
INTRADAY VOLATILITY IN INTEREST RATE AND FOREIGN EXCHANGE SPOT AND FUTURES MARKETS

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INTRODUCTION

This article explores how spot and futures interest and exchange rates adjust to scheduled macroeconomic announcements. Ederington and Lee (1993) examined the impact of news releases on interest and exchange rate futures prices and found that several announcements, such as the employment report, the PPI, and the CPI, are responsible for most of the observed time-of-day and day-of-the-week volatility patterns.

This article can be considered an extension of Ederington and Lee (1993) (hereafter referred to as E&L) because it examines how spot prices react to news releases in comparison to futures prices. However, the use of the spot market data allows this study to address several issues that E&L could not. Specifically, it is hypothesized that futures prices should react more quickly than spot prices to an economic announce-

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ment because of the liquidity and ease of trading in the futures market which can be attributed to differences in the microstructure of the spot and futures markets, which is manifested as an increase in volatility following an announcement. The article investigates volatility patterns and the individual impact of announcements. In addition, the article explores the Granger (1969, 1980) causal relationship between the spot and futures markets. Cumulative returns adjusted to informational content are analyzed also and reported to further the understanding of the market's response to economic announcements.

This article examines the impact of 19 monthly announcements on the Eurodollar and deutsche mark spot and futures markets using hourly price data.¹ These markets represent the most heavily traded short-term interest rate market and foreign exchange rate market in the U.S. The issue of *spot* price adjustment to new information in these markets has received scant attention. Thorough examinations have been conducted for the *futures* market, as in E&L. Specifically, the volatility patterns on announcement days of the spot and futures markets are compared. The article focuses on how long higher than normal volatility persists within the announcement day and tests whether there is any lead-lag relationship between the spot and futures volatilities on announcement days. The impact on futures prices of the individual announcements is contrasted with the impact on spot prices. Finally, the market efficiency issue is addressed for both spot and futures markets.

DATA

Economic Announcements

This article considers the 19 macroeconomic announcements listed in the Appendix. These are the announcements whose upcoming release is regularly reported in "The Week Ahead" section of *Business Week*. As shown in the Appendix, there are nine 8:30 AM (Eastern Time), two 9:15 AM, six 10:00 AM announcements and one 2:00 PM announcement. Only one announcement, installment credit, is not released at a fixed time. During the sample period—from September 24, 1990, through June 30, 1993—industrial production and capacity utilization were always released on the same day, as were construction spending and the NAPM survey. Only the NAPM survey is released by a private agency.

¹Treasury bond futures and spot prices are not used because intraday spot price data, which can be obtained from the Chicago Board of Trade, have only two intraday prices, 3:00 PM and 5:00 PM Eastern Time, per day, which makes the intraday analysis difficult to conduct.

All others are government releases. As described in E&L, reporters are given the reports about 30 minutes before the scheduled release time. They are allowed to write their reports but cannot leave the room, phone, or transmit until the phone lines are turned on at the scheduled release time.² The reports are immediately transmitted by the wire agencies to the markets. These reports appear on screens on the floors of the futures exchanges within a second or two.

This article examines how prices adjust to these announcements in the Eurodollar spot and futures markets and the deutsche mark spot and futures markets. These announcements could signal a potential change in the demand for credit or foreign exchange to the markets, and could influence the Federal Reserve's monetary policy. Hence market participants in the spot and futures markets incorporate the implications of news releases in their trading strategies. Discussion of market microstructure for each of the four markets and how prices are quoted in those markets along with a detailed description of the actual data used for this study follow.

The Eurodollar Spot and Futures Market Data³

A Eurodollar is any U.S. dollar held on deposit in a bank outside the United States. The London Interbank Offer Rate (LIBOR) is used as a basis for the rate at which major international banks offer to place Eurodollar deposits with one another. Eurodollar deposits do not fall under the jurisdiction of the Federal Reserve System and, therefore, are not subject to regulations such as reserve requirements. However, there would be potential regulations that complicate the transfer of deposits across countries. In addition, Eurodollar deposits are not guaranteed by any government. Nevertheless, the Eurodollar market is growing with an increasing number of financial institutions and corporations.

The great success of the Eurodollar spot market prompted the introduction of the Eurodollar futures contract by the International Monetary Market (IMM) of the Chicago Mercantile Exchange (CME) in December 1981. Since its inception, the Eurodollar contract has experienced dramatic expansion to become the world's most actively traded contract with current daily trading volume exceeding \$1 trillion. This futures market is effectively a 24-hour market. The IMM is open from 8:20 AM to 3:00 PM (ET); the Singapore International Monetary

²Until March 1992, the Bureau of Labor Statistics allowed reporters to leave but embargoed the news until the scheduled time.

³For more detailed information on the Eurodollar spot and futures markets, see Stigum (1990).

Exchange (SIMEX) opens around 7:30 PM and closes at 3:00 AM (ET); and the London International Financial Futures Exchange (LIFFE) opens at 3:00 AM and runs until noon (ET). However, the IMM provides much better liquidity than SIMEX or LIFFE. Large corporations, financial institutions, central banks, and governmental bodies trade principally through the IMM. Increasing use of the IMM contract has also influenced the spot market's liquidity. Although there is some liquidity in the mornings in London (3:00 AM ET), the highest liquidity is available when the IMM is open, from 8:00 AM through 3:00 PM (ET).

LIBOR is an add-on yield which is stated as a percentage of the face amount of the deposit and is quoted on a 360-day basis. Hourly three-month LIBOR data are from the daily information bulletin of the CME. The bulletin reports these data beginning with 7:00 AM and ending with 4:00 PM (ET).⁴ The CME obtains these quotes on an ongoing basis from Telerate Corp. of New York, which uses the offered rates for three-month Eurodeposits of a large number of randomly selected major banks in the London Eurodollar market, and samples them hourly. Tick-by-tick futures data are from the CME and sampled at hourly intervals, 8:20 AM (open), 9:00 AM, ..., 3:00 PM (ET). The most heavily traded contract on a given date is used. This is the nearby contract until it is switched to the next nearby contract when its trading volume exceeds the nearby. The quoted futures price is the IMM Index which is 100 minus the LIBOR. This LIBOR reflects the market's assessment about the spot rate at expiration of the contract. The spot LIBOR is subtracted from 100 to obtain the Eurodollar spot price which can be compared directly with the futures price. Also, the analysis focuses on only the hours during which both the spot and futures markets are the most liquid, namely 8:00 through 3:00 for the spot data and 8:20 through 3:00 for the futures data.

The Deutsche Mark Spot and Futures Market Data

The deutsche mark spot market like other foreign currency markets, has no geographical location and no fixed opening and closing time. Banks all over the world are constantly buying and selling currencies through telephone and teletype. An equilibrium exchange rate is based

⁴Prior to 9/24/90, the bulletin reported the data beginning with 9:00 AM (ET). The data from the time before that date, therefore, are not very useful since many of the announcements considered in the analysis are released at 8:30 AM.

on the demand and supply for a currency which can be measured by the country's balance of payments. National income, price levels, and interest rate levels in relation to those of other countries affect the balance of payments. Government policies on inflation, tariffs, and import quotas may also influence the exchange rate. Along with spot transactions, banks also buy and sell currencies for delivery at some time in the future, which leads to the forward currency market.

Despite the presence of the strong forward market, the deutsche mark futures contract was launched by the IMM of the CME in May 1972, and has grown to be the most heavily traded foreign exchange contract in the U.S. SIMEX trading volume is less than one percent of the IMM's trading volume. The fixed exchange rate system collapsed in March 1973, and the volatility of foreign currencies sharply increased which helped the futures market grow. The cost-of-carry relationship determines the futures price relative to the spot price: Futures price at $t = \text{Spot price at } t \times (1 + \text{Domestic interest rate}) / (1 + \text{Foreign interest rate})$, where the interest rate covers from t to the futures expiration. Therefore, the current spot rate and relative U.S. and German interest rates impact the current futures rate.

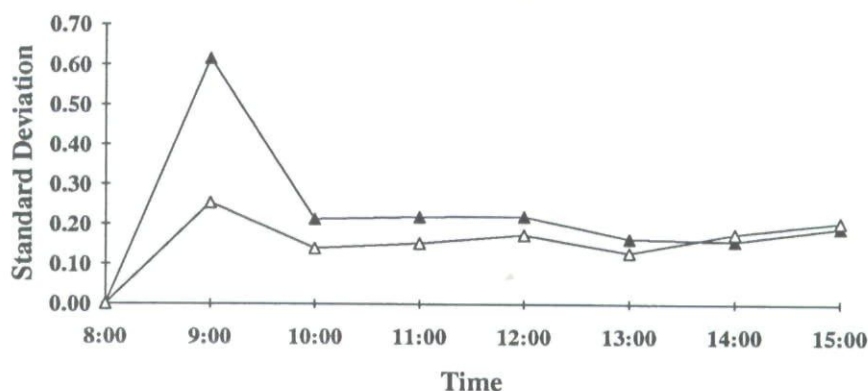
Hourly interbank deutsche mark spot rates are from the CME's daily information bulletin for the 7:00 AM—4:00 PM (ET) interval. Tick-by-tick futures data from the CME are used to prepare hourly data. Like Eurodollar futures, the nearby contract is used and it is switched to the next nearby when there is a shift in trading volume. The spot and futures market data are analyzed from 8:00 to 3:00 and from 8:20 (open) to 3:00, respectively.

VOLATILITY

Volatility Patterns

Standard deviation of returns is used as a volatility measure. Specifically, standard deviations are calculated for hourly log returns across daily observations from September 24, 1990, through June 30, 1993, to examine how the Eurodollar and deutsche mark markets respond to scheduled announcements. The sample is divided into announcement days (with at least one of the 19 news releases) and nonannouncement days. Figures 1 and 2 show the results for the Eurodollar and deutsche mark markets, respectively. In each figure, both futures and spot

Eurodollar Futures Volatility



Eurodollar Spot Volatility

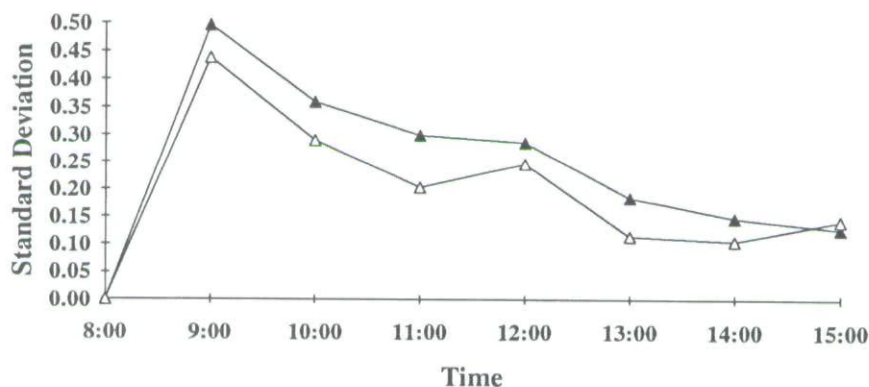


FIGURE 1

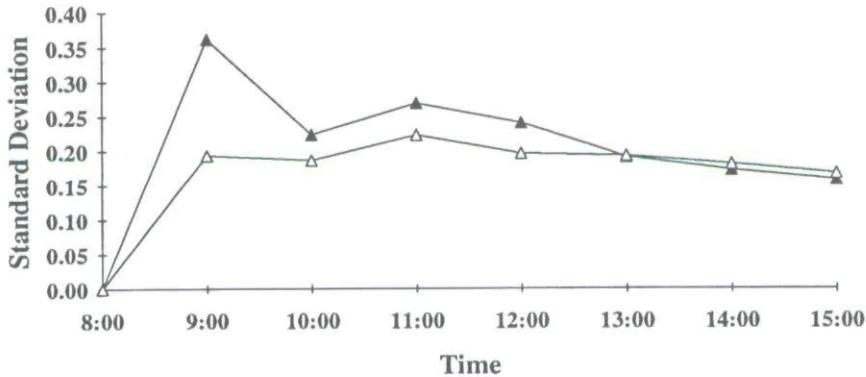
Intraday volatility patterns of the Eurodollar futures and spot returns. Hourly return standard deviations calculated across daily observations from September 24, 1990, through June 30, 1993, are reported for announcement days (shaded triangle) and nonannouncement days (open triangle). The reported standard deviations are the calculated values times 10^3 and the times shown are interval ending times in eastern time.

volatilities are depicted, and the time on the horizontal axis indicates the end of the interval in eastern time, e.g., 9:00 for 8:00 to 9:00 returns.⁵

E&L show that abnormally high volatility follows news releases in the Eurodollar futures market. The results as shown in Figure 1 for the intraday futures volatility pattern based on hourly returns confirm their

⁵The Eurodollar and deutsche mark futures markets open at 8:20 AM (ET). Therefore, the first period is 40 minutes in length in these futures markets. To compare with the other hourly periods, the 40 minute standard deviation is multiplied by $(60/40)^{0.5}$, assuming returns are serially independent.

Deutsche Mark Futures Volatility



Deutsche Mark Spot Volatility

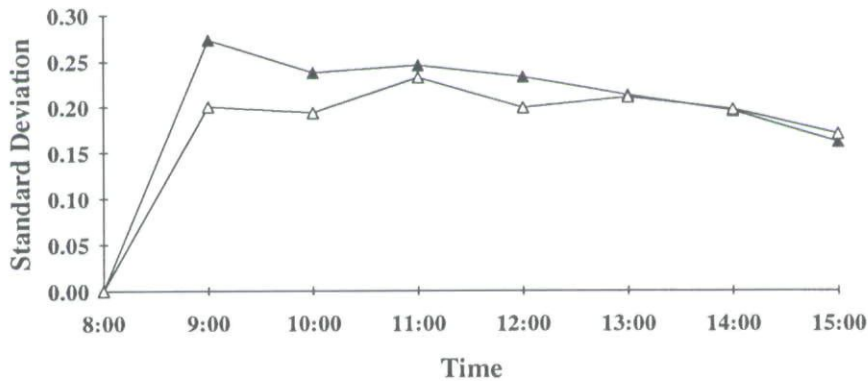


FIGURE 2

Intraday volatility patterns of the deutsche mark futures and spot returns. Hourly return standard deviations calculated across daily observations from September 24, 1990, through June 30, 1993, are reported for announcement days (shaded triangle) and nonannouncement days (open triangle). The reported standard deviations are the calculated values times 10^2 and the times shown are interval ending times in eastern time.

findings. The 8:20–9:00 period return volatility (adjusted to an hourly basis) is much higher on announcement days than on nonannouncement days. Until 1:00 PM the announcement day volatility exceeds the nonannouncement day volatility, while the latter is slightly higher than the former during the final two-hour period. The large volatility difference during the 8:20–9:00 period sharply decreases during the 9:00–10:00 period and then gradually lessens until 1:00 PM.

Now consider the intraday volatility pattern in the Eurodollar spot market. There are two interesting points. First, unlike the

futures volatility, both the announcement day volatility and the nonannouncement day volatility exhibit the highest value during the first hourly (8:00–9:00) period although the former is higher than the latter. This implies that the spot market is always volatile at the market open regardless of announcements and is relatively more volatile on announcement days. It also appears that the spot volatility gradually declines within the day. Second, the announcement day volatility is a little higher than the nonannouncement day volatility throughout most of the day except during only the last hour. This evidence suggests that the *aggregate* impact of news releases on the Eurodollar spot market is not significant. The article investigates later whether some individual announcements impact the market significantly. The volatility difference between announcement days and nonannouncement days seems to be more persistent throughout the day compared to that in the futures market.

Intraday volatility patterns in the deutsche mark futures and spot markets are shown in Figure 2. Consistent with Harvey and Huang (1991) and E&L, the 8:20–9:00 futures return volatility (adjusted to an hourly basis) is the highest on announcement days as the 8:30 announcements are reflected in futures prices. The nonannouncement futures volatility is basically flat all day long. Clearly, most of the futures price adjustment to news releases occurs before 9:00 AM, while volatility continues to be slightly elevated until 1:00 PM.

In sharp contrast to the Eurodollar spot volatility, there is some evidence of notable impact of information on the deutsche mark spot volatility. In Figure 2, the volatility difference between announcement days and nonannouncement days is the highest during the 8:00–9:00 period and it decreases until 1:00 PM. Like the deutsche mark futures market, implications of the 8:30 announcements are reflected by 9:00 AM and some further adjustment is made during the following hours.

In summary, the Eurodollar futures market and the deutsche mark futures and spot markets are much more volatile on announcement days than on nonannouncement days.⁶ There seems little impact of

⁶Average daily trading volume in the futures markets both on announcement days and nonannouncement days are examined as well. As expected, more trading goes on when announcements are released; approximately 30% and 10% more on announcement days than on nonannouncement days in the Eurodollar and deutsche mark futures markets, respectively. Unfortunately, hourly trading volume data are not available for intraday analysis. Since the spot markets are so widely spread all over the world, accurate trading volume is generally difficult to assess, while a representative trade price can be readily traced.

news releases on the Eurodollar spot market.⁷ This finding may be due to the fact that the Eurodollar spot market participants, as illustrated in Stigum (1990), usually react to economic announcements using derivatives such as forward rate agreements (FRA) and interest rate swaps and sometimes futures. They tend to avoid spot transactions since the derivative markets have better liquidity and can more efficiently implement their adjusted positions. It is also noted that the 8:30 announcements rather than the 9:15, 10:00, and 2:00 announcements are dominant in their impact on price movements.

Volatility Persistence

This article now explores the length of time required for the market to fully digest the information in the news release. Following the announcement, an initial price reaction to the release, bullish or bearish, can be expected. This is followed by some continued trading and price changes as those who disagree with the initial consensus view of the release's implication place their orders.⁸ Some evidence on volatility persistence has already been presented in Figures 1 and 2.

More precise evidence of the volatility adjustment is presented in Tables I and II for the Eurodollar and deutsche mark markets, respectively. The ratio of the announcement day standard deviation to the nonannouncement day standard deviation is calculated. Brown–Forsythe-modified Levene tests are also reported for homoskedasticity between announcement days and nonannouncement days.⁹ As shown in Table I, the announcement day standard deviation

⁷Some contend that the spot market has already incorporated new information so that no further adjustment is necessary. However, the previous close (3:00 PM) to open (8:00 AM) returns for announcement days does not exhibit any excess volatility, implying that no new information is incorporated in the spot price before 8:00 AM. Furthermore, a detailed investigation in Ederington and Lee (1994) reveals no information leakage before announcement.

⁸Patell and Wolfson (1984) and Jennings and Starks (1985) observe that following earnings and dividend announcements, the equity return variance remains higher than normal for several hours and even into the next day.

⁹Conover, Johnson, and Johnson (1981) compare over 50 methods for testing variance homogeneity and find that this test is both one of the most powerful and quite robust to nonnormality. One of the first studies in finance to apply this test to the homogeneity of intraday return variances was Lockwood and Linn (1990). The Brown–Forsythe-modified Levene test statistic is

$$F = \frac{\sum_{j=1}^J n_j (\bar{D}_{\cdot j} - \bar{D}_{\cdot\cdot})^2}{\sum_{j=1}^J \sum_{t=1}^{n_j} (D_{tj} - \bar{D}_{\cdot j})^2} \frac{(N - J)}{(J - 1)}$$

where $D_{tj} = |r_{tj} - \hat{M}_j|$; r_{tj} is the return for day t , interval j ; $\hat{M}_j$ is the sample median return for interval j computed over the n_j days included in the test; $\bar{D}_{\cdot j} = \sum_{t=1}^{n_j} (D_{tj}/n_j)$ is the mean absolute deviation (from the median) for interval j ; $\bar{D}_{\cdot\cdot} = \sum_{j=1}^J \sum_{t=1}^{n_j} (D_{tj}/N)$ is the grand mean; and $N = \sum_{j=1}^J n_j$. The statistic is distributed $F_{J-1, N-J}$ under the null hypothesis.

TABLE I
Volatility Persistence on Announcement Days
for the Eurodollar Futures and Spot Returns

Return Interval	Eurodollar Futures		Eurodollar Spot	
	Std. Dev. Ratio ($\sigma_{ann}/\sigma_{non}$)	B-F-L Statistic ($H_0: \sigma_{ann} = \sigma_{non}$)	Std. Dev. Ratio ($\sigma_{ann}/\sigma_{non}$)	B-F-L Statistic ($H_0: \sigma_{ann} = \sigma_{non}$)
8:00–9:00	2.428	38.64 ^c	1.131	3.05
9:00–10:00	1.532	16.58 ^c	1.238	3.56
10:00–11:00	1.435	13.02 ^c	1.466	6.29 ^a
11:00–12:00	1.269	4.40 ^a	1.159	0.31
12:00–1:00	1.272	13.47 ^c	1.624	3.79
1:00–2:00	0.896	1.09	1.401	1.69
2:00–3:00	0.930	0.25	0.893	0.10

Hourly return standard deviations are calculated and the ratios of the announcement day standard deviation to the nonannouncement day standard deviation are reported. The data period is 9/24/90 through 6/30/93. The Brown-Forsythe-modified Levene (B-F-L) test statistics for equality between the announcement day and nonannouncement day variances are reported.

^{a,b,c}Denote significance at the 5.0, 1.0, and 0.1% levels, respectively.

is consistently and significantly (0.1% level except the 11:00–12:00 interval) greater than the corresponding standard deviation on nonannouncement days until 1:00 PM in the Eurodollar futures market. On the other hand, this ratio of hourly variances is generally insignificant in the Eurodollar spot market although it exceeds one until 2:00 PM. Interestingly, this ratio during the 8:00–9:00 period is the second lowest

TABLE II
Volatility Persistence on Announcement Days for
the Deutsche Mark Futures and Spot Returns

Return Interval	Deutsche Mark Futures		Deutsche Mark Spot	
	Std. Dev. Ratio ($\sigma_{ann}/\sigma_{non}$)	B-F-L Statistic ($H_0: \sigma_{ann} = \sigma_{non}$)	Std. Dev. Ratio ($\sigma_{ann}/\sigma_{non}$)	B-F-L Statistic ($H_0: \sigma_{ann} = \sigma_{non}$)
8:00–9:00	1.865	20.73 ^c	1.365	13.09 ^c
9:00–10:00	1.197	3.65	1.226	4.45 ^a
10:00–11:00	1.208	0.18	1.059	1.48
11:00–12:00	1.225	5.39 ^a	1.169	4.62 ^a
12:00–1:00	0.989	0.09	1.013	1.18
1:00–2:00	0.952	0.66	0.992	1.43
2:00–3:00	0.941	0.58	0.947	0.87

Hourly return standard deviations are calculated and the ratios of the announcement day standard deviation to the nonannouncement day standard deviation are reported. The data period is 9/24/90 through 6/30/93. The Brown-Forsythe-modified Levene (B-F-L) test statistics for equality between the announcement day and nonannouncement day variances are reported.

^{a,b,c}Denote significance at the 5.0, 1.0, and 0.1% levels, respectively.

during the day. In summary, as already observed in Figure 1, volatility is extremely high in the first hourly period, declines sharply thereafter, but still remains higher than normal for several hours in the Eurodollar futures market. However, the Eurodollar spot market does not appear to reflect the implications of news releases as much as the Eurodollar futures market.

The deutsche mark futures prices respond to new information very rapidly as indicated in Table II. The standard deviation ratio is greater than one until 1:00 PM but the announcement day standard deviation is significantly (0.1% level) higher than the nonannouncement day standard deviation during only the 8:20–9:00 period. The deutsche mark spot volatility adjustment mirrors the futures volatility adjustment, although higher than normal volatility persists relatively longer (until 1:00 PM). Also, the impact of the 8:30 announcements on the spot prices is not as large as on the futures prices.

The deutsche mark results do not mirror the Eurodollar results. Both futures and spot prices are impacted by announcements. Most of the deutsche mark futures volatility adjustment is complete by 9:00 AM, while the deutsche mark spot market continues to be impacted by the 8:30 announcements until 10:00 AM. Those announcements released at other than 8:30 AM do not seem to affect futures and spot prices.

CAUSAL RELATIONSHIP BETWEEN FUTURES AND SPOT VOLATILITIES

In this section, the spot and futures return series are explored for any causal links between their volatilities in the Granger (1969, 1980) sense. If one accepts that futures markets serve as a primary price discoverer, then that implies that futures price movements lead spot price movements. The absolute values of the median adjusted spot (V_{jtS}) and futures (V_{jtF}) returns are examined. This specification of the median adjusted absolute return is consistent with the Brown–Forsythe-modified Levene tests of homoskedasticity. The variable V_{jtF} is said to Granger-cause the variable V_{jtS} if the information in past and present V_{jtF} helps to improve the forecasts of V_{jtS} . It is assumed that $[V_{jtF} V_{jtS}]'$ is a bivariate vector-autoregression process of order k , and that this is a stationary process with a zero mean, multivariate normal, and independent error structure. The bivariate vector-autoregression model

is of the following form:

$$\begin{bmatrix} V_{jtF} \\ V_{jtS} \end{bmatrix} = \begin{bmatrix} a_{11,1} & a_{12,1} \\ a_{21,1} & a_{22,1} \end{bmatrix} \begin{bmatrix} V_{j-1,t,F} \\ V_{j-1,t,S} \end{bmatrix} + \begin{bmatrix} a_{11,2} & a_{12,2} \\ a_{21,2} & a_{22,2} \end{bmatrix} \begin{bmatrix} V_{j-2,t,F} \\ V_{j-2,t,S} \end{bmatrix} + \dots + \begin{bmatrix} e_{jtF} \\ e_{jtS} \end{bmatrix} \tag{1}$$

where the endogenous variables V_{jtF} (V_{jtS}) are defined as the absolute value of the median adjusted futures (spot) return for intraday interval j on trading day t . For a given lag order k , it can be shown that V_{jtF} does not Granger-cause V_{jtS} , if, and only if, $H_0: a_{21,1} = a_{21,2} = \dots = a_{21,k} = 0$. H_0 is a statement of the null hypothesis that the estimated coefficients on the lags of V_{jtF} are jointly equal to zero. An F test of the sums of squared errors for the constrained and unconstrained models is used to test the null.¹⁰

This article is interested in the causal relation between spot return volatility and futures return volatility within the day. Specifically, the article addresses the question of whether volatility for hour j in the spot market is related to past volatility in the futures market. Tests are conducted also to determine if futures volatility is related to past spot volatility. Since there are seven hourly return observations per day with 9:00 AM through 3:00 PM (ET) as ending times of hourly interval returns, the lag order k can be between one and six. For example, there are six pairs of observations (10:00 AM–9:00 AM, 11:00 AM–10:00 AM, ..., 3:00 PM–2:00 PM) when k is one; while, for $k = 6$, only one set of observations (3:00 PM–2:00 PM, 1:00 PM, 12:00 PM, 11:00 AM, 10:00 AM, and 9:00 AM) is available per day. By stacking the days throughout the test period, the following regression model is estimated to investigate the relationship between V_{jtS} and the k lagged values of V_{jtS} and V_{jtF}

$$V_{jtS} = a_{oS} + \sum_{k=1}^K a_{22,k} V_{j-k,t,S} + \sum_{k=1}^K a_{21,k} V_{j-k,t,F} + e_{jtS} \tag{2}$$

where t covers all trading days during the sample period. Similarly, V_{jtF} is the dependent variable when testing whether V_{jtF} is Granger-caused by past V_{jtS} . Only within-day hourly return data are used in this study to avoid the problem of having to make adjustments to account for overnight return periods. The results for models including up to 6 lags

¹⁰See Judge et al. (1985).

are presented in Tables III and IV for the Eurodollar and deutsche mark markets, respectively.

Panel A of Table III reports test results for the estimated eq. (2). The F statistic is used to test whether past V_{jtF} Granger-causes V_{jtS} . On announcement days, there is uniform rejection of the null hypothesis that the lagged coefficients relating futures volatility to current spot volatility are equal to zero for all lags. The causal relationship is significant at the 0.1% level for lags 1 through 5, and at the 5% level for lag 6. The F value decreases as the number of lags increases. This causal relation is also observed on nonannouncement days. Although the F value is not as high as on announcement days, the null is rejected for lag 1 at the 0.1% level. In contrast to Panel A, the null hypothesis that spot volatility does not Granger-cause futures volatility is not rejected for all lags on announcement days as reported in Panel B. On nonannouncement days, for lags 5 and 6, some evidence exists that spot volatility causes futures volatility.

TABLE III

Granger Causality Tests for the Eurodollar Futures and Spot Return Volatilities

Announcement Days		Nonannouncement Days	
Number of Lags	F Statistic	Number of Lags	F Statistic
<i>Panel A: Null ~ Futures Volatility Does not Granger-Cause Spot Volatility</i>			
1	64.052 ^c	1	11.412 ^c
2	19.262 ^c	2	4.046 ^a
3	12.555 ^c	3	1.309
4	12.387 ^c	4	2.336
5	7.972 ^c	5	2.663 ^a
6	2.678 ^a	6	1.476
<i>Panel B: Null ~ Spot Volatility Does not Granger-Cause Futures Volatility</i>			
1	0.229	1	0.012
2	0.405	2	1.455
3	0.077	3	0.601
4	1.751	4	1.511
5	1.990	5	3.031 ^a
6	1.591	6	3.570 ^b

The estimated model for the null that the spot return volatility is not Granger-caused by the futures return volatility is $V_{jtS} = a_{0S} + \sum_{p=1}^P a_{22,p} V_{j-p,t,S} + \sum_{p=1}^P a_{21,p} V_{j-p,t,F} + e_{jtS}$. $V_{jtS(F)}$ is the absolute value of the median adjusted spot (futures) return over interval j on day t . Conversely, V_{jtF} is used as the dependent variable for the null that the futures return volatility is not Granger-caused by the spot return volatility. The data period is from 9/24/90 through 6/30/93. F tests of the joint hypothesis that the coefficients of the lagged values of the futures volatility equal zero when the spot volatility is the dependent variable are reported in Panel A, while F tests of the joint hypothesis that the lagged values of the spot volatility have coefficients equal to zero with dependent variable of the futures volatility are reported in Panel B. ^{a,b,c}Indicate significance at the 5.0, 1.0, and 0.1% levels, respectively. Results are reported for both announcement days and nonannouncement days.

TABLE IV
Granger Causality Tests for the Deutsche Mark Futures and Spot Return Volatilities

<i>Announcement Days</i>		<i>Nonannouncement Days</i>	
<i>Number of Lags</i>	<i>F Statistic</i>	<i>Number of Lags</i>	<i>F Statistic</i>
<i>Panel A: Null ~ Futures Volatility Does not Granger-Cause Spot Volatility</i>			
1	68.652 ^c	1	81.543 ^c
2	44.642 ^c	2	46.910 ^c
3	28.125 ^c	3	27.774 ^c
4	16.563 ^c	4	23.782 ^c
5	3.154 ^b	5	15.737 ^c
6	0.404	6	17.673 ^c
<i>Panel B: Null ~ Spot Volatility Does not Granger-Cause Futures Volatility</i>			
1	1.450	1	0.612
2	0.093	2	0.948
3	0.676	3	2.204
4	1.496	4	2.160
5	1.109	5	1.468
6	2.003	6	1.764

The estimated model for the null that the spot return volatility is not Granger-caused by the futures return volatility is $V_{j|S} = a_{0s} + \sum_{p=1}^P a_{22,p} V_{j-p,t,S} + \sum_{p=1}^P a_{21,p} V_{j-p,t,F} + e_{j|S}$. $V_{j|S(F)}$ is the absolute value of the median adjusted spot (futures) return over interval j on day t . Conversely, $V_{j|F}$ is used as the dependent variable for the null that the futures return volatility is not Granger-caused by the spot return volatility. The data period is from 9/24/90 through 6/30/93. F tests of the joint hypothesis that the coefficients of the lagged values of the futures volatility equal zero when the spot volatility is the dependent variable are reported in Panel A, while F tests of the joint hypothesis that the lagged values of the spot volatility have coefficients equal to zero with dependent variable of the futures volatility are reported in Panel B. ^{a,b,c}Indicate significance at the 5.0, 1.0, and 0.1% levels, respectively. Results are reported for both announcement days and nonannouncement days.

Causality test results for the deutsche mark spot and futures markets are summarized in Table IV. Regardless of announcements, the futures return volatility leads the spot return volatility for up to lag 5 on announcement days and for up to lag 6 on nonannouncement days. The F values are comparable to each other between announcement days and nonannouncement days for each lag. Similar to the Eurodollar results, Panel B shows that the current futures volatility is unrelated to the past spot volatility on both announcement and nonannouncement days.

In summary, overall results suggest that there is considerable interaction between the spot and futures markets at least in terms of the transfer of volatility from the futures market to the spot market but not in the opposite direction. This phenomenon confirms that the futures market helps discover new prices more prominently on announcement days than on nonannouncement days in the Eurodollar

spot and futures markets, while it is invariant to announcements in the deutsche mark markets.

WHICH ANNOUNCEMENTS IMPACT THE MARKETS

The aggregate impact of all announcements were examined by comparing volatility patterns on announcement and nonannouncement days and testing homoskedasticity. Now the *individual* impact of each of the announcements on the spot market as well as the futures market is investigated. Following E&L, this article estimates a regression in which the dependent variable is the absolute value of the difference between the actual return R_{jt} for hourly interval j on day t and the mean return $\bar{R}_j$ for interval j over all trading days. Dummy variable D_{kt} is defined to be 1 if announcement k is released on day t and zero otherwise. The regression format is

$$|R_{jt} - \bar{R}_j| = a_{0j} + \sum_{k=1}^K a_{kj} D_{kt} + e_{jt} \quad (3)$$

As explained in E&L, if log returns are normally distributed with constant mean but time-varying variance, $1.2533 a_{0j}$ provides an estimate of the standard deviation of returns on nonannouncement days and $1.2533 (a_{kj} + a_{0j})$ represents an estimate of the standard deviation on days when announcement k (and only k) is released.¹¹ Whether an announcement is bullish or bearish, a_{kj} should be positive if announcement k impacts the market, implying that volatility is greater than on nonannouncement days. The null hypothesis is that the market ignores announcement k , or $a_{kj} = 0$. Two pairs, industrial production-capacity utilization and construction spending-NAPM Survey, are released on the same day. Installment credit is released at no fixed time. Consequently, only 16 dummy variables are used in the regression.

Four sets of regressions are estimated with respect to the 8:30, 9:15, 10:00, and 2:00 announcements. Results for the Eurodollar futures and spot markets are shown in Table V. From Panel A, it is clear that the employment report, durable goods orders, the producer price index (PPI), and the consumer price index (CPI) (in descending order of impact) have a major impact on the Eurodollar futures price

¹¹For a more detailed discussion, see Schwert (1989) and Schwert and Seguin (1990).

TABLE V
The Impact of Announcements on the Intraday Volatility of the Eurodollar Futures and Spot Returns

	Panel A: Eurodollar Futures						
	8:00-9:00	9:00-10:00	10:00-11:00	11:00-12:00	12:00-1:00	1:00-2:00	2:00-3:00
Intercept	1.740 ^c	1.120 ^c	1.030 ^c	1.080 ^c	0.887 ^c	1.080 ^c	1.460 ^c
8:30 AM announcements							
Consumer price index	1.400 ^b	0.421	0.330	0.080	0.694 ^c	0.318	0.089
Durable goods orders	1.790 ^c	0.097	0.620 ^b	0.133	0.250	-0.010	0.250
Employment	7.560 ^c	0.773 ^b	0.242	0.836 ^b	0.654 ^c	0.179	0.014
Gross national product	0.627	-0.034	0.317	0.079	0.188	0.178	-0.075
Housing starts	0.813	0.175	0.041	-0.006	0.148	-0.289	0.030
Leading indicators	-0.255	0.334	0.282	-0.412	0.082	0.145	-0.158
Merchandise trade deficit	0.446	0.180	-0.016	-0.100	-0.031	-0.026	-0.224
Producer price index	1.480 ^b	0.498 ^a	0.213	0.669 ^a	0.390 ^a	0.360	-0.142
Retail sales	0.821	-0.219	-0.091	0.012	-0.137	-0.042	0.135
9:15 AM announcements							
Industrial production-capacity utilization	NA	0.221	-0.117	0.110	-0.276	-0.167	-0.124
10:00 AM announcements							
Business inventories	NA	NA	0.301	-0.051	-0.028	0.273	-0.158
Construction spending-NAPM survey	NA	NA	1.790 ^c	0.249	-0.118	0.144	0.178
Factory inventories	NA	NA	0.342	-0.089	0.245	-0.199	-0.317
New single-family home sales	NA	NA	0.384	0.120	0.086	-0.199	-0.339
Personal income	NA	NA	0.318	-0.094	0.657 ^c	-0.204	0.156
2:00 PM announcement							
Federal budget	NA	NA	NA	NA	NA	NA	0.122
Adjusted R ²	0.248	0.012	0.068	0.000	0.0322	-0.004	-0.009

continued

TABLE V (Continued)

	Panel B: Eurodollar Spot					
	8:00-9:00	9:00-10:00	10:00-11:00	11:00-12:00	12:00-1:00	1:00-2:00 2:00-3:00
Intercept	2.200 ^c	1.590 ^c	0.763 ^c	0.806 ^c	0.192 ^b	0.183 ^b 0.228 ^c
8:30 AM announcements						
Consumer price index	0.827	0.125	0.254	0.078	-0.120	-0.040
Durable goods orders	1.770 ^b	-0.227	-0.151	0.493	0.150	-0.146
Employment	3.510 ^c	1.480 ^b	0.718	1.090 ^b	0.372	-0.018
Gross national product	0.191	0.137	-0.116	-0.476	-0.131	-0.197
Housing starts	-0.106	-0.209	0.976 ^a	1.080 ^a	0.690 ^b	0.163
Leading indicators	-0.504	-0.246	0.047	-0.227	-0.304	0.010
Merchandise trade deficit	0.295	0.789	0.902 ^a	-0.341	-0.227	-0.234
Producer price index	0.449	1.550 ^b	0.031	-0.526	0.728 ^b	0.056
Retail sales	0.796	-0.621	0.295	0.694	-0.181	0.500 ^a
9:15 AM announcements						
Industrial production-capacity utilization	NA	0.292	-0.623	-0.720	0.216	-0.191 0.286
10:00 AM announcements						
Business inventories	NA	NA	0.490	0.435	0.236	0.065 -0.273
Construction spending-NAPM survey	NA	NA	1.050 ^b	0.732	0.290	-0.141 -0.168
Factory inventories	NA	NA	0.373	-0.506	0.585 ^a	-0.148 0.224
New single-family home sales	NA	NA	0.504	-0.451	0.270	0.092 0.072
Personal income	NA	NA	0.705	-0.514	0.250	-0.179 -0.168
2:00 PM announcement						
Federal budget	NA	NA	NA	NA	NA	NA 0.204
Adjusted R^2	0.036	0.016	0.008	0.014	0.011	0.004 -0.005

Coefficients a_{kj} of the regression $|R_{jt} - \bar{R}_j| = a_{0j} + \sum_{k=1}^K a_{kj} D_{kt} + e_{jt}$ are reported. R_{jt} is the log return over the hourly interval j where P_{jt} is the price at the end of interval j and day t . $D_{kt} = 1$ if announcement k is released on day t . The regression is estimated for j intervals of 8:00-9:00 (8:20-9:00 for futures), 9:00-10:00, 10:00-11:00, 11:00-12:00, 12:00-1:00, 1:00-2:00, and 2:00-3:00 over all trading days, t , between 9/24/90 and 6/30/93. Of the 18 announcements, only those issued in interval j or earlier are included in each regression. The reported coefficients are the actual coefficients times 10^4 .

a,b,c: Indicate significance at the 5.0, 1.0, and 0.1% levels, respectively, in a one-tailed t test.

movements. For example, on days with employment announcements, the standard deviation of returns is $(7.560 + 1.740)/1.740 = 5.3$ times as high as on nonannouncement days. The impact of the employment report persists until 1:00 PM. The construction spending-NAPM Survey announcements released at 10:00 also appear to impact the futures market significantly.

The question is whether the major announcements impacting the spot market are consistent with those of the futures market. As in Panel B of Table V, the employment report is again most significant in inducing higher spot volatility, and the impact persists until 12:00. Only one other announcement, durable goods orders, is significant during the 8:00–9:00 period, while the PPI and the CPI are insignificant. However, the impact of the PPI is significant during the 9:00–10:00 period and the 12:00–1:00 period. Like the futures market, all announcements released at times other than 8:30 tend to be ignored by the spot market except the construction spending-NAPM Survey announcements. Overall results suggest that the impact of individual announcements is much less in the spot market than in the futures market.¹² However, the impact of two individual announcements are significant, contrary to the insignificant aggregate impact of all announcements reported in Figure 1 and Table I.

Regression results for the deutsche mark futures and spot markets as shown in Table VI are distinguishable from those for the Eurodollar markets. As expected, the merchandise trade announcement, which is ignored in the Eurodollar markets, has a significant impact on both the deutsche mark futures and spot prices. The employment report, retail sales, durable goods orders, merchandise trade deficit, and the PPI are major announcements in both the futures and spot markets. Interestingly, the CPI is not considered important in the deutsche mark markets. In contrast to the Eurodollar spot market, there is clear evidence that the deutsche mark spot market is greatly impacted by those 8:30 major announcements. The overall impact of the 8:30 announcements generally persists until 10:00 as indicated by adjusted R^2 . The employment report continues to cause high volatility until 12:00 in the futures and spot markets, and merchandise trade deficit and the PPI move the spot market until about 2:00.

¹²The adjusted R^2 for the 8:00–9:00 regression is only 3.6% for Eurodollar spot, while it is 24.8% for Eurodollar futures, implying that the spot market does not reflect the impact of announcements as well as the futures market.

TABLE VI
The impact of Announcements on the Intraday Volatility of the Deutsche Mark Futures and Spot Returns

	Panel A: Deutsche Mark Futures						
	8:00-9:00	9:00-10:00	10:00-11:00	11:00-12:00	12:00-1:00	1:00-2:00	2:00-3:00
Intercept	12.090 ^c	13.570 ^c	17.280 ^c	15.730 ^c	13.330 ^c	1.128 ^c	11.340 ^c
8:30 AM announcements							
Consumer price index	-2.300	4.070	2.940	2.290	0.428	-0.203	4.050 ^a
Durable goods orders	8.220 ^b	0.572	1.150	-3.470	-0.688	0.219	-0.894
Employment	43.440 ^c	13.260 ^c	-0.897	5.200 ^a	0.796	0.254	0.212
Gross national product	4.750	0.837	3.340	-1.390	-2.740	0.235	0.165
Housing starts	4.080	5.460 ^a	-1.880	0.189	1.690	0.909	-3.360
Leading indicators	2.560	-0.822	-0.980	-0.668	-2.600	4.260 ^a	-0.570
Merchandise trade deficit	5.540 ^a	4.250	7.440 ^b	-0.059	-1.230	5.700 ^a	-0.498
Producer price index	5.290 ^a	4.050	5.340 ^a	4.860	3.390	-0.380	-1.650
Retail sales	9.160 ^b	-0.666	2.220	-1.080	-0.362	0.378	-0.792
9:15 AM announcements							
Industrial production-capacity utilization	NA	4.630 ^a	-1.720	-1.170	-0.117	0.404	1.250
10:00 AM announcements							
Business inventories	NA	NA	-0.873	-1.770	-0.886	-1.440	0.239
Construction spending-NAPM survey	NA	NA	2.690	2.330	2.320	-1.710	0.134
Factory inventories	NA	NA	2.030	-1.740	0.660	-1.600	-2.250
New single-family home sales	NA	NA	1.510	0.238	1.820	-3.500	-1.140
Personal income	NA	NA	6.720 ^a	4.190	2.540	-0.257	1.640
2:00 PM announcement							
Federal budget	NA	NA	NA	NA	NA	NA	-3.940
Adjusted R^2	0.231	0.046	0.005	-0.005	-0.011	-0.003	-0.007

continued

TABLE VI (Continued)

Panel B: Deutsche Mark Spot		8:00-9:00	9:00-10:00	10:00-11:00	11:00-12:00	12:00-1:00	1:00-2:00	2:00-3:00
Intercept		14.100 ^c	14.510 ^c	17.390 ^c	15.730 ^c	14.720 ^c	12.530 ^c	11.59 ^c
8:30 AM announcements								
Consumer price index		1.580	2.970	3.670	2.680	-1.600	-0.277	1.910
Durable goods orders		8.040 ^b	0.737	1.550	-0.285	-1.720	0.188	-3.030
Employment		30.850 ^c	9.900 ^c	-0.887	6.280 ^b	0.429	2.040	0.809
Gross national product		3.400	-2.960	1.700	1.520	-0.261	-0.561	-3.000
Housing starts		3.140	3.870	-4.430	-2.050	-1.300	-1.460	-1.920
Leading indicators		-1.670	-3.010	-2.290	-2.520	1.350	4.580	0.109
Merchandise trade deficit		5.800 ^a	7.380 ^b	4.170	5.480 ^a	-2.080	5.250 ^a	-0.363
Producer price index		4.630	5.830 ^a	5.980 ^a	-2.240	1.960	7.370 ^b	2.260
Retail sales		5.780 ^a	-1.660	-1.560	2.510	0.277	-2.470	-0.868
9:15 AM announcements								
Industrial production-capacity utilization		NA	6.050 ^a	-1.670	-0.112	0.156	0.076	0.141
10:00 AM announcements								
Business inventories		NA	NA	-0.770	-2.040	-1.600	-1.340	1.070
Construction spending-NAPM survey		NA	NA	2.300	0.787	0.283	0.155	0.814
Factory inventories		NA	NA	2.290	1.350	-1.670	-1.410	-3.620
New single-family home sales		NA	NA	-2.090	0.953	-4.200	-2.720	-0.535
Personal income		NA	NA	1.100	2.120	2.840	1.930	-1.370
2:00 PM announcement								
Federal budget		NA	NA	NA	NA	NA	NA	-3.290
Adjusted R^2		0.134	0.040	-0.004	0.002	-0.014	0.000	-0.006

Coefficients a_{kt} of the regression $|R_{jt} - \bar{R}_j| = a_{0t} + \sum_{k=1}^K a_{kt} D_{kt} + e_{jt}$ are reported. $R_{jt} = \ln(P_{jt}/P_{j-t,1})$ is the log return over the hourly interval j where P_{jt} is the price at the end of interval j and day t . $D_{kt} = 1$ if announcement k is released on day t . The regression is estimated for j intervals of 8:00-9:00 (8:20-9:00 for futures), 9:00-10:00, 10:00-11:00, 11:00-12:00, 12:00-1:00, 1:00-2:00, and 2:00-3:00 over all trading days, t , between 9/24/90 and 6/30/93. Of the 18 announcements, only those issued in interval j or earlier are included in each regression. The reported coefficients are the actual coefficients times 10^4 .

a,b,c) indicate significance at the 5.0, 1.0, and 0.1% levels, respectively, in a one-tailed t test.

MARKET EFFICIENCY AND PRICE ADJUSTMENT PATTERNS

Correlation Analysis

As reported in the previous sections, the 8:30 announcements appear to impact the markets most significantly. Therefore, the article focuses on only 8:30 announcements for the remaining analyses. If the market is inefficient, prices tend to rise or fall continuously for several hours, representing a profitable trading opportunity. The article examines whether it is possible to make excess profits by observing the initial price response and buying (selling) if the initial return is positive (negative). Note that continued high volatility does not necessarily mean serially correlated returns. If prices fully adjust to the available information immediately but continue to adjust in an independent manner as further details become available or as those who disagree with the market's initial consensus view about the information place their orders later, volatility may still remain higher than normal, and the market should not be considered inefficient.

Serial correlation coefficients are calculated for successive hourly returns following the 8:30 announcements. Results are shown in Tables VII and VIII for the Eurodollar and deutsche mark markets. Consider the correlation between the first and second hourly returns. There is no evidence in either market that the price adjustment which begins in the first hour continues into the second hour. Specifically,

TABLE VII
Serial Correlation Matrices for the Eurodollar Futures and Spot Returns

	<i>Eurodollar Futures</i>			<i>Eurodollar Spot</i>		
	<i>First Hour</i>	<i>Second Hour</i>	<i>Third Hour</i>	<i>First Hour</i>	<i>Second Hour</i>	<i>Third Hour</i>
First hour	1.000			1.000		
Second hour	-0.070	1.000		-0.140 ^a	1.000	
Third hour	-0.049	-0.053	1.000	-0.092	-0.229 ^b	1.000
Fourth hour	0.025	-0.035	-0.121	-0.058	0.071	-0.303 ^b
Fifth hour	0.084	0.018	-0.008	-0.083	0.014	-0.025
Sixth hour	-0.018	-0.022	0.027	0.098	0.003	-0.110
Seventh hour	0.089	0.037	0.090	-0.043	0.002	-0.120

Pearson correlation coefficients between hourly returns following the 8:30 announcements are reported.

^{a,b}Indicate significance at the 5 and 0.1% levels, respectively. The data period is from 9/24/90 through 6/30/93.

TABLE VIII
Serial Correlation Matrices for the Deutsche Mark Futures and Spot Returns

	<i>Deutsche Mark Futures</i>			<i>Deutsche Mark Spot</i>		
	<i>First Hour</i>	<i>Second Hour</i>	<i>Third Hour</i>	<i>First Hour</i>	<i>Second Hour</i>	<i>Third Hour</i>
First hour	1.000			1.000		
Second hour	-0.143 ^a	1.000		-0.006	1.000	
Third hour	-0.021	0.117	1.000	0.022	0.007	1.000
Fourth hour	0.120	0.117	0.164 ^b	0.098	0.130 ^a	0.278 ^c
Fifth hour	0.019	-0.020	0.069	0.060	-0.017	0.091
Sixth hour	0.005	0.037	0.201 ^b	0.000	0.035	0.092
Seventh hour	-0.007	-0.116	-0.008	-0.016	-0.017	-0.064

Pearson correlation coefficients between hourly returns following the 8:30 announcements are reported.
a,b,c Indicate significance at the 5, 1, and 0.1% levels, respectively. The data period is from 9/24/90 through 6/30/93.

the correlation between returns in the first two hours is negative but insignificant in the Eurodollar futures market and the deutsche mark spot market. However, in the Eurodollar spot market and the deutsche mark futures market, this correlation coefficient is significantly negative. This may imply that these markets tend to overreact to the news in the first hour and then correct in the second hour. In the Eurodollar spot market, the correlation coefficients for the first four hourly returns are all significantly negative, which implies that the direction of the spot price movement changes each hour. In summary, there is no evidence that the first hour price adjustment continues into the next several hours as the correlation between the first hourly return and the subsequent hourly returns are not significantly positive. There is also some evidence of potential overreaction in the Eurodollar spot and deutsche mark futures markets.

Price Adjustment

The article examines the price adjustment patterns and also seeks further evidence of the possible overreaction discussed above. The direction of the futures price change over the first 30 seconds following the release is used as a basis to determine whether an announcement is bullish or bearish.¹³ Specifically, the adjusted returns, AR_{jt} for hourly interval j on

¹³The Ederington and Lee (1994) study proposes the use of this 30-second interval to determine whether the news is bearish or bullish for interest and exchange rates. This article analyzes tick-by-tick price data for the Eurodollar and deutsche market futures, particularly the 8:30:00 price and the 8:30:30 price to determine the sign of the news.

day t is defined as $AR_{jt} = R_{jt} * D_t$ where $D_t = 1$ if the return between 8:30:00 and 8:30:30 is positive, $D_t = -1$ if the 8:30:00–8:30:30 return is negative, and $D_t = 0$ if the 8:30:00–8:30:30 return is zero. If prices in interval j are continuing to adjust in the same direction as in the 8:30:00–8:30:30 period, AR_{jt} would tend to be positive. Average adjusted returns are calculated both for announcement days and for nonannouncement days.

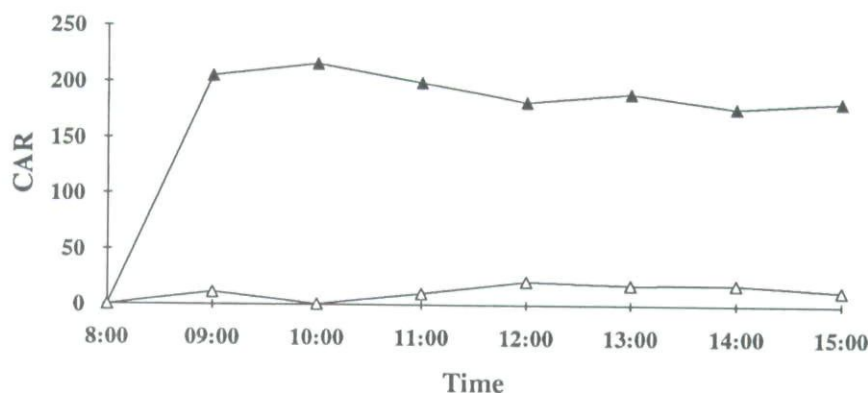
Average adjusted returns are summed in the cumulative average adjusted returns, CAR_{jt} , and these are graphed in Figures 3 and 4 for the Eurodollar and deutsche mark markets.¹⁴ Without exception, all CARs for nonannouncement days are approximately zero as all average adjusted returns fluctuate around zero. This indicates that the procedure to calculate adjusted returns is unbiased. Statistical significance for average adjusted returns on announcement days is also examined based on t tests. In both interest rate and exchange rate markets, the 8:00–9:00 average AR is significantly positive at the 0.1% level, supporting the findings in the previous sections that the price adjustment is almost complete by 9:00 AM. On the other hand, average adjusted returns fluctuate around, and are not significantly different from, zero even on announcement days when j is not the 8:00–9:00 period. These results are clearly reflected in cumulative average adjusted returns, CAR_{jt} , as shown in Figures 3 and 4. Consistent with the correlation results, there is no evidence that the 8:00–9:00 adjustment continues into the next hours. Furthermore, the possible overreaction in the Eurodollar spot and deutsche mark futures markets is not clearly detected in the CAR patterns.

CONCLUSIONS

This article explores how the Eurodollar and deutsche mark spot and futures markets adjust to regularly scheduled announcements. As pointed out in the data section, the futures and spot prices should move similarly to the extent that the cost-of-carry relationship holds. However, it can be hypothesized that differences in the market microstructure of the spot and futures markets may induce distinguishable adjustments to news releases.

¹⁴The cumulative average adjusted return, CAR, in this study should not be confused with the cumulative excess return measure frequently employed in event studies of market efficiency. This CAR is adjusted to news content. A big price increase follows important bullish news, while price goes down sharply following important bearish information. Since a dummy variable for informational content is used to calculate CAR, both huge price increases and decreases lead to an increase in CAR. On the other hand, the conventional cumulative excess return increases only when price increases.

Eurodollar Futures Price Adjustment



Eurodollar Spot Price Adjustment

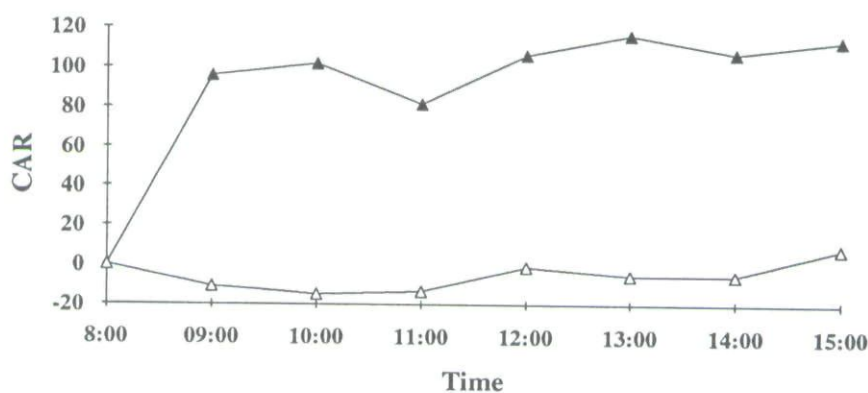
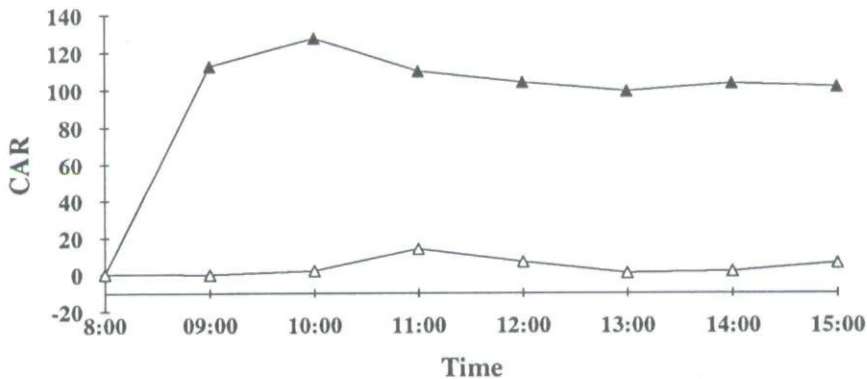


FIGURE 3

The Eurodollar futures and spot price adjustment following the 8:30 announcements. Cumulative average adjusted returns (CAR) are reported for announcement days (shaded triangle) and nonannouncement days (open triangle). CAR equals the sum of the average adjusted returns from 8:00 to the time shown. The adjusted return $AR_t = R_t * D_t$ where D_t is a +1, 0, -1 dummy variable based on the sign of the 8:30:00-8:30:30 futures return. The reported returns (CAR) are the actual returns times 10^6 .

The most important findings are as follows. First, in the Eurodollar futures market and the deutsche mark spot and futures market, volatility is considerably higher on announcement days than on nonannouncement days, implying that scheduled announcements move these markets to a great extent. However, most announcements seem not to be reflected in the Eurodollar spot market, except the employment report, durable goods orders, and construction spending-NAPM Survey. This finding is probably due to more frequent use of FRAs, interest swaps,

Deutsche Mark Futures Price Adjustment



Deutsche Mark Spot Price Adjustment

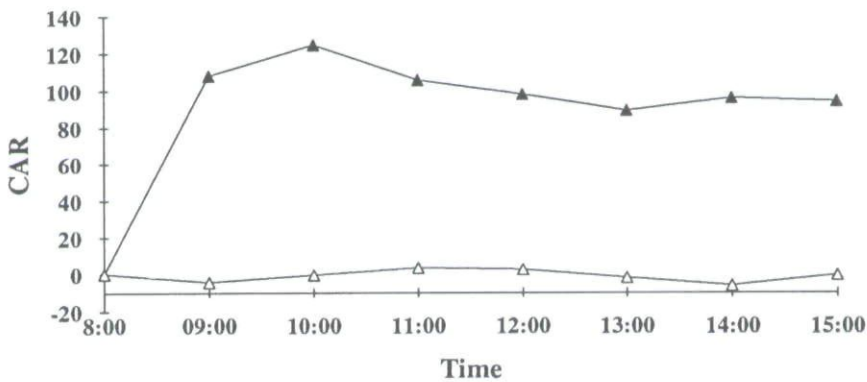


FIGURE 4

The deutsche mark futures and spot price adjustment following the 8:30 announcements. Cumulative average adjusted returns (CAR) are reported for announcement days (shaded triangle) and nonannouncement days (open triangle). CAR equals the sum of the average adjusted returns from 8:00 to the time shown. The adjusted return $AR_t = R_t * D_t$ where D_t is a +1, 0, -1 dummy variable based on the sign of the 8:30:00-8:30:30 futures return. The reported returns (CAR) are the actual returns time 10^5 .

and Eurodollar futures by the Eurodollar spot market participants when they adjust their positions to economic news.

Second, most price adjustments occur within the first hour following announcements, while there is some evidence that volatility remains higher than normal for the next several hours. The spot market is generally impacted by news releases for a longer period than the futures market.

Third, there is clear evidence that volatility is transferred from the futures market to the spot market, which confirms the price discovery role of futures. It is interesting to note that this causal relationship between futures and spot volatilities is generally more prominent on announcement days.

Fourth, there are several major announcements that impact the spot and futures markets. The employment report, durable goods orders, and the PPI are important to both the Eurodollar and deutsche mark markets. The CPI is important in the Eurodollar futures (but not spot) market, while the merchandise trade deficit and retail sales announcements influence the deutsche mark spot and futures markets.

Finally, there is no evidence of market inefficiency. The analysis of correlation coefficients and the price adjustment patterns shows that prices do not tend to rise or fall continuously for several hours after the initial price adjustment to new information.

The overall results suggest that the spot market incorporates news releases like the futures market; but the degree of the impact is lower and the speed of the price adjustment is slower compared to the futures market. This may be due to differences in the microstructure of the futures and spot markets. High liquidity and the ease of trading in the futures markets allows market participants to quickly react to news releases.

APPENDIX

Macroeconomic Announcements

<i>Time</i>	<i>Title of Report</i>	<i>Reporting Agency</i>
8:30 AM	Consumer Price Index	Bureau of Labor Statistics
8:30 AM	Durable Goods Orders	Bureau of the Census
8:30 AM	Employment	Bureau of Labor Statistics
8:30 AM	Gross National Product ^a	Bureau of Economic Analysis
8:30 AM	Housing Starts	Bureau of the Census
8:30 AM	Leading Indicators	Bureau of Economic Analysis
8:30 AM	Merchandise Trade Deficit	Bureau of the Census
8:30 AM	Producer Price Index	Bureau of Labor Statistics
8:30 AM	Retail Sales	Bureau of the Census
9:15 AM	Industrial Production	Federal Reserve Board
9:15 AM	Capacity Utilization	Federal Reserve Board
10:00 AM	Business Inventories	Bureau of the Census
10:00 AM	Construction Spending	Bureau of the Census

continued

<i>Time</i>	<i>Title of Report</i>	<i>Reporting Agency</i>
10:00 AM	Factory Inventories	Bureau of the Census
10:00 AM	NAPM Survey	National Association of Purchasing Managers
10:00 AM	New Single-Family Home Sales	Bureau of the Census
10:00 AM	Personal Income	Bureau of Economic Analysis
2:00 PM	Federal Budget	Department of the Treasury
No fixed time	Installment Credit	Federal Reserve Board

^aGross Domestic Product (GDP) has been released instead of GNP since January 1992. No distinction between GDP and GNP is made in the analysis because their impact on market prices is expected to be alike.

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