What Moves the Bond Market?

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To what extent can movements in the financial markets be attributed to the arrival of new information? In a landmark 1989 study of the stock market, David Cutler, James Poterba, and Lawrence Summers found that it was surprisingly difficult to identify information that could account for the largest price movements. No similar effort has been made, however, to explain the largest price movements in the bond market, although both theory and a large literature on announcement effects suggest that the results for this market should be more promising.

In this article, we take a close look at a single year in the U.S. Treasury securities market (which we refer to as the bond market) and attempt to identify information that may account for the sharpest price changes and the most active trading episodes. Sharp price moves may be attributed to changes in expectations shared by investors, and surges in trading activity to a lack of consensus on prices.[1] To explain the price changes and trading surges, we examine how closely these events correlate with the release times of macroeconomic announcements.

We also investigate whether the bond market's behavior is related to factors affecting the informational value of the announcements—specifically, the type of announcement and the magnitude of the surprise in the data released. While other studies have examined announcement effects in the bond market, our use of high-frequency market data and precise announcement release times allows us to identify such effects more precisely than most earlier studies. In addition, our analysis of the role of uncertainty in assessing the impact of macroeconomic announcements goes beyond the scope of earlier bond market studies. To represent the bond market in our analysis, we focus on the five-year U.S. Treasury note, one of the most actively traded U.S. Treasury securities.

For the period examined—August 23, 1993, to August 19, 1994—we find that each of the twenty-five

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sharpest price changes and each of the twenty-five greatest trading surges can be associated with a just-released announcement. We also show that the market differentiates among announcements containing different information, with the employment, producer price index (PPI), federal (fed) funds target rate, and consumer price index (CPI) announcements eliciting the most pronounced responses in terms of both price movements and trading activity. In addition, our precise data allow us to document for the first time a significant market impact from U.S. Treasury security auction results. Finally, we demonstrate that the market's reactions depend on the surprise component of a given announcement and on conditions of market uncertainty.

PREVIOUS STUDIES

The literature on announcement effects in the stock and bond markets is quite extensive. Our review of this literature serves two purposes: it pulls many of the different strands of the literature together for the first time and it suggests the extent to which our empirical results—based on a one-year sample—can be generalized to other periods.

STOCK MARKET STUDIES

Theory says that movements in financial asset prices should reflect new information about fundamental asset values. In the case of the stock market, however, such theory has been difficult to confirm. Most notably, in an analysis of the fifty largest one-day price moves in the Standard and Poor's Composite Stock Index since 1946, Cutler, Poterba, and Summers (1989) find that in most cases the information cited by the press as 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 (such as money supply and discount rate announcements). More recently, McQueen and Roley (1993) find a stronger relationship between stock prices and news after controlling for different stages of the business cycle. Even with their best effort, however, McQueen and Roley are able to explain only 3.9 percent of the daily variation in the S&P 500 Index.

The apparently weak informational effects found in the stock market are not entirely surprising. Much of the observable information likely to be relevant to the stock market as a whole takes the form of macroeconomic announcements. The theoretical effects of such announcements are often ambiguous for stocks, but not for bonds. The reason is that stock prices depend on both cash flows and the discount rate, while bond prices—for which cash flows are fixed in nominal terms—depend *only* on the discount rate. An upward revision of expected real activity, for example, raises the discount rate for both stocks and bonds, which would reduce prices. At the same time, however, the revision raises expected cash flows for stocks, an outcome that increases stock prices. The net effect on bond prices of such an announcement is clearly negative, but the net effect on stock prices will depend on whether the cash flow effect or the discount rate effect dominates.

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BOND MARKET STUDIES

Earlier findings on announcement effects in the bond market suggest that it will be easier to relate this market's movements to information arrival.[2] Indeed, studies over the years have documented a significant bond market impact from numerous macroeconomic announcements, including money supply, industrial production, PPI, CPI, unemployment rate, and nonfarm payroll employment numbers (Table 1). Market movements in these studies are typically based on daily interest rates, and announcements are measured by the extent of the surprise each entails—that is, the difference between the forecast and

the actual number released. Forecasts are either derived by the studies' authors from the time series of the variables or generated by the market analysis firm MMS International Inc. from surveys conducted a few days before the announcements.

Table 1
STUDIES FINDING THAT MACROECONOMIC ANNOUNCEMENTS SIGNIFICANTLY AFFECT INTEREST RATES

Announcement	Study Author	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
	Harvey and Huang (1993)	Dec. 1981 - Apr. 1988
	McQueen and Roley (1993)	Sep. 1977 - May 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
Retail sales	Hardouvelis (1988)	Oct. 1982 - Aug. 1984
	Edison (1996)	Feb. 1980 - Feb. 1995
Unemployment 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
Nonfarm payroll employment	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

Notes: The table lists those studies that have found a statistically significant relationship between the surprise component of an announcement and U.S. interest rates. For studies that examine the impact on several interest rates, we consider only the results for the longest maturity rate. Studies are not listed in which the impact of an announcement is found to have a sign opposite to that
predicted.

The literature provides evidence of a "flavor-of-the-month" aspect to the bond market's behavior, in which different announcements are regarded as important in different periods. Starting with Berkman (1978), studies from the late 1970s to the mid-1980s document a significant impact of money supply announcements. However, Dwyer and Hafer (1989) show a diminishing significance for such announcements in the mid-1980s. Studies in the 1980s, such as Urich and Wachtel (1984) and Smirlock (1986), begin to demonstrate the importance of the PPI, CPI, and unemployment rate announcements. More recent studies, particularly Cook and Korn (1991) and Krueger (1996), establish the ascendant importance of the nonfarm payrolls number in the Bureau of Labor Statistics' (BLS) employment report.

It is noteworthy that the bond market studies that consider several announcements tend to find that relatively few of them have significant effects on the market.[3] One possible reason for this finding 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, researchers ought to measure the market change from just before to just after the announcement. Another possible reason for the lack of significance 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 unemployment rate announcements on interest rates depends on the existing level of unemployment.

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Bond Market Studies Using Intraday Data

The recent availability of high-frequency intraday price data has increased the power of researchers' efforts to estimate announcement effects. Ederington and Lee (1993), for instance, use such data on Treasury bond futures to examine the impact of monthly economic announcements. They find that nine out of sixteen announcements have significant price effects, with the greatest impact coming from the employment, PPI, CPI, and durable goods orders releases. More recently, Fleming and Remolona (1997) analyze intraday cash market Treasury securities data and find that eight out of nineteen announcements have a significant impact on price and eleven out of nineteen have a significant impact on trading volume. Instead of measuring surprise components, both studies rely on dummy variables for announcement days to isolate the announcements' effects. They therefore measure the average impact of the announcements without regard for the particular numbers released in any given report.

If an announcement's impact depends only on the unexpected part of the released information, 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. For example, Becker, Finnerty, and Kopecky (1996) find that nonfarm payroll employment and CPI surprises affect the fifteen-minute returns on bond futures significantly, while housing starts and merchandise trade surprises do not. In addition, Balduzzi, Elton, and Green (1996) conclude that surprises from only six of twenty-three monthly announcements have a significant price impact on the ten-year U.S. 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 the difference between the effects of earnings announcements on prices and the effects on trading activity. Beaver (1968) argues, for example, 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 volume, but Jain (1988) finds that macroeconomic news has no effect on hourly trading volume. Moreover, Woodruff and Senchack (1988) find that the effects of earnings announcements on prices and trading volume depend on the magnitude of the surprises.

As hypothesized by Beaver (1968), an increase in trading activity after announcements may largely reflect differences of opinion among market participants.[4] Other literature on trading activity has focused on the idea that both price changes and trading activity reflect the arrival of private information.[5] The conveyance of private information through trading is probably not that important in the bond market, however, since much of the information relevant to the market is released to the public through scheduled announcements. An explanation for changes in trading activity that is more pertinent to the bond market is that investors with duration targets or dynamic hedging strategies rebalance their portfolios after price changes.[6]

In summary, macroeconomic announcements cannot account for the largest price moves in the stock market and, in fact, are typically found to have an insignificant impact on stock prices. In contrast, numerous studies find a significant impact on bond prices, although no study prior to this one has explicitly tried to account for the largest price movements. As for the effects of announcements on trading activity, differences of opinion among traders or portfolio rebalancing might lead to a surge in trading activity after a release, but studies have been limited largely to the stock market and the results so far have been mixed.

Methodology and Data

Analytical Approaches

Our analysis of the U.S. Treasury securities market combines the different approaches offered by the literature on announce-

ment effects. First, we follow Cutler, Poterba, and Summers (1989) in examining the largest price changes and determining the extent to which these changes coincide with the release times of announcements. Second, like Ederington and Lee (1993), we run dummy-variable regressions to measure the extent to which the market systematically differentiates among the different types of announcements to reflect the inherent differences in the information released. Third, we follow Becker, Finnerty, and Kopecky (1996) and other studies in investigating whether measured surprises in the announcements help explain the market's responses. Finally, following McQueen and Roley (1993), we analyze the possible effects of market conditions on the impact of a given announcement surprise.

We employ high-frequency price and trading data from the U.S. Treasury securities market, as well as data on the dates and exact release times of various macroeconomic announcements. These data allow us to correlate market movements closely with information releases and to identify the market impact of announcements precisely.

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U.S. Treasury Securities Data

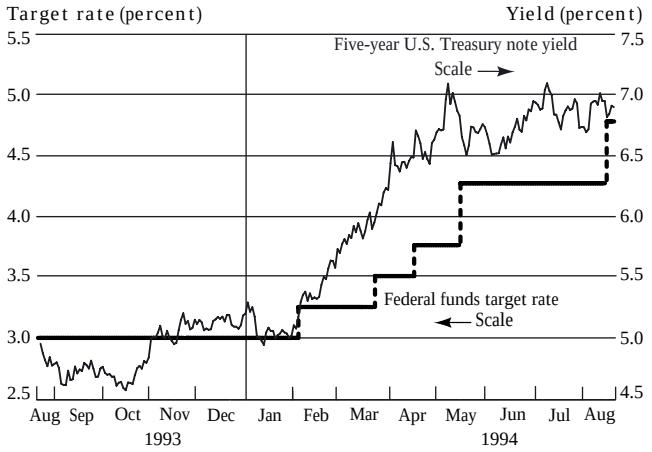
Our U.S. Treasury securities data cover one year of tick-by-tick trading activity in the interdealer broker market. Our data source is GovPX, Inc., a joint venture set up by the primary dealers and interdealer brokers in 1991 to improve the public's access to U.S. Treasury securities prices (*Wall Street Journal* 1991). GovPX consolidates and posts real-time quote and transaction data from five of the six major interdealer brokers, which together account for roughly 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. 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 ten holidays. The period is somewhat unusual in that it covers a time when the Federal Reserve was particularly active in monetary tightening, raising its fed funds target rate five times (Chart 1). We choose the on-the-run five-year U.S. Treasury note to represent the U.S. Treasury securities market in our analysis. On-the-run

Chart 1

Federal Funds Target Rate and Five-Year U.S. Treasury Note Yield

August 23, 1993, to August 19, 1994



Sources: Federal Reserve Bank of New York; GovPX, Inc.

Note: Federal Open Market Committee meeting dates are indicated by the blue vertical lines.

securities are the most recently issued securities of a given maturity and account for the majority of interdealer trading volume.[7] Fleming (1997) reports that among the on-the-run issues, the five-year note is the most actively traded security among the brokers reporting to GovPX. During our sample period, GovPX posted a daily average of 2,167 bid-ask quotations and 659 trades for this note.[8]

Announcement Dates and Release Times

We also collected data on the dates and release times of twenty-one different macroeconomic announcements (Table 2). These include the nineteen monthly announcements that regularly appear in "The Week Ahead" section of *Business Week*, as well as fed funds target rate announcements and announcements of U.S. Treasury security auction results.[9] Nineteen of the announcements come from government agencies and two come from the private sector. Eighteen of the nineteen monthly announcements are released at regularly scheduled times of the day, with ten released at 8:30 a.m. eastern time, one at 9:15 a.m., six at 10 a.m., and one at 2 p.m.[10] Announcement times vary for one monthly announcement (consumer credit), for the fed funds target rate announcements, and for the Treasury security auction results announcements. We rely on Bloomberg for the precise release times of these announcements.

As for release dates, 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 it is covering (Chart 2). 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 covered. The employment report, usually released on the first Friday of the month, is the first government report to be announced with informa-

Table 2
MACROECONOMIC ANNOUNCEMENTS

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.[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
8:30 a.m.	Trade balance[b]	U.S. International Trade in Goods and Services	Bureau of the Census, Bureau of Economic Analysis
9:15 a.m.	Industrial production and capacity utilization	Industrial Production and Capacity Utilization	Federal Reserve Board
10 a.m.	Business inventories	Manufacturing and Trade: Inventories and Sales	Bureau of the Census
10 a.m.	Construction spending	Value of New Construction Put in Place	Bureau of the Census
10 a.m.	Consumer confidence	Consumer Confidence Index	Conference Board
10 a.m.	Factory inventories	Manufacturers' Shipments, Inventories, and Orders	Bureau of the Census
10 a.m.	NAPM survey	National Association of Purchasing Management Report on Business	National Association of Purchasing Management
10 a.m.	New single-family home sales	New One-Family Houses Sold and For Sale	Bureau of the Census
2 p.m.	Federal budget	Treasury Statement (the Monthly "Budget")	Department of the Treasury
Varies[c]	Consumer credit	Consumer Installment Credit	Federal Reserve Board
Varies[d]	Federal funds target rate	N.A.	Federal Reserve Board
Varies[e]	Treasury security auction results	Treasury Security Auction Results	Department of the Treasury

Notes: The table reports the announcement time, title, and reporting entity for eighteen regularly scheduled announcements and three announcements with varying release times. All times are eastern.

[a]Personal income was reported at 10 a.m. for the first three announcements in the period of analysis and at 8:30 a.m. thereafter.

[b]This report replaced the Census Bureau's Report of U.S. Merchandise Trade in March 1994.

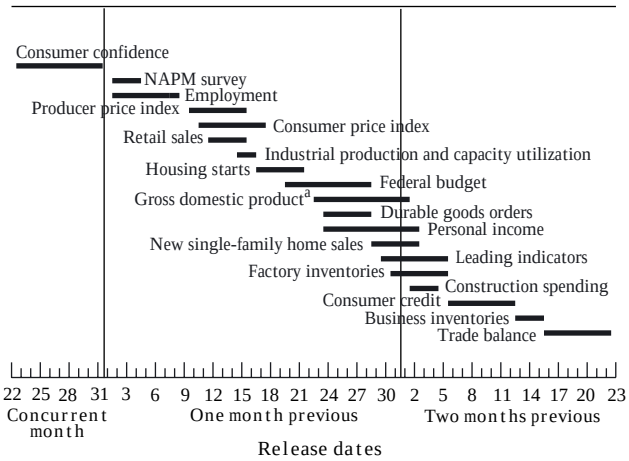
[c]Eight of the twelve announcements in our sample were made at 4 p.m. The others were made at 2:12 p.m., 2:45 p.m., 3:14 p.m., and 3:55 p.m.

[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.

[e]All of the auction results in our sample were announced between 12:30 p.m. and 2:15 p.m., with most reported between 1:30 p.m. and 2 p.m.

Chart 2

Macroeconomic Announcement Release Dates
August 23, 1993, to August 19, 1994



Sources: *Business Week*; Office of Management and Budget, *Schedule of Release Dates for Principal Federal Economic Indicators* (1993, 1994); Bloomberg L.P.

Note: The chart shows the range of release dates for scheduled monthly economic announcements and indicates the month of economic data included in the report.

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

tion about a given month.[11] It is followed by releases of the PPI, the CPI, retail sales, and industrial production and capacity utilization. The remaining twelve monthly reports are released in the second half of the month following the month covered, or in the month after that.

Our year of data contains twelve releases for each of the nineteen monthly announcements. In 1994, the Federal Reserve began making fed funds target rate announcements, the first one at its February 1994 Federal Open Market Committee (FOMC) meeting. This study provides the first intraday analysis of the fed funds target rate announcements, of which there are six in our sample.[12] The impact of the Treasury security auction results announcements, which are scheduled at regular intervals, are considered separately for each coupon security of a given maturity. Our year of data contains results of two thirty-year-bond auctions, four ten-year-note auctions, twelve five-year-note auctions, four three-year-note auctions, and twelve two-year-note auctions. In total, our sample contains 268 announcement releases on 173 separate days, leaving 77 days with no announcement.

Expectations and Announcements

Market expectations for the nineteen monthly announcements are obtained from the *Wall Street Journal*. Every Monday, the *Journal* publishes consensus forecasts provided by Technical Data, a market analysis firm, for the coming week's announcements. Technical Data produces the forecasts from a survey of twenty-five economists conducted the Friday before.[13] 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 that we could not get from the first two sources. We obtained a complete set of forecasts for eighteen of our nineteen monthly announcements and a partial set (eight out of twelve) for the remaining one (factory inventories). Actual announcement data are retrieved from these same three sources and are supplemented by data from Bloomberg when necessary.

Expectations for the fed funds target rate are calculated using the rates on fed funds futures contracts. Since the settlement price of a fed funds futures contract is based on the average effective overnight fed funds rate over an entire month, the rate at any point during a month i^f is a weighted average of the actual fed funds rate to date i^a and the rate expected to prevail for the rest of the month, i^m. Specifically, $i^f = \frac{T}{N} \times i^a + \frac{N-T}{N} \times i^m$, where T is the number of days passed to date and N is the number of days in the month. The fed funds target rate expected to prevail after an FOMC meeting is then calculated by solving for i^m using the daily rate data up to each FOMC announcement.[14]

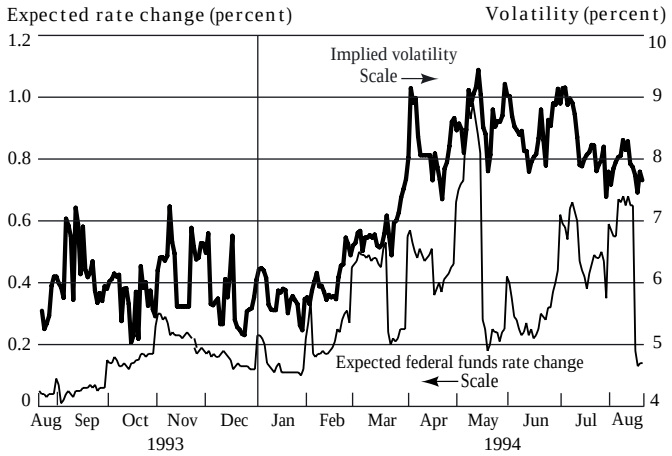
We can measure expectations for the Treasury security auction results much more precisely than other expectations. Our measure is the yield in the when-issued market (extracted from the GovPX data set) at the time of the auction. Actual results are then measured by the auction yield as reported in the next day's *Wall Street Journal*.[15]

Market Uncertainty

Our analysis of market conditions relies on two measures of market uncertainty (Chart 3). One is the implied volatility derived from options on U.S. Treasury futures traded on the Chicago Board of Trade. Specifi-

Chart 3

Measures of Market Uncertainty
August 23, 1993, to August 19, 1994



Source: Authors' calculations, based on data from the Chicago Board of Trade and the Federal Reserve Bank of New York.

Notes: The expected federal funds rate change is defined as the difference between the federal funds futures rate (drawn from the contract expiring at the end of the month two months ahead) and the federal funds target rate. Implied volatility is an annualized measure derived from futures options on ten-year U.S. Treasury notes.

cally, the volatility measure equals the average of six individual implied volatilities calculated using the nearest-to-the-money calls and puts on futures contracts on ten-year U.S. Treasury notes. The second measure is the expected change in the fed funds rate—defined as the difference between the fed funds futures rate (drawn from the contract expiring at the end of the month two months ahead) and the fed funds target rate. The expected fed funds rate change is positive for our entire sample year because the question during this period was largely whether the Federal Reserve was going to raise rates, and if so, by how much.

THE LARGEST MARKET MOVES

To account for the sharpest price changes and the greatest surges in trading activity in the bond market, we selected the twenty-five largest price changes and the twenty-five most active trading episodes from every five-minute interval across the global trading day from August 23, 1993, to August 19, 1994 (Tables 3 and 4).[16]

PRICE SHOCKS

It is striking that the twenty-five sharpest price changes in the bond market all occurred on announcement days.[17]

Table 3
SHARPEST PRICE CHANGES FOR THE FIVE-YEAR U.S. TREASURY NOTE

Price Change (Percent)	Date	Time	Announcement (Time)
-0.590	August 5, 1994	8:30-8:35 a.m.	Employment (8:30 a.m.)
-0.536	May 6, 1994	8:30-8:35 a.m.	Employment (8:30 a.m.)
-0.440	July 8, 1994	8:30-8:35 a.m.	Employment (8:30 a.m.)
-0.412	April 1, 1994	8:30-8:35 a.m.	Employment, personal income (8:30 a.m.)
0.407	July 29, 1994	8:30-8:35 a.m.	Gross domestic product (8:30 a.m.)
0.406	September 3, 1993	8:30-8:35 a.m.	Employment, leading indicators (8:30 a.m.)
0.384	May 12, 1994	8:30-8:35 a.m.	Producer price index, retail sales (8:30 a.m.)
-0.343	May 27, 1994	8:35-8:40 a.m.	Gross domestic product (8:30 a.m.)
0.332	November 9, 1993	8:30-8:35 a.m.	Producer price index (8:30 a.m.)
0.315	February 4, 1994	8:30-8:35 a.m.	Employment (8:30 a.m.)
0.313	September 10, 1993	8:30-8:35 a.m.	Producer price index (8:30 a.m.)
0.282	January 7, 1994	8:30-8:35 a.m.	Employment (8:30 a.m.)
-0.266	August 16, 1994	1:45-1:50 p.m.	Federal funds target rate (1:17 p.m.)
-0.265	June 3, 1994	8:40-8:45 a.m.	Employment (8:30 a.m.)
-0.259	February 4, 1994	11:05-11:10 a.m.	Federal funds target rate (11:05 a.m.)
-0.255	April 1, 1994	8:40-8:45 a.m.	Employment, personal income (8:30 a.m.)
0.253	July 14, 1994	8:30-8:35 a.m.	Retail sales (8:30 a.m.)
-0.249	September 14, 1993	8:30-8:35 a.m.	Consumer price index, retail sales (8:30 a.m.)
0.224	April 13, 1994	8:30-8:35 a.m.	Consumer price index, retail sales (8:30 a.m.)
-0.223	May 11, 1994	1:40-1:45 p.m.	Ten-year-note auction results (1:42 p.m.)
-0.223	April 1, 1994	8:35-8:40 a.m.	Employment, personal income (8:35 a.m.)
0.223	February 11, 1994	8:30-8:35 a.m.	Producer price index, retail sales (8:30 a.m.)
0.222	July 12, 1994	8:30-8:35 a.m.	Producer price index (8:30 a.m.)
0.221	May 17, 1994	2:35-2:40 p.m.	Federal funds target rate (2:26 p.m.)
-0.218	December 9, 1993	8:30-8:35 a.m.	Producer price index (8:30 a.m.)

Source: Authors' calculations, based on data from GovPX, Inc.

Notes: The table reports the largest percentage price changes by five-minute interval for the five-year U.S. Treasury note along with associated announcements (and announcement times). The largest price changes are chosen from all
five-minute intervals across the global trading day for the period August 23, 1993, to August 19, 1994. All times are eastern.

Moreover, all but one came within fifteen 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 were found to follow an employment report, six a PPI report, five a retail sales report, three a personal income report, two a CPI report, and two a GDP report. In eight instances, the shocks came after the concurrent release of two reports.

It is striking that the twenty-five sharpest price changes in the bond market all occurred on announcement days. Moreover, all but one came within fifteen minutes of an announcement's release.

Three other shocks followed a fed funds target rate announcement and one trailed a release of auction results for the ten-year U.S. Treasury note.

The fact that price shocks in the bond market are so explainable stands in contrast to the difficulty of explaining them in the stock market. It is true that we attempt to explain only a year in the bond market, while Cutler, Poterba, and Summers (1989) seek to explain more than forty years in the stock market. However, it is important to note that our explanations 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.[18] Because these are *ex post* explanations, the authors focus on whether the 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.

Table 4
MOST ACTIVE TRADING INTERVALS FOR THE FIVE-YEAR U.S. TREASURY NOTE

Number of Trades	Date	Time	Announcement (Time)
35	July 29, 1994	8:50-8:55 a.m.	Gross domestic product (8:30 a.m.)
30	September 14, 1993	8:40-8:45 a.m.	Consumer price index, retail sales (8:30 a.m.)
29	July 20, 1994	8:35-8:40 a.m.	Housing starts (8:30 a.m.)
28	January 7, 1994	8:45-8:50 a.m.	Employment (8:30 a.m.)
28	February 11, 1994	8:35-8:40 a.m.	Producer price index, retail sales (8:30 a.m.)
28	February 11, 1994	9:00-9:05 a.m.	Producer price index, retail sales (8:30 a.m.)
27	May 27, 1994	8:45-8:50 a.m.	Gross domestic product (8:30 a.m.)
27	July 14, 1994	8:35-8:40 a.m.	Retail sales (8:30 a.m.)
26	May 6, 1994	9:20-9:25 a.m.	Employment (8:30 a.m.)
26	May 13, 1994	8:50-8:55 a.m.	Consumer price index (8:30 a.m.)
25	November 5, 1993	8:35-8:40 a.m.	Employment (8:30 a.m.)
25	January 7, 1994	8:35-8:40 a.m.	Employment (8:30 a.m.)
25	January 28, 1994	8:40-8:45 a.m.	Gross domestic product (8:30 a.m.)
25	March 1, 1994	10:50-10:55 a.m.	NAPM survey, construction spending (10:00 a.m.)
25	March 15, 1994	8:35-8:40 a.m.	Producer price index (8:30 a.m.)
25	April 20, 1994	8:45-8:50 a.m.	Housing starts (8:30 a.m.)
25	June 3, 1994	8:35-8:40 a.m.	Employment (8:30 a.m.)
25	June 10, 1994	9:00-9:05 a.m.	Producer price index (8:30 a.m.)
25	July 8, 1994	8:40-8:45 a.m.	Employment (8:30 a.m.)
24[a]	March 4, 1994	8:45-8:50 a.m.	Employment, leading indicators (8:30 a.m.)
24[a]	April 20, 1994	9:40-9:45 a.m.	Housing starts (8:30 a.m.)
24[a]	June 29, 1994	9:15-9:20 a.m.	Gross domestic product (8:30 a.m.)
24[a]	July 8, 1994	8:45-8:50 a.m.	Employment (8:30 a.m.)
24[a]	July 12, 1994	8:35-8:40 a.m.	Producer price index (8:30 a.m.)
24[a]	July 12, 1994	8:40-8:45 a.m.	Producer price index (8:30 a.m.)

Source: Authors' calculations, based on data from GovPX, Inc.

Notes: The table reports the highest number of trades by five-minute interval for the five-year U.S. Treasury note along with associated announcements (and announcement times). The most active intervals are chosen from all five-minute intervals across the global trading day for the period August 23, 1993, to August 19, 1994. All times are eastern.

[a]Eight intervals with twenty-four trades are in the sample; we report the six with the largest number of bid-ask quotations.

TRADING SURGES

It is similarly striking that the twenty-five greatest surges in trading activity all occurred on announcement days. The evidence linking each surge to an announcement may seem less compelling than the corresponding evidence for price shocks because a longer lag separates these surges from the time of announcement. Nonetheless, all of the surges in activity came within seventy minutes of an announcement's release, nineteen of them within half an hour.[19] The greatest surge consisted of thirty-five transactions worth a total of $240 million (in face value) in a five-minute interval twenty minutes after the July 29, 1994, GDP report.[20] Eight of the other surges followed an employment report, six a PPI report, four a GDP report, four a retail sales report, three a housing starts report, and two a CPI report. In five instances, the surges followed the concurrent release of two reports.

It is similarly striking that the twenty-five greatest surges in trading activity all occurred on announcement days. . . . All of the surges in activity came within seventy minutes of an announcement's release, nineteen of them within half an hour.

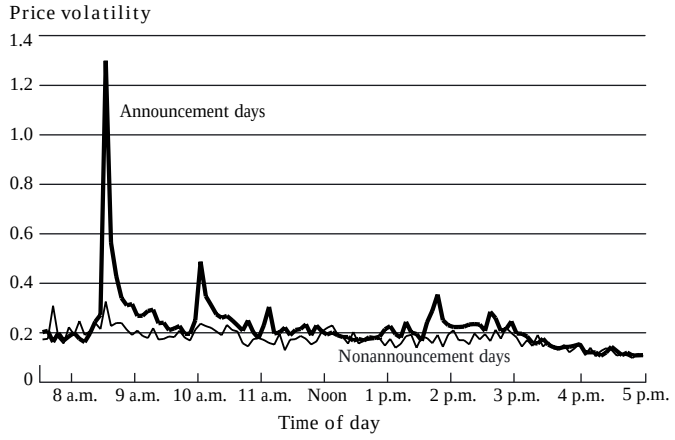
INTRADAY ANNOUNCEMENT PATTERNS

The largest movements in prices and surges in trading activity exhibit certain regularities. First, we account for all these movements with only twelve 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 twenty-five price shocks and eighteen of the twenty-five trading surges. Federal Reserve target rate changes and market uncertainty over those changes may explain this pattern, a hypothesis we explore later.

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, pronounced market movements follow announcement releases. On an average announcement day, we find that price volatility spikes just after the release times and that these spikes are absent on nonannouncement days (Chart 4).[21] This pattern has also been documented by Ederington and Lee (1993) and Fleming and Remolona (1997). In addition, we find that the average number of trades following release times on announcement days exceeds the average on nonannouncement days (Chart 5). Trading volume, which accounts for the size as well as the number of trades, follows a similar pattern, as documented in Fleming and Remolona (1997).

Chart 4

Intraday Price Volatility on Announcement and Nonannouncement Days

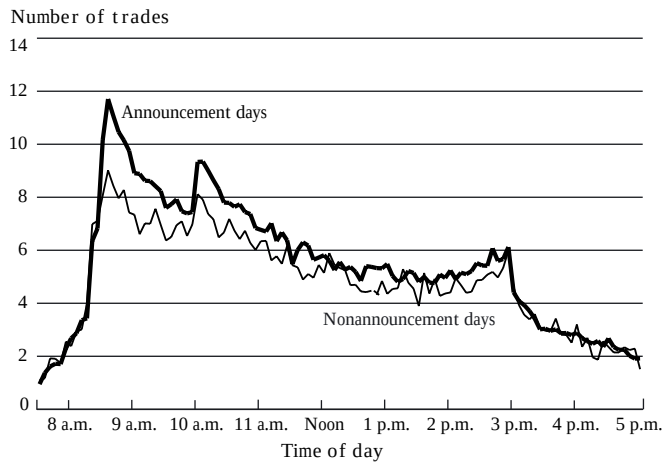


Source: Authors' calculations, based on data from GovPX, Inc.

Notes: The chart shows the standard deviation of log price changes by five-minute interval for the five-year U.S. 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 10^3. The period of analysis is August 23, 1993, to August 19, 1994. Times shown are interval starting times (eastern).

Chart 5

Intraday Trading Activity on Announcement and Nonannouncement Days



Source: Authors' calculations, based on data from GovPX, Inc.

Notes: The chart shows the mean number of interdealer trades by five-minute interval for the five-year U.S. 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, to August 19, 1994. Times shown are interval starting times (eastern).

Which Announcements Have the Most Relevance?

If the market's movements represent a reaction to new information, some types of announcements should induce a stronger reaction than others because of inherent differences in the information contained about the economy. We now test whether the market's price movements and trading activity serve to differentiate among the various announcements, and to the degree they do, which announcements matter the most. While differences from expectations in a given announcement may be an important determinant of the market's response—an issue we explore in the next section of the article—our first step is simply to determine which announcements consistently affect the market and to what extent.

Estimation of Announcement Importance

To establish the importance of the various announcements, we run regressions of price volatility and trading activity on dummy variables representing each of the announcements listed in Table 2. We measure price volatility by 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.[22] We measure trading activity as the number of transactions during the one-hour interval following the announcement. The longer interval for trading activity is consistent with Fleming and Remolona's (1997) results suggesting that prices adjust rapidly while high trading activity persists for an extended period after an announcement.

For our explanatory variables, 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.[23] We rely on an additional set of dummy variables D_t to control for intraday patterns of price volatility and trading activity. We denote the dependent variables by Y_{nt}^{j}, where the superscript j indicates whether the variable is price volatility or trading activity. Our regression equation is then $Y_{nt}^{j} = a_0^j + \Sigma_{t=1}^{T-1} a_t^j D_t + \Sigma_{k=1}^{K} b_k^j D_{knt} + e_{nt}^j$, where T=22 (the number of different intervals corresponding to the release times of the different announcements) and K=25 (the number of announcements we analyze). The coefficient of interest is b_k^j, which measures the impact of announcement k.

Announcements Affecting Price

Our results suggest that the bond market differentiates among the various types of announcements through the magnitude of its price movements. Nine of the twenty-five announcements examined are found to have a significant impact on price, six showing significant effects at the 1 percent level and three at the 5 percent level (Table 5). In order of importance, the significant announcements with the greatest effects on price are: (1) employment, (2) PPI, (3) fed funds target rate, (4) retail sales, (5) CPI, (6) NAPM survey, (7) five-year-note auction results, (8) industrial production and capacity utilization, and (9) consumer confidence. This list of significant announcements is longer than any such list in previous studies.

Our regression results are noteworthy for several other reasons. First, we document for the first time a significant market impact from U.S. Treasury security auction results. Second, bond prices react so consistently to four announcements—the NAPM survey, five-year-note auction

results, industrial production and capacity utilization, and consumer confidence—that these announcements are significant even when absent from the twenty-five largest price shocks. Third, although GDP releases account for two of our twenty-five largest price shocks, such releases fail to induce a price reaction consistently and hence are not found to be significant in our regressions.[24]

Our results, in conjunction with those of earlier researchers, also provide evidence of stability in the announcements that have relevance to bond prices. In their analysis of bond futures prices from November 1988 to November 1991, Ederington and Lee (1993) find the employment, PPI, CPI, and durable goods orders reports to be the most important regularly scheduled announcements. The continued significance of the employment report may be explained by the fact that it still offers the market the first comprehensive look at the economy's strength, with data on nonfarm payroll employment, the unemployment rate, and average hourly earnings.[25] The PPI and CPI reports also continue to be significant. Of Ederington and Lee's most important announcements, only the durable goods orders report has lost its significance.[26]

Table 5
IMPACT OF ANNOUNCEMENTS ON PRICE

Rank	Announcement	Coefficient
1	Employment	26.10**
2	Producer price index	13.71**
3	Federal funds target rate	11.00**
4	Gross domestic product	7.19
5	Retail sales	7.04*
6	Consumer price index	6.75**
7	Thirty-year-bond auction results	6.48
8	Ten-year-note auction results	5.84
9	NAPM survey	4.12*
10	Five-year-note auction results	3.62**
11	Industrial production and capacity utilization	3.42**
12	Consumer confidence	3.09*
13	New single-family home sales	2.58
14	Durable goods orders	1.78
15	Construction spending	1.78
16	Three-year-note auction results	1.76
17	Trade balance	1.68
18	Housing starts	1.34
19	Personal income	1.15
20	Business inventories	1.14
21	Consumer credit	0.86
22	Factory inventories	0.70
23	Two-year-note auction results	0.26
24	Federal budget	0.03
25	Leading indicators	-3.32
Memo:		
Adjusted R^2		0.40
χ^2 statistic[a]		362**
Number of observations		5,323

Source: Authors' calculations, based on data from GovPX, Inc.

Notes: The table presents the regression coefficients indicating the average difference in price volatility for the five-year U.S. Treasury note for the five-minute period after an announcement as compared with the same period on nonannouncement days. Volatility is defined as the absolute value of the log price change times 10^4. Coefficient significance is based on two-sided t-tests using heteroskedasticity-consistent (White) standard errors. The period of analysis is August 23, 1993, to August 19, 1994.

[a]The χ^2 statistic tests whether all model coefficients equal zero and is computed using the heteroskedasticity-consistent covariance matrix.

*Significant at the .05 level.

**Significant at the .01 level.

ANNOUNCEMENTS AFFECTING TRADING ACTIVITY

Our results, in conjunction with those of earlier researchers, also suggest that the bond market differentiates among announcements through the extent of trading activity elicited. Fourteen of the announcements have a significant positive impact on trading activity, twelve at the 1 percent level and two at the 5 percent level (Table 6). In order of importance, the announcements that generate significant trading activity are: (1) employment, (2) fed funds target rate, (3) thirty-year-bond auction results, (4) PPI, (5) ten-year-note auction results, (6) CPI, (7) NAPM survey, (8) GDP, (9) retail sales, (10) three-year-note auction results, (11) new single-family home sales, (12) factory inventories, (13) business inventories, and (14) industrial production and capacity utilization.

We note that, first, the announcements that matter for price also tend to matter for trading activity. The employment report, for example, has the greatest impact on both price and trading activity. Second, housing starts releases account for three of the twenty-five greatest trading surges but do not consistently produce a rise in trading activity. Third, eight announcements consistently lead to additional trading activity even when they do not account for any of the twenty-five greatest trading surges: fed funds target rate, thirty-year-bond auction results, ten-year-note auction results, three-year-note auction results, new single-family home sales, factory inventories, business inventories, and industrial production and capacity utilization.

Table 6
IMPACT OF ANNOUNCEMENTS ON TRADING ACTIVITY

Rank	Announcement	Coefficient
1	Employment	87.93**
2	Federal funds target rate	72.14**
3	Thirty-year-bond auction results	63.55**
4	Producer price index	58.29**
5	Ten-year-note auction results	46.50**
6	Consumer price index	45.92**
7	NAPM survey	39.72**
8	Gross domestic product	39.47**
9	Retail sales	38.21**
10	Three-year-note auction results	36.24**
11	New single-family home sales	30.05**
12	Factory inventories	26.14**
13	Business inventories	23.53*
14	Industrial production and capacity utilization	23.02*
15	Housing starts	15.37
16	Trade balance	13.54
17	Leading indicators	6.46
18	Consumer confidence	5.35
19	Personal income	3.72
20	Two-year-note auction results	0.72
21	Durable goods orders	-0.32
22	Consumer credit	-0.35
23	Construction spending	-1.21
24	Federal budget	-7.03
25	Five-year-note auction results	-10.42*

Memo:	
Adjusted R^2	0.38
χ^2 statistic[a]	6,721**
Number of observations	5,386

Source: Authors' calculations, based on data from GovPX, Inc.

Notes: The table presents the regression coefficients indicating the average difference in trading activity for the five-year U.S. Treasury note for the one-hour period after an announcement as compared with the same period on non-announcement days. Trading activity is defined as the number of interdealer broker transactions reported by GovPX. Coefficient significance is based on two-sided t-tests using heteroskedasticity-consistent (White) standard errors. The period of analysis is August 23, 1993, to August 19, 1994.

[a]The χ^2 statistic tests whether all model coefficients equal zero and is computed using the heteroskedasticity-consistent covariance matrix.

*Significant at the .05 level.

**Significant at the .01 level.

TIMELINESS

The timeliness of an announcement—that is, how soon data are released after the period covered ends—helps to explain its impact on prices and trading activity. Of the government reports, the most timely are employment, PPI, CPI, and retail sales, in that order (Chart 2). This order of timeliness is nearly matched by the reports' order of importance for both price shocks and trading activity. Timeliness, however, is not the sole determinant of market impact. The two private sector reports—consumer confidence and the NAPM survey—are even more timely than the employment report. Although both reports significantly affect the market, the bond market evidently regards their information about the economy as somewhat less important than the information in the government's employment, PPI, CPI, and retail sales reports. As we will demonstrate, the degree of surprise in a given announcement and conditions of market uncertainty also influence an announcement's importance.

ANNOUNCEMENT SURPRISES AND MARKET CONDITIONS

DOES THE MAGNITUDE OF SURPRISE MATTER?

A bond market that truly responds to the arrival of information should not only differentiate among the various types of announcements but also react more sharply to larger surprises in a given announcement.[27] Many bond market announcement studies focus on the surprise component because information is believed to have value only to the extent that it is unexpected. For example, an unexpectedly strong nonfarm payrolls number should cause a fall in bond prices, with a greater surprise causing a greater fall. The effect on trading activity is less clear, however, because a larger surprise would not necessarily lead to wider disagreement among traders about the appropriate price adjustment, although we might expect it to lead to greater portfolio rebalancing if the larger surprise is accompanied by a greater price change.

To measure the impact of unexpected information, we regress five-year U.S. Treasury note price changes and trading activity on the surprise components of announcements. We define surprises $S_{knt} \equiv A_{knt} - F_{knt}$, where A_{knt} is the actual number released in announcement k on day n in interval t and F_{knt} is the corresponding forecast number (S_{knt}=0 on days and in intervals without a release of announcement k). Although each announcement typically reveals several pieces of information, we limit our analysis to surprises in the headline number. For the employment report, we therefore focus on nonfarm payroll employment surprises; for industrial production and capacity utilization,

we focus on industrial production surprises. To facilitate a comparison of announcement effects and to ensure that our estimated coefficients are representative of a typical announcement, we scale the surprises by the mean absolute surprise $\overline{S_k} = \frac{1}{N_k}\Sigma_n |S_{knt}|$, where N_k is the number of releases of announcement k in our sample.

Hence, our regression equation for bond prices is given by $Z_{nt}^P = a_0^P + \Sigma_{k=1}^K c_k^P \frac{S_{knt}}{\overline{S_k}} + u_{nt}^P$, where Z_{nt}^P is the signed price change. In the case of trading activity, our equation is $Z_{nt}^Q = a_0^Q + \Sigma_{t=1}^{T-1} a_t^Q D_t + \Sigma_{k=1}^K c_k^Q \frac{|S_{knt}|}{\overline{S_k}} + u_{nt}^Q$, where Z_{nt}^Q is trading activity, D_t are dummy variables to control for intraday patterns of trading activity, and $|S_{knt}|$ are the absolute surprises.[28] The coefficients c_k^P and c_k^Q, which measure the effects of announcement surprises on prices and trading activity, respectively, are reported in Table 7 along with the mean absolute surprise for each announcement.

In general, the surprise components provide more precise estimates of announcement effects on bond prices, indicating a market that is indeed reacting to the arrival of information. Taking account of the magnitude and sign of the surprise lends significance to six announcements not found to be significant in the regressions with announcement dummy variables, adding to an already long list of significant announcements. The six additional announcements are the auction results for the ten-year U.S Treasury note and thirty-year U.S. Treasury bond, new single-family home sales, housing starts, the trade balance, and consumer credit. The fed funds target rate and retail sales announcements, however, lose their significance because their price effects do not bear a consistent sign. Increases in the fed funds target rate, in particular, often had a strong effect on bond prices during the period, but the effects were at times positive and at times negative.[29]

In the case of trading activity, it is much less clear that taking account of the magnitude of the surprise helps explain the bond market's response to announcements. A comparison of Tables 6 and 7 shows that the absolute surprises add significance to the effects of the business inventories releases but reduce significance for the new single-family home sales releases. Unlike the effects on prices, the significance of fed funds target rate actions for trading activity remains the same. On the whole, these results suggest that larger announcement surprises do not systematically widen the divergence in traders' views or lead to greater portfolio rebalancing.

Table 7
IMPACT OF ANNOUNCEMENT SURPRISES

Announcement	Mean Absolute Surprise	Price Coefficient	Trading Activity Coefficient
Employment (nonfarm payrolls)	92,000 jobs	-23.10**	60.52**
Producer price index	0.23%	-8.59**	27.87**
Ten-year-note auction results	0.02%	-8.05**	34.21**
Thirty-year-bond auction results	0.03%	-7.71**	40.41**
Retail sales	0.46%	-6.51	39.03**
Consumer price index	0.10%	-6.48**	24.56**
New single-family home sales	63,000 homes[a]	-5.08**	23.97*
Federal funds target rate	0.13%	-4.61	60.80**
Consumer confidence	3.92	-4.42**	9.62
Five-year-note auction results	0.01%	-4.20**	-7.86*
NAPM survey	0.93%	-4.17**	35.83**
Industrial production	0.18%	-3.87**	17.81*
Housing starts	62,000 homes[a]	-3.42**	12.05
Gross domestic product	0.36%	-3.20	29.04**
Trade balance	$1.04 billion	-2.50**	4.94
Construction spending	0.94%	-1.79	-5.35
Consumer credit	$2.10 billion	-1.70**	2.24
Durable goods orders	1.03%	-1.41	-5.10
Two-year-note auction results	0.01%	-1.25	6.37
Leading indicators	0.09%	-0.46	2.28
Federal budget	$1.33 billion	-0.29	-1.86
Business inventories	0.22%	0.05	24.88**
Personal income	0.19%	0.19	-1.66
Three-year-note auction results	0.02%	1.06	27.40**
Factory inventories	0.14%	1.61*	27.55**
Memo:			
Adjusted R^2		0.27	0.37
χ^2 statistic[b]		996**	5,655**
Number of observations		5,319	5,382

Source: Authors' calculations, based on data from GovPX, Inc.

Notes: The table presents the regression coefficients indicating the impact of announcement surprises on price and trading activity for the five-year U.S. Treasury note. Announcement surprises are the actual numbers announced minus the forecast numbers divided by the mean absolute surprise for each announcement type. The impact on price is examined with signed surprises while surprise magnitudes are used for trading activity. Price is defined as the log price change times 10^4 for the five-minute period immediately after announcement; trading activity is defined as the number of transactions in the one-hour period after an announcement. Coefficient significance is based on two-sided t-tests using heteroskedasticity-consistent (White) standard errors. The period of analysis is August 23, 1993, to August 19, 1994.

[a]Figure reported is at an annual rate.

[b]The χ^2 statistic tests whether all model coefficients equal zero and is computed using the heteroskedasticity-consistent covariance matrix.

*Significant at the .05 level.

**Significant at the .01 level.

DO MARKET CONDITIONS MATTER?

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 five-year U.S. Treasury 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.[30] The period seems to have been a time of great uncertainty, with previous announcements giving mixed signals about the strength of the economy and bond market participants trying to guess whether the Federal Reserve was about to raise rates for the fifth time in six months. Hence, the issue we examine is whether market participants attach more significance to the same information during times of greater uncertainty.

To analyze the impact of market uncertainty, we run regressions that allow the surprise variables to interact with our uncertainty variables. As described earlier, our measures of uncertainty are the implied volatility from Treasury futures options and the expected change in the fed funds rate. We specify the announcement surprise coefficients to depend on uncertainty, $c_k^P = g_k^P + h_k^{Pi} V_n^i$ and $c_k^Q = g_k^Q + h_k^{Qi} V_n^i$, where V_n^i is one of our two measures of uncertainty and the coefficients h_k^{Pi} and h_k^{Qi} measure the influence of uncertainty on announcement effects. The regression equation for bond prices then becomes

$$Z_{nt}^P = a_0^P + \Sigma_{k=1}^K g_k^P \frac{S_{knt}}{\overline{S}_k} + \Sigma_{k=1}^K h_k^{Pi} V_n^i \frac{S_{knt}}{\overline{S}_k} + u_{nt}^P$$

and the equation for trading activity becomes

$$Z_{nt}^Q = a_0^Q + \Sigma_{t=1}^{T-1} a_t^Q D_t + \Sigma_{k=1}^K g_k^Q \frac{S_{knt}}{\overline{S}_k} + \Sigma_{k=1}^K h_k^{Qi} V_n^i \frac{|S_{knt}|}{\overline{S}_k} + u_{nt}^Q .$$

Table 8 presents the results of these regressions for the 8:30 a.m. announcements, identifying the announcement surprises for which h_k^{Pi} and h_k^{Qi} are significant. Because the two measures of uncertainty are highly correlated, we analyze them in separate regressions.[31]

Our results show that the price response to a given announcement surprise is frequently greater under conditions of increased uncertainty. Uncertainty in the form of implied volatility from Treasury futures options helps explain the bond market's price reaction to durable goods orders, GDP, and housing starts surprises, while uncertainty in the form of an expected fed funds rate

Table 8
IMPACT OF MARKET CONDITIONS ON ANNOUNCEMENT RESPONSES

Model	Dependent Variable	Interaction Terms	Interaction χ^2[a]	Significant Interaction Coefficients[b]	Model χ^2[c]	Model R^2	Number of Observations
1	Price	None	N.A.	N.A.	219**	0.42	250
2	Price	Implied volatility	45**	Durable goods orders**, gross domestic product*, housing starts**	1,050**	0.44	250
3	Price	Expected federal funds rate change	22*	Durable goods orders**, employment (nonfarm payrolls)*	248**	0.44	250
4	Trading activity	None	N.A.	N.A.	158**	0.29	250
5	Trading activity	Implied volatility	82**	Consumer price index**, producer price index**, trade balance**	671**	0.34	250
6	Trading activity	Expected federal funds rate change	60**	Consumer price index**, durable goods orders*, employment (nonfarm payrolls)*, personal income**, producer price index**	514**	0.32	250

Source: Authors' calculations, based on data from GovPX, Inc.

Notes: The table presents the results from regressions of price and trading activity on announcement surprises and two variables interacted with announcement surprises for the five-year U.S. Treasury note. All results are derived from analyses of the 8:30 a.m. monthly announcements. The price regressions are run with signed announcement surprises and with signed price changes for the 8:30 a.m.-8:35 a.m. interval. The trading activity regressions are run with absolute announcement surprises and with trading activity measured as the number of trades in the 8:30 a.m.-9:30 a.m. interval. Coefficient significance is based on two-sided t-tests using heteroskedasticity-consistent (White) standard errors. The period of analysis is August 23, 1993, to August 19, 1994.

[a]This χ^2 statistic tests whether all interaction terms equal zero and is computed using the heteroskedasticity-consistent covariance matrix. The statistic is calculated excluding any significant interaction terms that have a sign opposite to that predicted.

[b]The list of coefficients excludes significant interaction terms that have a sign opposite to that predicted.

[c]This χ^2 statistic tests whether all model coefficients equal zero and is computed using the heteroskedasticity-consistent covariance matrix.

*Significant at the .05 level.

**Significant at the .01 level.

change helps explain the reaction to durable goods orders and employment surprises.

For trading activity, market uncertainty often heightens the trading surge that follows announcement surprises. Uncertainty as measured by implied volatility helps explain the rise in trading activity in the wake of CPI, PPI, and trade balance surprises, while uncertainty as measured by the expected fed funds rate change helps explain the increase in activity after CPI, durable goods orders, employment, personal income, and PPI surprises. These results suggest that uncertain market conditions contribute to the divergence in traders' interpretations of announcement surprises.

CONCLUSION

Our finding that the largest price shocks and the greatest surges in trading activity in the bond market stem from the arrival of public information is reassuring. Over the August 23, 1993, to August 19, 1994, sample period, each of the twenty-five sharpest price changes and each of the twenty-five greatest surges in trading activity can be associated with a just-released announcement. These results suggest that U.S. Treasury securities prices react largely to the arrival of public information about the economy. The surge in trading activity following the price shocks suggests a lack of consensus among market participants over whether the initial price change is precisely the appropriate adjustment to the new information, although portfolio rebalancing may also be important.

It is also reassuring to find that various measures of the information content of the different announcements generally help explain such market responses. In particular, the market distinguishes among announcements with inherently different information, reacting most dramatically—through both price movements and trading activity—to the employment, PPI, fed funds target rate, and CPI announcements. U.S. Treasury security auction results are also found to have significant effects on both price and trading activity.

Moreover, we find that the bond market's reactions depend on the unexpected component of a given announcement and on conditions of uncertainty. Taking account of the surprise component in a report's announced numbers extends our list of announcements that significantly affect bond prices from nine to thirteen, longer than any such list in previous studies. Greater market uncertainty also leads to a stronger market response, particularly in the form of increased trading activity. These results suggest that the bond market's price and trading reactions reflect differences of informational content in and among the varying announcements under changing market conditions.

ENDNOTES

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1. See Beaver (1968).

2. However, in an analysis similar to the Cutler, Poterba, and Summers (1989) study of the U.S. stock market, Elmendorf, Hirshfeld, and Weil (1996) find it difficult to relate the largest movements in U.K. bond prices from 1900 to 1920 to news arrival.

3. Roley and Troll (1983), for example, find no significant announcement effects from the CPI, the unemployment rate, and the PPI; 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 the CPI, industrial production, the unemployment rate, or merchandise trade.

4. Kim and Verrechia (1991) and He and Wang (1995) show theoretically how heterogeneity of views among investors can generate speculative trading activity.

5. French and Roll (1986), for example, attribute the fact that stock return volatilities are higher when the exchanges are open than when they are closed to the effect of private information conveyed through trading.

6. This is the argument used by Fleming and Remolona (1997) to explain the persistence of trading volume beyond price volatility in the Treasury market after an announcement. That study, as well as earlier stock market studies by Jain and Joh (1988) and Gallant, Rossi, and Tauchen (1992), suggests that price volatility causes trading activity.

7. Fleming (1997) finds that 64 percent of interdealer trading is in on-the-run issues, 24 percent is in off-the-run issues, and 12 percent is in when-issued securities. Off-the-run securities are issued securities that are no longer active; when-issued securities are securities that have been announced for auction but not yet issued.

8. Appendix B of Fleming and Remolona (1997) details the data cleaning and processing.

9. We count the announcement of gross domestic product (GDP) as a monthly release. Although GDP is a quarterly measure, the Bureau of Economic Analysis issues advance, preliminary, and final estimates in successive months.

10. Included in the 8:30 a.m. count is the personal income announcement, which was released at 10 a.m. for the first three announcements in our sample but at 8:30 a.m. thereafter.

11. The employment report was released on the second Friday in October 1993 and in July 1994.

12. Five announcements occurred after the regularly scheduled February, March, May, July, and August 1994 FOMC meetings. The other announcement occurred in April 1994, when the fed funds target rate was increased without an FOMC meeting. Cook and Hahn (1989), Pakko and Wheelock (1996), and Roley and Sellon (1996) use daily data to examine the impact of fed funds target rate changes.

13. Ideally, we would like to use forecasts that are based on expectations right before each announcement since expectations can change over the course of a week. Our use of weekly forecasts may bias the coefficients of our estimates toward zero in those regressions that depend on announcement surprises.

14. Krueger and Kuttner (1996) show that the fed funds futures rate is effective at identifying changes in the fed funds rate. Our methodology follows that of Pakko and Wheelock (1996), using effective fed funds rate data from the Federal Reserve Bank of New York and fed funds futures data from the Chicago Board of Trade.

15. The three-, ten-, and thirty-year securities are issued at price-discriminating auctions, so for these securities the yield corresponding to the lowest accepted price is used. The two- and five-year securities are issued at uniform-price auctions.

16. Andersen and Bollerslev (forthcoming) perform a similar exercise with Deutsche mark–dollar exchange rates and find that fifteen of the twenty-five largest five-minute absolute returns from October 1992 to September 1993 are directly associated with the release of economic news.

17. Note that there are seventy-seven 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.

18. 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."

19. Fleming and Remolona (1997) analyze the adjustment patterns of trading volume after major announcements. They find an appreciable lag in the surge in trading volume after the initial price shock and a persistence of high volume for a few hours afterward.

20. We use the number of transactions as our measure of trading activity instead of the face value of securities traded. We base this decision on Jones, Kaul, and Lipson's (1994) finding that transaction size has no information content beyond that contained in the frequency of trades.

21. On the days with 8:30 a.m. announcements, the price change in the first five minutes after the announcement explains 31 percent of the whole day's (7:30 a.m. to 5 p.m.) price change.

22. We could also use transaction prices, but using the bid-ask midpoints allows us to avoid complications associated with the "bid-ask bounce," in addition to providing us with more observations.

23. 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 p.m. release time implies an analysis based on the 1:35 p.m.-1:40 p.m. interval for price and the 1:35 p.m.-2:35 p.m. interval for trading activity, while a 1:33 p.m. release time implies an analysis based on the 1:30 p.m.-1:35 p.m. interval for price and the 1:30 p.m.-2:30 p.m. interval for trading activity.

24. As noted earlier, the releases consist of advance, preliminary, and final estimates of quarterly GDP announced in successive months. An advance estimate accounted for one of the two largest price shocks associated with GDP releases; a preliminary estimate accounted for the other.

25. As Krueger (1996) notes, the BLS now collects the nonfarm payroll employment data from a sample of more than 200,000 establishments that offers wide geographic and industry coverage. We document the employment report's importance for the bond market; Harris and Zabka (1995) and Andersen and Bollerslev (forthcoming) show its importance for the foreign exchange market.

26. The decreased significance of durable goods orders may reflect their declining reliability as an indicator of future manufacturing activity. Because an increasing share of durable goods are now shipped almost immediately, much of the lag time that existed between order receipt and shipment has been eliminated. In the past, that lag time enabled analysts to use durable goods orders to predict future manufacturing activity. Now, however, the reduction of that lag time has made such projections difficult. Compounding the problem, orders have increased for goods whose prices are changing rapidly, particularly computers; this price volatility has made it harder for the durable goods report to assess the quantity of goods ordered, since the report measures orders only in dollar terms.

27. We do not address issues of rationality or market efficiency in this article—that is, we do not test whether market prices properly reflect all available information, nor whether they adjust to such information in an appropriately rapid fashion.

28. Absolute surprises are used for the trading activity regression (and not the price regression) because we are testing whether the magnitudes of announcement surprises are correlated with changes in trading activity. For example, we suspect that nonfarm payroll surprises of 100,000 jobs and -100,000 jobs would have contrary effects on price, but that both would be associated with an increase in trading activity relative to smaller magnitude surprises.

29. Pakko and Wheelock (1996) discuss why the effects change in sign.

30. The average absolute nonfarm payroll employment surprise in the sample was 92,000 jobs (Table 7) and was as large as 206,000 on April 1, 1994. Other components of the employment report do not seem to explain the market's sharp August 5 response—the announced unemployment rate of 6.1 percent was expected, manufacturing overtime hours were unchanged at 4.6, average manufacturing hours actually declined to 41.9 from 42.0 the previous month, and the previous month's nonfarm payroll employment was revised down from 379,000 to 356,000. Nonfarm payroll employment was not the only sign of strength, however; average hourly earnings increased by 4¢ to $11.12.

31. The correlation between our implied volatility measure and the expected fed funds rate change is 0.73.

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