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Public Information Arrival

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ABSTRACT

We develop a measure of public information flow to financial markets and use it to document the patterns of information arrival, with an emphasis on the intraday flows. The measure is the number of news releases by Reuter's News Service per unit of time. We find that public information arrival is nonconstant, displaying seasonalities and distinct intraday patterns. Next we relate our measure of public information to aggregate measures of intraday market activity. Our results suggest a positive, moderate relationship between public information and trading volume, but an insignificant relationship with price volatility.

THE LINK BETWEEN INFORMATION and changes in asset prices is central to financial economics. A fundamental tenet of market efficiency is that investors react to new information as it arrives, resulting in price changes that reflect investors' expectations of risk and return. Recent studies in market microstructure explore how price-volume relations are formed in financial markets, with an emphasis on intraday trading.

A distinction is often made in the literature between public and private information (French and Roll (1986)). Whereas *public information* is available to the whole market and hence does not require trading to impact prices, *private information* is available to a narrow segment of the market and affects prices only through trading. Recent contributions (e.g., Admati and Pfleiderer (1988)) argue that private information plays a dominant role in explaining the time patterns of trading volume and return volatility in securities markets. Public information is relegated to a lesser role, that of an unspecified, exogenous factor. Our purpose is to investigate the rate of public information flow to see whether identifiable patterns exist that shed light on market volume and volatility relationships.

We begin by describing the timing and pattern of public information arrival to financial markets. Our database consists of news stories sent via the North American wire by Reuter's News Service in a recent test year, May 1990 through April 1991. We define the rate of public information flow as the number of stories carried over the news wire per unit of time and document the rate of public information flow over various time segments, such as when

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the market is open versus when it is closed. Next, we test the relationship between our measure of public information and measures of aggregate market activity, specifically trading volume and volatility. Overall, our intraday results suggest a positive, moderate relationship between public information and trading volume, but an insignificant relationship with price volatility.

We structure the article according to the customary template. In Section I, we provide a background perspective, focusing on key aspects of the literature and indicating the context of the study. We describe our data in Section II and discuss the seasonal and intradaily patterns contained therein. In Section III, we analyze the relationship between the measure of public information and measures of intraday market activity. We summarize the results and offer our conclusions in Section IV.

I. Background

Public information is the principal focus in Thompson, Olsen, and Dietrich (1987), which studies an extensive database of announcements related to firms listed on the New York Stock Exchange (NYSE) and American Stock Exchange (AMEX) as identified in the *Wall Street Journal Index* for 1983. With this firm-specific sample, they find that larger firms and certain industries (e.g., motor vehicles and communications) receive greater coverage, and that the number of announcements varies across days of the week (Mondays have the fewest) and months of the year (December has the fewest). The types of news items (e.g., earnings and dividend announcements versus management-related news) are also documented by day of the week and month of the year. Further, earnings and dividend stories are found to dominate the number of news items and to exhibit cyclical patterns related to quarterly reports. This study of corporate news events offers an instructive overview of interday public information and its relevance for capital market analysis.

In a related study, Mitchell and Mulherin (1992) analyze the effect of public information on market activity. For information proxies, they use the number of stories per day reported by Dow Jones on the *Broadtape* and in the *Wall Street Journal* and a measure of the 'magnitude of news' based on the number of category codes Dow Jones assigns each story. Their study does not isolate weekend information nor intraday (trading versus nontrading) information periods. They find seasonalities in the information flow by month, by day-of-the-week, and for holidays. They also document a positive, statistically significant relationship between public information and trading volume, but find only a weak relation with stock returns.[1]

[1] Another article that examines public information, by Atkins and Basu (1992), reports on news stories on the *Broadtape* related to 400 randomly selected firms on the NYSE during 1984. With this firm-specific sample, they examine the time pattern of public announcements, focusing on time periods after the market closes. They conclude that, for firms making announcements after the close, trading in their shares exhibits excess volume before the close as well as on the following opening.

The issue of information driving market relationships is as old as economics. Recently, the role of private information has received greater attention. One thrust of current research attempts to explain the higher return volatility during trading hours than during nontrading hours that is documented in several studies (Oldfield and Rogalski (1980), Christie (1982), and French and Roll (1986)). French and Roll (1986) estimate the return variance per hour during trading periods to be 13 times that for midweek holidays, and over 70 times the per-hour variance during weekends. French and Roll (1986) offer three explanations for higher trading hour volatility: first, public information is greater during trading hours; second, private information is generated during trading by informed investors; and third, pricing errors during trading hours increase volatility. They find that pricing errors do exist (from 4 to 12 percent of the daily variance), but that they have a relatively small impact; hence, variability in information flow is the major determinant of volatility. For the special case when the exchanges were closed on Wednesdays during the second half of 1968 for a paperwork backlog, they show that return variances are small on a per-hour basis. Because these are normal business days where the flow of public information would presumably be the same, they conclude that private information is the dominant factor.[2]

An interesting aspect of French and Roll's (1986) analysis is that most return volatility comes within the trading day. However, Harris (1986) studies intraday patterns using transaction data and shows that the major part of stock price moves occurs in the first 45 minutes of trading each day. He reasons that French and Roll's (1986) finding of much higher variances during trading periods may be due to the large move in prices during the first 45 minutes of the trading day. If the large price moves at the beginning of the trading day are in fact due to information arriving while the market is closed, then excluding this time segment from the calculation of the trading-period variances and including it in the nontrading-period variances may be appropriate. This adjustment presumably would reduce the trading-period variances and increase the nontrading-period variances, diminishing support for French and Roll's (1986) private information hypothesis. In any event, Harris' (1986) observation suggests that an intraday examination of price volatility and public information would offer further insight into the public information versus private information debate.

Our study aims to extend the literature on public information in several directions. The measure of public information used is a broad-based, compre-

[2] Stoll and Whaley (1990) also conclude that private information is the dominant factor and argue that structurally induced volatility is an important factor. This explanation agrees with that offered earlier by Amihud and Mendelson (1987) but conflicts with their more recent study based on Tokyo Stock Exchange data (Amihud and Mendelson (1991)). Gerety and Mulherin (1991) extend these results by analyzing the return variances hour-by-hour throughout the trading day over a 40-year period and conclude that trading per se facilitates the formation of prices. Also, Gerety and Mulherin (1992) provide empirical support for the importance of the daily market halt (i.e., the overnight closing) in explaining the trading volume patterns, and thus support the models developed by Admati and Pfleiderer (1988) and Brock and Kleidon (1992).

hensive measure, not restricted to firm-specific events. It includes not only firm-specific and industry information, but also macroeconomic, political, and international stories relevant to U.S. financial markets. Further, we emphasize the *intraday* arrival of public information and draw special attention to intraday patterns and their relation to measures of aggregate market activity, such as trading volume and price volatility. We examine the public information/market activity relation throughout the trading day, by one-half-hour time segments, to determine whether intraday patterns are evident. Our research thus seeks to improve our understanding of public information flow and its relationship to intraday market activity.

II. Data Description

Rather than isolate specific news events, we attempt to look at the overall flow of public information. To do so, we construct a proxy to represent the "news" or information that market participants rely on in forming their expectations of risk and return in securities markets. Our data source consists of all news releases sent by Reuter's News Service over their *North American Securities News* wire during a one-year time period, from May 1990 to April 1991.[3] The database contains all information events, not only firm-specific information, over the full 24-hour day.

Reuter's News is selected as our data source for public information flow because it provides market participants with a timely source of information on news stories that impact financial markets. The focus of the stories on Reuter's *North American Securities News* is the U.S. market. The key question in deciding whether a story, domestic or international, will be carried over this wire is whether the story will be of interest to U.S. customers. Market participants use this news service on a regular basis, along with Dow Jones News Service and perhaps a few other news wires, as a prime news source for economic decision making. An important news bulletin, such as a U.S. Government report, would be received around the world in a matter of seconds.[4]

We collect the date and time of each news story, with each news story counting as one observation. This results in over 120,000 observations. After converting them to eastern standard time (EST), we combine the observations into one-half-hour time segments. Our data set thus consists of the tabulated number of observations in each of the 48 one-half-hour periods for each day during the sample year. We then categorize the obervations into various convenient, although admittedly arbitrary, time intervals. These

[3] These data were provided by the Chicago office of Reuter's. We acknowledge Ted d'Afflisio, Maribeth Quinn, and John Marino for assistance in obtaining and interpreting the sample data. The views expressed herein are those of the authors and may not reflect those of Reuter's Information Service.

[4] See Thompson, Olsen, and Dietrich (1987) and Patell and Wolfson (1982) for a discussion on the news release process and disclosure requirements.

categories are selected to provide an overview of the information flow, to highlight interesting patterns, and to correspond to previous studies.

Table I displays data organized by day of the week, for both trading and nontrading days. The term "trading days" is used to refer to nonholiday business days, i.e., days when the NYSE is open. Trading hours refers to the hours of the NYSE (9:30 A.M. to 4:00 P.M. EST), with adjustments made for partial days, e.g., the NYSE closed at 2:00 P.M. on December 24, 1990. It is apparent from Table I that weekends as well as market holidays are remarkably light information days, and that Mondays and Fridays are light relative to the other trading days, especially to Tuesday and Thursday. Thus, public information arrival exhibits an inverted U-shaped pattern across trading days. A Kruskal-Wallis test under the hypothesis that all trading days have identical population distributions is rejected at the 1 percent confidence level.[5]

Figure 1 graphically presents public information arrival over the course of the trading day, with the data segmented in one-half-hour increments. Inter-

Table I

Average Information Flow by Day of the Week

The average number of observations reported by Reuter's News Service is presented by day of the week. The observations are reported for total days (trading plus nontrading hours) and for trading hours only, i.e., 9:30 A.M. to 4:00 P.M. eastern standard time. A Kruskal-Wallis test that all trading days have identical distributions is rejected at the 1 percent confidence level.

	Total Day			Trading Hours			Trading Hours as a Percentage of Total
Days of the Week	Mean	Std. Dev.	Mean Per Hour	Mean	Std. Dev.	Mean Per Hour	
Monday	437.53	94.99	18.23	252.57	55.70	38.86	57.7
Tuesday	497.14	92.33	20.71	271.44	55.44	41.76	54.6
Wednesday	477.20	98.67	19.88	258.04	57.96	39.70	54.1
Thursday	496.90	84.65	20.70	264.39	54.41	40.67	53.2
Friday	418.92	94.38	17.45	225.07	53.88	34.63	53.7
Saturday & Sunday	23.70	11.49	0.99				
Market Holidays*	48.51	45.02	2.02				

* There were eight market holidays: Memorial Day (Monday 5/28/90), Independence Day (Wednesday 7/4/90), Labor Day (Monday 9/3/90), Thanksgiving Day (Thursday 11/22/90), Christmas Day (Tues. 12/25/90), New Years Day (Tuesday 1/1/91), Presidents' Day (Monday 2/18/91), and Good Friday (Friday 3/29/91).

[5] Although they use a different data source (the *Wall Street Journal* and the *Broadtape*), Mitchell and Mulherin (1992) report similar daily patterns with comparable daily averages over an extended period, 1983 to 1990. In addition, our monthly observation totals correspond with the seasonalities documented in Mitchell and Mulherin (1992) and in Thompson, Olsen, and Dietrich (1987), with November and December as the lightest months and May and July as the heaviest months. January, April, July, and October are relatively high information months owing to the release of corporate quarterly reports. We find that May, November, December, and March are significantly different from the mean at the 1 percent confidence level, and July and August are significantly different at the 5 percent level.

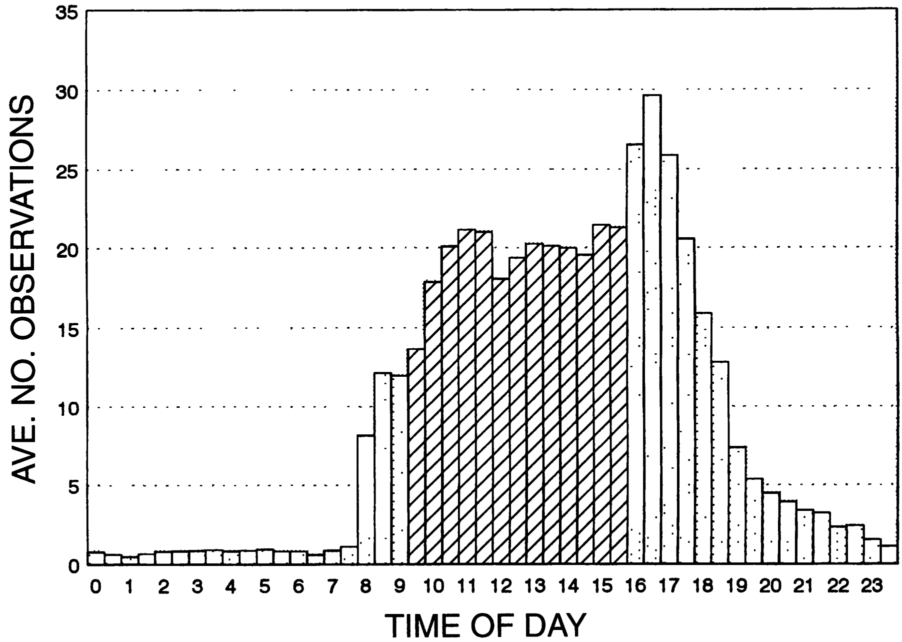

Figure 1. Average number of information observations by time of day. The average number of observations for all trading days is given by time of day in one-half-hour segments, for time intervals 0 through 23.5. Time interval 0 represents the 00:00 to 00:29 time period and interval 23.0 represents 23:00 to 23:29. Trading hours periods are cross-hatched.

esting and consistent intraday patterns are apparent. The information flow shows a substantial increase beginning at about 8:00 A.M., and continues to build until noon, when a lull occurs.[6] The flow then rises again and peaks between 4:30 and 5:00 P.M., after the market has closed. Despite the high concentration of information in the two hours (4:00 to 6:00 P.M.) directly following the market close and the greater number of hours in the nontrading period, the *total* information flow during market hours is still greater than during nontrading hours.

III. Relation to Market Activity

We now relate our measure of public information flow to measures of aggregate market activity, specifically trading volume and return volatility.[7] Intraday volume and return volatility based on one-half hour segments over

[6] We perform a nonparametric (sign) test to ascertain whether the noon hour (12:00 to 1:00 P.M.) contains fewer observations than the adjacent hours for each trading day. The results (significant at the 1 percent level) confirm the daily "lull" in information at the noon hour.

[7] Throughout the article, market returns are calculated as the log of price relatives for the S&P 500 index, and trading volume is the number of shares traded on the NYSE over each one-half-hour segment.

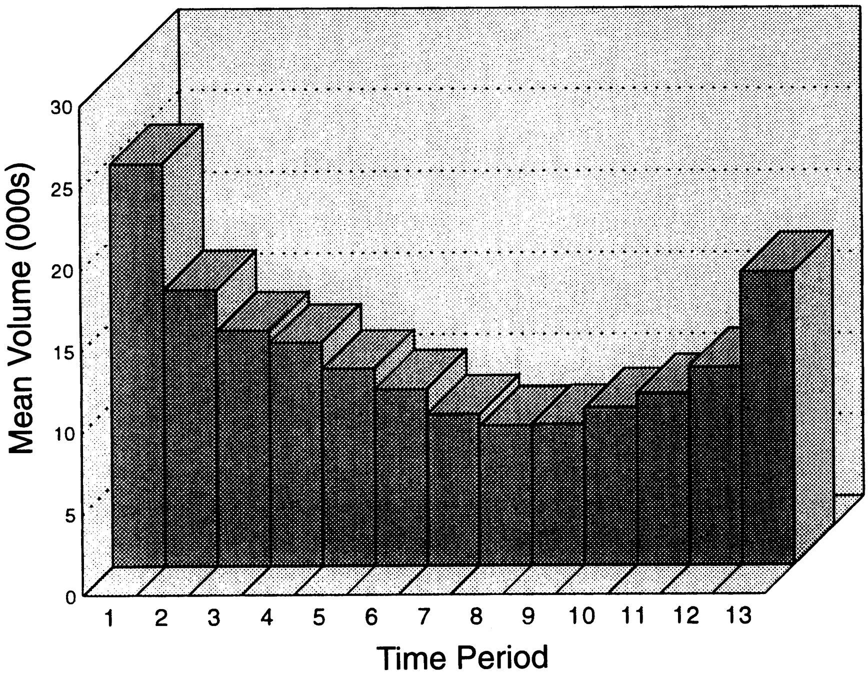

Figure 2. Average trading volume on NYSE over the 13 one-half-hour periods of the trading day. The average trading volume in shares on the NYSE is presented by one-half-hour segments over the trading days in the test year, May 1990 through April 1991. There are 13 one-half-hour segments over the normal trading day, i.e., 9:30 A.M. to 4:00 P.M. eastern standard time.

the trading day are presented graphically in Figures 2 and 3. The U-shaped patterns observed here have been previously documented both for trading volume (Jain and Joh (1988) and Foster and Viswanathan (1993)) and for return data (Harris (1986) and Wood, McInish, and Ord (1985)).

A. Trading versus Nontrading Periods

First, we provide greater detail on the trading versus nontrading periods in Table II. We present mean returns and return volatility along with the mean number of information events over these periods. Similar to the results of French and Roll (1986), we find that the volatility of returns is considerably greater during trading periods than during nontrading periods. However, we also observe from Table II that the information flow per hour is substantially greater during trading hours than during nontrading hours, with trading hours having a rate of flow over 10 times that of the weekend and holiday rates. Moreover, the pattern of volatility, as measured by the standard deviation of returns per hour, across the various periods conforms to the pattern of information flow per hour. The only exception is that our two holiday periods (both with $N = 4$) are reversed in the rankings but are of

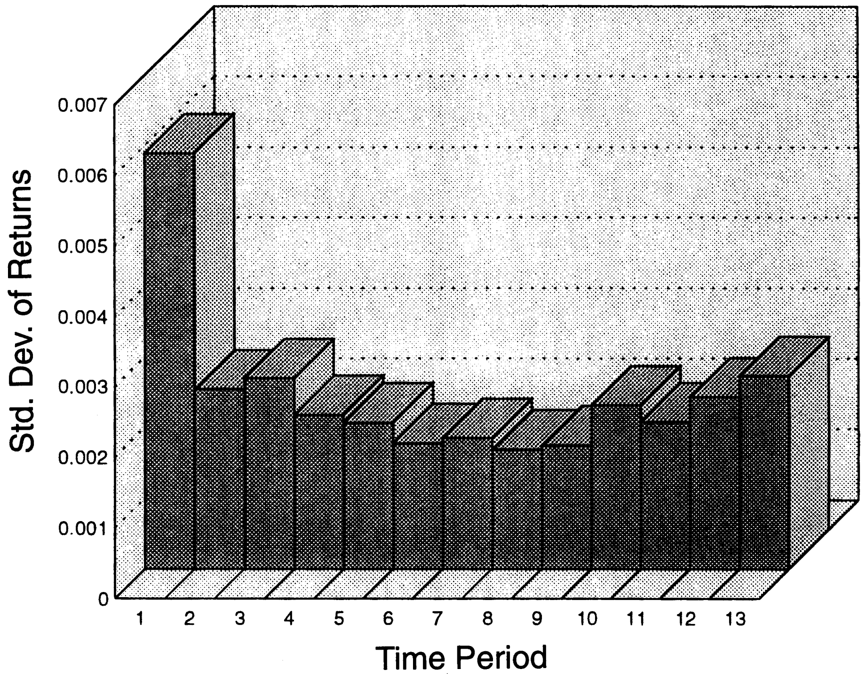

Figure 3. Standard deviation of returns for the 13 one-half-hour periods of the trading day. Returns are measured as the log of the price relatives of the S&P 500 for our sample period, May 1990 through April 1991. The standard deviation of returns is calculated for the 13 one-half-hour segments over the normal trading day.

approximately the same size. This striking result also holds generally for *total* information flow and standard deviations over these same periods.[8]

We can also observe this general pattern by examining days that are "holidays" for a significant portion of the business community, but on which

[8] Herein we recompute the number of news stories and volatilities contained in Table II following Harris' (1986) suggestion. Harris states, "if the large price changes seen in the first 45 minutes are in response to information that arrives while the market was closed, then perhaps these prices should be included in the computation of the non-trading variances and excluded from the computation of the trading variances" (p. 112). Accordingly, we include the first one-half hour of the trading day in the close-to-open calculation and exclude it from the open-to-close. The "adjusted" results for the mean information per hour and the standard deviation of returns per hour, respectively, are given below for the relevant periods:

	Mean Per Hour	Std. Dev. Per Hour
Trading hours (10:00 A.M. to close)	40.65	3.70
Overnight (close to 10:00 A.M.)	13.16	1.57
Weekends (Fri. close to Mon. 10:00 A.M.)	3.59	0.93

As Harris predicted, we observe an even closer correspondence between the number of information events and the volatility of returns.

Table II

Number of News Stories and Measures of Return for Trading Periods versus Nontrading Periods

The average number of information observations and measures of aggregate returns S&P 500 index are given for trading hours, weekends, midweek holidays, holiday weekends, and nontrading periods. The mean represents the average value for all such periods during the year. The time periods are designated as follows: Trading Hours is based on the information events for open-to-close for all trading days; Weekends is based on events within Friday close to Monday open for nonholiday weekends; Midweek Holidays is based on close-to-open, e.g., if Wednesday is a market holiday, then it is based on Tuesday close to Thursday open; Holiday Weekends is based on the close-to-open for weekends where either Friday or Monday is a holiday; and Overnight is based on close-to-open for Monday through Thursday trading days. All returns values are multiplied by 10^{-3}.

	Trading Hours	Overnight	Weekends	Holiday Weekends	Midweek Holidays
Information					
Mean	254.30	223.02	237.08	293.00	104.75
Mean per hour	39.12	12.74	3.62	3.27	2.52
Returns					
Mean	0.649	−0.01	−0.21	−0.89	−0.68
Std. dev.	10.493	2.137	0.882	0.659	0.549
Std. dev. per hour	4.116	0.511	0.109	0.070	0.085

the NYSE and other financial markets remain open. In Table III we present the mean of information events and return volatility for nonmarket holidays (e.g., Columbus Day) and days near holidays (e.g., the day after July 4th). Figure 4 gives the average number of observations per hour for trading hours versus nontrading hours for these days and compares the results to normal trading days. Although the market was open, the flow of information is especially light on these days. For example, the average number of observations during trading hours on days adjacent to market holidays is only 60 percent of the average number for "normal" trading days. The observations for nonmarket holidays is also substantially lower (20 percent less) than the average for normal trading days. For both cases, the difference relative to a normal trading day is statistically significant at the 1 percent confidence level. In Table III, we also show that the average trading volume and volatility of returns for these days is correspondingly lower than for the average trading day. Thus on certain trading days the flow of public information to the market drops predictably, which corresponds to a drop in trading volume and return volatility.

B. Intraday Information and Market Activity

These first-stage results on trading versus nontrading periods suggest that an examination of public information and market activities on an *intraday* basis is warranted. Accordingly, we turn our attention to the intraday rela-

Table III

Results from Nonmarket Holidays and Near-Holidays

The mean information events, return volatility, and trading volume are presented for nonmarket holidays and near-holidays. The return volatility is given by the standard deviation of the S&P 500 index, and trading volume is based on New York Stock Exchange (NYSE) data. Nonmarket holidays include Columbus Day, Rosh Hashanah, Hanukkah, and Martin Luther King Jr.'s Birthday (other potential nonmarket holidays such as Veterans Day and Yom Kippur fell on weekends). The days adjacent in time to market holidays (near-holidays) include the day after Independence Day (7/5/90), Labor Day (9/4/90), Thanksgiving Day (11/23/90), Christmas Day (12/26/90), and New Years Day (1/2/91) as well as New Years Eve day (12/31/90) and Christmas Eve (12/24/90).

	No. of Days	Average Information Observations During Trading Hours	Average Information Observations For the Total Day	Average Trading Volume	Std. Dev. of Returns
a) Nonmarket holidays	4	207.50*	389.75*	140,782.50*	0.010045
b) Days adjacent to market holidays	7	154.43*	258.28*	94,421.40*	0.00606
c) Combined (a + b)	11	173.70*	306.10*	111,280.00*	0.007813
d) All trading days	253	254.30	465.54	168,440.50	0.010493

* Significantly different from average normal trading days at the 5 percent confidence level.

tions between public information and measures of aggregate market activity, as given by regression analysis.

First, we examine the link between public information and a measure of aggregate price volatiltiy. We measure price volatility as the absolute value of the log of price relatives of the S&P 500 index. For each one-half-hour segment during the trading day, we regress the number of information events on the measure of price volatility. For example, the information events within the 9:30 to 10:00 A.M. period are regressed on the absolute value of returns for this time period across all days in the sample year. For the resulting thirteen regressions (one for each one-half-hour segment), none of the coefficients on the information variable is significant at the 5 percent confidence level.

To account for the possibility of lags in the effect of information events, and because of the arbitrary nature of the time intervals chosen to aggregate information and to calculate returns (i.e., one-half-hour segments), we explore alternative lag structures for the information variable. With a one-period lag structure, for example, we regress the absolute value of the return over a particular one-half-hour period with the cumulative information events occurring in that one-half-hour period plus the preceding one-half hour. We systematically expand the length of lag, one-half hour at a time, until we reach a full one-day lag structure. A one-day lag is defined to be the cumulative information events that fall within the time interval between the one-half-hour period under consideration and the previous close. The results for the regressions with the information variable systematically lagged in this manner indicate that public information is not statistically related to

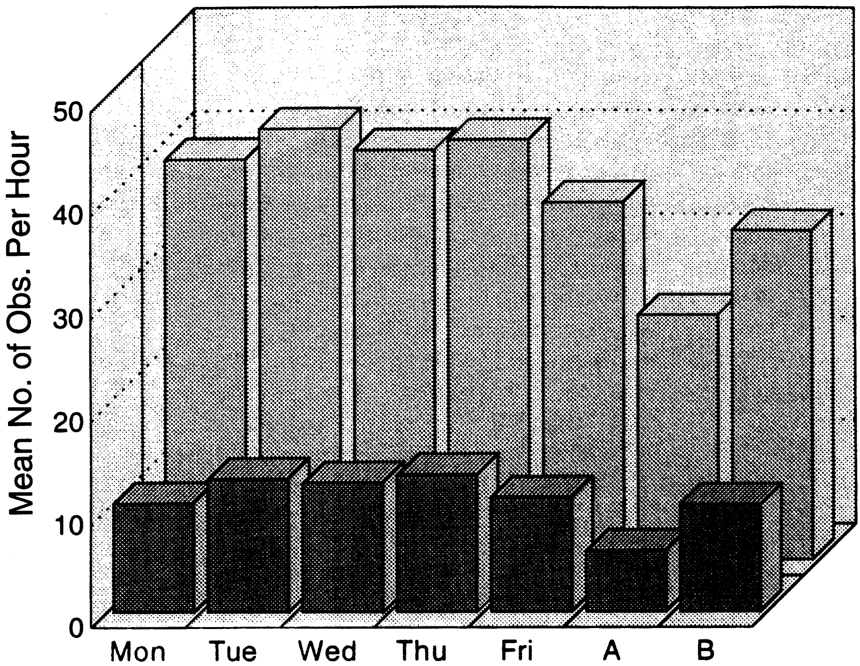

Figure 4. Average number of information events per hour for days of the week, nonmarket holidays, and days near holidays. The average number of observations per hour is presented for normal trading days, nonmarket holidays, and days near market holidays. The *bars* "A" and "B" designate the average number of observations for days adjacent to market holidays (e.g., the day after Thanksgiving) and nonmarket holidays (e.g., Columbus Day), respectively. The *bars* in the foreground (the *darkly-shaded bars*) give the average number of events per hour for nontrading hours only, and the bars in the background (the *lightly-shaded bars*) give the per-hour means for trading hours. For comparison, the average number of hourly events for Saturday and Sunday is 0.99 and for market holidays is 2.02.

price volatility on an intraday basis, as virtually all of the coefficients on the information variable are insignificant (at the 5 percent confidence level) over all lag structures.[9, 10]

Although our measure of public information does not appear to be significantly related to aggregate intraday market returns as measured here, we do not necessarily infer from this that public information is not a significant

[9] An interesting exception is the regression of information events from the previous close through the first half hour after the open with the absolute value of the returns during the first half hour. This regression results in a coefficient on the information variable of 1.21×10^{-5} with a t-value of 2.136 (significant at 5 percent), but an R-squared value of only 0.018. However, it is difficult to ascertain whether this result is an economically significant aspect of the opening or a spurious statistical result.

[10] We also examine the possibility of price reactions to forward-lagged information effects by regressing current-period price volatility with current and future information events. Using a systematic process in the same manner as the lags on past information, we again find no significant relationship between current aggregate price volatility and future public information.

variable, in part because we do not attempt to isolate "systematic" market-wide news events from firm-specific events.[11] Mitchell and Mulherin (1992) note that most public information is firm specific in nature and that its effect on market activity is moderated to some extent across firms, i.e., much of the movement in prices is "washed out" in the process of measuring aggregate market returns. Accordingly, they construct a measure of firm-specific returns based on the sum of the absolute value of the returns of individual firms. Their measures of public information are significantly related to this summed firm-specific return variable, with correlation coefficients about twice as large as those using overall market return measures.

To test whether this diversification effect may be obscuring significant relationships between the movement in prices and information events on an intraday basis, we develop an intraday measure of firm-specific returns, similar to that of Mitchell and Mulherin (1992). Using transaction data from the TORQ data base, we calculate the absolute value of the log-relative returns, for each of the 144 firms available, over each one-half-hour period during the sample data period, November 1, 1990 through January 31, 1991.[12] We then calculate the mean of the absolute value of the firm returns. Regressions with information events and the mean firm-specific return variable, similar to those using S&P 500 market returns, show no significant coefficients for any of the thirteen one-half-hour periods. The R-squares, while still low (approximately 0.02), are from four to five times higher than those in the regressions using returns based on the S&P 500 market index. Testing for lag structures in the information variable further suggests that there is no significant *intraday* relation between public information and price volatility.

C. Intraday Information and Trading Volume

Another important measure of market activity is trading volume. We measure trading volume as the number of shares traded on the NYSE over a given time period. In Table IV, we report regressions of both information and the absolute value of returns on trading volume over all days for each one-half hour daily segment. The results show that the coefficient for the information variable is significant (at the 5 percent level) for five of the thirteen one-half-hour segments. The coefficient for the absolute value of returns is significant in every period, which is consistent with previous studies.[13] These results lend some support to the notion that when informa-

[11] Other studies of information and aggregate market activity also find it difficult to establish this linkage (see, for example, Schwert (1989), Cutler, Poterba, and Summers (1989), and Roll (1988), among others). One recent exception, by McQueen and Roley (1993), finds a much stronger relationship between macroeconomic news and stock prices by allowing the relation to vary over the different stages of the business cycle.

[12] The TORQ database, available from the NYSE, contains transaction data on 144 firms, which were randomly selected from NYSE listed companies. Details on the selection procedures, data organization, and usage of the database are contained in Hasbrouck (1992).

[13] See Karpoff (1987) for a review of this evidence.

Table IV

Intraday Results of Aggregate Trading Volume Regressions

The dependent variable in the regressions is the trading volume on the New York Stock Exchange (NYSE) during the time periods within the trading day. The independent variables are 1) the information observations over the time period and 2) the absolute value of S&P 500 returns over the time period. β_1 signifies the regression coefficient on the information variable; β_2 gives the coefficient for the return variable. Results are reported for each of the 13 one-half-hour segments in the trading day (from 9:30 A.M. to 4:00 P.M. EST). All regressions are adjusted using the Cochrane-Orcutt procedure to correct for serial correlation.

Time Period	α	β_1	β_2	R^2
1	19,764.96	181.46	616,662.09	0.101
	(5.92)*	(1.97)**	(4.91)*	
2	13,598.17	83.07	963,662.52	0.125
	(12.67)*	(1.96)**	(5.67)*	
3	11,986.18	−17.50	1,427,802.70	0.390
	(14.34)*	(−0.63)	(12.45)*	
4	10,408.99	61.11	1,210,198.75	0.234
	(14.20)*	(2.35)**	(8.29)*	
5	10,093.07	23.51	997,768.02	0.256
	(14.66)*	(0.95)	(9.10)*	
6	8,907.16	17.62	1,197,937.10	0.221
	(14.27)*	(0.68)	(8.29)*	
7	6,953.80	38.89	1,122,698.40	0.304
	(13.74)*	(2.16)**	(10.25)*	
8	6,763.96	27.93	990,158.95	0.271
	(13.05)*	(1.51)	(9.31)*	
9	6,632.82	38.11	959,668.36	0.237
	(13.48)*	(2.32)**	(8.56)*	
10	7,827.81	14.39	1,021,068.31	0.427
	(17.06)*	(0.92)	(13.45)*	
11	10,183.26	−40.75	727,230.17	0.152
	(17.67)*	(−1.90)	(6.36)*	
12	9,965.06	14.27	1,008,333.60	0.306
	(16.04)*	(0.69)	(10.31)*	
13	15,981.40	−10.23	1,092,644.70	0.087
	(12.41)*	(−0.21)	(4.81)*	

t-values are given in parentheses.
** Significant at the 5 percent confidence level.
* Significant at the 1 percent confidence level.

tion flow is light, trading is slow and the price moves tend to be smaller (Tauchen and Pitts (1983)).[14]

We next check for lagged information effects on volume by employing the same systematic lagging procedure described earlier. The lagged information

[14] To see whether the relationship between the absolute value of returns and volume becomes stronger as the volatility of information increases, we also calculate the correlation coefficient between the absolute value of returns and trading volume for each of the thirteen time segments. We then associate these coefficients with the variance of information events for the corresponding periods and obtain a correlation coefficient between the two of 0.5041, which is significant at the 10 percent confidence level.

variables provide a modest improvement in the results. For example, for a one-hour lag there are six significant coefficients and the R-squares show minor improvements, compared with those in Table IV. For a full one-day lag (defined as all information from the previous close through the period in question), all thirteen coefficients are positive: seven of the thirteen are significant at a 5 percent or better level, another three at a 10 percent level, and two at approximately 15 percent. These results are interesting in that they highlight the modest success of information as an explanatory variable on an intraday basis with the notable exception of one period, which is the last one-half-hour period in the trading day.[15]

In addition we investigate whether overnight information is related to opening volume and, in so doing, offer an alternative test of Gerety and Mulherin's (1992) finding of a positive relation between opening volume and unexpected overnight volatility (a proxy for overnight information). We regress overnight information observations (denoted *INFO*), from close through the next opening half hour, with trading volume for the open half hour of the following trading day (denoted *VOL*), as well as for subsequent one-half-hour periods. For the first two time periods, we have the following regression results (t-values are given in parentheses; $N = 248$):

9:30 to 10:00 A.M.

$$\underset{}{VOL} = \underset{(5.81)}{15199} + \underset{(2.77)}{33.15}\, INFO + e \qquad R^2 = 0.026$$

10:00 to 10:30 A.M.

$$\underset{}{VOL} = \underset{(7.21)}{8863.81} + \underset{(2.68)}{18.93}\, INFO + e \qquad R^2 = 0.025$$

The coefficients on the *INFO* variable decline in successive periods and become insignificant after the third period. The positive and significant coefficients (at a 1 percent confidence level) for the early periods support the notion that the overnight information is linked to opening volume.

In sum, even without matching specific types of information to market responses, we find a moderately strong relationship between our public information variable and trading volume for some, but not all subperiods during the trading day. Lagging the information variable improves the fit marginally and increases the significance of the information coefficients in the regressions.

[15] This final one-half-hour period is of interest because it is the only period in which trading volume turns out to be related to future information events. To check for future lag relationships, we regress the volume in each one-half-hour period with the information events in the period(s) immediately following that period. Only volume in the last one-half hour of the trading day is consistently related to future information events. When closing volume is regressed with the information events from the close to the next open, the coefficient on the information variable is 17.96 with a t-value of 2.13 (significant at the 5 percent level). This result, that the volume at close is related to future information, is consistent with the findings of Atkins and Basu (1992) and Gerety and Mulherin (1992).

IV. Summary and Conclusion

The measure of public information flow developed here is the number of news releases by Reuter's New Service via the *North American Securities News* wire per unit of time over a recent test year, May 1990 to April 1991. In the first part of the analysis, we document the general patterns of public information, with an emphasis on the intraday arrival of information. Overall, we find that public information arrival is nonconstant, displaying seasonalities and distinct intraday patterns. For example, consistent with earlier studies, we find that information arrival exhibits an inverted U-shape pattern across trading days, with Monday and Friday containing the fewest observations. Over the average trading day, the flow of public information increases throughout the morning hours and then falls over the midday period, between noon and 2:00 P.M. Following that period, the rate of information rises over the later market hours and reaches the highest daily rate during the two hours after the market closes, 4:00 to 6:00 P.M. Moreover, the average number of observations per hour during trading hours is over three times greater than for weekday nontrading hours and over ten times greater than for weekend hours.

The second part of our analysis focuses on the relation between the public information variable and measures of intraday market activity, specifically trading volume and volatility. The patterns of return volatility across the time periods studied (i.e., trading hours, overnight, weekend, and holiday periods) conform to the patterns of information flow across the same time periods. Results from regression analysis of information and the absolute value of returns across the thirteen one-half-hour periods throughout the trading day, however, show no significant relationship. Results for similar regressions with trading volume indicate a positive, statistically significant relationship in five of the thirteen time periods. Transforming the information variable into a cumulative lagged measure adds marginally to the strength of the public information/trading volume relationship. Although only of moderate significance, the result is remarkable in light of the aggregate nature of the public information and trading volume variable employed.

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