per contract. This far exceeds all required transaction costs.

The null hypotheses, $PR_i^A = PR_i^B = PR_i^N$, where $i = 1, \ldots, 80$, are rejected at 34 intervals for JY and 38 intervals for DM at the 5% marginal significance level. Figures 3-(E) and 3-(F) show that the significant difference between $PR_i^B$'s and $PR_i^N$'s is, again, right around the announcement times. This, once more, demonstrates that major announcements have a greater and more lasting impact on both exchange rate paths than the minor announcements. Also, for both currencies, intraday patterns of $PR_i^A$'s, $PR_i^B$'s, and $PR_i^N$'s exist at the 1% marginal significance level, which are shown in Table III.

### *The Number of Price Changes*

Following Bagehot (1971), Copeland and Galai (1983) categorize the traders faced by the dealer into two types: the informed traders who pos-

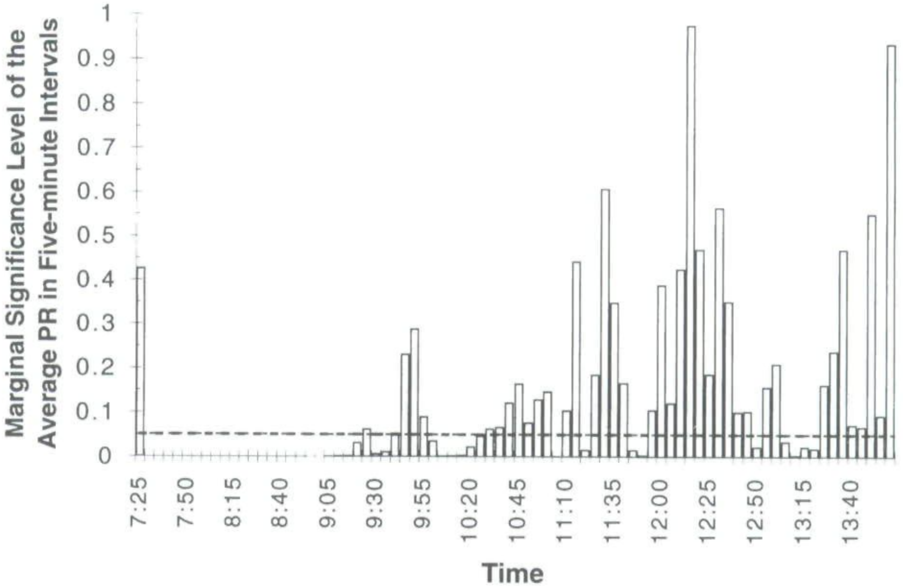


**FIGURE 3(C)**
Deutsche mark. H0: Sample mean of major ann. = sample mean of minor ann. only = sample mean of nonann.

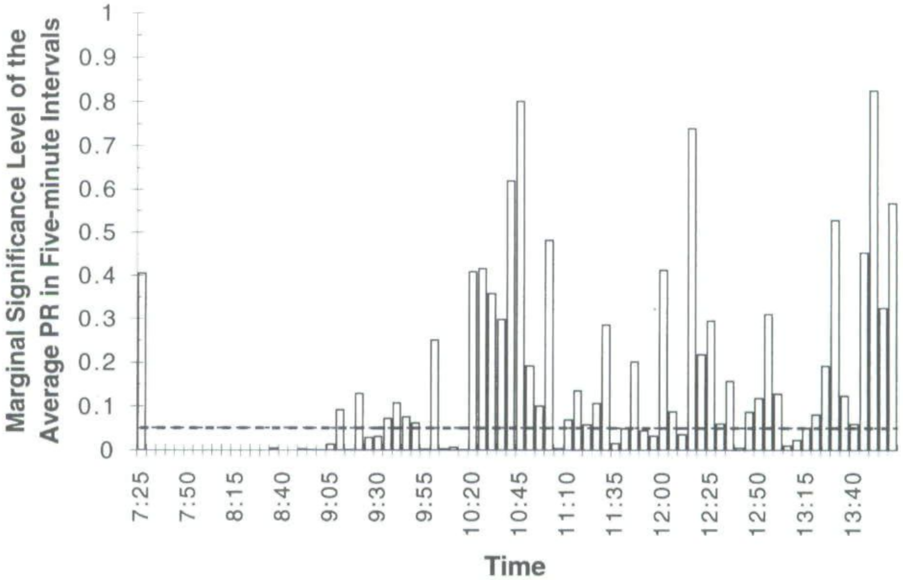


**FIGURE 3(D)**
Japanese yen. H0: Sample mean of major ann. = sample mean of minor ann. only = sample mean of nonann.

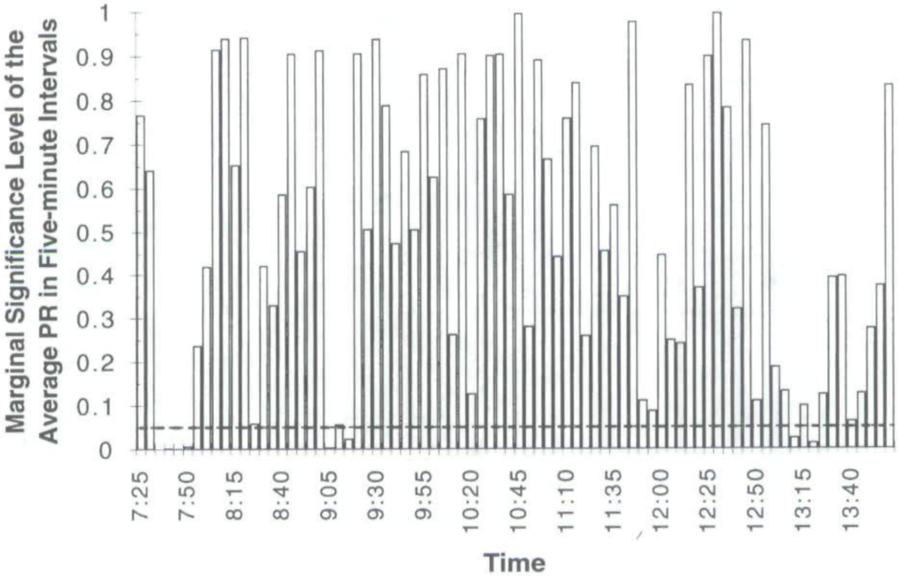


FIGURE 3(E)
Deutsche mark. H0: Sample mean of minor ann. only = sample mean of nonann.

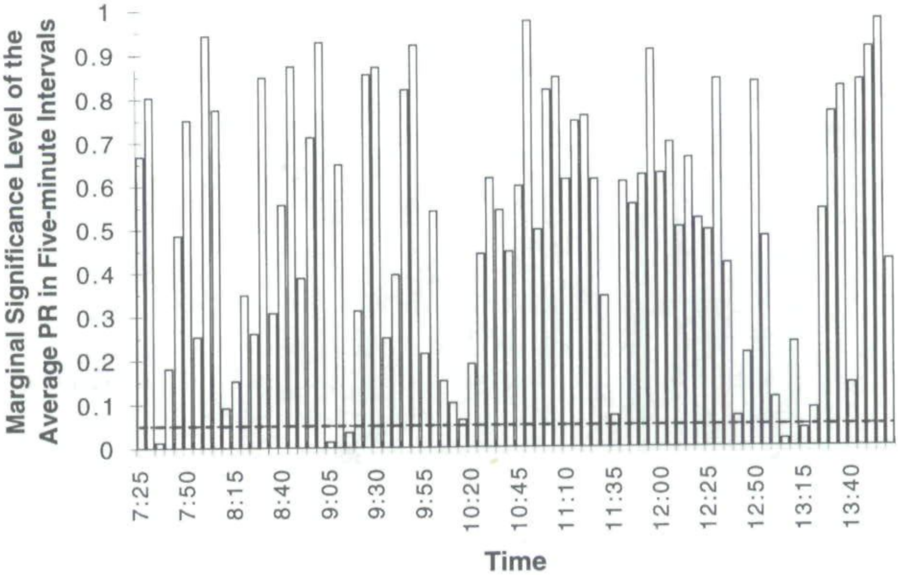


FIGURE 3(F)
Japanese yen. H0: Sample mean of minor ann. only = sample mean of nonann.

**TABLE III**

The Average PR. H0: No Intraday Pattern

| | *Major Announcement A-Sample* | | *Minor Announcement B-Sample* | | *Nonannouncement N-Sample* | |
|---|---|---|---|---|---|---|
| | $\chi^2(8)$ | *P-Value* | $\chi^2(8)$ | *P-Value* | $\chi^2(8)$ | *P-Value* |
| Deutsche mark | 645.9425 | 0.0000 | 256.8709 | 0.0000 | 155.4189 | 0.0000 |
| Japanese yen | 376.4409 | 0.0000 | 219.5546 | 0.0000 | 126.7222 | 0.0000 |

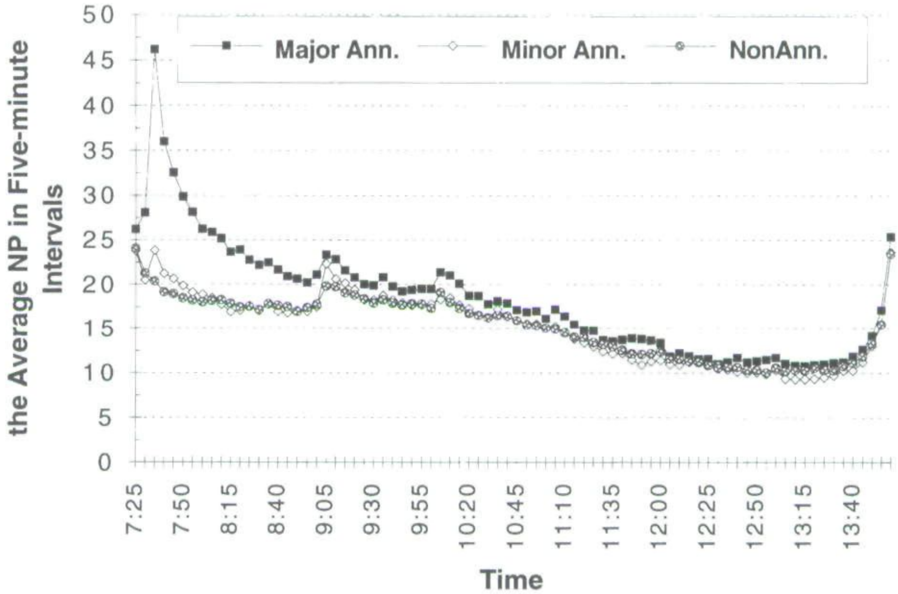


**FIGURE 4(A)**
Deutsche mark: 11/01/88–11/05/93.

sess special information and the liquidity-motivated traders. Holding information trading constant, the higher liquidity trading in the market is expected to increase NP without affecting FAC, AAC, and PR. In other words, the higher NP mainly comes from the higher random arrival rate of orders. On the other hand, holding liquidity trading constant, the higher information trading is likely to increase FAC, AAC, PR, and NP, because of higher fundamental variances. As Bagehot (1971) observes, information and liquidity trading are usually negatively correlated. Since the value of NP depends on both types of trading, the intraday pattern of the average NP for days without announcements is not obvious. However,

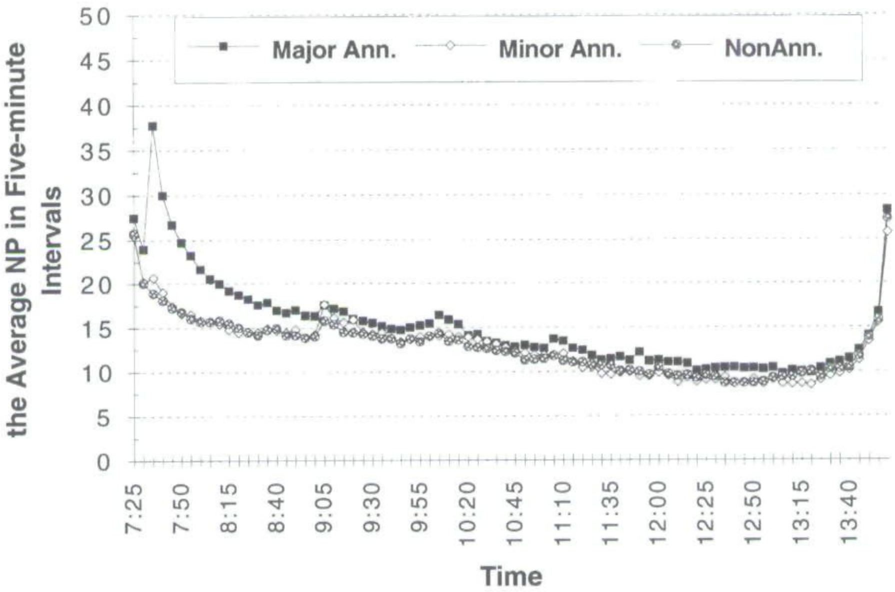


**FIGURE 4(B)**
Japanese yen: 11/01/88–11/05/93.

the average NP is expected to increase right after the announcements owing to the drastic increase in information trading which surpasses the decrease in liquidity trading.

Figures 4-(A) and 4-(B) show that, for both DM and JY, higher average NP's for the $A$-sample ($NP_i^A$'s) are recorded throughout the trading intervals than those for the $B$-sample ($NP_i^B$'s), and $N$-sample ($NP_i^N$'s). It is noteworthy that, for the $N$-sample of both currencies, $NP_{80}^N$ is higher than any other $NP_i^N$'s, where $i \neq 80$. Recall that, compared with the average FAC's and AAC's of other trading intervals, $FAC_{80}^N$ is more negative and $AAC_{80}^N$ is smaller most of the time. This indicates that the trading at the end is mainly driven by the liquidity demand of closing out outstanding positions. Meanwhile, the intraday pattern of $NP_i^N$'s is not inverse U-shaped, which suggests that the intraday pattern of liquidity trading for the $N$-sample is U-shaped. The high $NP_i^N$'s around opening and closing are attributed to liquidity-motivated portfolio rebalance trading [Brock and Kleidon (1992)], and the high $NP_i^N$'s around 9:00 and 10:00 generally comes from the increase in formation trading. For the $A$-sample, as expected, $NP_3^A$ is the largest for both DM and JY. The average time between price changes immediately following an announcement is 6–8 seconds. On the other hand, for the $B$-sample, both DM and JY display two small spikes at 7:30–7:35 and 9:00–9:05 intervals.

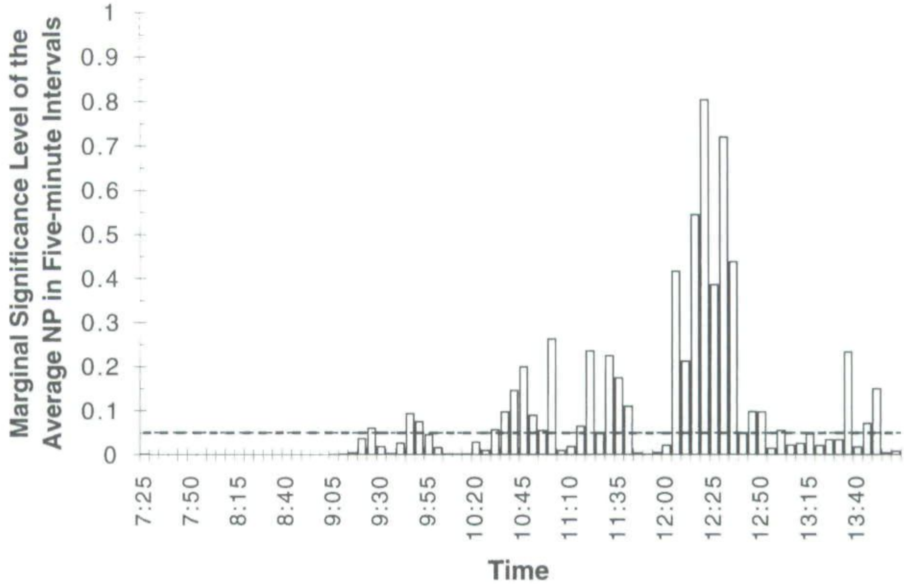


**FIGURE 4(C)**
Deutsche mark. H0: Sample mean of major ann. = sample mean of minor ann. only = Sample mean of nonann.

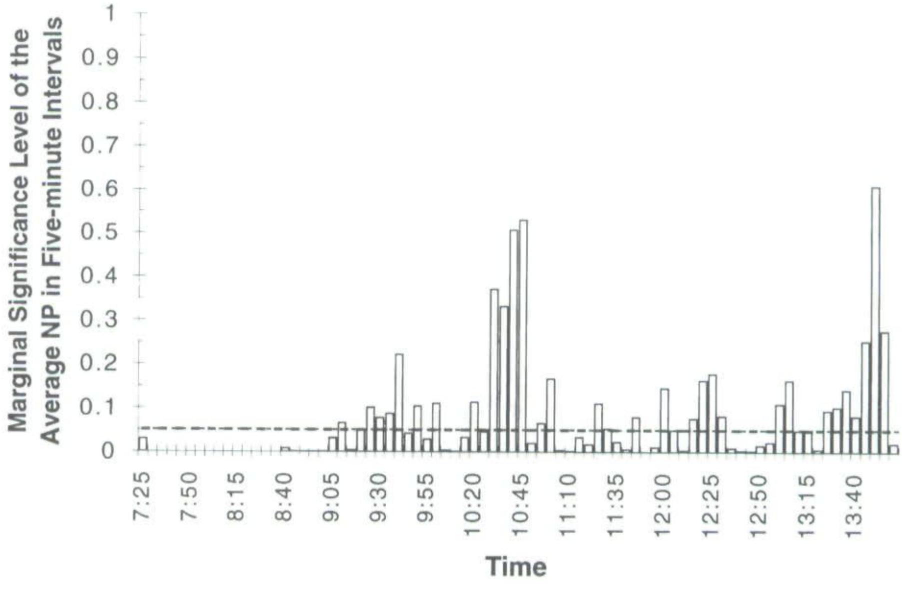


**FIGURE 4(D)**
Japanese yen. H0: Sample mean of major ann. = sample mean of minor ann. only = Sample mean of nonann.

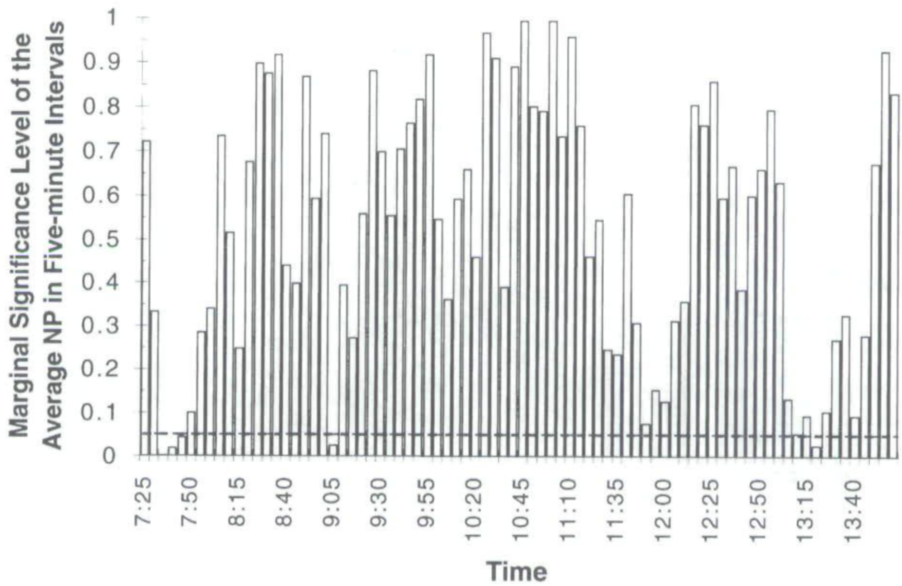


FIGURE 4(E)
Deutsche mark. H0: Sample mean of minor ann. only = sample mean of nonann.

Figures 4-(C) and 4-(D) show that the null hypotheses of equality between $NP_i^A$, $NP_i^B$, and $NP_i^N$ are rejected for most of the trading intervals at the 1% or 5% marginal significance level. However, the null hypotheses of $NP_i^B = NP_i^N$, where $i = 1, \ldots, 80$, can only be rejected right around the announcement times which are 7:30, 9:00, and 13:00. This further shows that the major announcements attract more information trading than the minor announcements.

As shown in Table IV, for both currencies, the null hypotheses of no intraday pattern are significantly rejected at the 1% marginal significance level for the *A*-sample, *B*-sample, and *N*-sample.

## CONCLUSIONS

This article presents how the dollar/mark and dollar/yen exchange rates react to the anticipated U.S. monthly macroeconomic announcements. Several important findings and conclusions follow.

First, for both currencies, the 7:30–7:35 interval, immediately after the major announcements, not only has the largest average AAC, NP, and PR and is the only trading interval with positive average FAC. The impact of seven major announcements on these four price statistics lasts for at least an hour. On the other hand, the impact of the other 11 minor an-

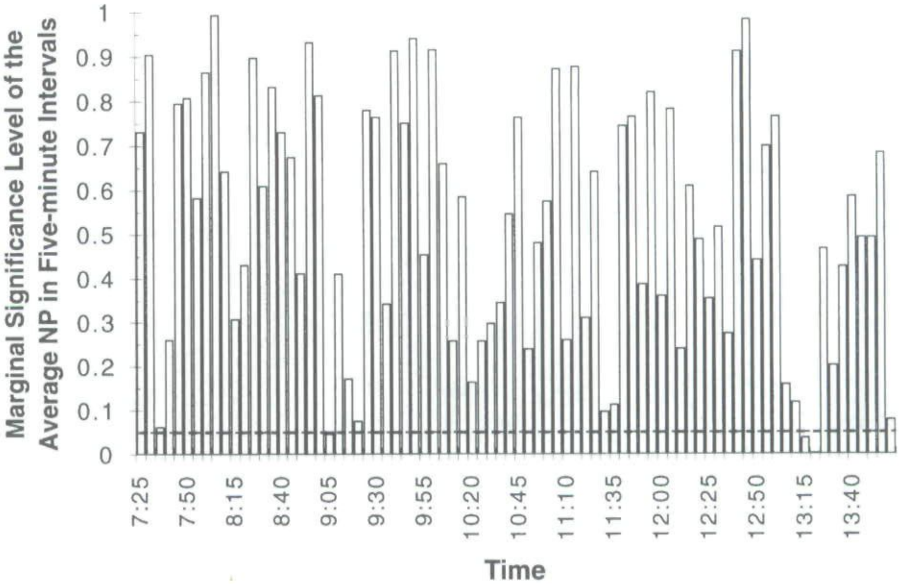


FIGURE 4(F)
Japanese yen. H0: Sample mean of minor ann. only = sample mean of nonann.

**TABLE IV**

The Average NP. H0: No Intraday Pattern

| | *Major Announcement A-Sample* | | *Minor Announcement B-Sample* | | *Nonannouncement N-Sample* | |
|---|---|---|---|---|---|---|
| | $\chi^2(8)$ | *P-Value* | $\chi^2(8)$ | *P-Value* | $\chi^2(8)$ | *P-Value* |
| Deutsche mark | 1775.5119 | 0.0000 | 822.3581 | 0.0000 | 1172.6679 | 0.0000 |
| Japanese yen | 1429.0743 | 0.0000 | 874.0548 | 0.0000 | 1364.3260 | 0.0000 |

nouncements is rather short lived. This indicates that higher information flows are more likely to be accompanied by partial price adjustments, higher transaction costs, a greater range of price fluctuations (large potential speculative profits), and more intensive information trading. These findings are intuitive in the sense that scalpers, unlike the NYSE specialists, have no obligation to make the market. Moreover, unlike the stock market, every participant in the market knows when important news is released. If the market is obviously on one side after the announcement, the optimal strategy for scalpers is to offer less quantity with enlarged bid–ask spreads [Lee, Mucklow and Ready (1993)] or even to jump on the price trend bandwagon [Working (1954)]. Therefore, the transaction price will change more rapidly and dramatically. In any case, market reaction to the news will stabilize in two to three hours.

Second, for the *A*-sample, the higher NP, caused by information trading after the announcements, also generates higher liquidity trading. This, in turn, stimulates higher NP at closing time. Hence, as closing time approaches, the average NP soars even though there is no significant difference in the other three mean statistics between the *A*-sample and the *N*-sample.

Third, for the *N*-sample, intraday patterns for the average FAC, AAC, and PR are inversely U-shaped, indicating that intraday information trading and transaction costs exhibit the same patterns.

Leng (1992) finds that DM and JY futures are efficient at the daily frequency. After observing the significant intraday patterns of the above four price statistics, one would ask whether the DM and JY futures are efficient at the intradaily frequency. Ederington and Lee (1994) and Ederington and Lee (1995) find that it only takes 50 seconds for JY and 40 seconds for DM to complete the reaction to the initial news release by focusing on two minutes before and ten minutes after the announcements. Nonetheless, the question whether there is a systematic price adjustment pattern at the intradaily frequency of whole trading days with explicitly considering the timing of macroeconomic announcements is left for future research.

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