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EFFICIENCY IN INFORMATION PROCESSING: A STUDY OF NON-NEARBY CURRENCY FUTURES AND RELATIONSHIPS WITH NEARBY COUNTERPARTS

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This paper provides a comprehensive analysis of the responses of non-nearby Japanese yen and Deutsche mark futures contracts to macroeconomic announcements and the efficiency of information flow between the nearby and non-nearby contracts. The results show that macroeconomic announcements affect the non-nearby futures returns more through their effects on interest rate differentials than through the underlying spot exchange rates. Information flows efficiently between the Deutsche mark nearby and non-nearby contracts, while information flows primarily from the Japanese yen nearby contracts to the non-nearby counterparts.

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INTRODUCTION

The responsiveness of financial asset prices to information has long been used to characterize market efficiency. The speed of price and volatility adjustment and risk-and-return relationships all have been used to measure the "responsiveness." The financial assets studied vary from common stocks, bonds, to T-bond futures and foreign currency futures. These markets are shown to incorporate information in short time periods, ranging from less than 30 minutes in foreign currency futures markets to several hours in stock markets.[1]

To pinpoint the effect of information, many studies use financial instruments that are moved mainly by public information as vehicles (e.g., T-bonds and financial futures) and scheduled macroeconomic announcements as information shocks for their endeavors. Some conclude that volatility patterns in foreign currency futures and T-bond futures are attributable to the concentration of macroeconomic announcements on Thursdays and Fridays, e.g., Harvey and Huang (1991),

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Ederington and Lee (1993), and Leng (1996). Andersen and Bollerslev (1998) and Han et al. (1999), however, conclude that macroeconomic announcements raise volatilities and help shape volatility patterns of the Deutsche mark and currency futures (including the Deutsche mark futures), but non-information factors such as trading motivated by portfolio rebalancing and microstructure of the markets do play a dominant role in shaping volatilities of futures.

Several recent studies on non-equity instruments focus on the information effects on returns and risk-return relationships. For the most part, announcement effects are incorporated into returns in one minute to four hours (e.g., Balduzzi et al. (2001) and Hotchkiss and Ronen (2002)). Jones et al. (1998) and Han and Ozocak (2002) find some risk/return tradeoffs in T-bonds and foreign currency futures, respectively. Li and Engle (1998), however, find no statistically significant risk premium for the higher volatility following the announcements.

Those studies on futures have uniformly used nearby contracts as instruments and have yielded important results.[2] Nearby contracts are important for hedging and speculation and are thus liquid. Non-nearby contracts, although less important in both functions, are natural instruments for hedging for periods longer than three months. Furthermore, non-nearby futures are important for some hedging and speculative strategies. The calendar spread, for example, uses futures options with the same strike price but different expiration dates in opposite positions. A trader may create a calendar spread by selling a call option on March futures with a certain strike price and buying a call option on June futures with the same strike price, and *vice versa*. At the expiration of the March contract, traders may trade their position forward by buying the June contract and selling the September contract at expiration of the March contract. Although most futures options trading does not involve the delivery of the underlying futures, the trading of futures options tends to make the futures markets efficient.

The manner in which nearby contracts respond to information is well documented as briefed above, but it is not so for non-nearby contracts. Our understanding of financial market efficiency in information processing would be incomplete without the knowledge of how the less liquid contracts incorporate new information and how the less liquid and the more liquid contracts interact (perhaps with the aide of the trading of futures options) in search of new equilibriums.

This study attempts to fill that void by providing a comprehensive analysis of non-nearby contracts' responses to macroeconomic announcements and by examining the interactions of nearby and non-nearby contracts. Non-nearby contracts differ from nearby contracts in two main areas: less liquidity and longer maturity. Less liquidity makes it likely that returns on non-nearby contracts include a liquidity premium as a component.[3] A longer maturity suggests that macroeconomic announcements can affect futures returns by way of their effect on interest rate differential as well as on the underlying spot exchange rate. These can potentially cause non-nearby contracts to process information differently from nearby contracts. Furthermore, it is important to examine whether and to what extent that non-nearby contracts' illiquidity hinders the interaction of nearby and non-nearby markets.

This study modifies the interest rate parity relationship by incorporating the effects of macroeconomic announcements on non-nearby futures returns through their effects on the underlying spot exchange rate, interest rate differential, and liquidity premium. The futures on the Deutsche mark and Japanese yen are chosen as the financial instruments because their non-nearby contracts are illiquid enough to differ from nearby contracts but liquid enough to complete price adjustments within hours and also because they are thought to be moved mainly by public information like macroeconomic announcements.

Although information or announcements made in Japan and Germany can also affect these futures, it is not the intent of this study to examine non-nearby contracts' response to all information.[4] Instead, this study focuses on the seven indicators regularly announced at 7:30 am CT: the consumer price index (CPI), durable goods order (DGO), non-farm payroll or employment (EMP), gross domestic product (GDP), merchandise trade deficit (MTD), producer price index (PPI), and retail sales (RTS).[5] Han and Ozocak (2002) show that nearby Japanese and Deutsche mark contracts respond differently to indicators with different information content. This differentiation is particularly important to the study of non-nearby contracts. The longer maturity may make non-nearby contracts more responsive to indicators with high content of information on inflation as Fleming and Remelona (1997) have found for T-bonds.

The results show that the announcement surprises affect non-nearby futures returns more through their impact on interest rate differentials than through the underlying spot exchange rates.[6] Both currency futures respond to the seven macroeconomic indicators examined here, but in different patterns. For example, the Japanese yen shows most responses to the producer price index and retail sales surprises, while the Deutsche mark shows most responses to the merchandise trade deficit and consumer price index surprises.

Admati and Pfleiderer (1988) predict that liquidity premium may decline as liquidity traders come into the market to seek the liquidity created by information traders.[7] This study finds that the Deutsche mark exhibits a significant reduction in liquidity premium in the fifth trade, followed by an immediate recovery to the pre-announcement level in the sixth trade, while the Japanese yen shows no reduction in liquidity premium throughout the first 10 trades. These suggest that the information-stimulated trading not be sufficient to reduce liquidity premium, but the announcements do raise the volatilities. Similar to nearby contracts, the non-nearby contracts show day-of-the-week effect in volatility even in the absence of the announcements.

This study examines the flow of information between the nearby and non-nearby contracts by assessing the extent to which the non-nearby contracts move in the same direction as the nearby contracts after observing the latter and *vice versa*, similar to the method used in Patell and Wolfson (1984).[8] An advantage of this method is that it does not depend on any pricing model and is therefore free of pricing specification errors.

Surprisingly, despite of the non-nearby contracts' illiquidity, the Deutsch mark nearby and non-nearby contracts exhibit feedback relationships in the first 13 trades of non-nearby contracts. The announcements make the flow of information in both directions more pronounced only in the first, second, third, and fifth trade on the announcement days. By contrast, the Japanese yen shows no such announcement effect. Furthermore, the Japanese yen nearby contracts lead the non-nearby contracts in all 13 trades examined here, as opposed to the feedback relationships observed in the Deutsche mark futures. This suggests that information flows more efficiently between the Deutsche mark nearby and non-nearby contracts than between the Japanese yen contracts. The striking difference is perhaps due to the fact that the CME trading hours and Japan's normal business hours do not overlap.

The remainder of this paper is organized as follows. The next section provides the statistical description of the data on scheduled macroeconomic announcements, the methodology utilized to form the return series, and the results of the regression of the response times on the announcement surprises. The section after next describes the GARCH model and reports the results. It is then followed by the section which studies the interactions (or lead-lag relationships) of the nearby and non-nearby contracts. The last section concludes this study.

DATA, RETURN SERIES CONSTRUCTION, AND PRELIMINARY RESULTS

The data on scheduled announcements of seven major macroeconomic indicators, namely, the consumer price index (CPI), durable goods order (DGO), non-farm payroll or employment (EMP), gross domestic product (GDP), merchandise trade deficit (MTD), producer price index (PPI), and retail sales (RTS) for the period spanning from January 1992 to December 1997 are obtained from Thomson Global Markets. These indicators are announced at 7:30 am Central Time (CT) and are chosen based on their importance in previous research.[9] The data set contains the dates and times of the announcements, the minimum, maximum, and median forecast values, and the actually announced values.

Table 1 shows the cross tabulation of the above macroeconomic announcements by indicators and days of the week. Concurrent announcements on the same days are rare. The EMP announcements are made exclusively on Thursdays and Fridays. The announcements of other indicators such as CPI and RTS, are more evenly distributed across the week. On the whole, the announcements concentrate more on the later part of the week.

As in Han and Ozocak (2002), we capture the macroeconomic announcement effects on returns and volatilities with announcement surprises and announcement dummies, respectively. To allow for comparisons across macroeconomic indicators, the announcement surprises are calculated according to Balduzzi et al. ((2001), eq. 3):

Table 1
Distribution of Announcements

Announcement	*Mon*	*Tue*	*Wed*	*Thu*	*Fri*	*Sum*
Consumer Price Index (CPI)	1	17	21	15	20	74
Durable Goods Orders (DGO)	0	5	36	17	14	72
Employment (EMP)	0	0	0	2	70	72
Gross Domestic Product (GDP)	0	7	15	19	29	70
Merchandise Trade Deficit (MTD)	0	10	20	27	15	72
Producer Price Index (PPI)	0	14	10	23	26	73
Retail Sales (RTS)	1	20	10	25	18	74
Sum of Announcements	2	73	112	128	192	507
Number of Announcement Days	2	62	102	113	174	453

Notes: The above seven different macroeconomic announcements were made at 7:30 am (Central Time) during the period ranging from January 2 1992 through December 31 1997. The sum of announcements refers to the total number of announcements made on each trading day, while the number of announcement days refers to the trading days when one or more announcements were made.

$$surp_{m,t} = \frac{A_{m,t} - G_{m,t}}{\sigma_m} \tag{1}$$

where $surp_{m,t}$ denotes the standardized surprise of indicator *m* on day *t*; $A_{m,t}$ denotes the announced value of indicator *m* on day *t*; $G_{m,t}$ denotes the median of the survey data from Thomson Global Markets; σ_m denotes the standard deviation of the surprises ($A_{m,t} - G_{m,t}$) for indicator *m*. Table 2 reports the summary statistics on announcement surprises. DGO and MTD have the highest announcement surprises. Due to government shutdown from November 1995 to January 1996, not all macroeconomic indicators have the same numbers of announcements during the sample period.

Table 2
Simple Statistics of Announcement Surprises

Announcement	*N*	*Mean*	*Median*	*Std Dev*	*Min*	*Max*
Consumer Price Index (CPI)	74	-0.0257	0.0000	0.1048	-0.3000	0.3000
Durable Goods Orders (DGO)	72	0.2610	0.6500	2.3314	-4.6000	6.9000
Employment (EMP)	72	-0.0431	0.0000	0.1591	-0.4000	0.4000
Gross Domestic Product (GDP)	70	0.0871	0.1000	0.7167	-4.1000	1.6000
Merchandise Trade Deficit (MTD)	72	0.0710	-0.3000	3.1220	-4.0000	20.3000
Producer Price Index (PPI)	73	-0.0781	-0.1000	0.2083	-0.6000	0.4000
Retail Sales (RTS)	74	-0.0581	-0.0500	0.4068	-1.1000	1.1000

Notes: The above announcement surprises are computed by taking the difference between the actual and predicted values of the announcements.

Tick futures data on the Deutsche mark and Japanese yen for the same time period are obtained from the Futures Industry Institute. The data encompass the time and price of every trade involving a price change.

At any given time, three to four contracts for each currency futures are traded on the market. This study uses two contracts to construct two price series. To construct the nearby price series, the prices of the March 1992 contract, for example, are used for the price series running from January 2, 1992 until the last trading day in February 1992 and then the prices of the June 1992 contract are used until the last trading day in May 1992. For the non-nearby price series, the prices of the June 1992 contract are used from January 2, 1992 until the last trading day in February 1992 and the prices of the September 1992 contract are used for the trading days of March through May. The days to maturity for the nearby contracts range from 15 to 112 days while those for the non-nearby contracts range from 105 to 204 days.

Previous studies using high-frequency data usually set a time interval, often one-minute or five minute interval, for which the return is calculated. The interval return is then calculated as the natural logarithm of the ratio of the last price in the current interval over the last price in the previous interval. This method works fairly well for the nearby price series because nearby contracts are extremely liquid and therefore the actual time spaces for the last-to-last returns do not vary widely. This method, however, will create a large variability in the actual time space between the last-to-last prices for the non-nearby return series, no matter what time space is chosen because the time space between any two trades for the non-nearby contracts varies widely. Moreover, setting the time interval too short will create a large number of missing observations, while setting the time interval too long will dilute any announcement effect there might be. A solution to this problem is to create return series from a series of consecutive trades and then to perform analyses with the time space in between controlled for. For example, the first return series is created by taking the natural logarithm of the ratio of the transaction price immediately after 7:30 am CT over the transaction price immediately before or upon 7:30 am. The second return series is created by taking the natural logarithm of the ratio of the second over the first price after 7:30 am.

Table 3 presents the simple statistics for the time space (also referred to as response time) between two consecutive trades. The first response time averages 12.27 seconds for Deutsche mark's nearby contracts and 1,316 seconds (about 22 minutes) for non-nearby contracts on announcement days. [10] On non-announcement days, they are 26 seconds and 1,717.5 seconds, respectively. Similar observations hold for the Japanese yen futures. The table not only contrasts the liquidity of nearby and non-nearby contracts but also shows that the announcements reduce response times by and large.

Admati and Pfleiderer (1988) show theoretically that, if there is at least one information trader, information releases attract informed traders to the markets, creating liquidity that would further bring in discretionary liquidity traders and thus raising the liquidity of the financial asset in question. This explains why response times for both nearby and non-nearby contracts should shorten on announcement days at least for the first few trades. Nonparametric Mann-Whitney tests are used to test the significance of the announcement effect on the response times.[11] The announcements appear to have less effect on Japanese yen non-nearby contract's response times.

The differences in the response times of the nearby contracts and non-nearby contracts strongly suggest that the first trade of the non-nearby contracts be executed with the information implicit in the trades of the nearby contracts occurring before it. It is also likely that the trades of the nearby contracts take cues from the trades of non-nearby contracts. This is examined in a later section.

An immediate follow-up question is whether the reduction in response time is related to the absolute values of surprises. The contention is that the larger the surprise, the higher the profit potential for those who bet in the right direction (or the larger the loss for those who bet in the wrong direction). Thus, traders are more likely either to realize the profit or to cut the loss quickly when the surprise is large, leading to a reduction in response time. Regressions of response times on the absolute values of surprises are performed for both currencies' nearby and non-nearby contracts. With a few exceptions, the response times and the absolute values of surprises are negatively correlated but not statistically significant at the 5% level.[12] This lack of statistical significance is factored into our modeling of the return generating function presented in the next section.

GARCH MODEL AND RESULTS

Previous studies have shown that nearby foreign currency futures contracts respond to macroeconomic announcements very quickly both in return and volatility. Similar results could

Table 3
Simple Statistics of Response Times

Panel A:		*Nearby Deutsche mark futures contracts*								*Non-nearby Deutsche mark futures contracts*							
		N	*N**	*Mean*	*Median*	*Std Dev*	*Min*	*Max*	*P-Value*	*N*	*N**	*Mean*	*Median*	*Std Dev*	*Min*	*Max*	*P-Value*
t_1	Ann.	450	0	12.27	7.0	29.12	1	531	0.0000	437	0	1316.0	317.0	2597.0	2	21987	0.0000
	Non-ann.	1065	0	26.21	10.0	86.93	1	2440		1022	0	1717.5	535.0	2976.2	1	23409	
t_2	Ann.	450	0	10.67	6.0	14.82	1	145	0.0000	425	12	1351.0	412.0	2137.0	4	18020	0.0066
	Non-ann.	1065	0	23.62	12.0	41.47	1	575		995	27	1592.9	615.0	2501.8	4	19071	
t_3	Ann.	450	0	9.64	6.0	12.17	1	108	0.0000	415	22	1203.0	410.0	1915.1	3	13539	0.0002
	Non-ann.	1065	0	24.92	12.0	42.23	1	450		960	62	1472.8	632.0	2180.5	6	16982	
t_4	Ann.	450	0	10.88	6.0	18.55	1	196	0.0000	403	34	1310.0	480.0	2214.0	2	15511	0.1416
	Non-ann.	1065	0	24.47	12.0	45.13	1	791		918	104	1171.4	488.5	1810.4	3	19747	
t_5	Ann.	450	0	11.25	6.0	16.19	1	158	0.0000	387	50	1224.8	497.0	1937.7	4	12814	0.0650
	Non-ann.	1065	0	27.89	13.0	58.80	1	811		887	135	1292.1	514.0	1925.9	4	14192	
Panel B:		*Nearby Japanese yen futures contracts*								*Non-nearby Japanese yen futures contracts*							
		N	*N**	*Mean*	*Median*	*Std Dev*	*Min*	*Max*	*P-Value*	*N*	*N**	*Mean*	*Median*	*Std Dev*	*Min*	*Max*	*P-Value*
t_1	Ann.	450	0	15.64	9.0	26.30	1	227	0.0000	430	0	1934.0	496.0	3532.0	1	23498	0.0834
	Non-ann.	1066	0	24.88	12.0	44.11	1	473		996	0	1821.7	563.0	3108.7	1	23338	
t_2	Ann.	450	0	14.20	7.0	31.40	1	565	0.0000	414	16	1709.0	502.0	2943.0	4	18994	0.3086
	Non-ann.	1066	0	23.39	12.0	36.38	1	388		955	41	1599.3	550.0	2685.0	2	17415	
t_3	Ann.	450	0	14.96	7.0	29.06	1	383	0.0000	398	32	1513.0	431.0	2654.0	3	20210	0.1629
	Non-ann.	1066	0	28.77	12.0	58.28	1	749		920	76	1499.0	550.0	2362.6	3	17758	
t_4	Ann.	450	0	13.98	7.0	27.01	1	337	0.0000	376	54	1339.0	424.0	2408.0	5	17876	0.0015
	Non-ann.	1066	0	24.84	11.0	59.42	1	1360		875	121	1515.2	600.0	2341.0	3	17052	
t_5	Ann.	450	0	13.33	7.0	21.70	1	248	0.0000	361	69	1242.4	514.0	1882.4	6	12150	0.2117
	Non-ann.	1066	0	25.33	11.0	56.25	1	790		836	160	1378.9	559.5	2163.8	4	13453	

Notes: t_i (for $i = 1,2,\ldots,5$) denotes the i^{th} response time (in seconds) on announcement (Ann.) and non-announcement (Non-ann.) days, *N* denotes the number of response times from 1992 to 1997, and *N** denotes number of missing observations. Also, the nonparametric Mann-Whitney test of the equality of two population medians is used to test the hypotheses: H_0: no difference between the median of the response times when there is/are announcement(s) and the median of the response times when there is no announcement versus H_a: the median of the response times when there is/are announcement(s) is less than the median of the response times when there is no announcement.

be expected for their non-nearby counterparts. As discussed in Introduction, on the one hand, liquidity and maturity differentiate the two contracts. On the other hand, the efficiency of non-nearby contracts is expected to be held in check by trading strategies involving futures options. It is particularly interesting to examine whether and how the lower liquidity affect the non-nearby contracts' response to announcements. This section provides a comprehensive examination of the non-nearby contracts' responses in terms of returns and volatilities. The model specification is based on the following considerations and is detailed in the Appendix.

It is well known that returns on foreign currencies and their derivatives exhibit heteroscedasticity (e.g., Harvey and Huang (1991), Ederington and Lee (1993), Andersen and Bollerslev (1997 & 1998), Christine-David and Chaudhry (1999), and Han et al. (1999)), which can be controlled for with the use of ARCH/GARCH models. This study employs a GARCH model to correct the heteroscedasticity and to examine average returns and volatilities simultaneously. Han and Ozocak (2002) find that foreign currency futures' returns and volatilities have linear relationships with announcement surprises and announcement dummies, respectively. This study follows their suit with a major modification by differentiating the surprises' effects on the spot exchange rate, interest rate differential between the domestic rate and foreign rate, and liquidity premium.

As shown in eq. (A-1) in the Appendix, the derivation starts with the interest rate parity specification of futures' price with an additional term to capture liquidity premium. The announcement effects on spot exchange rate and spot interest differential are assumed to be linear to the announcement surprise with a constant term. This specification allows for the possibility that, even in the absence of surprises, the spot exchange rate may change (eq. (A-6)). Although the futures price is supposed to reflect the average expectation of the macroeconomic indicator's value before the announcement, it is likely that investors revise their view of the indicator's impact after the announcement even if there is no surprise. The specification for interest rate differential (eq. (A-7)), on the other hand, assumes that interest rate differential will stay constant in the absence of announcement surprises.

In addition, the announcement also affects the return through its effect on liquidity trading and thus liquidity premium. With surprises being used to capture the effect of information, announcement dummies are left as the only means to capture the announcement effects on liquidity premium. Not to overburden the model, all macroeconomic indicators are assumed to have the same effect on liquidity (and thus liquidity premium) as shown in eq. (A-8).

The insignificant relationships between the response times of the non-nearby contracts and the absolute values of the surprises lead us to model the response times independent of the announcement surprises. Substituting the component response equations (eqs. (A-6), (A-7), and (A-8)) into the expression of the non-nearby return, eq. (A-5), yields a return generating function with only response time, time to maturity, announcement surprises, announcement dummy, and their interaction terms as independent variables in the first-moment equation.

Under the assumption that the return and its variance in a unit of time are independent of those in successive times, a T-minute return should be T times the one-minute return and the T-minute variance should be T times the one-minute variance. Because all return series of the non-nearby contracts have varying time spaces, response time is controlled for in the second-moment equations of the GARCH model.

Another set of variables in the second-moment equation is the day-of-the-week dummies. Han et al. (1999) find day-of-the-week effects in volatilities of foreign currency futures on non-announcement days. Han and Ozocak (2002) confirm day-of-the-week effects in volatilities but find no such effects in returns on foreign currency futures, all with macroeconomic announcements controlled for. This study therefore controls for day-of-the-week effects in the second-moment equation but not in the first-moment equation.

The above considerations lead to the following model:[13]

$$R_{i,t} = \mu_i + \psi_i T_t + \rho_i d_{i,t} + \kappa_i D_t + \sum_{m=1}^{7} \delta_{i,m} \left(surp_{m,t} \right) + \sum_{m=1}^{7} \tau_{i,m} \left(surp_{m,t} \cdot d_{i,t} \right) + \sum_{m=1}^{7} \varphi_{i,m} \left(surp_{m,t} \cdot T_t \right) + \varsigma_{i,t}, \quad (2)$$

$$\vartheta_{i,t} = \left(1 + \sum_{m=1}^{7} \eta_{i,m} ANN_{m,t} + \sum_{k=2}^{5} \lambda_{i,k} DOW_{k,t} \right) T_t, \quad (3)$$

$$h_{i,t} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1}, \quad (4)$$

where $R_{i,t}$ is the i^{th} log return at time t calculated from the non-nearby price series. T_t denotes the days to maturity on day t. $d_{i,t}$ denotes the response time (or time space) for the i^{th} trade on day t. D_t denotes the announcement dummy, which has the value of 1 if any of the seven indicators is announced on day t and 0 otherwise. $ANN_{m,t}$ is a dummy variable for macroeconomic indicator m, which has the value of 1 if indicator m is announced on day t and 0 otherwise. $DOW_{k,t}$ is the dummy for day k of the week. $\varsigma_{i,t} = \vartheta_{i,t}^{1/2} \varepsilon_{i,t}$ is the i^{th} error term where $\varepsilon_{i,t}$ is a random variable with conditional mean zero and conditional variance $h_{i,t}$, independent of $\vartheta_{i,t}$. The specification of allows for the accounting of announcement, day-of-the-week, and days-to-maturity effects on conditional variances. For example, if the coefficients for employment announcements and Fridays are significant, then the conditional variance for the employment announcements on Friday is . The Appendix has the details on the parameters and variables in the above equations.

The Simplex method is employed to find preliminary estimates, which subsequently serve as the initial values for the maximum likelihood estimation with the BHHH (Berndt, Hall, Hall, and Hausman) method. The results for the first five trades of the Deutsche mark non-nearby return series are reported in Table 4 to provide perspectives on the magnitudes and significances of the coefficients. To conserve space, the results for the Japanese yen non-nearby contracts are not reported but are summarized in Table 5, along with the summary for the Deutsche mark non-nearby contracts.[14]

Table 4
Estimation of Parameters in the GARCH Model for the Non-nearby Deutsche Mark Futures Contracts

Predictor	*1st Return Coefficient*	*2nd Return Coefficient*	*3rd Return Coefficient*	*4th Return Coefficient*	*5th Return Coefficient*
Intercept	-0.03680	-0.01293	0.00893	-0.01041	-0.01990
Days to maturity (T_t)	0.00033	0.00012	-0.00004	0.00008	0.00023
Response time ($d_{i,t}$)	-0.00013	-0.00024**	0.00011	-0.00016*	-0.00026**
Announcement Dummy (D_t)	-0.00880	-0.00009	-0.00786	0.00320	-0.01572*
Consumer Price Index Surprise (CPIS)	0.09644	-1.40061	1.12173	-0.82719	-0.20178
Durable Goods Orders Surprise (DGOS)	0.04937	-0.04290	0.00668	-0.04207	-0.06830
Employment Surprise (EMPS)	1.22176	-1.02672	0.61538	-0.28431	-0.33820
Gross Domestic Product Surprise (GDPS)	0.12373	0.02633	-0.20280	0.15541	0.01444
Merchandise Trade Deficit Surprise (MTDS)	0.09354	0.00442	0.08494*	-0.04376	-0.01697
Producer Price Index Surprise (PPIS)	-1.89800**	0.22356	0.09659	0.17831	-0.00659
Retail Sales Surprise (RTSS)	-0.29778	-0.04220	-0.28704	-0.17735	0.05048
$d_{i,t}$ x CPIS	-0.00127	0.00396	0.01917**	-0.00169	0.00150
$d_{i,t}$ x DGOS	0.00072*	-0.00038	-0.00026	0.00005	-0.00069
$d_{i,t}$ x EMPS	-0.00034	0.01266*	0.00267	-0.00485	-0.00991*
$d_{i,t}$ x GDPS	0.00419	0.00083	0.00143	0.00153	0.00181
$d_{i,t}$ x MTDS	0.00058	0.00006	0.00093*	-0.00048*	0.00015
$d_{i,t}$ x PPIS	-0.00178	0.00226	-0.00180	-0.00335	0.00229
$d_{i,t}$ x RTSS	-0.00134	-0.00015	-0.00547**	0.00020	0.00064
T_t x CPIS	-0.00031	0.00778	-0.00827	0.00675	0.00291
T_t x DGOS	-0.00058	0.00031	-0.00012	0.00036	0.00056
T_t x EMPS	-0.00478	0.00559	-0.00362	0.00256	0.00229
T_t x GDPS	-0.00154	-0.00019	0.00176	-0.00130	-0.00018
T_t x MTDS	-0.00081	-0.00002	-0.00074*	0.00034	0.00018
T_t x PPIS	0.01329**	-0.00254	-0.00091	-0.00087	-0.00020
T_t x RTSS	0.00209	-0.00037	0.00234	0.00082	-0.00034
Second-Moment Equations					
Consumer Price Index ($ANN_{1,t}$)	-0.36442**	-0.14127	0.00291	-0.24028	-0.49243*
Durable Goods Orders ($ANN_{2,t}$)	0.06421	0.05826	0.66329*	0.07995	-0.00709
Employment ($ANN_{3,t}$)	2.26492**	2.25416**	1.52237**	1.14439**	1.43570**
Gross Domestic Product ($ANN_{4,t}$)	0.00050	0.64164*	2.50052**	0.39869	1.48710**
Merchandise Trade Deficit ($ANN_{5,t}$)	0.02653	1.19559**	0.04981	0.94518**	0.92079**
Producer Price Index ($ANN_{6,t}$)	0.51345*	0.23212	1.97002**	0.18840	-0.00022
Retail Sales ($ANN_{7,t}$)	-0.31085*	0.06963	-0.11080	-0.89899**	0.53552
Tuesday Dummy ($DOW_{2,t}$)	-0.01302	-0.07005	0.52196**	1.25651**	0.50794**
Wednesday Dummy ($DOW_{3,t}$)	0.82713**	0.01634	0.80238**	0.81203**	0.63854**
Thursday Dummy ($DOW_{4,t}$)	0.61566**	0.25161**	0.68614**	1.51615**	1.55312**
Friday Dummy ($DOW_{5,t}$)	-0.04695	0.20010*	0.40015*	0.68183**	0.52155**
ARCH0 (ω_i)	0.00004**	0.00008**	0.00001**	0.00001**	0.00001**
ARCH1 (α_i)	0.00035**	0.00001	0.00013**	0.00020**	0.00006
GARCH1 (β_i)	0.00284**	0.00026	0.00279**	0.00213**	0.00262**

Notes: ** denotes significant at the 1% significance level and * denotes significant at the 5% significance level.

Table 5
Signs of the Significant Coefficients in the GARCH Model for the Non-nearby Deutsche Mark and Japanese Yen Futures Contracts

		Panel A: Non-nearby Deutsche mark futures contracts										*Panel B: Non-nearby Japanese yen futures contracts*									
	Coefficients	*1st*	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*	*9th*	*10th*	*1st*	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*	*9th*	*10th*
1	Intercept, μ_i																				
2	Days to maturity (T_t), ψ_i																	+			
3	Time Period ($d_{i,t}$), ρ_i		-		-	-					-	-	-								
4	Announcement Dummy (D_t), κ_i					-															
5	Consumer Price Index Surprise (CPIS), $\delta_{i,m}$													+							
6	Durable Goods Orders Surprise (DGOS), $\delta_{i,m}$																			-	
7	Employment Surprise (EMPS), $\delta_{i,m}$																+		-		
8	Gross Domestic Product Surprise (GDPS), $\delta_{i,m}$																				-
9	Merchandise Trade Deficit Surprise (MTDS), $\delta_{i,m}$			+						-		+									
10	Producer Price Index Surprise (PPIS), $\delta_{I,m}$	-												+							
11	Retail Sales Surprise (RTSS), $\delta_{i,m}$													-							+
12	$d_{i,t}$ x CPIS, $\tau_{i,m}$			+				-	+			+				-					
13	$d_{i,t}$ x DGOS, $\tau_{i,m}$	+																	+	-	
14	$d_{i,t}$ x EMPS, $\tau_{i,m}$		+			-															
15	$d_{i,t}$ x GDPS, $\tau_{i,m}$															-		-			
16	$d_{i,t}$ x MTDS, $\tau_{i,m}$			+	-					+											
17	$d_{i,t}$ x PPIS, $\tau_{i,m}$									+				+	+	+	-		-		
18	$d_{i,t}$ x RTSS, $\tau_{i,m}$			-								-		-		-	+				+
19	T_t x CPIS, $\varphi_{i,m}$								-					-							
20	T_t x DGOS, $\varphi_{i,m}$																			+	
21	T_t x EMPS, $\varphi_{i,m}$																-		+		-
22	T_t x GDPS, $\varphi_{i,m}$													+							+
23	T_t x MTDS, $\varphi_{i,m}$			-						+		-									
24	T_t x PPIS, $\varphi_{i,m}$	+												-							
25	T_t x RTSS, $\varphi_{i,m}$													+							-

Table 5(Continued)

Coefficients	Panel A: Non-nearby Deutsche mark futures contracts										Panel B: Non-nearby Japanese yen futures contracts									
	1st	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*	*9th*	*10th*	*1st*	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*	*9th*	*10th*
26 Consumer Price Index, $\eta_{i,m}$	-				-		+	-	-	-	-	+	-		-	-	-	-	-	
27 Durable Goods Orders, $\eta_{i,m}$			+			-	+			-		-		-	-	-				
28 Employment, $\eta_{i,m}$	+	+	+	+	+						+	+	+	+				-	-	
29 Gross Domestic Product, $\eta_{i,m}$		+	+		+			+	+	+	+		+	+	+	+				+
30 Merchandise Trade Deficit, $\eta_{i,m}$		+		+	+			+			+	+	+	+	+		-	-		+
31 Producer Price Index, $\eta_{i,m}$	+		+						-					-		-		-		
32 Retail Sales, $\eta_{i,m}$	-			-		-			+	+	+		+		-	+				-
33 Tuesday Dummy, $\lambda_{i,k}$			+	+	+	+					+		+	-	-	+	+	+	+	+
34 Wednesday Dummy, $\lambda_{i,k}$	+		+	+	+	+	-			+		+	+		+				+	
35 Thursday Dummy, $\lambda_{i,k}$	+	+	+	+	+	+	+			+	+		+		+		+	+	+	+
36 Friday Dummy, $\lambda_{i,k}$		+	+	+	+	+				+	+	+	+				+		+	
37 ARCH0, $\omega?_i$	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
38 ARCH1, α_i	+		+	+		+	+	+	+	+	+	+	+		+	+		+	+	+
39 GARCH1, $\beta?_i$	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

The intercept term (μ_i) in equation (2) is the sum of the constant term from the spot exchange rate's response equation (χ_i) and the constant term from the liquidity premium's response equation (γ_i). The test of $\mu_i = 0$ is a test of the stability of spot exchange rate plus liquidity premium in the absence of announcement surprises. Row 1 of Table 5 shows that μ_i is statistically zero for the first 10 return series for both currencies. A sufficient condition for $\mu_i = 0$ is that both the spot exchange rate and the liquidity premium do not change in the absence of announcement surprises. While it is possible that both spot exchange rate and liquidity premium can be non-zero over a long period of time in the absence of announcement surprises, it seems to be reasonable to assume that they are zero in such a short time space.

The regression coefficient of the days-to-maturity variable, ψ_i, represents the difference between the constant term from the interest rate differential equation (ϕ_i) in eq. (A-7) and the interest rate differential ($r_{i-1,\,t}$) implicit in the return from the previous trade. Row 2 of Table 5 shows that only the seventh return series of the non-nearby Japanese yen futures has a significantly positive coefficient. That is, according to the model, the interest rate differentials implicit in the return series are not different from one trade to the next in the absence of surprises. In other words, the implied interest rate differentials are stable during the day.

The model also says that the regression coefficient of the time space between two consecutive trades, ρ_i, is equal to the negative value of the average non-announcement interest rate differential for return series i, ϕ_i. The empirical results reported in Table 4 and summarized in row 3 of Table 5 show that they are either statistically zero or negative. For example, they are negatively significant for the first two returns for the Japanese yen and for the 2nd, 4th, 5th , and 10th returns for the Deutsche mark. That is, the interest rate differentials (the domestic rate minus the foreign rate) implicit in the non-nearby returns are either zero or positive.

The regression coefficient of the announcement dummy variable, κ_i , captures the change in liquidity premium due to the announcements. The liquidity premium implicit in the non-nearby futures return is expected to decline as both information and liquidity trading increases following an announcement. After the information and liquidity motivated trading subsides, the liquidity premium is expected to rebound. As to how soon the liquidity premium declines and for how long the decline lasts before rebounding, these are empirical issues. The results for the Deutsche mark futures are in Table 4, and the summary for both currencies is in row 4 of Table 5. They show that the liquidity premium for the Deutsche mark futures reduces in the fifth trade and rebounds to the normal level in the next trade and that liquidity premiums for the Japanese yen futures remain unchanged throughout the first 10 trades. These results suggest that the announcements fail to enhance non-nearby contracts' liquidity sufficiently to reduce liquidity premium, even though the announcements raise volatilities significantly as reported below.[15]

The coefficient for the surprise variable ($\delta_{i,m}$) measures the impact of the announcement surprises on the spot exchange rate (eq. (A-6)). As shown in Table 5, the Japanese yen futures show at least one statistically significant coefficient to each of the seven macroeconomic indicators. The Japanese yen futures respond to the MTD surprises in the first trade after the announcements; they respond to CPI, PPI, and RTS surprises in the third trade; they respond to the EMP surprises, DGO surprises, and GDP surprises in the 6th trade, 9th trade, and 10th trade, respectively. The third trade seems to be where the returns show the most significant responses (i.e., in response to the surprises of CPI, PPI, and RTS). The market's initial responses to the CPI, MTD, and PPI surprises are consistent with the predicted signs. For example, positive CPI and PPI surprises suggest higher U.S. inflation rates and thus a weakening U.S. dollar, leading to positive coefficients. The market's initial responses to the DGO, GDP, and EMP surprises can be either positive or negative. Take EMP for example. A positive surprise suggests a stronger economy, which may lead to a stronger U.S. dollar or a higher inflation rate (and thus a weaker dollar). Despite the mixed results, it is clear that the announcement surprises affect the Japanese yen non-nearby returns through their effects on the underlying spot exchange rate.

Rows 5 through 11 under panel A of Table 5 summarize the signs and significances of the coefficients for the surprise variables for the Deutsche mark futures. The coefficients are statistically significant for the 1st trade after the PPI announcements and for the 3rd and 9th trades after the MTD announcements. The Deutsche mark futures' initial response to the MTD surprises is positive and consistent with prediction, while their initial response to the PPI surprises is opposite to the predicted sign. The most conspicuous result here is how little impact the announcement surprises have on the spot exchange rate implicit in the Deutsche mark non-nearby contracts.

Announcement surprises affect futures returns also by way of their effects on interest rate differentials. Eq. (A-9) in the Appendix shows that the interaction term of surprise and response time and the interaction term of surprise and days to maturity capture those effects. The former in particular captures the part of the futures return that comes from the change in interest rate differential during the response time. Rows 12 through 18 of Table 5 show that, in this regard, the CPI and MTD surprises are most important to the Deutsche mark futures and PPI and RTS most important to the Japanese yen. These results are not surprising because all those indicators are clear indicators of inflation. Furthermore, the third trade has the largest number (three) of significant coefficients, suggesting that information trading be most active in the 3rd trade. The coefficients ($\varphi_{i,m}$) for CPI, PPI, and RTS are expected to be negative for the first return series because a positive surprise indicates a higher inflation rate and thus a higher interest rate differential, making $\varphi_{i,m}$ positive and $\tau_{i,m} = -\varphi_{i,m}$ negative. Table 4 shows that the coefficients for the interaction terms of CPI, PPI, and RTS are negative, though not significant, for the first series of the Deutsche mark. The signs for the subsequent return series, however, cannot be predicted because they may reverse as a result of correction for overshooting in either direction.[16]

The coefficients for the interaction terms of days to maturity and surprises estimate whether and how the impact of the announcement surprises on interest rate differentials vary with days to maturity (ranging from 105 to 204 days for the sample). For a given amount of surprise, the interest rate parity relationship suggests that, the longer the days to maturity, the larger the impact. In other words, the coefficient, $\varphi_{i,m}$, should be positive if the interest rate differentials respond to the surprises positively and *vice versa*.

The empirical results here are mixed. For Deutsche mark's first return series, T_i x PPIS and T_i x RTSS have the predicted sign, but only the former is statistically significant. The Japanese yen futures have more significant coefficients. The coefficient for T_i x MTDS is the only significant coefficient for the first return and is negative. The relationship between MTD and inflation is not straightforward. The result here suggests that MTD and inflation have a negative relationship for the sample period. For the third return series, the coefficients for T_i x GDPS and T_i x RTSS are significantly positive and that for T_i x PPIS is significantly negative. The signs are hard to interpret because of correction of overshooting in either direction over time.

The above results point to two observations. First, the days to maturity affect the two currency futures' responses to the macroeconomic announcements and should be controlled for in a study where the futures' days to maturity are not short. Second, the results show that macroeconomic announcements affect the futures returns by way of their effect on spot exchange rates as well as their effect on interest rate differentials. If the number of significant coefficients is a good indication, their effect on interest rate differential is more significant than their effect on the underlying spot exchange rates.

The results for the second-moment equations (eqs. (4) and (5)) are far more uniform for both currency futures. Rows 26 through 39 of Table 5 show that the majority of the announcement dummies in the second-moment equation are significant throughout the ten return series for both currency futures, indicating that the macroeconomic announcements increase volatilities for both. Nevertheless, volatility stays unchanged in the first trade of the Deutsche mark after the announcements of DGO, GDP, and MTD, unlike their nearby counterparts and other futures whose responses to macroeconomic announcements immediately show in volatility. The coefficients of the day-of-the-week dummies are also mostly significant, indicating that volatilities are generally higher on Tuesdays through Fridays than on Mondays, even in the absence of the announcements. These results are consistent with those of Han et al. (1999) and Han and Ozocak (2002).

The observation that the volatilities increase immediately in most cases and that the returns respond in later trades suggests that liquidity trading may have accelerated sooner than information trading. Last but not least, the significant ARCH/GARCH coefficients throughout the first 10 returns indicate statistically significant volatility persistence.

LEAD-LAG RELATIONSHIP BETWEEN NEARBY AND NON-NEARBY CONTRACTS

A major objective of this study is to examine the flow of information between the nearby and non-nearby contracts. The Granger causality test (1969) and its variations are often used for such purposes. Unfortunately, they cannot be employed here because of the wide-varying time spaces between two consecutive trades for non-nearby contracts as explained previously. A new method is devised here based on the unique characteristics of futures trading. The futures are traded on the Chicago Mercantile Exchange (CME) without designated market makers. Scalpers function as if they were market makers on a voluntary basis. They, along with other traders in the pits, observe trading dynamics (e.g., buy and sell orders, quantities, and contracts) and attempt to make profits by exploiting these observations. Therefore, it is reasonable to assume that those who intend to trade non-nearby contracts, for example, are able to do so with their observations of the nearby markets, and *vice versa*.

A simple way to capture this spirit is to examine whether the price movements of nearby contracts are informative about the price movements of non-nearby contracts, and *vice versa*. If the nearby contracts move upward more frequently than downward and if traders in the non-nearby markets take that cue from the nearby markets, the next move for the non-nearby contracts would more likely be upward. When this is true, the nearby contracts are considered leading the non-nearby contracts. Otherwise, the nearby contracts and non-nearby contracts are considered having no lead-lag relationship. If the non-nearby contracts move up and the nearby contracts move up more than down within the time space before the next trade of the non-nearby contract, then the non-nearby contract is considered leading the nearby contracts. Otherwise, the non-nearby contracts are considered having no lead-lag relationship. This method is not original. It is similar to the method employed by Patell and Wolfson (1984) in testing the effect of dividends and earnings announcements on common stocks. As they explain, the method is free from problems arising from asset pricing misspecification. The method devised here is not a traditional Granger causality method, but it follows Granger's underlying principle. That is, variable X is considered leading variable Y, if the lags of X have explanatory power of Y.

The methodology described above is implemented as follows. Take the first non-nearby return series for example. For each day, first count the numbers of the nearby returns that are positive and negative, respectively, within the time space for the first non-nearby return.[17] The number of the nearby returns with positive signs can be larger than, equal to, or smaller than that with negative signs on day 1. If the positive nearby returns outnumber the negative nearby returns, day 1 is counted as a "positive" day. If the first non-nearby return on day 1 is also positive, then the nearby return is said to lead the non-nearby return. The same can be said about day 1 if both the nearby return and non-nearby return are negative. In any other cases, nearby is said not to lead non-nearby. Second, count the number of days where nearby is considered leading non-nearby and take its proportion relative to the total number of days in the sample. Repeat the process for the subsequent return series in the sample. Note that this method treats each "positive" (or negative) day equally without assigning more weights to the days with larger positive or negative numbers. This is because any weighting scheme can inject biases that are unknown to us and not discussed in the literature. Perhaps for the same reason, Patell and Wolfson (1984) did not use any weighting scheme either.

The results are reported in Tables 6 and 7. By using the number of trades for the nearby contracts between two consecutive non-nearby trades, the methodology assumes that those who trade non-nearby contracts know exactly when the next price change would occur. In reality, it is of course not possible. Therefore, the results here are *ex post* in nature and thus cannot be used for prediction purposes.

Similar procedures are applied to examining whether the price movements of the non-nearby contracts are informative about the price movements of the nearby contracts. For example, on day 1, upon observing the sign of the first non-nearby return, we count the numbers of nearby returns that are positive and negative, respectively, before the occurrence of the next non-nearby trade. If the first non-nearby return is positive and there are more positive nearby returns than their negative counterpart before the third non-nearby trade, day 1 is counted as a "positive" day. The same can be said about day 1 if both the non-nearby return and the dominating sign of the nearby returns are negative. Otherwise, non-nearby is said not to lead nearby. The number of days where non-nearby is considered leading nearby is tallied and its proportion relative to the total number of days in the sample is taken. The process is then repeated for the subsequent return series in the sample. For ease of explanation, the hypothesis tests are formally stated as follows:

Hypothesis testing H_0(A): Announcements do not change the percentage of the days in which nearby contracts are considered leading non-nearby contracts.

Hypothesis testing H_0(B): Announcements do not change the percentage of the days in which non-nearby contracts are considered leading nearby contracts.

Hypothesis testing H_0(C): The percentage of the days in which nearby contracts are considered leading non-nearby contracts is equal to that in which non-nearby contracts are considered leading nearby contracts.

The results for all returns pooled together are presented in panel A of Tables 6 and 7. Panel A of Table 6 shows that the Deutsche mark nearby contracts are considered leading the non-nearby contracts on 69.53% of the announcement days and on 68.87% of the non-announcement days. The two percentages are not statistically different at the 5% significance level. This suggests that the announcements do not affect the lead of the nearby contracts over the non-nearby contracts. Panel A of Table 6 also shows that the non-nearby contracts are considered leading the nearby contracts on 68.88% of the announcement days and 68.21% of the non-announcement days, and they are not statistically different. That is, the announcements do not affect the lead of the non-nearby contracts over the nearby contracts. Pooling the announcement days and non-announcement days together, the nearby contracts lead the non-nearby contracts on 69.08% of all days in the sample, and the non-nearby contracts lead the nearby contracts on 68.21% of all days. The two percentages are statistically different, suggesting that information flows more from the nearby contracts to the non-nearby contracts than the reverse. The corresponding percentages for the Japanese yen futures, shown in Panel A of Table 7, lead to the same conclusion. However, the percentages for the non-nearby contracts to lead the nearby contracts are far smaller, 31.97% on announcement days and 44.27% days on non-announcement days than those for the nearby contracts to lead the non-nearby contracts.

Since the above counting process pools all return series, there might be some aggregation effects. We repeat the above counting process and test the same hypotheses for each of the first 13 return series. The results for the Deutsche mark and Japanese yen futures are presented in panels B through H of Tables 6 and 7, respectively.

Panels B through N of Table 6 show that, for the Deutsche mark futures, the announcements affect the lead of the nearby contracts over the non-nearby contracts for return series 1, 2, 3, and 5. The announcements affect the lead of the non-nearby contracts over the nearby contracts for return series 1, 2, and 5. And hypothesis C cannot be rejected for return series 1 through 13. That is, the likelihood for the nearby contracts to lead the non-nearby contracts is statistically no different from that for the reverse for all 13 return series when the announcement and non-announcement days are pooled together. The percentages of the leads in either direction range from 62% to 75%. This suggests that the two types of contracts have strong feedback relationships whether there are announcements or not.

Table 6
Summary of Nearby leads Non-nearby and Non-nearby leads Nearby Deutsche mark contract

	Panel A: Deutsche mark (Announcements vs. non-announcements)						*Panel B: Deutsche mark (1st Response Time)*					
	Nearby leads Non-nearby			Non-nearby leads Nearby			Nearby leads Non-nearby			Non-nearby leads Nearby		
	Announcements			Announcements			Announcements			Announcements		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	9112	19197	28309	9337	19660	28997	310	636	946	312	637	949
N	13105	27874	40979	13556	28824	42380	437	1021	1458	435	1017	1452
Proportion	0.6953	0.6887	0.6908	0.6888	0.6821	0.6842	0.7094	0.6229	0.6488	0.7172	0.6264	0.6536
P-Value*	0.089			0.083			0.001			0.000		
P-Value**			**0.040**						**0.788**			

	Panel C: Deutsche mark (2nd Response Time)						*Panel D: Deutsche mark (3rd Response Time)*					
	Nearby leads Non-nearby			Non-nearby leads Nearby			Nearby leads Non-nearby			Non-nearby leads Nearby		
	Announcements			Announcements			Announcements			Announcements		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	334	712	1046	340	723	1063	308	672	980	315	690	1005
N	417	963	1380	425	994	1419	400	937	1337	415	960	1375
Proportion	0.8010	0.7394	0.7580	0.8000	0.7274	0.7491	0.7700	0.7172	0.7330	0.7590	0.7188	0.7309
P-Value*	0.007			0.002			0.023			0.061		
P-Value**			**0.587**						**0.269**			

	Panel E: Deutsche mark (4th Response Time)						*Panel F: Deutsche mark (5th Response Time)*					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	289	656	945	294	661	955	283	604	887	286	610	896
N	392	896	1288	401	917	1318	378	873	1251	386	883	1269
Proportion	0.7372	0.7321	0.7337	0.7332	0.7208	0.7246	0.7487	0.6919	0.7090	0.7409	0.6908	0.7061
P-Value*	0.424			0.322			0.021			0.036		
P-Value**			**0.601**						**0.870**			

contd

TABLE 6(Continued)

	Panel G: Deutsche mark (6th Response Time)						*Panel H: Deutsche mark (7th Response Time)*					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	259	572	831	267	584	851	259	569	828	259	581	840
N	364	817	1181	373	841	1214	356	782	1138	358	806	1164
Proportion	0.7115	0.7001	0.7036	0.7158	0.6944	0.7010	0.7275	0.7276	0.7276	0.7235	0.7208	0.7216
P-Value*	0.346			0.226			0.501			0.463		
P-Value**			**0.887**						**0.750**			

	Panel I: Deutsche mark (8th Response Time)						*Panel J: Deutsche mark (9th Response Time)*					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	251	557	808	255	566	821	227	536	763	229	539	768
N	339	756	1095	347	774	1121	328	731	1059	333	748	1081
Proportion	0.7404	0.7368	0.7379	0.7349	0.7313	0.7324	0.6921	0.7332	0.7205	0.6877	0.7206	0.7105
P-Value*	0.450			0.450			0.916			0.865		
P-Value**			**0.769**						**0.607**			

	Panel K: Deutsche mark (10th Response Time)						*Panel L: Deutsche mark (11th Response Time)*					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	237	499	736	242	505	747	212	485	697	219	494	713
N	317	705	1022	323	721	1044	304	669	973	313	688	1001
Proportion	0.7476	0.7078	0.7202	0.7492	0.7004	0.7155	0.6974	0.7250	0.7163	0.6997	0.7180	0.7123
P-Value*	0.095			0.053			0.812			0.724		
P-Value**			**0.815**						**0.842**			

TABLE 6(Continued)

	Panel M: Deutsche mark (12th Response Time)						Panel N: Deutsche mark (13th Response Time)					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	204	469	673	206	480	686	196	433	629	198	447	645
N	290	646	936	294	667	961	273	621	894	282	643	925
Proportion	0.7034	0.7260	0.7190	0.7007	0.7196	0.7138	0.7179	0.6973	0.7036	0.7021	0.6952	0.6973
P-Value*	0.761			0.725			0.266			0.416		
P-Value**			**0.802**						**0.770**			

Notes: 1 denotes announcement(s) and 0 denotes non-announcement (s). The Two Proportions hypothesis test of the difference between two proportions is used to test the hypotheses: H_0: no difference between the proportion when there is/are announcement(s) and the proportion when there is no announcement versus H_a: the proportion when there is/are announcement(s) is greater than the proportion when there is no announcement. Also, *P*-Value* is for testing the proportions when there is/are announcement(s) vs. when there is no announcement within Nearby leads Non-nearby and Non-nearby leads Nearby respectively and *P*-Value** is for the testing the proportions (in bold) of Nearby leads Non-nearby and Non-nearby leads Nearby.

TABLE 7

Summary of Nearby leads Non-nearby and Non-nearby leads Nearby Japanese yen contract

	Panel A: Japanese yen (Announcements vs. non-announcements)						*Panel B: Japanese yen (1st Response Time)*					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	8216	17724	25940	5365	11415	16780	290	642	932	200	451	651
N	12164	25795	37959	16780	25785	42565	428	995	1423	421	978	1399
Proportion	0.6754	0.6871	0.6834	0.3197	0.4427	0.3942	0.6776	0.6452	0.6550	0.4751	0.4611	0.4653
P-Value*	0.989			0.606			0.120			0.316		
P-Value**			**0.000**						**0.000**			

	Panel C: Japanese yen (2nd Response Time)						*Panel D: Japanese yen (3rd Response Time)*					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	299	681	980	242	459	701	280	625	905	166	381	547
N	407	932	1339	462	888	1350	392	899	1291	392	899	1291
Proportion	0.7346	0.7307	0.7319	0.5229	0.5172	0.5191	0.7143	0.6952	0.7010	0.4235	0.4238	0.4237
P-Value*	0.440			0.405			0.246			0.504		
P-Value**			**0.000**						**0.000**			

	Panel E: Japanese yen (4th Response Time)						*Panel F: Japanese yen (5th Response Time)*					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	259	640	899	151	385	536	253	602	855	168	369	537
N	368	857	1225	368	857	1225	355	812	1167	355	812	1167
Proportion	0.7038	0.7468	0.7339	0.4103	0.4492	0.4376	0.7127	0.7414	0.7326	0.4732	0.4544	0.4602
P-Value*	0.941			0.896			0.846			0.277		
P-Value**			**0.000**						**0.000**			

contd

TABLE 7(Continued)

	Panel G: Japanese yen (6th Response Time)						*Panel H: Japanese yen (7th Response Time)*					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	222	549	771	146	353	499	231	537	768	139	335	474
N	331	777	1108	331	777	1108	314	745	1059	314	745	1059
Proportion	0.6707	0.7066	0.6958	0.4411	0.4543	0.4504	0.7357	0.7208	0.7252	0.4427	0.4497	0.4476
P-Value*	0.883			0.657			0.310			0.583		
P-Value**			**0.000**						**0.000**			

	Panel I: Japanese yen (8th Response Time)						*Panel J: Japanese yen (9th Response Time)*					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	215	501	716	130	289	419	218	507	725	126	274	400
N	306	718	1024	306	718	1024	291	684	975	291	684	975
Proportion	0.7026	0.6978	0.6992	0.4248	0.4025	0.4092	0.7491	0.7412	0.7436	0.4330	0.4006	0.4103
P-Value*	0.439			0.253			0.398			0.173		
P-Value**			**0.000**						**0.000**			

	Panel K: Japanese yen (10th Response Time)						*Panel L: Japanese yen (11th Response Time)*					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	203	479	682	124	272	396	198	436	634	113	279	392
N	296	656	952	296	656	952	279	620	899	279	620	899
Proportion	0.6858	0.7302	0.7164	0.4189	0.4146	0.4160	0.7097	0.7032	0.7052	0.4050	0.4500	0.4360
P-Value*	0.920			0.451			0.422			0.896		
P-Value**			**0.000**						**0.000**			

contd.

TABLE 7(Continued)

	Panel M: Japanese yen (12th Response Time)						Panel N: Japanese yen (13th Response Time)					
	Nearby leads Non-nearby			*Non-nearby leads Nearby*			*Nearby leads Non-nearby*			*Non-nearby leads Nearby*		
	Announcements			*Announcements*			*Announcements*			*Announcements*		
	1	0	Total	1	0	Total	1	0	Total	1	0	Total
Sum	177	416	593	124	287	411	186	409	595	115	250	365
N	266	592	858	266	592	858	258	569	827	258	569	827
Proportion	0.6654	0.7027	0.6911	0.4662	0.4848	0.4790	0.7209	0.7188	0.7195	0.4457	0.4394	0.4414
P-Value*	0.863			0.693			0.475			0.432		
P-Value**			**0.000**						**0.000**			

Notes: 1 denotes announcement(s) and 0 denotes non-announcement (s). The Two Proportions hypothesis test of the difference between two proportions is used to test the hypotheses: H_0: no difference between the proportion when there is/are announcement(s) and the proportion when there is no announcement versus H_a: the proportion when there is/are announcement(s) is greater than the proportion when there is no announcement. Also, *P*-Value* is for testing the proportions when there is/are announcement(s) vs. when there is no announcement within Nearby leads Non-nearby and Non-nearby leads Nearby respectively and *P*-Value** is for the testing the proportions (in bold) of Nearby leads Non-nearby and Non-nearby leads Nearby.

The results for the Japanese yen futures, shown in Panels B through N of Table 7, are strikingly different. Hypothesis A cannot be rejected for return series 1 through 13, indicating that the announcements do not affect the nearby contracts' lead of the non-nearby contracts. Neither can hypothesis B be rejected for all 13 return series. That is, the announcements do not affect the lead of the non-nearby contracts over the nearby contracts. Hypothesis C is rejected for the first 13 return series, indicating that the Japanese yen nearby contracts lead the non-nearby contracts for all 13 returns series on more days (65% - 75% of days) than the reverse (40-48% of days).

It is rather surprising that Deutsche mark's nearby and non-nearby contracts show strong feedback relationships. This suggests that, even with the illiquidity of the non-nearby contracts, both markets process information shocks from the announcements and from each other equally efficient. For the Japanese yen, information appears to flow primarily from the nearby contracts to the non-nearby contracts, although the non-nearby contracts still lead the nearby contracts on over 40% of the days. In comparison, the information flow between the nearby and non-nearby Japanese yen futures markets seem to be less spontaneous than the Deutsche mark futures markets. The flow of information may be hindered by the fact that the CME trading hours do not overlap with Japan's normal business hours.

CONCLUDING REMARKS

All previous studies examine how futures process macroeconomic announcements using nearby contracts as a way to understand financial markets' efficiency in information processing. This study adds to the literature with the examination of how non-nearby currency futures (the less liquid assets) respond to macroeconomic announcements and how they interact with their nearby counterparts. Although not as widely used as nearby futures, non-nearby futures are important for some hedging and speculative strategies involving futures options and are likely to be made more efficient as a result. Their efficiency in information processing and interaction with nearby contracts are important to our understanding of financial markets' processing of public information.

The return on a non-nearby contract is supposed to comprise risk-free rate, risk premium, and liquidity premium. The shock from a macroeconomic announcement is therefore expected to affect these three components. The two futures' responses to macroeconomic announcements differ by indicator (e.g., the Japanese yen futures are most responsive to PPI while the Deutsche mark futures most responsive to MTD). More important, the returns are driven more by the macroeconomic announcements' effects on interest rate differentials than on the underlying spot exchange rates. As to liquidity premium, only the non-nearby Deutsche mark futures show a significant reduction in the 5th trade which is followed by an immediate recovery to the pre-announcement level in the 6th trade. This is perhaps why the feed-back relationship between the nearby and non-nearby Deutsche mark contracts is enhanced in the 5th trade by the announcements.

The interactions of the nearby contracts and non-nearby contracts are examined using the frequency of price continuation and the frequency of price reversal, similar to the method employed by Patell and Wolfson (1984). The interpretation of the results is based on Granger's concept of lead-lag. The Deutsche mark non-nearby contracts exhibit strong feedback relationships with the nearby contracts in the first 13 trades on 65%-75% of the days in the sample. The macroeconomic announcements enhance the lead of the nearby futures in the 1st, 2nd, 3rd, and 5th trade, while they enhance the lead of the non-nearby contracts over the nearby contracts in the 1st, 2nd, and 5th trade. By contrast, information flows predominantly from Japanese yen's nearby contracts to the non-nearby contracts, and the announcements change neither the lead of the nearby contracts over the non-nearby contracts nor the reverse. The lag in response does not seem to stop the Japanese yen non-nearby contracts from adjusting to information shocks as briefed above. On the whole, the results suggest the foreign currency futures markets to be fairly efficient.

APPENDIX

Derivation of Returns on Currency Futures

According to the interest rate parity relationship, the futures price at time 0 is expressed as follows:

$$f_0 = s_0 \exp (r_0 T), \qquad \text{(A-1)}$$

where f_0 denotes the futures price at time 0;
s_0 denotes the spot price at time 0;
r_0 denotes the difference between the domestic and foreign interest rate at time 0;
T denotes the days to maturity.

Adding liquidity premium to equation (A-1) yields

$$f_0 = s_0 \exp (r_0 T + l_0), \qquad \text{(A-2)}$$

where l_0 denotes the liquidity premium at time 0. Taking the natural logarithm of equation (A-2) and defining the difference of the domestic and foreign risk-free rates as interest rate differential gives

$$F_0 = S_0 + r_0 T + l_0, \qquad \text{(A-3)}$$

where F_0 denotes the natural logarithm of the futures price at time 0, i.e., $F_0 = \text{In} (f_0)$;
S_0 denotes the natural logarithm of the spot price at time 0, i.e., $S_0 = \text{In} (s_0)$.

Let d denote the time space between any two consecutive trades and expression (A-3) can be rewritten as

$$F_d = S_d + r_d (T - d) + l_d. \qquad \text{(A-4)}$$

To denote intraday returns, more subscripts are added for clarity. The i^{th} return on day t is computed by taking the difference between the natural logarithm of the i^{th} futures price on day t and that of the $(i$-1$)^{th}$ futures price on day t, i.e.,

$$R_{i,t} = F_{i,t} - F_{i-1,t} = (S_{i,t} - S_{i-1,t}) + [r_{i,t} (T_t - d_{i,t}) - r_{i-1,t} (T_t)] + (l_{i,t} - 1_{i-1,t}),\ i = 1,2,... \qquad \text{(A-5)}$$

where $R_{i,t}$ denotes the i^{th} return on day t;
$F_{i,t}$ denotes the natural logarithm of the i^{th} futures price on day t;

$S_{i,t}$ denotes the natural logarithm of the i^{th} spot price on day t;

$r_{i,t}$ denotes the i^{th} interest rate differential on day t;

T_t denotes the days to maturity on day t;

$d_{i,t}$ denotes the time span between i^{th} and $(i\text{-}1)^{th}$ trades on day t;

$l_{i,t}$ denotes the i^{th} liquidity premium on day t.

As mentioned in the section on GARCH Model and Results, Han and Ozocak (2002) find that foreign currency futures' returns and volatilities have linear relationships with announcement surprises and announcement dummies, respectively. Thus, the i^{th} spot return is formulated as a linear function of announcement surprises with a constant term:

$$(S_{i,t} - S_{i-1,t}) = \chi_i + \sum_{m=1}^{7} \delta_{i,m} (surp_{m,t}) + \xi_{i,t}, \qquad \text{(A-6)}$$

where χ_i and $\delta_{i,m}$ denote the i^{th} parameters;

$surp_{m,t}$ denotes the m^{th} announcement surprise for $m = 1,2,..., 7$;

$\xi_{i,t}$ denotes the i^{th} random error on day t with mean $E(\xi_{i,t})$, variance $V(\xi_{i,t}) = \sigma^2_{\xi}$, and $Cov\left(\xi_{i,t}, \xi_{j,t}\right) = 0 \ \forall \ i, j, i \neq j$.

The i^{th} interest rate is also formulated as a linear function of announcement surprises with a constant term:

$$r_{i,t} = \phi_i + \sum_{m=1}^{7} \varphi_{i,m} \left(surp_{m,t}\right) + \zeta_{i,t}, \qquad \text{(A-7)}$$

where ϕ_i and $\varphi_{i,m}$ denote the i^{th} parameters;

$\zeta_{i,t}$ denotes the i^{th} random error on day t with mean $E(\zeta_{i,t}) = 0$, variance $V(\zeta_{i,t}) = \sigma^2_{\zeta}$, and $Cov(\zeta_{i,t}, \zeta_{j,t}) = 0 \ \forall \ i, j, i \neq j$.

The change in liquidity premium is specified as a linear function of the announcement dummy for reasons explained in the section on GARCH Model and Results.

$$(l_{i,t} - l_{i-1,t}) = \gamma_i + \kappa_i D_t + \upsilon_{i,t}, \qquad \text{(A-8)}$$

where γ_i and κ_i denote the i^{th} parameters;

D_t denotes the announcement dummy on day t; i.e.,

$D_t =$ 1 if there is an announcement on any of the seven indicators studied here;
0 otherwise.

$\upsilon_{i,t}$ denotes the i^{th} random error on day t with mean $E(\upsilon_{i,t}) = 0$, variance $V(\upsilon_{i,t}) = \sigma^2_{\upsilon}$, and $Cov\ (\upsilon_{i,t}, \upsilon_{j,t}) = 0 \ \forall \ i, j, i \neq j$.

Substituting expressions (A-6), (A-7), and (A-8) into (A-5), we have

$$R_{i,t} = \chi_i + \sum_{m=1}^{7} \delta_{i,m}\left(surp_{m,t}\right) + \left\{\left[\phi_i + \sum_{m=1}^{7} \varphi_{i,m}\left(surp_{m,t}\right)\right]\left(T_t - d_{i,t}\right) - r_{i-1,t}\left(T_t\right)\right\} + \gamma_i + \kappa_i D_t + \varsigma_{i,t}$$

$$= \mu_i + \left(\phi_i - r_{i-1,t}\right)T_t - \phi_i d_{i,t} + \kappa_i D_t + \sum_{m=1}^{7} \delta_{i,m}\left(surp_{m,t}\right) - \sum_{m=1}^{7} \varphi_{i,m}\left(surp_{m,t} \cdot d_{i,t}\right) + \sum_{m=1}^{7} \varphi_{i,m}\left(surp_{m,t} \cdot T_t\right) + \varsigma_{i,t}$$

$$= \mu_i + \psi_i T_t + \rho_i d_{i,t} + \kappa_i D_t + \sum_{m=1}^{7} \delta_{i,m}\left(surp_{m,t}\right) + \sum_{m=1}^{7} \tau_{i,m}\left(surp_{m,t} \cdot d_{i,t}\right) + \sum_{m=1}^{7} \varphi_{i,m}\left(surp_{m,t} \cdot T_t\right) + \varsigma_{i,t}, \tag{A-9}$$

where $\mu_i = \chi_i + \gamma_i$;

$\psi_i = \phi_i - r_{i-1,t}$;

$\rho_i = -\phi_i$;

$\tau_{i,m} = -\varphi_{i,m}$;

$\varsigma_{i,t} = \xi_{i,t} + \zeta_{i,t} + \upsilon_{i,t}$ denotes the i^{th} error on day t described by a process;

$Cov\left(\xi_{i,t}, \zeta_{i,t}\right) = 0,$ $Cov\left(\xi_{i,t}, \upsilon_{i,t}\right) = 0,$ and $Cov\left(\zeta_{i,t}, \upsilon_{i,t}\right) = 0,$

$$\varsigma_{i,t} = \vartheta_{i,t}^{1/2} \varepsilon_{i,t}, \tag{A-10}$$

where is a random variable with conditional mean zero and conditional variance $h_{i,t}$, independent of $\vartheta_{i,t}$;

$$\vartheta_{i,t} = \left(1 + \sum_{m=1}^{7} \eta_{i,m} ANN_{m,t} + \sum_{k=2}^{5} \lambda_{i,k} DOW_{k,t}\right) T_t, \tag{A-11}$$

where $\eta_{i,m}$ and $\lambda_{i,k}$ denote the i^{th} parameters;

$ANN_{m,t}$ denotes the m^{th} type of announcements for m = 1,2,..., 7;

$DOW_{k,t}$ denotes the k^{th} day of the week (day-of-the-week effects) for k = 2,..., 5;

$$h_{i,t} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1}, \tag{A-12}$$

where $\omega_i > 0$, $\alpha_i \geq 0$, and $\beta_i \geq 0$ denote the i^{th} parameters;

$\varepsilon_{i,t-1}$ and $h_{i,t-1}$ denote the 1[st] lags of the random variable $\varepsilon_{i,t}$ and its conditional variance $h_{i,t}$ respectively.

NOTES

1. Some previous studies focus on the speed at which a financial market processes information: Patell and Wolfson (1984) and Jennings and Starks (1985) for equity markets, Balduzzi et al. (2001) and Fleming and Remelona (1999) for Treasury securities, Hotchkiss and Ronen (2002) for corporate bonds, Ederington and Lee (1993) for futures on Eurodollars, and Han and Ozocak (2002) for foreign currency futures.
2. Nearby contracts are contracts whose maturity is shortest among all contracts traded in the market at any given time except in their maturing months. Non-nearby contracts, referred to here, are contracts with the second shortest maturity among all contracts traded in the market except in their maturing months. Details are provided in the next section. The corresponding terms used by traders are front month contracts and back month contracts, respectively.
3. Liquidity premium is the extra return that an investor requires for holding an illiquid asset. The return specification is detailed in the Appendix.
4. Many previous studies, e.g., Ederington and Lee (1993) and Leng (1996), also choose to focus on announcements made in the U.S.
5. These indicators are shown in previous studies, cited in footnote 4, to be important to foreign currency futures.
6. An announcement surprise is the standardized difference between the actually announced value and the median of surveyed values. The detailed measure is presented in the next section.
7. Liquidity traders are those who trade for reasons other than information. Trading to rebalance a portfolio is an example of liquidity trading.
8. The commonly used Granger causality test (1969) is not employed here because of the illiquidity of non-nearby contracts. The details are in the "Lead-Lag Relationship between Nearby and Non-nearby Contracts" section.
9. Harvey and Huang (1991), Ederington and Lee (1993), Leng (1996), and Han et al. (1999) use approximately the same set of macroeconomic indicators.
10. The first response time is the time space between the trade immediately before or upon the announcement and the one immediately after the announcement.
11. This nonparametric test for comparing population locations is utilized rather than the parametric two-sample *t*-test for comparing population means because the distribution of response times are heavily skewed to the right, which violates the required condition of normality in the two-sample *t*-test.
12. Because of the lack of significance, the regression results are not reported to save space. They are available from the authors upon request.
13. See the Appendix for details on the derivation of equations (2), (3), and (4). Also, $surp_{m,t} \cdot T_t$ in equation (2) and $ANN_{m,t} \cdot T_t$ in equation (3) appear correlated, but their correlation coefficient is less than 10%.
14. The detailed regression results are available upon request.
15. Trading volume data (an indication of liquidity) are not available to the general public.
16. Imposition of constraints on the coefficients is avoided as it will complicate the (non-linear) estimation process and even leads to non convergence on the coefficients. Our choice places more emphasis on obtaining converged estimates of the coefficients.

17. As explained in the Data, Return Series Construction, and Preliminary Results section, returns are non-zero by the construction of the data series – a transaction price is recorded only when it differs from the previous one.

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