

WHAT MOVES THE BOND MARKET?

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Abstract

We take a close look at a year in the U.S. Treasury market and try to explain the sharpest price changes and most active trading episodes. The virtue of our analysis lies in its use of high-frequency data on market movements and accurate release times for a comprehensive set of economic announcements. For the period August 1993 to August 1994, we attribute the 25 largest price moves and 25 greatest trading surges to just-released announcements. The bond market's response to announcements in general is consistent with the way we would expect it to react to new information.

Keywords: Announcement effects, bond market, trading activity

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1. Introduction

To what extent can movements in the bond market be attributed to the arrival of new information? In the case of the stock market, Cutler, Poterba, and Summers (1989) have shown that it is difficult to identify consequential information to account for most of the market's largest price movements. There has been no such study for the bond market, although both theory and the existing empirical literature suggest that the results should be more promising. In this paper, we take a close look at a single year in the U.S. Treasury market and try to explain the sharpest price changes and the most active trading episodes. Our analysis derives its advantage from the use of high-frequency data on market movements and accurate release times for a comprehensive list of announcements.

Unlike most bond market announcement studies, we analyze trading activity as well as price movements. Beaver (1968) has attributed large price changes in the stock market to revisions in expectations shared by investors and surges in trading activity to a lack of consensus on prices. As we discuss in this paper, the distinction is more applicable to the bond market than to the stock

market, because the conveyance of private information through trading is less important a phenomenon in the bond market than in the stock market.

To explain the sharp price movements and heightened trading activity, we examine how closely the events correlate with announcement release times. We then relate market behavior to factors affecting the information content of the announcements, specifically the nature of the announcement, the magnitude of the surprise in the data announced, and the market uncertainty surrounding bond prices. Among our announcements, we consider two that have not been analyzed before: Federal Reserve funds target rate announcements and U.S. Treasury auction results.

We begin by providing the first extensive survey of the literature on the effects of macroeconomic announcements on stock and bond markets. We then proceed to examine the largest price movements and most active trading periods in the U.S. Treasury securities market during the August 1993 to August 1994 period and see how many of the market events we can attribute to various announcements. To see whether the market's behavior is generally consistent with rational reactions to new information, we estimate the relative importance of the individual announcements and analyze the extent to which the degree of surprise in the announcements matters. Finally, we explore the possible effects of changing market conditions on the way the market responds to a given type of announcement.

2. Explaining market movements: previous studies

Stock market studies

Theory tells us that movements in financial asset prices should reflect new information about fundamental asset values. In the stock market's case, however, the theory has been difficult to confirm. Most notably, Cutler, Poterba, and Summers (1989) examine the fifty largest one-day price moves in the S&P Composite Stock Index since 1946 and judge that in most of these cases, the public information apparently causing the market move "is not particularly important." In earlier studies, Schwert (1981), Pearce and Roley (1985), and Hardouvelis (1987) find little evidence that the stock market responds to macroeconomic news other than monetary information. More recently, McQueen and Roley (1993) show that conditioning on different stages of the business cycle leads to stronger announcement effects. Even with their best effort, however, they are able to explain only 3.9 percent of the daily variation in stock prices.

The apparently weak market-wide informational effects found in the stock market are not entirely surprising. In empirical work, such effects on whole markets are likely to be harder to discern for stocks than for bonds, because much of the relevant observable information takes the form of announcements about macroeconomic developments. In the case of such information, the theoretical effects are often more ambiguous for stocks than for bonds. Stock cash flows depend on economic conditions, while Treasury bond cash flows are fixed in nominal terms. As a result the link between asset prices and economic news tends to be straightforward for the bond market but not for the stock

market. An upward revision of expected real activity, for example, raises expected cash flows for stocks while raising discount rates for both stocks and bonds. The effect on bond prices is clearly negative, while the effect on stock prices is ambiguous, depending on whether the cash flow effect dominates the discount rate effect.

Bond market announcement studies

Indeed the literature on announcement effects in the bond market is voluminous. Table 1 lists the studies that find macroeconomic announcements with a significant impact on the U.S. Treasury market along with the sample periods covered by the analyses.¹ In these studies, market movements are typically based on daily interest rates and announcements are measured in terms of their surprises, which are the differences between forecasts and the actual numbers released. Forecasts are either derived by the authors from the time series of the variables or provided by Money Market Services (MMS) based on surveys conducted a few days before the announcements. Over the years, the announcements most frequently identified as significant have been the money supply, industrial production, producer price index (PPI), consumer price index (CPI), jobless rate, and nonfarm payrolls numbers.

The literature provides evidence of a “flavor-of-the-month” aspect to the market’s behavior, in which some announcements are regarded as important in some periods but not in others. Starting with Berkman (1978), studies from the late 1970s to the mid-1980s document a significant impact of money supply announcements. Dwyer and Hafer (1989) show, however, a diminishing

¹ In the cases where the studies examine several interest rates, we report only the results for the longest maturity rate.

significance for such announcements in the mid-1980s. Studies in the 1980s, such as Urich and Wachtel (1984) and Smirlock (1986), began to focus on the PPI, CPI, and jobless rate announcements. More recent studies, particularly Cook and Korn (1991) and Krueger (1996), establish the ascendant importance of the nonfarm payrolls number in the employment report.

It is notable that those bond market studies that consider several announcements tend to find relatively few of them significant. Roley and Troll (1983), Hardouvelis (1988), and Dwyer and Hafer (1989), for example, find that many of the monthly announcements they examine have no significant effect on interest rates.² One possible reason is that the daily interest rate data on which these studies rely are not of sufficiently high frequency to capture the market's reaction cleanly. As Hardouvelis (1988) points out, ideally one should measure the market change from just before to just after the announcement. Another possible reason is that the effect of a given announcement surprise may vary even over short periods of time, depending on what else is going on in the economy. Prag (1994), for example, shows that the effect of jobless rate announcements on interest rates is conditional on the existing level of unemployment.

Studies using intraday data

The recent availability of high-frequency intraday price data has increased the power of efforts to estimate announcement effects. Ederington and Lee (1993) exploit such data on Treasury bond futures to examine the impact of

² Roley and Troll (1983) find no significant announcement effects from CPI, PPI, and the jobless rate; Hardouvelis (1988) finds none from consumer credit, housing starts, industrial production, leading indicators, merchandise trade, or personal income; and Dwyer and Hafer (1989) find none from CPI, industrial production, the jobless rate, or merchandise trade.

monthly economic announcements on price volatility. They find nine out of 16 announcements to have significant effects, with the greatest impact coming from the employment, PPI, CPI, and durable goods orders releases. More recently, Fleming and Remolona (1996) analyze intraday cash market Treasury securities data and identify eight significant announcements for price volatility and 11 for trading volume. Rather than measuring surprise components, both of these studies rely on dummy variables to isolate the announcements effects.

If an announcement's impact depends only on the part of released information that is unexpected, then accounting for the sign and magnitude of the unexpected component should improve the estimates of announcement effects. Nonetheless, intraday studies relying on such surprises do not identify more significant announcements than do studies relying only on announcement dummy variables. Becker, Finnerty, and Kopecky (1996) find nonfarm payrolls and CPI surprises to significantly affect the fifteen-minute returns on bond futures, but not housing starts or merchandise trade surprises. Balduzzi, Elton and Green (1996) find surprises from only five of 23 monthly announcements to have a significant price impact on the 10-year Treasury note.

Studies of trading activity

Much of the research on trading activity has been limited to the stock market, with the early literature focusing on a dichotomy between the effects of earnings announcements on prices and the effects on trading activity. Beaver (1968, p. 69) argued that stock price movements in weeks of earnings announcements reflect "changes in the expectations of the market as a whole" while surges in trading activity reflect "a lack of consensus regarding the price." Morse (1981) provides evidence that earnings announcements affect daily

trading volumes, but Jain (1988) finds that macroeconomic news has no effect on hourly trading volumes. Woodruff and Senchack (1988) find that the effects of earnings announcements on prices and trading volume depend on the magnitudes of the surprises.

The more recent literature, however, has focused on the idea that price changes and trading activity both reflect the arrival of private information. In an influential paper, French and Roll (1986) show that stock return volatilities are higher when the exchanges are open than when they are closed. By examining business days when the exchanges were closed, they are able to attribute the pattern not to the release of public information during normal business hours but to the effect of private information conveyed through trading. French and Roll's analysis led to the revival of the "mixture of distributions hypothesis" of Clark (1973), Epps and Epps (1976), and Tauchen and Pitts (1983), which treats trading activity as an indirect measure of private information. Most recently, Andersen (1996) exploits the hypothesis to explain changes in price volatility.

Public information clearly plays a more important role in the bond market, precisely because much of the relevant information is released to the public through scheduled announcements. In this case, trading activity would largely reflect differences of opinion among market participants, as Beaver (1968) hypothesized. Kim and Verrecchia (1991) and He and Wang (1995) show theoretically how some form of heterogeneity of views among investors can generate speculative trading activity.

3. Market data, announcements, and expectations

U.S. Treasury securities data

Our U.S. Treasury securities data cover one year of tick-by-tick trading activity among the primary dealers in the interdealer broker market. The source of the data is GovPX, Inc., a joint venture set up by the primary dealers and interdealer brokers in 1991 to improve the public's access to U.S. Treasury security prices. GovPX consolidates and posts real-time quote and transactions data from five of the six major interdealer brokers, accounting for two-thirds of the interdealer broker market. Posted data include the best bids and offers, trade prices and sizes, and the aggregate volume of trading for all Treasury bills, notes, and bonds.³ GovPX data are distributed electronically to the public through several on-line vendors.

Our sample period runs from August 23, 1993 to August 19, 1994, giving us a year with 250 trading days after excluding 10 holidays. Chart 1 depicts the period as a bear market for bonds, with the Federal Reserve raising its target fed funds rates five times. We focus our analysis on the *on-the-run* 5-year Treasury note. On-the-run securities are the most recently issued securities of a given maturity and account for the majority of interdealer trading volume.⁴ Fleming (1996) reports that among the on-the-run issues, the 5-year note is the most actively traded security among the brokers reporting to GovPX. During our

³ Fleming (1996) describes the data in terms of intraday patterns of price volatility, trading volume, and bid-ask spreads for various maturities.

⁴ Fleming (1996) finds that 64% of interdealer trading is in on-the-run issues, 24% is in *off-the-run* issues, and 12% is in *when-issued* securities. Off-the-run securities are issued securities that are no longer active, while when-issued securities are securities that have been announced for auction but not yet issued.

sample period, GovPX posted a daily average of 2,167 bid-ask quotations and 659 trades for the on-the-run 5-year note.⁵

Data on announcement dates and times

We also collected data on the date and time of 21 different macroeconomic announcements. These include the 19 monthly announcements that regularly appear in “The Week Ahead” section of Business Week, as well as Federal Reserve funds target rate announcements and U.S. Treasury auction results announcements.⁶ As shown in Table 2, 19 of the announcements come from government agencies and two from the private sector. Table 2 also shows that 18 of the 19 monthly announcements are released at regularly scheduled times, with ten at 8:30 AM eastern time (ET), one at 9:15 AM, six at 10:00 AM, and one at 2:00 PM.⁷ Announcement times for one of the monthly announcements (consumer credit), for the Federal Reserve funds target rate announcements, and for the auction results announcements are variable. We rely on Bloomberg to determine the precise release times for these announcements.

The ranges of release dates for the 19 monthly reports in the sample are shown in Chart 2. Consumer confidence is the first report to be released with information about a given month and is actually released at the end of the same month on which it is reporting. The NAPM survey, the other private sector report in our sample, is typically the next report released -- on the first business day of the month following the month on which it is reporting. Employment,

⁵ Appendix B of Fleming and Remolona (1996) details the cleaning and processing of the data.

⁶ One of these “monthly” announcements is gross domestic product (GDP). While GDP is a quarterly measure, advance, preliminary, and final estimates are released in successive months.

⁷ Included in the 8:30 AM count is personal income, which was released at 10:00 AM for the first three announcements in our sample.

usually released on the first Friday of the month, is the first government report to be announced with information about a given month.⁸ It is followed by PPI, CPI, retail sales, and industrial production and capacity utilization. The remaining twelve reports are released in the second half of the month following the month on which they are reporting, or in the following month.

Our year of data contains twelve releases for each of the 19 monthly announcements. It was during this year that the Federal Reserve began making target rate announcements, the first one with its February 1994 meeting. We have six of these announcements in our sample, and this study provides the first analysis of such announcements.⁹ The impact of the U.S. Treasury auctions, which are scheduled at regular frequency, are considered separately for every coupon security of a given maturity. Our year of data contains results for two 30-year auctions, four 10-year auctions, twelve 5-year auctions, four 3-year auctions, and twelve 2-year auctions. In total, our sample contains 268 announcement releases on 173 separate days, leaving 77 days with no announcement.

Data on expectations and announcements

Market expectations for the 19 monthly announcements are obtained from the Wall Street Journal. Every Monday, the Journal publishes consensus forecasts provided by Technical Data for the coming week's announcements. Technical Data obtains the forecasts from a survey of 25 economists conducted

⁸ Employment was released on the second Friday in October 1993 and July 1994.

⁹ Five of the six announcements occurred after the regularly scheduled February, March, May, July, and August 1994 Federal Open Market Committee (FOMC) meetings. The other announcement occurred when the fed funds target rate was increased without a FOMC meeting in April 1994.

the Friday before. We refer to Barron's (which also relies on Technical Data) for forecasts unavailable in the Wall Street Journal, and to Business Week (which relies on MMS International) for forecasts we could not obtain from the first two sources. Actual announcement data are obtained from these same three sources and are supplemented by data from Bloomberg when necessary.

We measure market expectations for the fed funds target rate and for auction results using prices from related markets. Expectations of fed funds rate changes are measured as the difference between the fed funds futures rate and the existing target fed funds rate. To ensure that the fed funds futures rate incorporates expectations regarding at least one FOMC meeting we use the rate from the contract expiring at the end of the month two months ahead. The fed funds futures rate for January 12, for example, comes from the contract expiring at the end of March. We are able to measure expectations for the Treasury auctions much more precisely than other expectations. Our measure is the yield in the when-issued market five minutes before auction results are announced. The data are available from GovPX. Actual results are then measured as the auction yield as reported in the next day's Wall Street Journal.¹⁰

¹⁰ The 3-year, 10-year, and 30-year securities are issued at price-discriminating auctions, and for these securities the yield corresponding to the lowest accepted price is used. The 2-year and 5-year securities are issued at uniform-price auctions.

4. The largest market moves: August 1993 to August 1994

Can we account for the sharpest price shocks and the greatest surges in trading activity in the bond market? We selected the 25 largest price movements and the 25 most active trading episodes from every five-minute interval across the global trading day during the August 1993 to August 1994 sample period. Table 3 lists the date and time of the largest such price movements, while Table 4 lists the date and time of the most active trading episodes, with trading activity measured in terms of the number of transactions during the interval.¹¹

The price shocks

It is not terribly difficult to account for the 25 greatest price shocks. Every one of the shocks occurred on an announcement day.¹² Moreover, all but one of these shocks came within 15 minutes of an announcement's release. The largest shock was a price decline of 0.59 percent (a yield increase of 14 basis points) immediately upon the release of the August 5, 1994 employment report. Nine other shocks followed an employment report, six a PPI report, five a retail sales report, three a CPI report, three a personal income report, and two a gross domestic product (GDP) report. In eight instances, the shocks came after the concurrent release of two reports. Three other shocks followed an announcement of a Federal Reserve funds target rate increase and one a release of auction results for the 10-year note.

¹¹ We use this measure of trading activity as Jones, Kaul, and Lipson (1994) find that transaction size has no information content beyond that contained in the frequency of trades.

¹² Note that there are 77 nonannouncement days on which purely random shocks could have taken place. With a sample of 250 days, the probability that all 25 of the shocks occur on an announcement day purely by chance is 0.01 percent.

That price shocks in the bond market are so easy to explain stands in contrast to the difficulty of explaining such shocks in the stock market. It is true that we try to explain only a year of the bond market, while Cutler, Poterba, and Summers (1989) try to explain over 40 years of the stock market. It is important to note, however, that our explanations for the bond market are based on an *ex ante* list of announcements, thus reducing the bias of hindsight in the analysis. Cutler, Poterba, and Summers rely on explanations offered by the New York Times after the events.¹³ Because these are *ex post* explanations, the authors focus on whether these explanations are convincing. Although our analysis is limited to a single year, it is a year for which we are able to verify precise release times for announcements that we have reason to believe *a priori* contain information relevant to the market.

The trading surges

It is similarly striking that the 25 greatest surges in trading activity also all occur on announcement days. Attributing every such surge to an announcement may seem less compelling than in the case of price shocks, because there is a longer lag between these surges and the times of announcements.¹⁴ Nonetheless all these surges in activity came within 70 minutes after an announcement's release, 19 of them within half an hour. The greatest surge consisted of 33 transactions worth a total of \$240 million (in face values) in a five-minute interval 20 minutes after the July 29, 1994 GDP report. Seven of the other surges followed an employment report, six a PPI report, four a GDP report, four a retail sales

¹³ The explanation for the 20 percent decline on October 19, 1987, for example, is "Worry over dollar decline and trade deficit, fear of U.S. not supporting dollar."

¹⁴ Fleming and Remolona (1996) analyze the adjustment patterns of trading volume after major announcements. They find an appreciable lag in the surge in trading volume after the price shock and a persistence in high volume for a few hours afterwards.

report, three a housing starts report, and two a CPI report. In five instances, the surges followed the concurrent release of two reports.

Announcement patterns

The largest movements in prices and surges in trading activity reveal certain regularities. First, we account for all these movements with only 12 of our announcements. Among these, the employment, PPI, and retail sales announcements appear to be consistently important for both price shocks and trading surges, fed funds target rate actions for price shocks, and housing starts announcements for trading surges. Second, the large movements tend to be concentrated in the second half of the period. Sixteen of the 25 price shocks and 18 of the 25 the trading surges took place after February 1994, the midpoint of our sample period.

The association between announcement release times and the largest price shocks and trading surges reflects a more general intraday pattern seen on most announcement days. In general, there are pronounced market movements after an announcement. Chart 3 shows that on an average announcement day, price volatility spikes just after the release times and that these spikes are absent on other days.¹⁵ This pattern has been documented by Ederington and Lee (1993) and Fleming and Remolona (1996). Chart 4 shows that the average number of trades following release times on announcement days exceeds the average on other days. Fleming and Remolona (1996) find a similar pattern for trading volume, a somewhat different measure of trading activity.

¹⁵ On the days with 8:30 AM announcements, the price change in the first five minutes after the announcement explains 31 percent of the whole day's (7:30 AM to 5:00 PM) price change.

5. Which announcements matter?

If the market's movements are a reaction to new information, some announcements should consistently induce a stronger reaction than others, simply because some announcements are more informative about the economy than others. In this section, we identify which announcements consistently matter for price movements and trading activity, independent of how much of the data released is unexpected.

Estimation

To establish which announcements matter, we run regressions with dummy variables, one for each of the announcements listed in Table 1. We measure price volatility as the absolute value of the change in log prices in the five-minute interval following an announcement, with prices defined as the midpoints between bid and ask quotes.¹⁶ We measure trading activity as the number of transactions during the one-hour interval following the announcement. The longer interval length for trading activity is consistent with Fleming and Remolona's (1996) results suggesting that prices adjust rapidly while high trading activity persists for an extended period after an announcement.

We run five separate sets of regressions, one set for each of the four intervals corresponding to the fixed release times of the regularly scheduled monthly announcements and one which pools all the intervals that correspond to

¹⁶ We could also use transactions prices, but using the bid-ask midpoints allows us to avoid complications associated with the "bid-ask bounce" besides providing us with more observations.

the varying release times of the consumer credit, auction results, and fed funds target rate announcements. In each of the regressions, we control for the possibility that other announcements during the day may have an effect as well as the possibility that price volatility or trading activity may vary according to time of day.

For the single-interval regressions, we define dummy variables D_{kn} where $D_{kn} = 1$ if announcement k is made on day n and $D_{kn} = 0$ otherwise. The regression equation is then $Y_{nt}^j = a_{0t}^j + \sum_{k=1}^{K_t} b_{kt}^j D_{kn} + e_{nt}^j$ where the superscript j indicates whether the dependent variable is price volatility or trading activity, the subscript t indicates the time interval, and K_t is the number of different announcements included in the regression, which varies by interval t since we control for announcements released earlier in the day.¹⁷ Our interest is primarily in the coefficient b_{kt}^j , which measures the impact of announcement k on price volatility or trading activity.

For the pooled regressions, we define announcement dummy variables D_{knt} where $D_{knt} = 1$ if announcement k is made on day n just before interval t and $D_{knt} = 0$ otherwise.¹⁸ The regressions rely on two more sets of dummy variables D_t and D_n to control for possible time-interval effects and for possible effects of other announcements during the day. The equation for the pooled regression is

¹⁷ For example, the regression for the 10:00 AM interval includes dummy variables for the 8:30 AM and 9:15 AM announcements.

¹⁸ For announcements released in the final minute of an interval, we begin the analysis at the start of the next interval. For all other announcements, the analysis begins in the same interval. For example, a 1:34 release time implies an analysis based on the 1:35-1:40 interval for price volatility and the 1:35-2:35 interval for trading activity, while a 1:33 release time implies an analysis based on 1:30-1:35 for price volatility and 1:30-2:30 for trading activity.

then $Y_{nt}^j = a_0^j + \sum_{t=1}^{T-1} a_t^j D_t + \sum_{k=1}^K b_k^j D_{knt} + \sum_{l=1}^L c_l^j D_{nl} + e_{nt}^j$ where $T = 18$ or the number of different intervals corresponding to the varying release times of the consumer credit, auction results, and fed funds target rate announcements; $K = 7$ or the number of announcements of interest; and L is the number of other announcements we control for. The coefficient of interest is b_k^j , which measures the impact of announcement k .

Announcements that matter for price volatility

The estimated effect on price volatility is a measure of the average information content of the individual announcement. As shown in Table 5, ten announcements have a significant impact on price volatility, six showing significant effects at the 1% level and four at the 5% level. Our list of significant announcements is longer than any such list in previous studies. In the order of their importance, the significant announcements with the greatest effects on price volatility are: (1) employment, (2) PPI, (3) fed funds target rate, (4) CPI, (5) retail sales, (6) NAPM survey, (7) 5-year note auction results, (8) industrial production and capacity utilization, (9) consumer confidence, and (10) merchandise trade.

These regression results have the following noteworthy features. First, two of the announcements found significant -- the fed funds target rate and the auction results -- have not previously been analyzed in the literature. Second, although GDP releases account for two of our 25 largest price shocks, such releases fail to consistently induce a price reaction and hence are not found to be significant in our regressions.¹⁹ Third, bond prices react so consistently to five

¹⁹ As noted in footnote 6, the GDP releases consist of advance, preliminary, and final estimates of quarterly GDP announced in successive months. Among the releases that accounted for two of the largest price shocks, one was an advance estimate and the other a preliminary estimate.

announcements -- NAPM survey, 5-year note auction results, industrial production and capacity utilization, consumer confidence, and merchandise trade -- that these turn up significant even when absent from the 25 largest price shocks.

These results also provide evidence of stability in the announcements that matter for price volatility. In their analysis of bond futures prices from November 1988 to November 1991, Ederington and Lee (1993) find employment, PPI, CPI, and durable goods orders to be the most important regularly scheduled announcements. The employment report is based on large surveys of establishments and households. It has maintained its unsurpassed ranking because it still offers the market the first comprehensive look at the economy. In the past, the durable goods orders report offered data useful for predicting investment. The report may have lost its significance due to the increased importance of computer shipments, for which price changes are critical, but which the report measures only in nominal terms.

Announcements that matter for trading activity

The estimated effect on trading activity is a measure of the average degree of price disagreement arising from the announcement. As shown in Table 6, 12 announcements have a significant impact on trading activity, 11 at the 1% level and one at the 5% level. In the order of their importance, the announcements that generate significant trading activity are: (1) employment, (2) fed funds target rate, (3) 30-year bond auction results, (4) PPI, (5) 10-year note auction results, (6) CPI, (7) NAPM survey, (8) GDP, (9) retail sales, (10) 3-year note auction results, (11) new single-family home sales, and (12) factory inventories.

The following remarks serve to characterize these results. First, the announcements that matter for price volatility also tend to matter for trading activity. The GDP announcement is the most important one that is significant for trading activity but not for price volatility. Second, housing starts releases account for three of the 25 greatest trading surges but the announcement does not consistently produce a rise in trading activity. Third, six announcements do consistently lead to additional trading activity even when not accounting for any of the 25 greatest trading surges: fed funds target rate, 30-year bond auction results, 10-year note auction results, 3-year note auction results, new single-family home sales, and factory inventories.

Timeliness

The timeliness of an announcement at its release partly explains the announcement's impact on prices and trading activity. As shown in Chart 2, among the government reports, the most timely are employment, PPI, CPI, and retail sales in that order. This order of timeliness is matched by their order of importance for both price shocks and trading activity. The two private sector reports -- consumer confidence and NAPM survey -- are even more timely than the employment report. While both significantly impact the market, the bond market evidently regards their data as less informative about the economy than the data in the government reports.

6. Announcement surprises and market conditions

Does the magnitude of surprise matter?

Most of the announcement literature assumes both that the magnitude of the surprise matters and that the direction of the effect is always the same. For example, an unexpectedly strong nonfarm payrolls number is assumed to always cause a fall in bond prices with a greater surprise causing a greater fall. To the extent that studies examine trading activity, the assumption is that the larger the surprise the greater the trading surge. If these assumptions hold, we should improve our estimates of announcement effects by taking account of the magnitude of surprises and the signed effects on bond prices and trading activity.

In general, the magnitude of surprise does provide tighter estimates of announcement effects. Table 7 reports regressions measuring the impact of absolute surprises on price volatility, signed surprises on signed price changes, and absolute surprises on trading activity. In most cases, the announcements found to significantly affect prices when we use dummy variables remain significant when we use announcement surprises. Indeed taking account of the magnitude or sign of the surprise lends significance to seven announcements, adding to an already long list of significant announcements. The seven additional announcements are the auction results for the 30-year, 10-year, and 2-year maturities, new single-family home sales, consumer credit, housing starts, and business inventories. Three announcements that were significant at the 5% level become significant at the 1% level, namely retail sales, NAPM survey, and consumer confidence. In the case of trading activity, taking account of the

magnitude of the surprise improves significance for three announcements: business inventories, consumer confidence, and 2-year note auction results.

Do market conditions matter?

It is notable that the largest price shock in our sample followed an employment report that contained relatively little surprise. Specifically, on August 5, 1994, the price of the 5-year note fell 0.59 percent within five minutes of the release of a nonfarm payrolls number that exceeded the forecast by only 54,000 jobs.²⁰ The period seems to have been a time of great uncertainty, with bond market participants trying to guess whether the Federal Reserve was about to raise rates for the fifth time in six months. The issue in general is to what extent do market conditions affect the strength of the bond market's reaction to a given announcement? The issue in particular is do market participants attach more significance to the same information during times of greater uncertainty?

Our analysis of market conditions relies on two measures of market uncertainty. As shown in Chart 5, one measure is the implied volatility derived from 10-year note options traded on the Chicago Board of Trade.²¹ Another measure is the expected increase in the fed funds rate as proxied by the spread between the fed funds futures rate with two months to maturity and the existing Federal Reserve's target fed funds rate. The expected fed funds rate increase can be regarded as a measure of uncertainty because the question during the period was largely whether the Federal Reserve was going to raise rates and if so by how much.

²⁰ The average nonfarm payrolls surprise in the sample was 92,000 jobs and was as large as 206,000 on April 1, 1994. The announced jobless rate on August 5 was the same as the forecast.

²¹ The volatilities are based on the average from the six nearest-to-the-money calls and puts on futures contracts on 10-year notes.

We find some evidence that market conditions matter in ways that are consistent with rational reactions to information. Table 8 reports regressions of price volatility and trading activity on announcement dummy variables and several interaction variables representing market uncertainty. The analysis is limited to the six 8:30 AM announcements found to have significant impact at the 1% level on price volatility or trading activity in our previous analyses, namely employment, PPI, CPI, GDP, housing starts, and retail sales. In general, accounting for market uncertainty helps significantly in explaining price volatility. In particular, uncertainty in terms of implied volatility helps explain the bond market's price reaction to housing starts and retail sales announcements. The evidence for trading activity is weaker, although uncertainty seems to intensify trading activity after the release of the employment, PPI, and CPI reports.

7. Conclusion

It is reassuring that we can explain the largest price shocks and the greatest surges in trading activity in the U.S. Treasury market in terms of the arrival of information. For information variables, we rely only on 18 monthly macroeconomic announcements that are regularly released at fixed times and three other announcements that are released at varying times. By choosing the announcements before examining the market's movements, we eschew some of the benefits of hindsight in the analysis. Remarkably, we are able to associate each of the 25 largest price shocks and each of the 25 greatest surges in trading

activity with a just-released announcement. These results suggest that bond prices react largely to the arrival of public information about the economy. The ensuing surge in trading activity suggests that there is a lack of consensus among market participants that the initial price change is precisely the appropriate adjustment to the new information.

Further analysis suggests that the explanations of the largest price shocks and trading surges tend to hold for smaller price and trading movements and to be consistent with rational market reactions to information arrival. First, the market considers certain announcements to be consistently important, with the employment, PPI, and CPI reports among the most important announcements for price movements and trading activity. Second, the greater the magnitude of the surprise in the announcements the stronger the market's reaction. Taking account of the surprise component gives us a list of 16 announcements with a significant effect on bond prices and 15 with a significant effect on trading activity. Third, the degree of uncertainty in the market also helps explain the strength in the market's response. These results suggest that the price and trading reactions are not arbitrary reactions to announcements but reactions that reflect the differences of information content in the different announcements under different market conditions.

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Table 1

Studies Finding Significant Impact of Macroeconomic Announcements on Interest Rates

Table lists authors and associated sample periods for studies that have found a significant relationship between the surprise component of the noted macroeconomic announcement and U.S. interest rates.^a

Announcement	Authors	Sample Period
Money Supply	Berkman (1978)	Jul 1975 - Jun 1977
	Grossman (1981)	Sep 1977 - Sep 1979
	Urich and Wachtel (1981)	Jan 1974 - Dec 1977, Jan 1979 - Sep 1979
	Cornell (1982, 1983)	Oct 1979 - Dec 1981
	Roley (1982)	Sep 1977 - Nov 1981
	Roley (1983)	Sep 1977 - Oct 1982
	Roley and Troll (1983)	Sep 1977 - Oct 1982
	Urich and Wachtel (1984)	Nov 1977 - Jul 1982
	Roley and Walsh (1985)	Oct 1979 - Oct 1982
	Hardouvelis (1988)	Oct 1979 - Aug 1984
	Dwyer and Hafer (1989)	Feb 1980 - Dec 1981, Jan 1983 - Dec 1983
	Thornton (1989)	Jan 1978 - Jan 1984
	Strongin and Tarhan (1990)	May 1980 - Jan 1984
	McQueen and Roley (1993)	Sep 1977 - May 1988
Industrial Production	Roley and Troll (1983)	Sep 1977 - Oct 1979
	McQueen and Roley (1993)	Sep 1977 - May 1988
	Harvey and Huang (1993)	Dec 1981 - Apr 1988
	Edison (1996)	Feb 1980 - Feb 1995
Producer Price Index	Urich and Wachtel (1984)	Oct 1979 - Jul 1982
	Smirlock (1986)	Oct 1979 - Dec 1983
	Hardouvelis (1988)	Oct 1979 - Aug 1984
	Dwyer and Hafer (1989)	Feb 1980 - Dec 1980
	McQueen and Roley (1993)	Sep 1977 - May 1988
	Edison (1996)	Feb 1980 - Feb 1995
Consumer Price Index	Smirlock (1986)	Oct 1979 - Dec 1983
	Hardouvelis (1988)	Oct 1982 - Aug 1984
	McQueen and Roley (1993)	Sep 1977 - May 1988
	Edison (1996)	Feb 1980 - Feb 1995
Durable Goods Orders	Hardouvelis (1988)	Oct 1982 - Aug 1984
Jobless Rate	Hardouvelis (1988)	Oct 1982 - Aug 1984
	Cook and Korn (1991)	Feb 1985 - Apr 1991
	McQueen and Roley (1993)	Sep 1977 - May 1988
	Prag (1994)	Jan 1980 - Jun 1991
	Edison (1996)	Feb 1980 - Feb 1995
Retail Sales	Hardouvelis (1988)	Oct 1982 - Aug 1984
	Edison (1996)	Feb 1980 - Feb 1995
Nonfarm Payrolls	Cook and Korn (1991)	Feb 1985 - Apr 1991
	McQueen and Roley (1993)	Sep 1977 - May 1988
	Edison (1996)	Feb 1980 - Feb 1995
	Krueger (1996)	Feb 1979 - Apr 1996

^a For studies that examine the impact on several interest rates we report only the results for the longest maturity rate. Studies are not listed where the impact of an announcement on price is found to be opposite in sign of that predicted.

Table 2

Macroeconomic Announcements

Announcement time, title, and reporting entities for eighteen regularly scheduled announcements and three announcements with varying release times. All times are eastern time (ET).

Time	Short Title	Full Title	Reporting Entity
8:30 A.M.	Consumer Price Index (CPI)	Consumer Price Index	Bureau of Labor Statistics
8:30 A.M.	Durable Goods Orders	Advance Report on Durable Goods Manufacturers' Shipments and Orders	Bureau of the Census
8:30 A.M.	Employment	The Employment Situation	Bureau of Labor Statistics
8:30 A.M.	Gross Domestic Product (GDP)	Gross Domestic Product	Bureau of Economic Analysis
8:30 A.M.	Housing Starts	Housing Starts and Building Permits	Bureau of the Census
8:30 A.M.	Leading Indicators	Composite Indexes of Leading, Coincident, and Lagging Indicators	Bureau of Economic Analysis
8:30 A.M.	Merchandise Trade	Report of U.S. Merchandise Trade	Bureau of the Census
8:30 A.M. ^a	Personal Income	Personal Income and Outlays	Bureau of Economic Analysis
8:30 A.M.	Producer Price Index (PPI)	Producer Price Indexes	Bureau of Labor Statistics
8:30 A.M.	Retail Sales	Advance Retail Sales	Bureau of the Census
9:15 A.M.	Industrial Production and Capacity Utilization	Industrial Production and Capacity Utilization	Federal Reserve Board
10:00 A.M.	Business Inventories	Manufacturing and Trade: Inventories and Sales	Bureau of the Census
10:00 A.M.	Consumer Confidence	Consumer Confidence Index	Conference Board
10:00 A.M.	Construction Spending	Value of New Construction Put in Place	Bureau of the Census
10:00 A.M.	Factory Inventories	Manufacturers' Shipments, Inventories, and Orders	Bureau of the Census
10:00 A.M.	NAPM Survey	National Association of Purchasing Management Index	National Association of Purchasing Management
10:00 A.M.	New Single-Family Home Sales	New One-Family Houses Sold and For Sale	Bureau of the Census
2:00 P.M.	Federal Budget	Treasury Statement (The Monthly "Budget")	Department of the Treasury
Varies ^b	Consumer Credit	Consumer Installment Credit	Federal Reserve Board
Varies ^c	Treasury Coupon Auction Results		Department of the Treasury
Varies ^d	Fed Funds Target Rate		Federal Reserve

^a Personal income was reported at 10:00 A.M. for the first three announcements in the period of analysis and at 8:30 A.M. thereafter.

^b Eight of the twelve announcements in the sample period were made at 4:00 P.M. The others were at 2:12 P.M., 2:45 P.M., 3:14 P.M., and 3:55 P.M.

^c All of the auction results in our sample period were announced between 12:30 and 2:15 P.M., with most reported between 1:30 and 2:00 P.M.

^d The six announcements in our sample were made at 10:06 A.M., 11:05 A.M., 1:17 P.M., 2:18 P.M., 2:20 P.M., and 2:26 P.M.

Table 3

Largest Price Changes for the Five-Year Treasury Note

Largest percentage price changes by five-minute interval for the five-year Treasury note along with associated announcement (and announcement time). The largest price changes are chosen from all five-minute intervals across the global trading day for the period August 23, 1993 - August 19, 1994.

Price Change (%)	Date	Time	Announcement (time)
-0.590	August 5, 1994	8:30-8:35 AM	Employment (8:30 AM)
-0.536	May 6, 1994	8:30-8:35 AM	Employment (8:30 AM)
-0.440	July 8, 1994	8:30-8:35 AM	Employment (8:30 AM)
-0.412	April 1, 1994	8:30-8:35 AM	Employment, Personal Income (8:30 AM)
0.407	July 29, 1994	8:30-8:35 AM	Gross Domestic Product (8:30 AM)
0.406	September 3, 1993	8:30-8:35 AM	Employment, Leading Indicators (8:30 AM)
0.384	May 12, 1994	8:30-8:35 AM	Producer Price Index, Retail Sales (8:30 AM)
-0.343	May 27, 1994	8:35-8:40 AM	Gross Domestic Product (8:30 AM)
0.332	November 9, 1993	8:30-8:35 AM	Producer Price Index (8:30 AM)
0.315	February 4, 1994	8:30-8:35 AM	Employment (8:30 AM)
0.313	September 10, 1993	8:30-8:35 AM	Producer Price Index (8:30 AM)
0.282	January 7, 1994	8:30-8:35 AM	Employment (8:30 AM)
-0.266	August 16, 1994	1:45-1:50 PM	Fed Funds Target Rate Increase (1:17 PM)
-0.265	June 3, 1994	8:40-8:45 AM	Employment (8:30 AM)
-0.259	February 4, 1994	11:05-11:10 AM	Fed Funds Target Rate Increase (11:05 AM)
-0.255	April 1, 1994	8:40-8:45 AM	Employment, Personal Income (8:30 AM)
0.253	July 14, 1994	8:30-8:35 AM	Retail Sales (8:30 AM)
-0.249	September 14, 1993	8:30-8:35 AM	Consumer Price Index, Retail Sales (8:30 AM)
0.224	April 13, 1994	8:30-8:35 AM	Consumer Price Index, Retail Sales (8:30 AM)
-0.223	May 11, 1994	1:40-1:45 PM	10-Year Note Auction Results (1:42 PM)
-0.223	April 1, 1994	8:35-8:40 AM	Employment, Personal Income (8:35 AM)
0.223	February 11, 1994	8:30-8:35 AM	Producer Price Index, Retail Sales (8:30 AM)
0.222	July 12, 1994	8:30-8:35 AM	Producer Price Index (8:30 AM)
0.221	May 17, 1994	2:35-2:40 PM	Fed Funds Target Rate Increase (2:26 PM)
-0.218	December 9, 1993	8:30-8:35 AM	Producer Price Index (8:30 AM)

Table 4

Most Active Trading Intervals for the Five-Year Treasury Note

Largest number of trades by five-minute interval for the five-year Treasury note along with associated announcement (and announcement time). The most active intervals are chosen from all five-minute intervals across the global trading day for the period August 23, 1993 - August 19, 1994.

Trades (#)	Date	Time	Announcement (time)
33	July 29, 1994	8:50-8:55 AM	Gross Domestic Product (8:30 AM)
30	September 14, 1993	8:40-8:45 AM	Consumer Price Index, Retail Sales (8:30 AM)
29	July 20, 1994	8:35-8:40 AM	Housing Starts (8:30 AM)
28	January 7, 1994	8:45-8:50 AM	Employment (8:30 AM)
28	February 11, 1994	8:35-8:40 AM	Producer Price Index, Retail Sales (8:30 AM)
28	February 11, 1994	9:00-9:05 AM	Producer Price Index, Retail Sales (8:30 AM)
27	May 27, 1994	8:45-8:50 AM	Gross Domestic Product (8:30 AM)
27	July 14, 1994	8:35-8:40 AM	Retail Sales (8:30 AM)
26	May 6, 1994	9:20-9:25 AM	Employment (8:30 AM)
26	May 13, 1994	8:50-8:55 AM	Consumer Price Index (8:30 AM)
25	November 5, 1993	8:35-8:40 AM	Employment (8:30 AM)
25	January 7, 1994	8:35-8:40 AM	Employment (8:30 AM)
25	January 28, 1994	8:40-8:45 AM	Gross Domestic Product (8:30 AM)
25	March 1, 1994	10:50-10:55 AM	NAPM Survey, Construction Spending (10:00 AM)
25	March 15, 1994	8:35-8:40 AM	Producer Price Index (8:30 AM)
25	April 20, 1994	8:45-8:50 AM	Housing Starts (8:30 AM)
25	June 3, 1994	8:35-8:40 AM	Employment (8:30 AM)
25	June 10, 1994	9:00-9:05 AM	Producer Price Index (8:30 AM)
25	July 8, 1994	8:40-8:45 AM	Employment (8:30 AM)
24*	March 4, 1994	8:45-8:50 AM	Employment, Leading Indicators (8:30 AM)
24*	April 20, 1994	9:40-9:45 AM	Housing Starts (8:30 AM)
24*	June 29, 1994	9:15-9:20 AM	Gross Domestic Product (8:30 AM)
24*	July 8, 1994	8:45-8:50 AM	Employment (8:30 AM)
24*	July 12, 1994	8:35-8:40 AM	Producer Price Index (8:30 AM)
24*	July 12, 1994	8:40-8:45 AM	Producer Price Index (8:30 AM)

* Eight intervals with twenty-four trades are in the sample. Reported are the six with the largest number of bid-ask quotations.

Table 5

Impact of Announcements on Price Volatility

Average difference in price volatility in five-minute period after announcement as compared to nonannouncement days for the five-year Treasury note. Volatility is defined as the absolute value of the log price change times 10^4 . One and two asterisks denote significance at the .05 and .01 levels, respectively, determined using heteroskedasticity consistent (White) standard errors. The period of analysis is August 23, 1993 - August 19, 1994.

Rank	Announcement	Difference
1	Employment	26.04**
2	Producer Price Index	14.16**
3	Fed Funds Target Rate	10.87**
4	Consumer Price Index	7.79**
5	Gross Domestic Product	7.32
6	Retail Sales	6.68*
7	30-Year Bond Auction Results	6.49
8	10-Year Note Auction Results	6.39
9	NAPM Survey	4.90*
10	5-Year Note Auction Results	3.61**
11	Industrial Production and Capacity Utilization	3.58**
12	Consumer Confidence	3.34*
13	New Single-Family Home Sales	3.08
14	Merchandise Trade	2.56*
15	3-Year Note Auction Results	1.84
16	Durable Goods Orders	1.73
17	Construction Spending	1.39
18	Personal Income	1.34
19	Housing Starts	1.18
20	Consumer Credit	0.84
21	Factory Inventories	0.77
22	Business Inventories	0.70
23	Federal Budget	0.46
24	2-Year Note Auction Results	0.37
25	Leading Indicators	-3.25

Table 6

Impact of Announcements on Trading Activity

Average difference in trading activity in one hour period after announcement as compared to nonannouncement days for the five-year Treasury note. Trading activity is defined as the number of interdealer broker transactions reported by GovPX. One and two asterisks denote significance at the .05 and .01 levels, respectively, determined using heteroskedasticity consistent (White) standard errors. The period of analysis is August 23, 1993 - August 19, 1994.

Rank	Announcement	Difference
1	Employment	88.21**
2	Fed Funds Target Rate	68.96**
3	30-Year Bond Auction Results	61.09**
4	Producer Price Index	58.02**
5	10-Year Note Auction Results	47.43**
6	Consumer Price Index	45.73**
7	NAPM Survey	45.60**
8	Gross Domestic Product	39.39**
9	Retail Sales	38.47**
10	3-Year Note Auction Results	36.54**
11	New Single-Family Home Sales	31.05*
12	Factory Inventories	27.57**
13	Business Inventories	21.03
14	Industrial Production and Capacity Utilization	17.95
15	Housing Starts	15.49
16	Merchandise Trade	13.02
17	Leading Indicators	6.50
18	Consumer Confidence	5.93
19	2-Year Note Auction Results	5.09
20	Personal Income	2.94
21	Federal Budget	1.11
22	Durable Goods Orders	-0.11
23	5-Year Note Auction Results	-1.72
24	Consumer Credit	-2.51
25	Construction Spending	-9.24

Table 7

Impact of Announcement Surprise Components

Impact of announcement surprise components on price volatility, price, and trading activity for the five-year Treasury note. Announcement surprise is the actual number announced minus the forecast number. The impact on price is examined with signed surprises while surprise magnitudes are used for price volatility and trading activity. Price is defined as the log price change times 10^3 for the five-minute period immediately after announcement, price volatility is defined as the absolute value of the log price change, and trading activity is defined as the number of transactions in the one hour period after announcement. One and two asterisks denote significance at the .05 and .01 levels, respectively, determined using heteroskedasticity consistent (White) standard errors. The period of analysis is August 23, 1993 - August 19, 1994.

Announcement	Measure (Units)	Price Volatility	Price	Trading Activity
Employment	Nonfarm Payrolls (100,000 workers)	3.26**	-2.64**	32.03
	Jobless Rate (1%)	-6.72*	2.39	283.88**
Producer Price Index	(1%)	3.90**	-3.59**	118.27**
Fed Funds Target Rate	(1%)	3.77*	-0.87	330.82**
Consumer Price Index	(1%)	6.50**	-6.86**	270.55**
Gross Domestic Product	(1%)	1.40	-0.95	81.87**
Retail Sales	(1%)	1.26**	-1.33	83.76**
30-Year Bond Auction Results	(1%)	25.72*	-25.88	2189.47**
10-Year Note Auction Results	(1%)	21.31**	-23.40**	1099.28**
NAPM Survey	(1%)	0.31**	-0.43**	38.66**
5-Year Note Auction Results	(1%)	24.07**	-26.23**	-209.77
Industrial Production and Capacity Utilization	Industrial Production (1%)	2.10*	-1.49	100.49
	Capacity Utilization (1%)	-0.01	-0.73	-38.04
Consumer Confidence	(1)	0.09**	-0.12**	2.82*
New Single-Family Home Sales	(annual rate in millions)	5.12	-8.27**	384.79*
Merchandise Trade	(deficit in \$billions)	0.02	-0.00	-0.11
3-Year Note Auction Results	(1%)	-5.46	1.40	2266.20**
Durable Goods Orders	(1%)	0.04	-0.11	-3.86
Construction Spending	(1%)	0.10	-0.18	-6.21
Personal Income	(1%)	-1.46	0.40	38.53
Housing Starts	(annual rate in millions)	1.99	-5.58**	204.01
Consumer Credit	(\$billions)	0.04*	-0.08**	0.36
Factory Inventories	(1%)	0.37	1.30*	207.97**
Business Inventories	(1%)	0.93**	0.02	119.83**
Federal Budget	(deficit in \$billions)	0.01	0.01	0.80
2-Year Note Auction Results	(1%)	7.20**	-10.15**	375.25**
Leading Indicators	(1%)	-2.95*	-0.78	-35.75

Table 8

Impact of Market Conditions on Announcement Responses

Results from regressions of price volatility and trading activity on announcement dummy variables and several variables interacted with announcement dummy variables for the five-year Treasury note. Results in this table are from analyses only on the 8:30 A.M. announcements found to have significant effects at the .01 level in Tables 5, 6, or 7 (CPI, Employment, GDP, Housing Starts, PPI, Retail Sales). The price volatility regressions are run for the 8:30-8:35 A.M. interval while the trading activity regressions are run for the 8:30-9:30 A.M. interval. One and two asterisks denote significance at the .05 and .01 levels, respectively, determined using heteroskedasticity consistent (White) standard errors. The period of analysis is August 23, 1993 - August 19, 1994.

Model	Dependent Variable	Interaction Terms	Interaction χ^2 ^a	Significant Interaction Coefficients ^b	Model χ^2	Model R ²
A1	Price volatility	None	n/a	n/a	71.77**	0.48
B1	Price volatility	Implied volatility	14.79*	Retail sales*	111.84**	0.53
C1	Price volatility	Expected fed funds hike	13.24*	Employment*, GDP*	124.92**	0.56
D1	Price volatility	Announcement surprise	61.03**	CPI**, nonfarm payroll*, PPI**	193.89**	0.62
E1	Price volatility	Implied volatility	16.76*	Housing starts**, retail sales*	337.79**	0.71
		Expected fed funds hike	4.50	-		
		Announcement surprise	28.88**	CPI**		
A2	Trading activity	None	n/a	n/a	237.17**	0.41
B2	Trading activity	Implied volatility	9.94	-	324.56**	0.41
C2	Trading activity	Expected fed funds hike	12.45	CPI*, employment*	309.47**	0.41
D2	Trading activity	Announcement surprise	10.28	-	371.96**	0.41
E2	Trading activity	Implied volatility	12.33	PPI**	541.46**	0.41
		Expected fed funds hike	12.18	CPI*, employment*		
		Announcement surprise	15.73*	Jobless rate*, retail sales*		

^a Tests null hypothesis that interaction terms add no explanatory power to model. Statistic is calculated excluding interaction terms found to be significantly negative (jobless rate announcement surprise in models D1 and E1 and expected fed funds hike x housing starts in model E1).

^b Excluding interaction terms found to be significantly negative (jobless rate announcement surprise in models D1 and E1 and expected fed funds hike x housing starts in model E1).

Chart 1

Fed Funds Target Rate and Five-Year Treasury Note Yield

Chart shows fed funds target rate and five-year Treasury note yield from August 23, 1993 - August 19, 1994. FOMC meeting dates are indicated by vertical dashed lines.

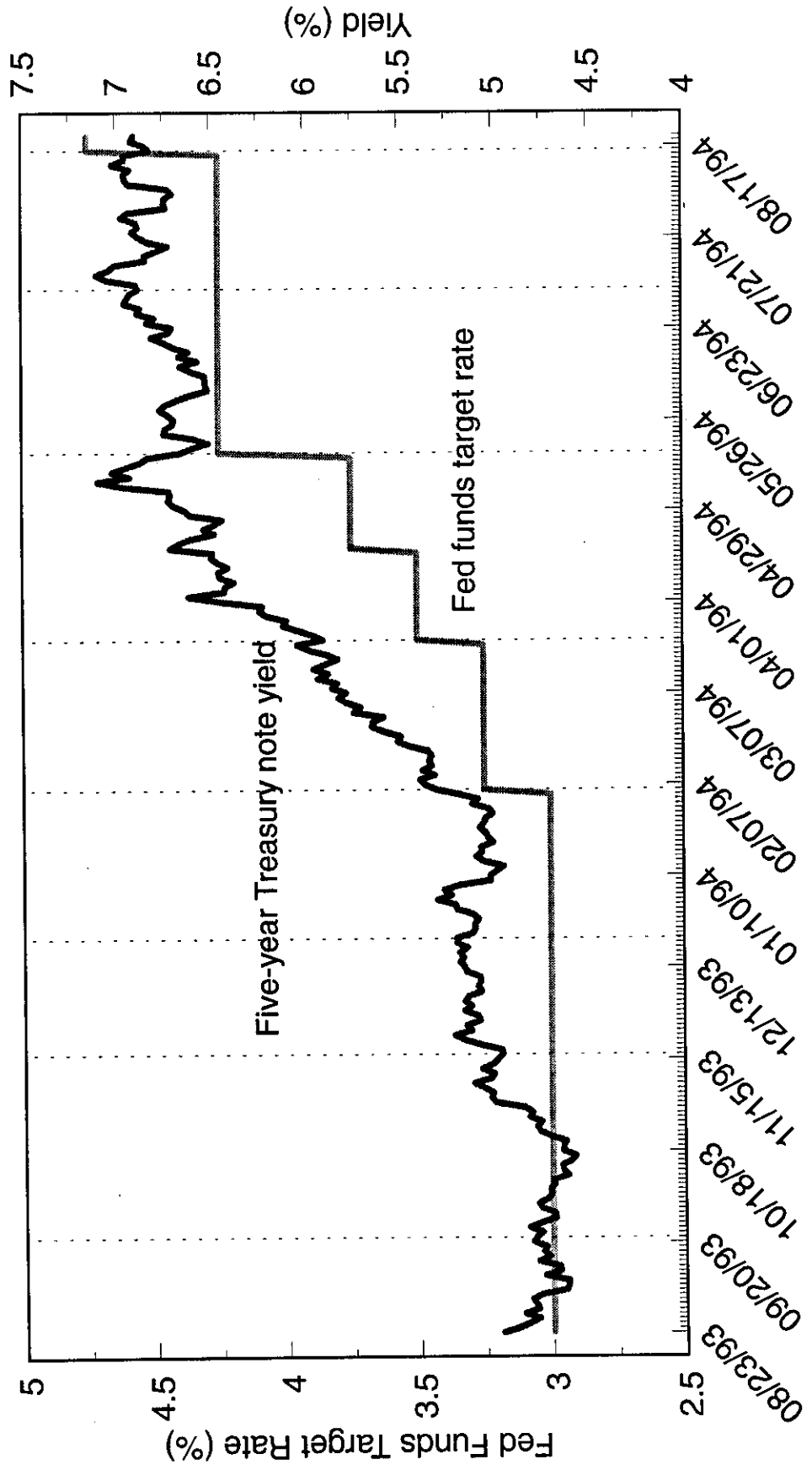
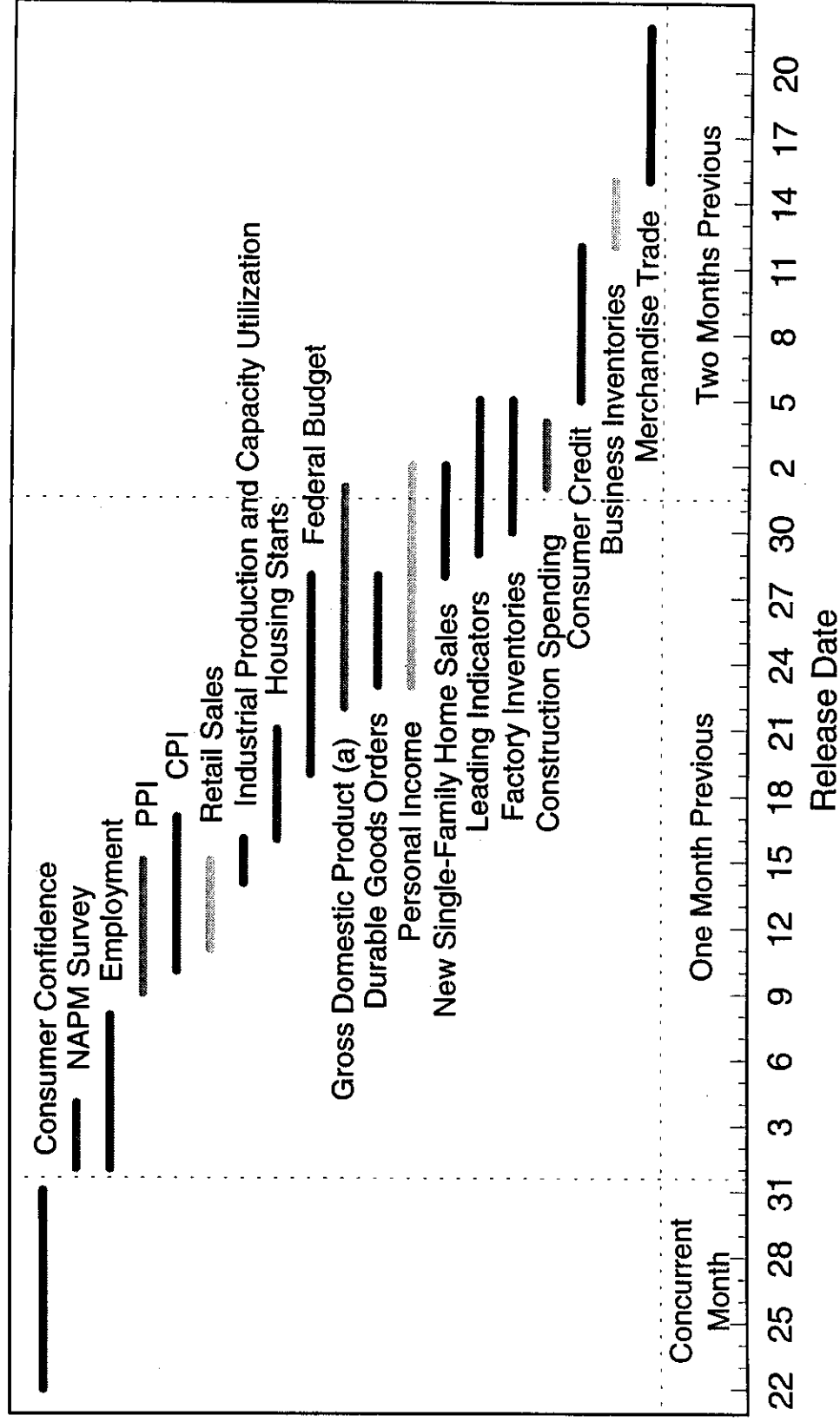


Chart 2

Macroeconomic Announcement Release Dates

Charts shows range of release dates for scheduled monthly economic announcements and indicates the month of economic data included in report. Date ranges are based on August 23, 1993 - August 19, 1994 period.



(a) While gross domestic product is a quarterly statistic, advance, preliminary, and final estimates are released in successive months. The advance statistic is released roughly one month after the end of the quarter.

Chart 3

Intraday Price Volatility on Announcement and Nonannouncement Days

Standard deviation of log price changes for the five-year treasury note for days with at least one of the twenty-one announcements listed in Table 2 and days with none of these announcements. The standard deviation equals the actual standard deviation times 1000, the period of analysis is August 23, 1993 - August 19, 1994, and times shown are interval start times (ET).

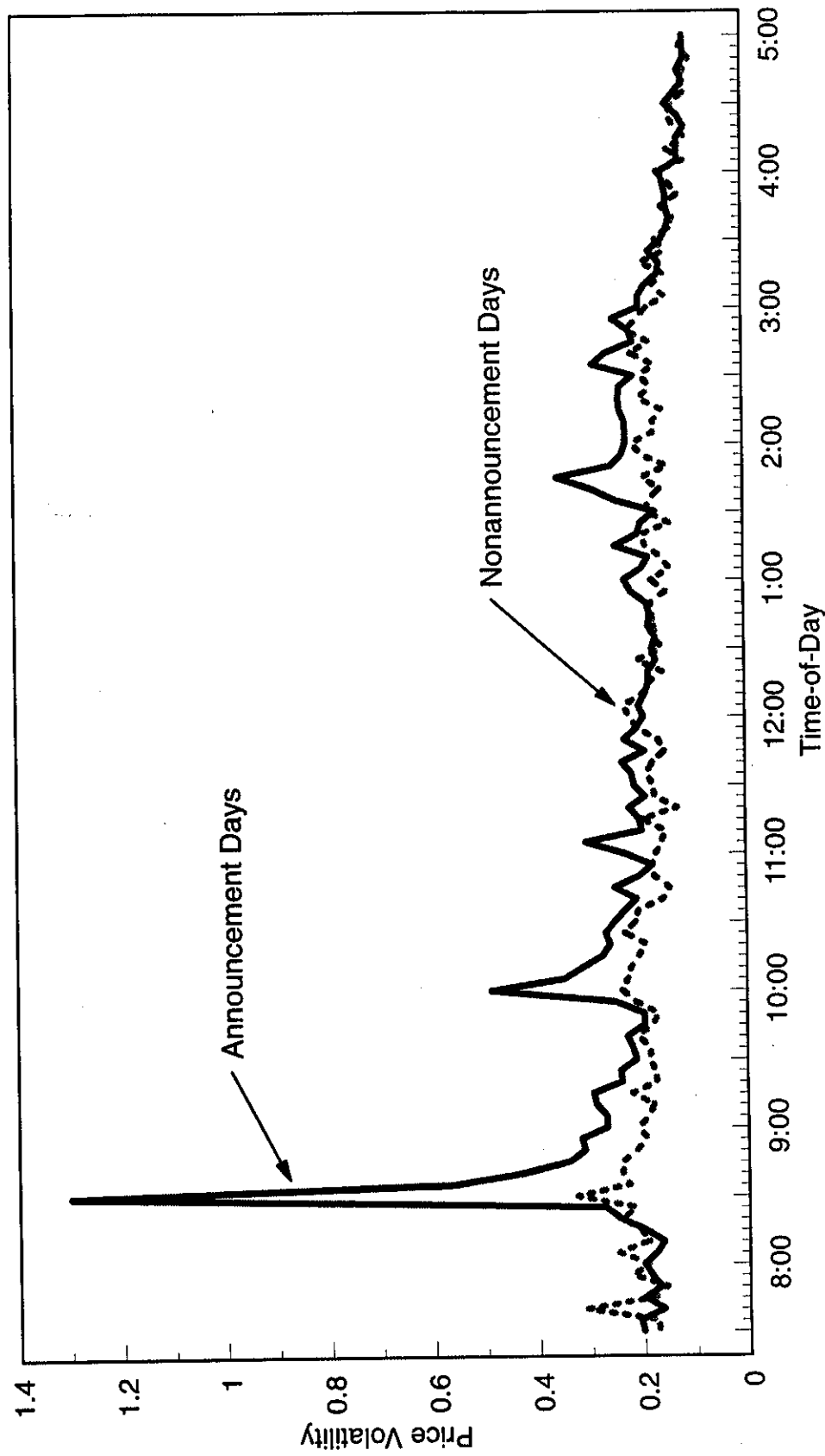


Chart 4

Intraday Trading Activity on Announcement and Nonannouncement Days

Mean number of interdealer trades for the five-year treasury note for days with at least one of the twenty-one announcements listed in Table 2 and days with none of these announcements. The period of analysis is August 23, 1993 - August 19, 1994, and times shown are interval start times (ET).

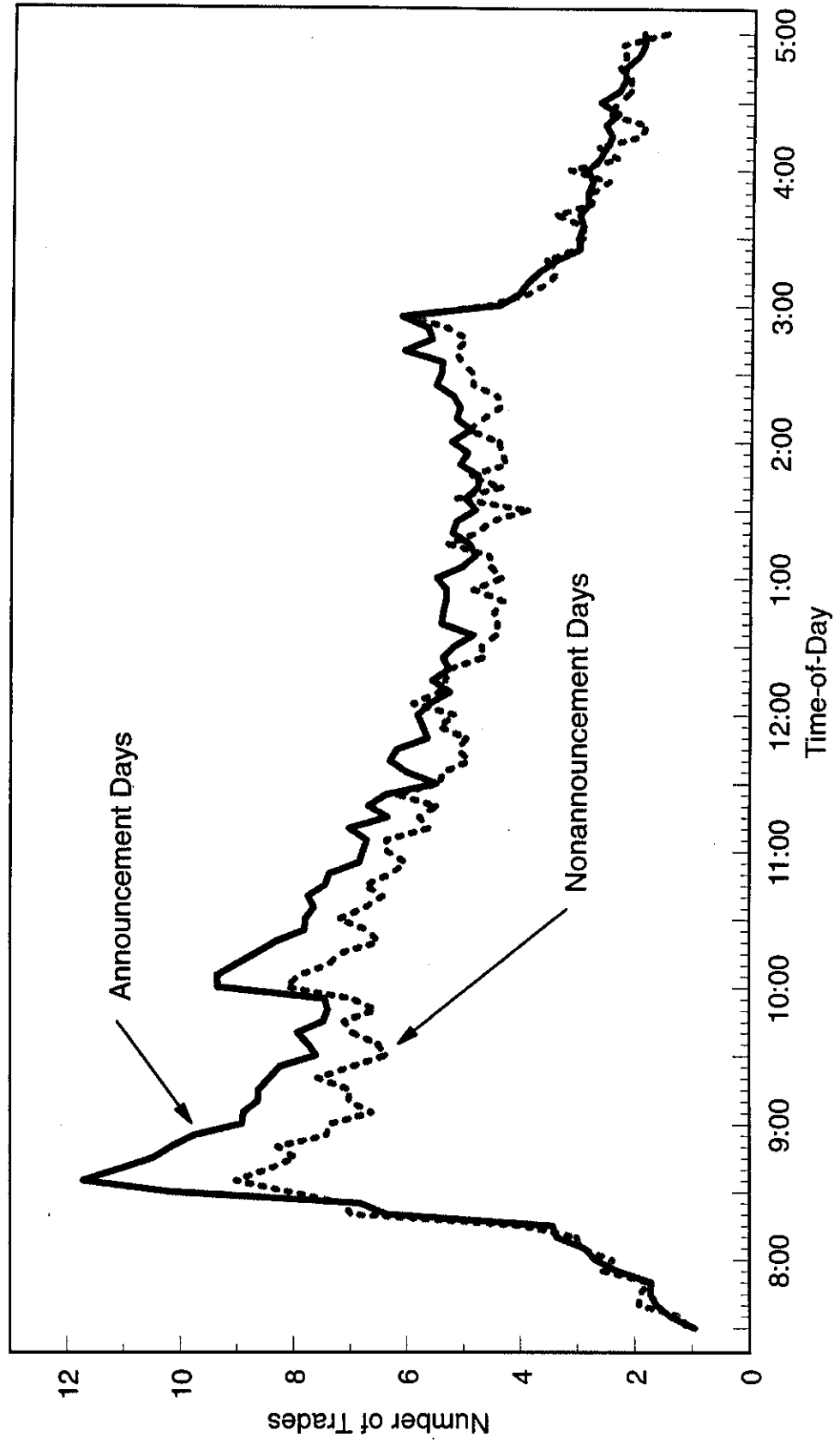
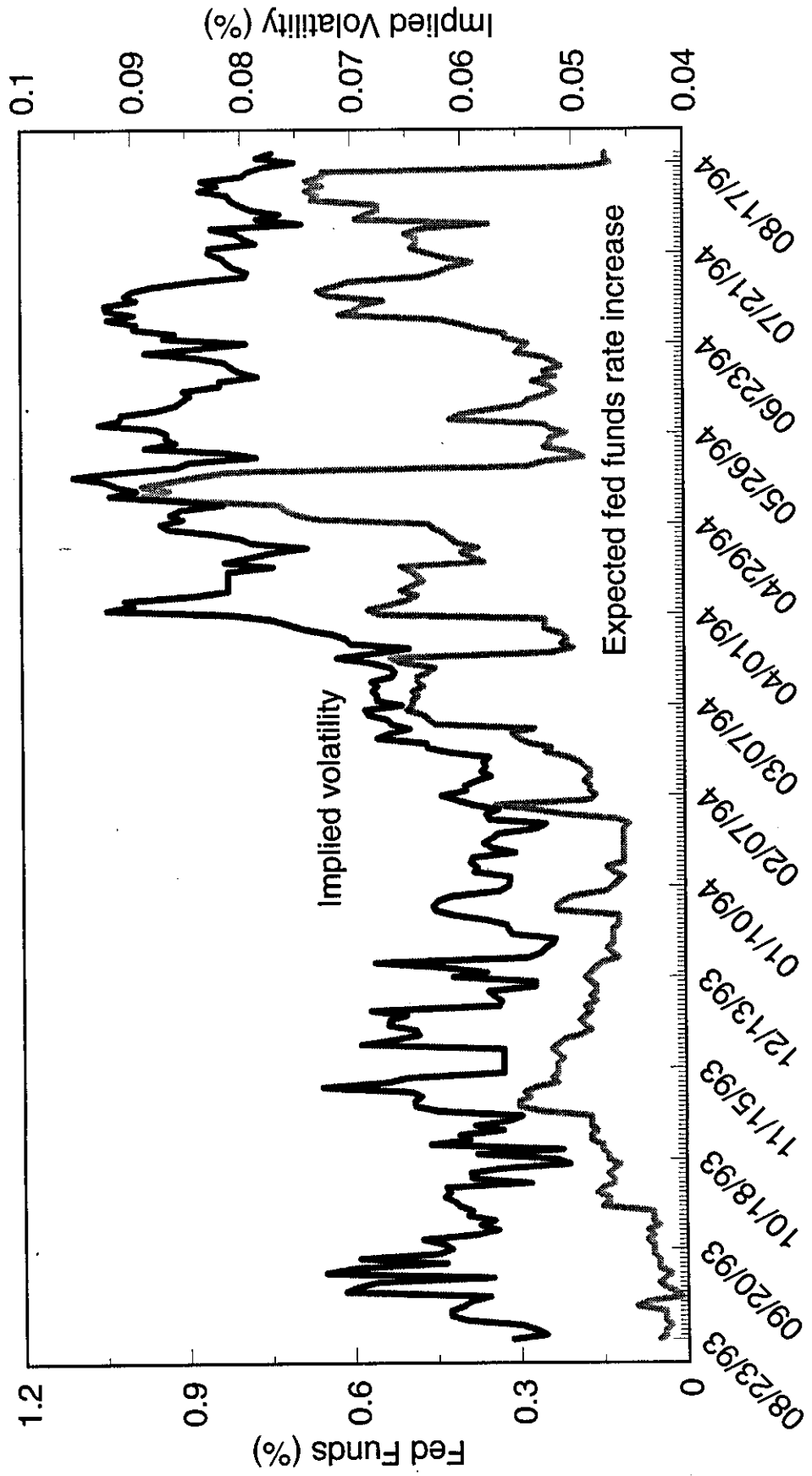


Chart 5

Expected Fed Funds Rate Increase and Implied Volatility

Chart shows expected fed funds rate increase and implied volatility for the ten-year Treasury note from August 23, 1993 - August 19, 1994. The expected fed funds rate increase is defined as the difference between the fed funds futures rate (using the contract expiring at the end of the month two months ahead) and the target fed funds rate.



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