An Analysis of Prices, Bid/Ask Spreads, and Bid and Ask Depths Surrounding Ivan Boesky's Illegal Trading in Carnation's Stock

Sugato Chakravarty and John J. McConnell

Sugato Chakravarty is an Assistant Professor of Consumer Economics at Purdue University. John J. McConnell is the Emmanuel T.Weiler Professor of Finance at Purdue University.

During the three-month period prior to the acquisition of Carnation by Nestlé in 1984, Ivan Boesky purchased 1.7 million shares of Carnation's stock on the basis of illegally obtained inside information. Detailed records of Boesky's trades permit us to examine the relation between his trading and Carnation's stock price, bid/ask spread, and bid and ask depth. We find a positive and significant relation between Boesky's trades and stock price changes, but bid/ask spreads appear to be unaffected, and depths appear to be unaffected or improved by his trades.

■ This paper examines trading activity surrounding the acquisition of Carnation Company by Nestlé S.A. in 1984. During the summer of 1984, prior to the first public announcement by Carnation or Nestlé of merger discussions, Ivan Boesky acquired 1,711,200 shares of Carnation stock, which constituted just under 5% of Carnation's outstanding shares. The Securities and Exchange Commission (SEC) later charged that Boesky traded in Carnation's stock on the basis of illegally obtained information. Boesky acknowledged that he had received material non-public information regarding the Nestlé takeover of Carnation from Martin Siegel, an investment banker at Kidder, Peabody & Co.

Because of the SEC investigation and subsequent related litigation, detailed documents regarding Boesky's trading activity, including the dates, times, and prices at which he purchased shares, have been compiled. We use these court records to investigate the way in which insider information is

impounded in stock prices and the effect of insider trading on two aspects of market liquidity—bid/ask spread and market depth.

The prior literature most closely related to ours is Meulbroek (1992) and Cornell and Sirri (1992). Meulbroek analyzes 320 cases in which the SEC formally charged investors with illegal insider trading during the period of 1980 to 1989. After controlling for overall market movements and public news announcements, she finds a positive and statistically significant relation between insider trading and contemporaneous changes in stock price. Cornell and Sirri conduct a detailed analysis of insider trading around the acquisition of Campbell Taggart by Anheuser-Busch in 1982. They report a positive and significant relation between the stock price run-up prior to the announcement of the acquisition and purchases by illegally informed insiders. Both studies indicate that prices adjust to incorporate nonpublic information. Cornell and Sirri also evaluate the effect of insider trading on market liquidity as measured by estimated bid/ask spreads in Campbell Taggart stock where the estimated spread is computed as in Roll (1984). They report that the estimated spreads did not rise during the period of insider trading and conclude, therefore,

that liquidity did not fall.

As with the takeover of Campbell Taggart by Anheuser-Busch, the takeover of Carnation by Nestlé provides an opportunity to study price and spread reaction to trades by an identifiable and asymmetrically informed trader and, therefore, to conduct a "robustness" check on the conclusions reached by Meulbroek (1992) and Cornell and Sirri (1992). However, we go beyond their analyses in several respects.

First, both Meulbroek (1992) and Cornell and Sirri (1992) use daily data to examine the correlation between stock price changes and insider trading. Meulbroek notes that these data limit her ability to draw inferences regarding causation. That is, she cannot determine whether insider trading caused large price changes or vice versa. Because our database includes the actual times of Boesky's trades, we are able to conduct an hour-by-hour analysis of his trading and changes in Carnation's stock price. Like Meulbroek and Cornell and Sirri, we find a positive and significant contemporaneous relation between Boesky's purchases and changes in stock price. A further analysis indicates that Boesky's trades led to further subsequent price increases, suggesting that Boesky's trades "caused" the price increases rather than the other way around.

Second, depending upon the number of shares traded, we classify Boesky's trades as "small," "medium," or "large." Our motivation for doing so follows from Barclay and Warner (1993) who report that pre-acquisition stock price run-ups are more highly correlated with "medium-sized" orders than with either large or small orders. Our investigation of Boesky's trades in Carnation indicates that it is only Boesky's large trades that are significantly correlated with changes in Carnation's stock price prior to the takeover announcement.

Third, we go beyond the analysis of the effect of insider trading on market liquidity conducted by Cornell and Sirri (1992) to consider the effect of insider trading on both the size of the bid/ask spread and on the level of market depth. As noted by Harris (1990), a complete characterization of market liquidity encompasses two dimensions: 1) the bid/ask spread, i.e., the price at which the market maker is willing to buy (the bid) and sell (the ask); and 2) the market depth, i.e., the number of shares available at each bid and ask price (the bid depth and the ask depth, respectively). When liquidity is defined in terms of these two dimensions, it is entirely conceivable that a reduction in liquidity could occur through a reduction in bid or ask depth even though the quoted or effective spread is unchanged. It is for that reason that we investigate the effect of Boesky's trading in Carnation's stock on both spread and depth. We find that Boesky's trades had no significant adverse effect on either quoted or effective bid/ask spreads. Additionally, we find that

Boesky's trading clearly had no adverse effect on bid and ask depths and, depending upon the level at which significance is judged, may even have had a positive effect on both bid and ask depth.

A policy implication that follows from our analysis is that insider trading appears to facilitate price discovery and to have no adverse effect on market liquidity. Additionally, our analysis permits insights into certain aspects of market microstructure. An interpretation of our results is that market liquidity (i.e., spread and depth) is relatively insensitive to the presence of informed traders. The corollary implication is that the adverse selection component of market liquidity (both spread and depth) is modest. This result is consistent with those of George, Kaul, and Nimalendran (1991) who determine that the adverse selection component of the bid/ask spread is negligible, but contrary to those of Stoll (1989) who finds that quoted spreads contain a large and statistically significant adverse selection component and with those of Lee, Mucklow, and Ready (1993) who report a significant decline in market depth around corporate earnings announcements. Each of these studies infers the presence of informed traders on the basis of changes in price and trading volume, whereas we base our analysis on admissions by an accused inside trader.

The next section of this paper describes in more detail Boesky's trading in Carnation's stock and highlights certain events surrounding the Nestlé/Carnation merger. Section II describes the data used in the empirical analysis. Section III empirically examines the relation between Boesky's trades and Carnation's stock price. Section IV briefly reviews the theoretical literature on market microstructure that provides a framework for our empirical analysis, in Section V, of the relation between Boesky's trades and market liquidity. Section VI provides summary and conclusions.

I. Nestlé, Carnation, and Boesky's Purchases of Carnation's Stock

On Tuesday, September 4, 1984, Nestlé and Carnation jointly announced that Nestlé would make an offer to purchase all of the outstanding shares of Carnation at $83.00 per share. On Friday, August 31, 1984, the last trading day before the announcement, Carnation's stock closed at $75.00 per share. Approximately three months prior to that announcement, on June 5, 1984, Carnation's stock closed at $59.75 per share. Between June 5, 1984 and August 31, 1984, Carnation's stock experienced a run-up of 26% in contrast to an increase of 8.5% in the S&P 500 Index over this same interval.

This run-up in Carnation's stock price coincided with

the accumulation of a major position in Carnation's stock by Ivan Boesky. Specifically, on June 6, 1984, Boesky, purchased 45,000 shares of Carnation stock. Over the ensuing three months, Boesky purchased a total of 1,711,200 shares of Carnation stock representing just under 5% of the total Carnation shares then outstanding. Based upon the prices at which he purchased Carnation stock and the prices at which he sold the stock following the merger announcement, Boesky realized a profit of approximately $28 million from his trades in Carnation.

Carnation Co. was founded by E.A. Stuart in 1899. In 1984, the Stuart family still controlled a substantial fraction of the company's shares. During the early spring of 1984, Dwight Stuart, the former CEO of Carnation, approached First Boston Corp. about the possibility of selling his shares as a block to a single buyer. About the same time, because of concerns about a possible hostile takeover attempt, the Carnation board of directors retained Kidder Peabody for assistance in takeover defense measures. Shortly thereafter, Dwight Stuart informed the Carnation board of his contacts with First Boston. The board immediately relayed this information to Kidder Peabody.

At the time when the Carnation board hired First Boston and during the time period in which Boesky purchased Carnation's stock, Martin Siegel was an investment banker with Kidder Peabody. On February 13, 1987, the SEC filed a "Complaint for Injunctive and Equitable Relief" against Siegel in which the SEC charged that Siegel learned "...material non-public information concerning the interest of a controlling shareholder in selling his controlling position in Carnation...," which information he illegally disclosed to Boesky, knowing that disclosure "...was likely to result in Boesky's purchase of common stock of Carnation" (p. 8). The Siegel complaint also charged that during the summer of 1984, "...Siegel met with Boesky and, based upon material non-public information concerning a possible acquisition...which Siegel learned by virtue of his employment at Kidder, encouraged Boesky to continue to purchase shares of the common stock of Carnation." Siegel never admitted to passing illegal information to Boesky regarding Carnation. However, he did acknowledge receiving a cash fee from Boesky for "consulting" services. Boesky, however, did testify about his involvement with Siegel on two occasions: in *United States vs. John Mulherin* and in *Maxus Corporate Company vs. Kidder*, *Peabody & Co., Inc.*, *Martin A. Siegel*, *and Ivan F. Boesky*. In both cases, Boesky testified that he had traded illegally in Carnation stock on the basis of information received from Siegel. He also testified that he had paid $700,000 in cash to Siegel. The

payments had been made in two installments with the cash given to Siegel in a suitcase in the Plaza Hotel in New York City.

Based upon the facts of the case as well as the testimony rendered, there is the strong appearance that Boesky had inside information regarding the takeover of Carnation prior to the public release of any information about the merger and that Boesky used that information to trade in Carnation's stock. We now turn to the questions of whether Boesky's trading affected Carnation's stock price and market liquidity.

II. Data

Our empirical analysis makes use of four data sets: 1) a time-stamped record of Boesky's trades in Carnation's stock over the period of June 6, 1984 through August 28, 1984; 2) a time series of trades and quotes in Carnation's stock from the database of the Institute for the Study of Security Markets (ISSM) for the period January 1, 1984 through August 31, 1984; 3) daily stock returns from the files of the Center for Research in Security Prices (CRSP); and 4) the intraday prices on the three-month S&P 500 Index futures contract obtained from the Chicago Mercantile Exchange (CME) for the period January 1, 1984 through August 31, 1984.

A record containing the order-entry time and the order-execution time of Boesky's trades along with the type of trade (i.e., limit or market order), quantity traded, and the price at which the trade occurred was constructed from Boesky's files. The record includes 366 individual transactions encompassing 1,731,200 shares purchased on 24 days beginning with June 6, 1984 and ending with August 28, 1984. For each trade in Carnation (with the exception of certain missing days), the ISSM database contains the date and time of the trade, the price of the trade, and the number of shares traded. The database also contains "quotes." Each quote consists of a bid and an ask price and their corresponding depths (i.e., the number of shares that can be sold at the current bid and the number of shares that can be purchased at the current ask). A quote is available whenever there is a change in either the bid or ask prices or in the bid or ask depth, regardless of whether any trades have occurred since the previous quote. Daily returns on Carnation's stock, a daily equally-weighted index of all NYSE stocks, and a daily index representative of the food products industry are taken from the CRSP files. For the intraday analysis, hourly returns on the three-month S&P 500 Index futures contract from the CME are used as a proxy for a market index.

III. The Relation Between Boesky's Trades and Carnation's Stock Price

We first examine the relation between Boesky's trades in Carnation and changes in Carnation's stock price. In this analysis, we investigate whether insider trading moves prices.

A. Stock Price Changes and Boesky's Stock Purchases

In order to determine the statistical significance of the relation between Boesky's purchases and the run-up in Carnation's stock price prior to the announcement of the purchase offer by Nestlé, a regression is estimated in which the dependent variable is the daily rate of return on Carnation's stock over the period January 1, 1983 through August 28, 1984. The independent variables include the daily return on the value-weighted index of all NYSE stocks, the daily return on a food industry index,[1] an indicator variable to identify each of the eight days on which Carnation made an earnings announcement during this period,[2] an indicator variable to identify each of the seven days on which Carnation made a dividend announcement during this period, an indicator variable to indicate the 10 days on which brokerage firms issued "favorable" analysts reports, an indicator variable to capture the five days on which brokerage firms issued "unfavorable" analysts reports regarding Carnation's stock,[3] and an indicator variable to denote the four days on which a newspaper article appeared citing Carnation as a possible takeover candidate.[4] These independent variables are included to control for other market factors and news events that could explain the Carnation stock price run-up. The regression also includes an indicator variable to identify days on which Boesky purchased shares of Carnation's stock. The results of the regression are reported in the second column of Table 1. As the table indicates, the market

index and the Boesky-buying indicator variable are statistically significant with p-values of 0.005 and 0.025, respectively.

To determine the robustness of these results, a second regression is estimated in which the Boesky-buying indicator variable is replaced with Boesky's share purchases each day as a fraction of total Carnation volume on that day. This variable is constructed as (one plus) the number of shares purchased by Boesky on a given day divided by the total number of shares of Carnation's stock traded on that day (i.e., total daily volume). As shown in the third column of Table 1, the same variables are statistically significant. A third variation of the regression is estimated in which the dependent variable is the daily return on Carnation's stock and the independent variables are the daily return on the NYSE index, the daily return on the food industry index, the indicator variables for dividend and earnings announcements, and the indicator variable for days on which articles identifying Carnation as a possible takeover candidate appeared in the press. Additionally, the number of shares purchased by Boesky on each day and the total Carnation volume less Boesky purchases on each day (i.e., non-Boesky volume) are included as independent variables. The results of this regression are reported in the fourth column of Table 1. In this regression, the coefficients of the NYSE index, the Boesky-buying variable, and the non-Boesky market volume are all positive and significant with p-values of 0.003, 0.002, and 0.097, respectively.

The results of these regressions indicate that Boesky's buying was significantly correlated with Carnation's stock price run-up during the summer of 1984. The results are consistent with three scenarios: 1) Boesky's buying "caused" the stock price run-up; 2) Boesky watched the market and placed his trades during days on which the stock price had already run-up so as to disguise his trading activity from possible later detection by legal authorities (i.e., the stock price run-up caused Boesky's buying); or 3) both the stock price run-up and Boesky's buying were caused by a third, unidentified factor. The control variables included in the regressions would seem to preclude the obvious exogenous third factors. However, the regressions cannot distinguish between the other two explanations. That is, the regressions cannot determine whether it was Boesky's buying that caused the stock price run-up or vice versa.

To take a closer look at the question of causation, Boesky's trades are classified according to the hour of the day, beginning with 9:30 a.m. and ending with 4:00 p.m., in which they were submitted to the specialist for execution (i.e., the trades are classified by order entry time). For one transaction of 200 shares, the

---

[1]The food industry index comprises all stocks, excluding Carnation, included in the Standard & Poor's Foods Composite Index. Because the food-industry index and the equal-weighted index of all NYSE stocks are highly correlated, we regress the industry index against the market index. The residuals from this regression are now independent of the market index and are used as the food industry index in subsequent regressions.
[2]See also Sivakumar and Waymire (1994) and Green and Watts (1996).
[3]Analysts reports typically provide readers with a "buy," "hold," or "sell" recommendation. We categorize buy and hold recommendations as favorable, and a sell recommendation as unfavorable. Specifically, the favorable days were identified as 1/11/84, 2/28/84, 3/2/84, 3/21/84, 3/28/84, 5/16/84, 5/22/84, 5/30/84, 6/1/84, and 6/7/84. The unfavorable days were 7/6/84, 7/16/84, 8/15/84, 8/30/84, and 8/31/84.
[4]The four days are June 20, 1984, July 3, 1984, July 5, 1984, and August 8, 1984.

Table 1. Regression Analysis of Daily Returns on Carnation's Stock Over the Period January 1, 1983 Through August 31, 1984

In the regression, the dependent variable is Carnation's daily stock return. The independent variables are the daily returns on an equally weighted index of all NYSE stocks, the daily returns on an equally weighted index of food products stocks, daily non-Boesky Carnation trading volume, an indicator variable for the days in which a takeover-related article appeared in the national press, an indicator variable for the days of earnings announcements by Carnation, an indicator variable for the dividend announcements by Carnation, an indicator variable for the days corresponding to favorable analyst reports on Carnation, an indicator variable for the days corresponding to unfavorable analyst reports on Carnation, and three different measures of Boesky's buying activity. The p-values of the coefficient estimates are in parentheses below the coefficients.

Independent Variables (1)	(2)[a]	(3)[b]	(4)[c]
Intercept	0.0007	0.0007	-0.0001
	(0.312)	(0.282)	(0.865)
Index of NYSE Stocks	0.3703***	0.3824***	0.3864***
	(0.005)	(0.003)	(0.003)
Index of Food Product Stocks	0.1645	0.1508	0.1434
	(0.199)	(0.239)	(0.256)
Non-Boesky Carnation Volume	——	——	0.0000*
			(0.097)
Boesky-Buying	0.0066**	0.0330***	0.0000***
	(0.025)	(0.008)	(0.002)
Takeover Related Articles[d]	0.0043	0.0028	-0.0062
	(0.530)	(0.690)	(0.400)
Earnings Announcements[e]	-0.0009	-0.0006	-0.0007
	(0.833)	(0.898)	(0.881)
Dividend Announcements[f]	0.0039	0.0023	0.0042
	(0.433)	(0.645)	(0.395)
Analyst Reports - Favorable[g]	-0.0035	-0.0039	-0.0045
	(0.388)	(0.334)	(0.255)
Analyst Reports - Unfavorable[h]	0.0025	0.0021	-0.0017
	(0.657)	(0.720)	(0.781)
R^2	0.07	0.08	0.10

***Significant at the 0.01 level.
 **Significant at the 0.05 level.
  *Significant at the 0.10 level.
[a]The Boesky-buying variable in column (2) is an indicator variable for the days in which Boesky purchased Carnation's stock.
[b]The Boesky-buying variable in column (3) is Boesky's purchases during the day divided by total Carnation volume during the day.
[c]The Boesky-buying variable in column (4) is the number of shares purchased by Boesky each day.
[d]The days on which a newspaper article appeared citing Carnation as a possible takeover candidate are 6/20/84, 7/3/84, 7/5/84, and 8/8/84.
[e]The earnings announcement days are 4/27/83, 5/17/83, 8/16/83, 11/15/83, 2/21/84, 4/25/84, 5/15/84, and 8/15/84.
[f]The dividend announcement days are 2/22/83, 5/23/83, 8/23/83, 11/18/83, 2/21/84, 5/21/84, and 8/20/84.
[g]The favorable (buy/hold) analyst report days are 1/11/84, 2/28/84, 3/2/84, 3/21/84, 3/28/84, 5/16/84, 5/22/84, 5/30/84, 6/1/84, and 6/7/84.
[h]The unfavorable (sell) analyst report days are 7/6/84, 7/16/84, 8/15/84, 8/30/84, and 8/31/84.

trading slip had the order execution time, but not the order entry time, and for one transaction of 20,000 shares, the trading slip had neither the order entry time nor the order execution time. Both of these trades are dropped from this analysis. Table 2 summarizes Boesky's trading by hour of the day. As the exhibit indicates, of the trades for which order entry times are available, none were submitted before 10 a.m. and the bulk of Boesky's trading occurred after 1 p.m.[5] Additionally, the trading slips indicate that all of Boesky's orders were market buy orders. That is, Boesky tended to buy late in the day by means of market orders. These results are consistent with the idea that Boesky waited for large price moves early in the day and then entered his orders. To draw more definitive conclusions, however, the trade data must be compared with price changes.

To do that, the ISSM database is accessed to calculate hour-by-hour rates of return on Carnation's stock for the period January 1, 1984 through August 31, 1984. Also retrieved from the ISSM database is the total hour-by-hour trading volume in Carnation's stock.[6] A regression is then estimated in which the dependent variable is the hourly rate of return on Carnation's stock and the independent variables are the hourly return on the three-month S&P 500 Index futures contract (which serves as a proxy for the market index)[7] and an indicator variable to identify whether Boesky purchased stock during the hour.[8]

As shown in the second column of Table 3, the Boesky-buying indicator variable is positive and statistically significant with a p-value of 0.040. As before, two additional variations of the regression are estimated in which the Boesky-buying variable is

Table 2. Summary of Boesky's Trades in Carnation Stock by Hour of the Day[a] Over the Period June 6, 1984 Through August 31, 1984

(1)	(2)	(3)
Time of Day[b]	Number of Carnation Shares Purchased by Boesky	Number of Trades in Carnation's Stock by Boesky
9:30 a.m. - 10 a.m.	0	0
10 a.m. - 11 a.m.	66,000	5
11 a.m. - 12 p.m.	83,000	21
12 p.m. - 1 p.m.	232,600	46
1 p.m. - 2 p.m.	377,000	131
2 p.m. - 3 p.m.	329,000	52
3 p.m. - 4 p.m.	623,400	109
Total	1,711,000	364

[a]In addition to the purchases reported in the table, Boesky also had over two other transactions which could not be classified within a specific hourly interval. One transaction for 200 shares had no order-entry time, while another transaction for 20,000 shares had neither an order-entry time nor an order-execution time. Taking these two transactions into consideration, Boesky's total purchases of Carnation stock were 1,731,200 shares in 366 separate transactions.
[b]Trades are classified by order-entry time.

specified as Boesky volume over total Carnation volume and in which Boesky volume is entered along with non-Boesky volume as separate independent variables. In both cases (also reported in Table 3), the coefficient of the Boesky-buying variable is positive with a p-value of less than 0.01. The regression results indicate that Carnation stock price changes are contemporaneous with Boesky's purchases and are consistent with the idea that it was Boesky's purchases that caused the stock price run-up.

To investigate the idea a bit further, the first regression is re-estimated except that in addition to the contemporaneous return on the market index and the contemporaneous Boesky-buying variable, the Boesky-buying variable for each of the three prior hours is also included. This regression addresses the question of whether there is a correlation between stock price changes and prior purchases by Boesky. The results of this regression are presented in Table 4. As before, the coefficient of the contemporaneous Boesky-buying variable is positive and significant (p-value = 0.029). Additionally, the coefficient of the Boesky-buying variable for two hours prior to the price

---

[5]As it turns out, there are no quotes or trades in Carnation stock before 10 a.m. in the ISSM files from January 1984 through August 1984. Hence, our hourly intervals were all constructed from 10 a.m. onwards.

[6]Unfortunately, Carnation data are missing from the ISSM database for 42 of the 170 trading days over this period. More importantly, of these 42 days, Boesky traded on four of them. Specifically, the four days on which Boesky traded are August 7 through August 10, 1994. Although we cannot say for certain, it is likely that the absence of the four Boesky trading days would tend to attenuate the observed relationship between Boesky's trading and prices and liquidity and reduce the likelihood of rejecting the null hypothesis. Of the other 38 trading days for which data are missing, 33 of them were prior to June 6, 1984, the first day on which Boesky purchased any Carnation stock. These 42 days are, thus, omitted from the analysis.

[7]The hourly rate of return on the S&P Index futures contract is calculated as the price at the end of the hour divided by the price at the beginning of the hour divided by the price at beginning of the hour.

[8]Because a preliminary diagnostic analysis indicated that the error terms of the OLS regression are serially correlated, the Cochrane-Orcutt two-step procedure is used to estimate the regression.

Table 3. Regression Analysis of Hourly Returns on Carnation's Stock Over the Period January 1, 1984 Through August 31, 1984

In the regression, the dependent variable is Carnation's hourly stock return. The independent variables are the hourly returns on the three-month S&P 500 Index futures contract, non-Boesky Carnation trading volume, and three different measures of Boesky's buying volume. The p-values of the coefficient estimates are in parentheses below the coefficients.

Independent Variables (1)	(2)[a]	(3)[b]	(4)[c]
Intercept	0.0002	0.0001	-0.0002
	(0.504)	(0.563)	(0.396)
S&P 500 Index Futures	-0.1534	-0.1543	-0.1675
	(0.198)	(0.195)	(0.157)
Non-Boesky Carnation Volume	——	——	0.0000***
			(0.005)
Boesky-Buying	0.0022**	0.0046***	0.0000***
	(0.040)	(0.008)	(0.010)
R^2	0.05	0.05	0.05

***Significant at the 0.01 level.
**Significant at the 0.05 level.
[a]The Boesky-buying variable in column (2) is an indicator variable showing whether Boesky purchased Carnation stock during each hour.
[b]The Boesky-buying variable in column (3) is Boesky's purchases during each hour divided by total Carnation volume during the hour.
[c]The Boesky-buying variable in column (4) is the actual number of shares purchased by Boesky during each hour.

change is also positive and statistically significant with a p-value of 0.050, but none of the other lags of the Boesky-buying variable is statistically different from zero. As before, two variations of the regression are estimated with the two different definitions of the Boesky-buying variable. The results are presented in columns 3 and 4 of Table 4. In both regressions, the contemporaneous Boesky-buying variables have p-values of less than 0.01. The two-hour lagged Boesky-buying variables have p-values of 0.062 and 0.014. In the third regression, the one-hour lagged Boesky variable has a p-value of 0.076. Thus, these regressions provide support for the idea that there is a lagged Boesky effect in Carnation's stock price movement. The stronger relationship is between Boesky's trades and contemporaneous stock price changes. That is, Carnation's stock price appears to respond to the information embedded in Boesky's trading activity contemporaneously with his trades, but there also is some evidence of a lag in the stock price reaction to Boesky's purchases.

We now reverse the regression to address the question of whether stock price changes led Boesky's buying activity. Here, we estimate two regressions. In the first, the dependent variable is the number of shares purchased by Boesky as a fraction of total Carnation volume over each hour of the day. The independent variables are the contemporaneous hourly rate of return on Carnation's stock and the hourly rate of return

on Carnation's stock over each of the three prior hours. In this regression, we ask whether Boesky's trading as a fraction of total Carnation volume depends upon prior changes in Carnation's stock price. In the second regression, the dependent variable is the number of Carnation shares purchased by Boesky during the hour. The independent variables are the contemporaneous and lagged hourly returns on Carnation's stock and the contemporaneous and lagged hourly non-Boesky Carnation trading volume. Here we are asking whether Boesky's raw trading volume depends upon prior Carnation stock price changes.

The results are presented in columns 2 and 3 of Table 5. In both regressions, the coefficient of the contemporaneous Carnation stock return is positive and has a p-value of less than 0.01. In neither regression is the p-value of any of the lagged independent variables less than 0.10. It, thus, appears unlikely that Boesky was simply trading behind stock price changes. The second of these regressions also permits some insight into another variation on the idea that Boesky traded so as to disguise his trades behind other market activity. It goes as follows: Suppose that, rather than watching stock price changes as a guide for when to place his orders, Boesky instead watched market volume. That is, to disguise his actions, Boesky waited for high volume days to place his orders. In that case,

Table 4. Regression Analysis of Hourly Returns on Carnation's Stock on Contemporaneous and Lagged Boesky-Buying Over the Period January 1, 1984 Through August 31, 1984

In the regression, the dependent variable is Carnation's hourly stock return. The independent variables are the hourly returns on the three-month S&P 500 Index futures contract, non-Boesky Carnation trading volume, and contemporaneous and three lagged measures of Boesky's buying volume. The p-values of the coefficient estimates are in parentheses below the coefficients. The OLS estimation is based on adjusted White's heteroscedasticity-consistent standard errors.

Independent Variables (1)	(2)[a]	(3)[b]	(4)[c]
Intercept	0.0002	0.0001	-0.0002
	(0.452)	(0.620)	(0.383)
S&P 500 Index Futures	-0.1476	-0.1505	-0.1773
	(0.217)	(0.206)	(0.132)
Non-Boesky Carnation Volume	____	____	0.0000***
			(0.001)
Boesky-Buying	0.0027**	0.0048***	0.0000***
	(0.029)	(0.009)	(0.000)
Boesky-Buying(-1)	0.0005	0.0012	0.0000*
	(0.664)	(0.486)	(0.076)
Boesky-Buying(-2)	0.0018**	0.0031*	0.0000**
	(0.050)	(0.062)	(0.014)
Boesky-Buying(-3)	-0.0004	0.0013	-0.0000
	(0.740)	(0.462)	(0.650)
R^2	0.05	0.05	0.05

***Significant at the 0.01 level.
**Significant at the 0.05 level.
*Significant at the 0.10 level.

[a]The Boesky-buying variable in column (2) is an indicator variable showing whether Boesky purchased Carnation stock during each hour.
[b]The Boesky-buying variable in column (3) reflects his purchases during each hour divided by total Carnation volume during the hour.
[c]The Boesky-buying variable in column (4) is the actual number of shares purchased by Boesky during each hour.

Boesky purchases should follow non-Boesky trading volume. The regression provides no support for that conjecture either. That is, there is no significant correlation between Boesky's trading activity and prior non-Boesky volume.

B. Sequential Price Changes

The results in Table 4 indicate that positive price changes during the hours in which Boesky traded tended to be followed by further positive price changes during the immediately subsequent hours. That is, the data indicate that the positive price effect associated with Boesky's purchases was not subject to reversal. To examine the question in more detail, the correlation between the hourly returns during any hour in which Boesky traded and the hourly return over the subsequent hour is calculated for the period June 1, 1984, through August 31, 1984. This correlation is 0.102 with a p-value of 0.585. As a benchmark, the correlation between the return over any hour in which Boesky did not trade and the return during the subsequent hour is also calculated. This correlation is -0.005 with a p-value of 0.993. Thus, neither of the correlations is significantly different from zero.

The results in Table 4 do indicate a lagged positive correlation between the price changes during the hours in which Boesky traded and the price changes over the second subsequent hour. The correlation coefficient computed here also bears out that effect. Specifically, the correlation between the return over the hours in which Boesky traded and the return during the second subsequent hour is 0.311 with a p-value of 0.090. The corresponding benchmark correlation between the return over the hours in which Boesky did not trade and the return over the second

Table 5. Regression Analysis of Carnation Stock Purchases by Boesky Over the Period January 1, 1984 Through August 31, 1984

In the first regression, the dependent variable is the number of shares purchased by Boesky during each hour divided by the total Carnation volume during the hour. In the second regression, the dependent variable is the number of Carnation shares purchased by Boesky during the hour. The independent variables are contemporaneous and lagged hourly Carnation stock returns and contemporaneous and lagged hourly non-Boesky Carnation trading volume. The regression procedure used is the two-stage Cochrane-Orcutt method given by

$$y_t = \alpha + \sum_i \beta_i x_{it} + \mu_t \ ; \ \mu_t = \rho \mu_{t-1} + \varepsilon_t$$

where α and βs are the coefficients to be estimated, ρ is the first order autoregressive parameter, and ε is white noise. The p-values of the coefficients are in parentheses below the coefficients.

Independent Variables (1)	(2)	(3)
Intercept	0.0231***	3.6695
	(0.000)	(0.467)
Carnation Stock Return	1.9842**	1583.1000***
	(0.008)	(0.000)
Carnation Stock Return(-1)	0.5059	803.1100
	(0.503)	(0.830)
Carnation Stock Return(-2)	1.3293	861.0000
	(0.790)	(0.620)
Carnation Stock Return(-3)	-1.0506	-938.4800
	(0.158)	(0.340)
Non-Boesky Carnation Volume	——	0.0079
		(0.408)
Non-Boesky Carnation Volume(-1)	——	0.0125
		(0.183)
Non-Boesky Carnation Volume(-2)	——	0.0197
		(0.350)
Non-Boesky Carnation Volume(-3)	——	0.0121
		(0.192)
First Order Autoregressive Parameter	0.1818***	0.2931***
	(0.000)	(0.000)
R^2	0.06	0.14

***Significant at the 0.01 level.
 **Significant at the 0.05 level.

subsequent hour is -0.094 with a p-value of 0.101.

These lagged correlations indicate that the price effects associated with Boesky trades were not reversed in subsequent hours. Indeed, rather than a price reversal, the correlations indicate that the price increases over the hours in which Boesky traded tended to be followed by further price increases.

C. Stock Price Changes and Trade Size

The positive relationship between Boesky's trades and price changes gives rise to a further intriguing question of whether the size of Boesky's individual trades had a differential impact on market price. For example, it is intuitively reasonable to suspect that Boesky's large orders had a greater impact on price than did his small orders. However, as we noted at the outset, Barclay and Warner (1993) present evidence that pre-acquisition stock price run-up is more highly correlated with medium-sized orders than with either large or small orders. They cast up their analysis in terms of a stealth trading hypothesis in which informed traders attempt to disguise their trading activity by

trading primarily in medium-sized order quantities. Specifically, Barclay and Warner use a sample of 105 NYSE-listed firms that were targets of 108 tender offers over the period 1981 through 1984. They define small trades as individual trades between 100 and 400 shares, medium trades as individual trades between 500 and 9,900 shares, and large trades as individual trades of 10,000 shares or more. They report that "...medium-sized trades are responsible for an estimated 92.8% of the cumulative price change..." during the period prior to the announcement of the tender offer.

We use the same categorization as Barclay and Warner to classify Boesky's individual trades as small, medium, or large. Of Boesky's 366 transactions, 81 transactions (totaling 17,300 shares or about 1% of Boesky's purchases) were small, 241 transactions (totaling 692,400 shares or about 40% of Boesky's purchases) were medium, and 44 transactions (totaling 1,021,300 shares or about 59% of Boesky's purchases) were large.

To determine the relation between price changes and order size, we estimate three regressions. In each regression, the dependent variable is the hourly rate of return on Carnation's stock. The hourly return on the S&P 500 Index futures contract is used as an independent variable to control for changes in the market index over the hour. The regressions differ according to the variable used to indicate Boesky's trade size. In the first regression, three indicator variables are used to identify when Boesky entered a small, medium, or large trade during the hour. For the second regression, we construct a variable to indicate the fraction of the total volume each hour that is due to Boesky's small, medium, and large trades. Specifically, we construct Boesky's small-trade variable for each hour by summing the total quantity of all of Boesky's small trades within that hour and dividing by the total Carnation volume for that hour. Similarly, Boesky's medium-trade variable for each hour is the total quantity of all of Boesky's medium-sized trades within that hour divided by the total Carnation trading volume for that hour. Boesky's large-trade variable is constructed in an analogous manner. In the third regression, the total number of shares traded each hour according to trade size is entered as the dependent variable. For example, the small-trade variable is the total number of shares purchased with small trades during the hour.

The results are presented in Table 6. In each regression, the coefficient of the large-trade variable is positive and significant, but in no regression are the coefficients of the small- or medium-sized trade variables significant.

The analysis of Carnation's stock price run-up prior to the acquisition announcement indicates that Carnation's stock price moved contemporaneously with Boesky's trades. There is also some evidence that Boesky's purchases had a continuing effect on the stock price even after he traded in that stock price changes show a lagged correlation with Boesky's trades. Additionally, it appears that Boesky's large trades had a more consequential effect on the stock price than did his small- or medium-sized trades.

IV. Informed Trading, Bid/Ask Spreads, and Market Depth

We now turn to the relation between Boesky's trading and market liquidity. The theoretical literature on market microstructure provides the framework for our empirical investigation. Arguably, the microstructure literature of interest to us originates with the intuitive insights of Bagehot (1971). Bagehot observes that a market maker trades with both informed and uninformed traders and that the market maker loses on trades with informed traders and profits from trades with uninformed traders. The market maker's challenge is to set the stock's bid/ask spread at a sufficiently low level so that it will not discourage order flow from uninformed traders while setting it at a sufficiently high level so as to provide protection against trades from informed traders. Many of Bagehot's ideas subsequently have been modeled formally by authors such as Admati and Pfleiderer (1988), Copeland and Galai (1983), DeLong, Shleifer, Summers, and Waldmann (1990), Easley and O'Hara (1987), Glosten and Milgrom (1985), and Kyle (1985).

In these models, the market maker's challenge is to set the bid/ask spread wide enough so as to be able to earn enough on trades with uninformed traders (also referred to as liquidity and/or noise traders) so as to compensate for losses incurred on trades with informed traders. In these models, the spread is a function of the probability that any given trader is an informed trader. If the specialist believes that the probability of trading with an informed trader has increased, he will increase the spread. That is, informed traders have an adverse effect on the bid/ask spread and, therefore, have an adverse effect on market liquidity.

Harris (1990) argues that the spread is only one component of market liquidity. The other is market depth. On the NYSE, the quotes posted by the specialist comprise the current bid and ask prices and the number of shares that can be bought or sold at each of those prices. Technically, bid depth is the number of shares that the specialist is willing to buy at the current bid price and ask depth is the number of shares that the specialist is willing to sell at the current ask price. From the perspective of market liquidity, depth indicates the number of shares that can be

Table 6. Regression Analysis of Hourly Returns on Carnation's Stock on Boesky's Small, Medium and Large-Sized Trades Over the Period January 1, 1984 Through August 31, 1984

In the regression, the dependent variable is Carnation's hourly stock return. The independent variables are the hourly returns on the three-month S&P 500 Index futures contract, hourly non-Boesky Carnation volume, and contemporaneous hourly size-based Boesky-buying volume. The p-values of the coefficient estimates are in parentheses below the coefficients.

Independent Variables (1)	(2)	(3)	(4)
Intercept	-0.0002	0.0001	-0.0002
	(0.464)	(0.543)	(0.413)
S&P 500 Index Futures	-0.1598	-0.1588	0.1741
	(0.179)	(0.182)	(0.142)
Non-Boesky Carnation Volume	0.0000***	____	0.0000***
	(0.008)		(0.009)
Boesky-Buying Small[a]	0.0002	0.1162	0.0002
	(0.952)	(0.389)	(0.625)
Boesky-Buying Medium[b]	-0.0008	-0.0014	-0.0000
	(0.731)	(0.811)	(0.541)
Boesky-Buying Large[c]	0.0028*	0.0062***	0.0000***
	(0.093)	(0.010)	(0.001)
R^2	0.03	0.02	0.03

***Significant at the 0.01 level.
  *Significant at the 0.10 level.
[a]The "Boesky-buying small" variable in column (2) is an indicator variable showing whether Boesky entered an order for 100-400 shares of Carnation stock during the hour. The same variable in column (3) is the sum of the orders entered for 100-400 shares of Carnation stock by Boesky during the hour divided by the total Carnation volume during the hour. Finally, the "Boesky-buying small" variable in column (4) is the sum of the orders entered for 100-400 shares of Carnation stock by Boesky during the hour.
[b]The "Boesky-buying medium" variable in column (2) is an indicator variable indicating whether Boesky entered an order for 500-9,900 shares of Carnation stock during the hour. The same variable in column (3) is the sum of the orders entered for 500-9,900 shares of Carnation stock by Boesky during the hour divided by the total Carnation volume during the hour. Finally, the "Boesky-buying medium" variable in column (4) is the sum of the orders entered for 500-9,900 shares of Carnation stock by Boesky during the hour.
[c]The "Boesky-buying large" variable in column (2) is an indicator variable indicating whether Boesky entered an order for 10,000 or more shares of Carnation stock during the hour. The same variable in column (3) is the sum of the orders entered for 10,000 or more shares of Carnation stock by Boesky during the hour divided by the total Carnation volume during the hour. Finally, the "Boesky-buying large" variable in column (4) is the sum of the orders entered for 10,000 or more shares of Carnation stock by Boesky during the hour.

traded with no effect on market price. In "deep" markets, many shares can be traded with little or no effect on market price, whereas in "shallow" markets, even a relatively small trade can affect price.

A corollary prediction of the adverse selection models of the market maker is that the depth of the market declines as the probability of trading with an informed trader increases. The intuition that underlies this prediction is the same as for the predicted effect of informed trading on the spread. If the market maker believes that an informed trader has entered the market, he will attempt to reduce his exposure to losses from trading with the informed trader. One way to reduce that exposure is to reduce the number of shares for which the market maker will transact at the current bid and ask quotations. Thus, an examination of only the spread in the presence of an informed trader could

give an incomplete portrayal of the effect of inside traders on market liquidity.

V. Boesky's Trading and Market Liquidity

Table 7 provides an overview of spreads and depth in Carnation's stock for the period January 1, 1984 through August 31, 1984. The exhibit presents the average quoted dollar spread, the average effective spread, the average bid and ask depths, and the average daily trading volume on a month-by-month basis for the period January through May of 1984. The average quoted spread is the equal-weighted average of all quoted spreads from the ISSM database for the relevant time interval. To compute the average effective

spread, an effective spread is calculated for each transaction as twice the absolute difference between the mid-point of the prevailing quoted spread and the transaction price at which the trade occurred (Garfinkel and Nimalendran, 1995). The average effective spread is the equally weighted average of all such computed effective spreads. Finally, the average ask and bid depths are the equal-weighted averages of all quoted bid and ask depths. For example, the average ask depth during the month of January is the average of all quoted ask depths recorded during the month.

The average quoted bid/ask spread over the first five months of 1984 shows only modest month-to-month variation. To the extent that there is variation in the quoted spreads, it is that the average quoted spread is lower in May than in the first four months of the year. Likewise, the effective spreads over the first five months of the year show modest month-to-month variation. The average depths and volume show somewhat greater month-to-month variation over the first five months of the year. Again, however, it is May that differs from the first four months of the year. During May, the average bid and ask depths and average daily volume are greater than during the first four months of the year.

The exhibit also presents average bid/ask spreads, depths, and daily volume for the period June through August of 1984.[9] Over this period, the days are classified as either Boesky-buying days, of which there are 20, or non-Boesky-buying days, of which there are 36.

For the period June through August, the average quoted bid/ask spread of 0.333 on Boesky-buying days is essentially identical to the spread of 0.334 on non-Boesky-buying days. The average quoted spreads are marginally higher during the June through August period than during May, but they are lower during June through August than during the first four months of the year. As regards the effective spreads, for the period June through August, the average effective spread of 0.220 on the days on which Boesky traded is marginally higher than the average effective spread of 0.208 on which Boesky did not trade. The p-value for the difference is 0.101. Similarly, the average effective spread on days in which Boesky traded is marginally higher than average effective spreads during the first five months of the year. Contrarily, the average effective spread on non-Boesky buying days during June through August is marginally lower than average effective spreads during the first five months of the year.

Average daily volume during the June through August period is much greater on Boesky-buying days than on non-Boesky-buying days, and both bid and ask depths are somewhat greater on Boesky-buying days than on non-Boesky-buying days. During the June through August period, however, both volume and bid and ask depths are much higher than during the first five months of the year. On average, during June through August, daily volume is roughly twice as great on Boesky-buying days as on non-Boesky-buying days. On average, Boesky's trades account for 48% of the incremental volume on the Boesky-buying days, while non-Boesky trades account for the remaining 52% of the incremental volume.

Our overview of bid/ask spreads and depths indicates that Boesky's trading activity had, at best, a modest impact on spreads and, if there was any effect on depths, it was that his trading increased depth. From our analysis of price and trading volume in Section IV, it also appears to be the case that Boesky's trading activity actually attracted additional trading volume. The data in Table 7 support that proposition as well.

The apparent absence of any consequential adverse effect of Boesky's trading on bid/ask spreads and market depth could arise because there are two offsetting effects at work in the market. On the one hand, the presence of an informed trader (i.e., Boesky) could tend to have the effect of widening the bid/ask spread and reducing the willingness of the market maker (and other traders) to provide depth at the quoted bid and ask prices. On the other hand, the additional volume that Boesky attracted could represent trades by uninformed (or "noise") traders. The presence of additional uninformed traders (and the profits to be made therefrom) could have offset the market maker's losses to the informed trader such that the market maker was willing to keep the bid/ask spread "narrow" and to offer greater depth at the quoted bid and ask prices. In our macroscopic look at the data, these offsetting effects could net out.

To take a closer look at the relation between Boesky's trading and bid/ask spreads, a regression is estimated in which the dependent variable is the average quoted bid/ask spread over each hour of the day and the independent variables are Boesky's trading volume and total non-Boesky trading volume in Carnation during the hour. In each hourly interval, the average quoted spread is the average of all quoted spreads within that hour. The regression is based on 765 hourly intervals between January 1, 1984 and August 31, 1984 for which data are available. The results of the regression[10] with quoted spreads are presented in the second column of Table 8. The coefficient of Boesky's

---

[9]Unfortunately, some of the trading days within this period are missing from ISSM's records. Specifically, there are no records for June 29, July 12, July 13, August 6 through August 10, and August 31, 1984. As mentioned before, August 7, 8, 9, and 10, coincide with four (out of 24) days on which Boesky purchased stock.

[10]Because preliminary diagnostics revealed significant serial correlation in the error terms, the two-step Cochrane-Orcutt method is used to estimate the regression.

Table 7. Overview of Average Bid/Ask Spreads, Bid Depth, Ask Depth, and Trading Volume in Carnation's Stock Over the Period January 1, 1984 Through August 31, 1984

The effective spread is computed as twice the absolute difference between the transaction price and the prevailing quoted spread midpoint. The average (quoted and effective) spreads are reported in dollars. The average ask and bid depths and the average daily volumes are reported in round lots of 100 shares. The average standard deviation of each variable is given in parentheses below. The standard deviations are computed on a daily basis. The monthly averages are the average of the daily standard deviations.

Variable	January	February	March	April	May	Days on Which Boesky Bought June-August	Days on Which Boesky Did Not Buy June-August
Avg. Quoted Bid/Ask Spread	0.341 (0.0522)	0.364 (0.0826)	0.384 (0.1150)	0.356 (0.0654)	0.320 (0.0527)	0.333 (0.0543)	0.334 (0.0646)
Avg. Effective Bid/Ask Spread	0.193 (0.0307)	0.200 (0.0547)	0.214 (0.0597)	0.216 (0.0269)	0.212 (0.0318)	0.220 (0.0432)	0.208 (0.0264)
Avg. Ask Depth	11.150 (9.33)	9.580 (7.21)	10.600 (7.19)	5.930 (4.85)	18.330 (8.43)	26.650 (15.11)	21.080 (11.60)
Avg. Bid Depth	12.350 (8.43)	20.120 (15.60)	12.000 (10.00)	8.620 (8.15)	23.430 (10.57)	28.000 (12.48)	25.000 (12.66)
Avg. Daily Volume	497.400 (95.1)	562.900 (140.9)	222.100 (54.1)	303.700 (58.9)	865.000 (168.9)	3060.000 (465.6)	1554.400 (197.8)

trading volume is positive and the coefficient of non-Boesky volume is negative, but neither is statistically different from zero at any reasonable level of significance. The p-values of the coefficients are 0.922 and 0.380, respectively.

The same regression is estimated using the average effective spread as the dependent variable. The results are presented in the third column of Table 8. In this case, the coefficient of Boesky's trading volume is positive but, with a p-value of 0.840, is not significant. The one peculiar result of this regression is that the coefficient of the non-Boesky volume is also positive with a p-value of 0.080.

We now take a closer look at the data to determine whether Boesky's trading activity had any significant effect on either bid or ask depth. To do so, we estimate two regressions—one in which the dependent variable is average bid depth over each hour of the trading day and one in which the dependent variable is the average ask depth over each hour of the trading day. In both regressions, the independent variables are Boesky's trading volume during the hour and non-Boesky-trading volume during the hour. The results are presented in the fourth and fifth columns of Table 8.

In both regressions, the coefficients of both Boesky volume and non-Boesky volume are positive and statistically significant with p-values ranging from 0.000 to 0.042. These results indicate that, not only did Boesky's trading not have an adverse effect on market depth, but his trading actually appears to have had a significant positive effect on depth. The positive coefficient on Boesky volume, in the ask-depth regression, suggests that traders were actually lining up to sell to Boesky.

For symmetry with our analysis of the effect of Boesky's trades on price, we also estimate the spread and depth regressions with lagged Boesky volume and lagged non-Boesky volume (with lags of one, two, and three hours), and we estimate regressions with size-based Boesky buying volume. The spread and depth regressions with lagged independent variables are reported in Table 9. In the regression in which the dependent variable is the average quoted spread, the coefficients of non-Boesky volume are negative contemporaneously and at each lag, but none have p-values less than 0.10. Contemporaneous Boesky volume has a positive coefficient, as does the first hour lag, but the second and third hour lags have negative signs and none have p-values below 0.10. In the regression in which the dependent variable is the average effective spread, the coefficient of the contemporaneous and lagged non-Boesky

Table 8. Regression Analysis of Bid/Ask Spreads, Bid Depths, and Ask Depths for Carnation's Stock Over the Period January 1, 1984 Through August 31, 1984

In the regression, the dependent variables are the hourly average quoted bid/ask spread, the hourly average effective bid/ask spread, the hourly average bid depth, and the hourly average ask depth. The independent variables are the contemporaneous hourly non-Boesky Carnation trading volume and the contemporaneous hourly Boesky-buying volume. The regression procedure used is the two-stage Cochrane-Orcutt method given by

$$y_t = \alpha + \sum_i \beta_i x_{it} + \mu_t \, ; \, \mu_t = \rho \mu_{t-1} + \varepsilon_t$$

where α and βs are the coefficients to be estimated, ρ is the first order autoregressive parameter, and ε is white noise. The p-values of the coefficients are in parentheses below the coefficients.

Independent Variables (1)	Quoted Bid/Ask Spread (2)	Effective Bid/Ask Spread (3)	Bid Depth (4)	Ask Depth (5)
Intercept	0.3422***	0.2128***	17.2270***	15.7650***
	(0.000)	(0.000)	(0.000)	(0.000)
Non-Boesky Carnation Volume	-0.0000	0.0000*	0.0125***	0.0044**
	(0.380)	(0.080)	(0.000)	(0.014)
Boesky-Buying	0.0000	0.0000	0.0201***	0.0121**
	(0.922)	(0.840)	(0.011)	(0.042)
First Order Autoregressive Parameter	0.3021***	-0.1626***	0.3922***	0.4661***
	(0.000)	(0.000)	(0.000)	(0.000)
R^2	0.10	0.04	0.23	0.26

***Significant at the 0.01 level.
**Significant at the 0.05 level.
*Significant at the 0.10 level.

volume alternates signs and none have p-values less than 0.10. In short, there is no evidence of a lagged or contemporaneous effect of Boesky's trades on bid/ask spreads.

In both the bid and ask depth regressions (presented in columns 4 and 5 in Table 9), the contemporaneous Boesky volume has a positive and significant coefficient (p-values = 0.018 and 0.070, respectively). The coefficients of the lagged Boesky volume are sometimes positive and sometimes negative and none have p-values that are even close to 0.10. Contrarily, both the contemporaneous and lagged coefficients of non-Boesky volume are significant and positively correlated with bid and with ask depth. In short, to the extent that Boesky's trading attracts depth, the effect is short-lived. To the extent that high market volume attracts depth, the effect appears to last for several hours.

The results of the regressions based on the size of Boesky's trades are presented in Table 10. Column 2 contains the results when the dependent variable is average hourly quoted spread, column 3 contains the results when the dependent variable is the average hourly effective spread, and columns 4 and 5 present results when the dependent variables are bid depth and ask depth, respectively. The independent variables are contemporaneous non-Boesky volume and sized-based variables to represent Boesky's small, medium, and large trades. In these regressions, the trade-size variable is the sum of Boesky's small, medium, or large trades during the hour.[11]

None of the trade-size variables is significant in either of the spread regressions. That is, not even Boesky's large trades had a significant impact on Carnation's quoted or effective bid/ask spreads. In both the bid and the ask depth regressions, however, only the large-size variable is statistically significant. That is, it was Boesky's large trades that attracted bid and ask depth.

VI. Conclusion

During the summer of 1984, Ivan Boesky purchased over 1.7 million shares of Carnation stock prior to an announcement on September 3, 1984 that Nestlé would acquire Carnation. Also during the summer of 1984, Carnation's stock experienced a run-up in price of roughly 26%. Subsequently, Boesky admitted to having purchased Carnation's stock on the basis of

---

[11]For example, the small-size variable is the sum of Boesky's small-sized purchases during the hour, and so on for the medium- and large-size variables.

Table 9. Regression Analysis of Bid/Ask Spreads, Bid Depths, and Ask Depths of Carnation's Stock with Lagged Independent Variables Over the Period January 1, 1984 Through August 31, 1984

In the regression, the dependent variables are the hourly average quoted bid/ask spreads, the hourly average effective bid/ask spreads, the hourly average bid depth, and the hourly average ask depths. The independent variables are contemporaneous and lagged hourly non-Boesky Carnation trading volume and contemporaneous and lagged hourly Boesky-buying volume. The regression procedure used is the two-stage Cochrane-Orcutt method given by

$$y_t = \alpha + \sum_i \beta_i x_{it} + \mu_t \,; \; \mu_t = \rho \mu_{t-1} + \varepsilon_t$$

where α and βs are the coefficients to be estimated, ρ is the first order autoregressive parameter, and ε is white noise. The p-values of the coefficients are in parentheses below the coefficients.

Independent Variables (1)	Quoted Bid/Ask Spread (2)	Effective Bid/Ask Spread (3)	Bid Depth (4)	Ask Depth (5)
Intercept	0.34684***	0.21403***	14.64600***	11.05500***
	(0.000)	(0.000)	(0.000)	(0.000)
Non-Boesky Carnation Volume	-0.00001	0.00002	0.01243***	0.00717***
	(0.413)	(0.122)	(0.000)	(0.000)
Non-Boesky Carnation Volume (-1)	-0.00001	-0.00001	0.00279	0.01336
	(0.254)	(0.524)	(0.179)	(0.000)
Non-Boesky Carnation Volume (-2)	-0.00001	0.00000	0.00657***	0.00483***
	(0.156)	(0.842)	(0.001)	(0.007)
Non-Boesky Carnation Volume (-3)	-0.00000	-0.00000	0.00489**	0.00425**
	(0.853)	(0.801)	(0.015)	(0.016)
Boesky-Buying	0.00001	0.00001	0.01896**	0.00991*
	(0.733)	(0.764)	(0.018)	(0.070)
Boesky-Buying (-1)	0.00001	0.00001	0.00555	-0.00050
	(0.727)	(0.793)	(0.488)	(0.943)
Boesky-Buying (-2)	-0.00000	0.00005	-0.00602	-0.00017
	(0.991)	(0.144)	(0.460)	(0.900)
Boesky-Buying (-3)	-0.00001	-0.00002	-0.00006	0.00392
	(0.735)	(0.604)	(0.994)	(0.285)
First Order Autoregression Parameter	0.29521***	-0.16257***	0.36782***	0.40228***
	(0.000)	(0.000)	(0.000)	(0.000)
R^2	0.10	0.04	0.25	0.31

***Significant at the 0.01 level.
 **Significant at the 0.05 level.
  *Significant at the 0.10 level.

illegally obtained inside information. Because of litigation surrounding this event, a detailed record of Boesky's purchases of Carnation's stock was compiled. We use these data to investigate the effect of informed trading on stock price, trading volume, and market liquidity. In keeping with other recent empirical work, we examine both bid/ask spreads and bid and ask depths as proxies for market liquidity.

We find that Boesky's purchases are positively and significantly correlated with daily and hourly changes in Carnation's stock price. When we estimate various lagged regressions, we find no correlation between prior price changes or prior non-Boesky trading volume and Boesky's purchases.

We also examine Carnation's quoted and effective bid/ask spreads and bid and ask depths during the periods of Boesky's trades to determine whether the presence of an informed trader had an adverse effect

Table 10. Regression Analysis of Bid/Ask Spreads, Bid Depths, and Ask Depths of Carnation's Stock with Size-Based Boesky Trades Over the Period January 1, 1984 Through August 31, 1984

In the regression, the dependent variables are the hourly average quoted bid/ask spreads, the hourly average effective bid/ask spreads, the hourly average bid depths, and the hourly average ask depths. The independent variables are the contemporaneous hourly non-Boesky Carnation trading volume and the contemporaneous size-based hourly Boesky-buying volume. The regression procedure used is the two-stage Cochrane-Orcutt method given by

$$y_t = \alpha + \sum_i \beta_i x_{it} + \mu_t \,; \; \mu_t = \rho\mu_{t-1} + \varepsilon_t$$

where α and βs are the coefficients to be estimated, ρ is the first order autoregressive parameter, and ε is white noise. The p-values of the coefficients are in parentheses below the coefficients.

Independent Variables (1)	Quoted Bid/Ask Spread (2)	Effective Bid/Ask Spread (3)	Bid Depth (4)	Ask Depth (5)
Intercept	0.3419***	0.2125***	17.2970***	15.7090***
	(0.000)	(0.000)	(0.000)	(0.000)
Non-Boesky Carnation Volume	-0.0000	0.0000	0.0125***	0.0044**
	(0.366)	(0.114)	(0.000)	(0.014)
Boesky-Buying Small[a]	-0.0015	-0.0023	-0.2235	0.0477
	(0.687)	(0.551)	(0.750)	(0.911)
Boesky-Buying Medium[b]	0.0002	0.0003	-0.0019	0.0163
	(0.180)	(0.120)	(0.901)	(0.600)
Boesky-Buying Large[c]	-0.0001	-0.0000	0.0290***	0.0101**
	(0.227)	(0.524)	(0.004)	(0.025)
First Order Autoregressive Parameter	0.2998***	-0.1610***	0.3940***	0.4679***
	(0.000)	(0.000)	(0.000)	(0.000)
R^2	0.11	0.04	0.23	0.26

***Significant at the 0.01 level.
 **Significant at the 0.05 level.
[a]The "Boesky-buying small" variable is the sum of the orders entered for 100-400 shares of Carnation stock by Boesky during the hour.
[b]The "Boesky-buying medium" variable is the sum of the orders entered for 500-9,900 shares of Carnation stock by Boesky during the hour.
[c]The "Boesky-buying large" variable is the sum of the orders entered for 10,000 shares of Carnation stock by Boesky during the hour.

on market liquidity. We find little (or no) evidence that Boesky's trades had any adverse effect on spreads in Carnation's stock—not even during the hours in which Boesky traded most heavily and not even during the hours when he entered his largest trades. Similarly, we find that Boesky's trades had no adverse effect on either bid or ask depth. Indeed, to the extent that Boesky's trades had any effect on depths, his trades appear to have increased both bid and ask depth. It also appears to be the case that Boesky's trading attracted non-Boesky trading volume—on the days on which Boesky traded, total trading volume was twice as great as on the days on which Boesky did not trade. Furthermore, Boesky's trades accounted for about 50% of the incremental trading volume and non-Boesky trades accounted for the remaining 50% of the incremental volume on these days.

The virtue of analyzing a specific case such as Boesky's trading in Carnation is that data can be examined microscopically. The disadvantage is the uncertainty as to whether the results can or should be generalized to a larger population or to a different time period. It remains to be seen if other studies using similar data on insider trading episodes uncover results similar to the ones reported here. ■

References

Admati, A.R. and P. Pfleiderer, 1988, "A Theory of Intraday Patterns, Volume and Price Variability," *Review of Financial Studies* (Spring), 3-40.

Bagehot, W., 1971, "The Only Game in Town," *Financial Analysts Journal* (March), 12-14.

Barclay, M.J. and J.B. Warner, 1993, "Stealth Trading and Volatility: Which Trades Move Prices," *Journal of Financial Economics* (December), 281-305.

Copeland, T. and D. Galai, 1983, "Information Effects and the Bid-Ask Spread," *Journal of Finance* (December), 1457-1469.

Cornell, B. and E. Sirri, 1992, "The Reaction of Investors and Stock Prices to Insider Trading," *Journal of Finance* (September), 1031-1059.

DeLong, B., A. Shleifer, L.H. Summers, and R. Waldmann, 1990, "Noise Trader Risk in Financial Markets," *Journal of Political Economy* (August), 703-738.

Easley, D. and M. O'Hara, 1987, "Price, Trade Size and Information in Securities Markets," *Journal of Financial Economics* (March), 69-90.

Garfinkel, J.A. and M. Nimalendran, 1995, "Market Structure and Trader Anonymity: An Analysis of Insider Trading," University of Florida Working Paper.

George, T.J., G. Kaul, and M. Nimalendran, 1991, "Estimation of the Bid-Ask Spread and Its Components: A New Approach," *Review of Financial Studies* (Winter), 623-656.

Glosten, R.L. and P.R. Milgrom, 1985, "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders," *Journal of Financial Economics* (March), 71-100.

Green, J.T. and S.G. Watts, 1996, "Price Discovery on the NYSE and the NASDAQ: The Case of Overnight and Daytime News Releases," *Financial Management* (Spring), 19-42.

Harris, L., 1990, "Liquidity, Trading Rules and Electronic Trading Systems," Monograph Series in Finance and Economics, New York University.

Kyle, A.S., 1985, "Continuous Auctions and Insider Trading," *Econometrica* (November), 1315-1336.

Lee, C.M.C., B. Mucklow, and M.J. Ready, 1993, "Spreads, Depths, and the Impact of Earnings Information: An Intraday Analysis," *Review of Financial Studies* (Summer), 345-374.

Meulbroek, L., 1992, "An Empirical Analysis of Illegal Insider Trading," *Journal of Finance* (October), 1661-1699.

Roll, R., 1984, "A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market," *Journal of Finance* (August), 1127-1139.

Sivakumar, K. and G. Waymire, 1994, "Insider Trading Following Material News Events: Evidence from Earnings," *Financial Management* (Spring), 23-32.

Stoll, H., 1989, "Inferring the Components of the Bid-Ask Spread: Theory and Empirical Tests," *Journal of Finance* (March), 115-134.