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Author(s): Charles Cao, Hyuk Choe, Frank Hatheway
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Does the Specialist Matter? Differential Execution Costs and Intersecurity Subsidization on the New York Stock Exchange

CHARLES CAO, HYUK CHOE, and FRANK HATHEWAY*

ABSTRACT

This article tests for differences in execution costs among specialist firms for New York Stock Exchange listed securities. Execution cost differences provide a measure of the relative performance of specialist firms. We find a substantial difference in effective spreads and order processing costs across specialist firms, controlling for stock characteristics. While economically significant, the differences in execution costs between specialist firms are much smaller than the cross-market differences reported by Huang and Stoll (1996). Within a specialist firm, there is a positive relation between order processing costs and trading activity that is consistent with the hypothesis that active stocks subsidize inactive stocks.

THIS ARTICLE INVESTIGATES WHETHER differential execution costs exist across New York Stock Exchange (NYSE) specialist firms and among stocks traded by the same specialist firm. Execution costs are paid by investors when completing a trade, and are separate from the commission costs paid to a broker. Execution costs arise from the bid-ask spread and the price impact of an investor's order on the future bid-ask quote. Stoll (1985) shows that a transactionally efficient financial market which minimizes execution costs also minimizes the deviation in transaction prices from the true price of the underlying security. Evidence of differential execution costs for similar securities can be used to identify high cost and low cost liquidity providers on the NYSE. Furthermore, differential execution costs among stocks traded by the same specialist firm provide evidence consistent with a subsidy from actively traded to inactively traded stocks.

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This article focuses on the effective spread for stocks listed on the NYSE. The effective spread is estimated using the microstructure model of Glosten and Harris (1988). The components of the effective spread include order processing costs, which are established by the specialist firm, and asymmetric information costs, which are determined by the information characteristics of the stock.

The first academic article to address the role of specialist firms is the proposal of Barnea (1974) for comparing NYSE specialists based on stock volatility. Recently, Corwin (1996) finds that transitory volatility and trading continuity differ across specialist firms. Additionally, Coughenour and Deli (1996) report that inventory holding costs are associated with the organizational form of the specialist firm. Our article explores the importance of the identity of the specialist firm using several measures of execution costs. We use a cross-sectional regression analysis and a matched sample comparison to control for differences in the stocks assigned to a specialist firm.

Our primary finding is that execution costs differ significantly across specialist firms after controlling for stock specific characteristics. The average effective spread for the 40 specialist firms is estimated to be 9.7 cents per share with a standard deviation of 0.6 cents. The 90th percentile and the 10th percentile effective spreads are 10.68 and 8.64 cents per share with this difference significant at the 5 percent level. This represents a cost difference to investors of over $4.1 million per year based on an average daily volume of 68,600 shares across the 23 stocks assigned to the 90th percentile specialist firm.[1] The result indicates that there may be differences in efficiency and/or profitability across NYSE specialist firms. While the 2 cent per share difference in execution costs across specialist firms is economically significant, it is dramatically smaller than the 22 cent per share difference reported by Huang and Stoll (1996) between stocks on the NYSE and stocks on the National Association of Security Dealers Automated Quotation (Nasdaq) system. Thus, differences in market structure impose much higher costs relative to differential efficiencies in specialist firms.

For stocks traded by the same specialist firm, the order processing costs associated with providing liquidity, intuitively the noninformational costs of trading, are higher for actively traded stocks. Among 40 specialist firms, 37 firms show a positive relation between order processing costs and the number of trades in the stock, of which 21 are significant at the 5 percent level. This implies that, all else equal, the more actively a stock trades, the greater is the execution cost paid by investors in that stock on a per share basis. The evidence is consistent with the existence of a cross-subsidy from actively traded stocks to inactively traded stocks within a specialist firm.

While we do not formally test for a subsidy, our finding that the costs paid by investors for executing trades increase in trading frequency is consistent with prior beliefs. Easley, Kiefer, O'Hara, and Paperman (1996) note that inactive stocks are assigned to specialists as part of a portfolio of stocks with

[1] 1.02 cents $\times$ 68,600 shares/day $\times$ 256 days $\times$ 23 stocks = $4,120,000.

the understanding that frequently traded stocks will subsidize infrequently traded ones.

The structure of the article is as follows. Section I discusses the institutional background of the NYSE specialist firms. Section II develops the testable hypotheses, and Section III describes the data. In Section IV, we present the microstructure models used to estimate the effective spread and its components. Section V presents empirical estimates of execution costs, evidence of differential costs across specialist firms, and the nature of differential costs for stocks assigned to each specialist firm. Section VI concludes.

I. Institutional Background

The sole responsibility for making a market (establishing bid and ask prices) in NYSE listed securities is assigned to one NYSE member firm by the Allocation Committee of the NYSE. A specialist firm typically is assigned many common stocks, from 12 to several hundred. Under the rules of the NYSE, the specialist firm accepts an obligation to maintain a "continuous and orderly" market in the stock in return for the informational benefits of a permanent presence at the apex of NYSE trading in that stock. Such an obligation may force the specialist firm to subsidize unprofitable stocks with profitable, actively traded issues.

The NYSE sets several performance criteria for a specialist firm. Four of these are stressed in the NYSE's report on market quality and performance, and included in the *New York Stock Exchange Fact Book* (1993): (1) Price continuity: Minimize successive price changes. A change of \$⅛ or less occurs on 97 percent of all trades. (2) Quotation spreads: Minimize the difference between the quoted bid and asked prices. A difference of \$¼ or less occurs on 89 percent of posted quotes. (3) Market depth: Minimize price changes for trades of 3,000 shares. A change of \$⅛ or less occurs on 88 percent of such trades. (4) Stabilization: Buy on down-ticks and sell on up-ticks. Stabilizing trades are 78 percent of specialist trades. Similar statistics apply for the 1995 data.

In addition, specialists cannot compete with public orders and must allow all public orders on the same side of the market as the specialist to trade at the current price before the specialist can trade at that price. A formal surveillance process determines how well these criteria are satisfied. Allocation decisions are influenced by the surveillance reports as well as by subjective factors.[2] It is uncommon for the NYSE to reassign a stock based on the failure of the existing specialist firm to fulfill its responsibilities. Indeed, only two reassignments have occurred in the past five years. Finally, although a specialist firm can request the withdrawal of its specialist registration merely by writing to the NYSE's Allocation Committee, no specialist firm in recent memory has

[2] A complete list of the allocation criteria is provided in *New York Stock Exchange Policy and Procedures*, 1995.

done so. In practice, specialist firms are discouraged from surrendering assigned stocks even though they are unprofitable.

Meeting the performance criteria of the NYSE may be costly since the specialist is mandated to provide liquidity at times when other traders decline to do so. Therefore, the specialist risks incurring undesired, long lived, and potentially costly changes in their inventory as documented by Madhavan and Smidt (1993). Furthermore, the stabilization requirement limits the specialist's ability to run the book (hitting successive bids or taking successive offers) in reaction to new information.

The specialist receives compensation for the NYSE requirements in two ways. First, he observes all the order flow on the NYSE, the identity of submitting brokers, and the contents of the limit order book which provide an informational advantage in trading. Second, the specialist is able to capture the bid-ask spread. Hasbrouck and Sofianos (1993) have documented that both advantages are profitable to specialists with the bid-ask spread being the principle source of income.

Historically, specialist firms were relatively small, independent broker-dealers organized as partnerships or closely held corporations. However, the number of specialist firms has been declining over the years with noticeable decreases around certain events. A spate of acquisitions and consolidations followed the deregulation of commissions in 1975. Most recently, 21 specialist firms have merged, been acquired or otherwise been absorbed since the 1987 stock market crash (*The Wall Street Journal*, July 2, 1992). The current collection of specialist firms includes very small, closely held firms whose only line of business is their specialist activities to financial giants such as Merrill Lynch & Co., Inc.

II. Testable Hypotheses

This section develops three testable hypotheses. The first two address differences in execution costs among specialist firms. The third concerns differences in execution costs for stocks traded within specialist firms. Differences in execution costs between specialist firms can provide evidence of the relative efficiency/profitability of specialist firms. Differences in execution costs for stocks traded by a single specialist firm are consistent with the presence of a subsidy in trade executions.

The first two hypotheses are developed from the implications of existing market microstructure studies. These studies have shown that the bid-ask spread can be decomposed into two components: the order processing component and the asymmetric information component (see Glosten and Harris (1988), Stoll (1989), George, Kaul, and Nimalendran (1991), and Madhavan, Richardson, and Roomans (1994) among others). The order processing component covers costs to the specialist for transaction services and includes the direct costs of handling the order, inventory costs related to financing inventory, exchange seat fees, other fixed costs, and profit. The nature of these costs implies that the costs of transaction services have both a fixed and a variable component. The existing empirical evidence suggests that the inventory cost is small (for example, Hasbrouck (1988), Stoll (1989) and Madhavan and Smidt (1991)). For this reason, we do not distinguish among order processing, other fixed costs, and inventory costs. All costs to investors other than asymmetric information costs are referred to as order processing costs.

The question of whether there are any differences in execution costs across specialist firms is addressed in the first hypothesis. After controlling for differences in stocks' characteristics, **H1** may be stated as:

H1: *The effective spreads per share are equal across specialist firms.*

As indicated, the effective spread consists of both order processing costs and asymmetric information costs, so evidence of differences in the effective spread warrants further analysis of the components of the spread. We focus on differences in the order processing cost component. Since we assume that asymmetric information costs are determined exogenously by such factors as insider holdings, volatility of the stock's cash flows, analysts' research activities, and others, we do not develop a formal hypothesis about asymmetric information costs. After controlling for differences in stocks' characteristics, **H2** may be stated as:

H2: *Order processing costs per share are equal across specialist firms.*

Differential order processing costs provide evidence of the relative efficiency and/or profitability of specialist firms. As argued previously, order processing costs consist primarily of internal costs (a measure of specialist firm efficiency) and profit. Under an assumption of zero economic profit, two equally efficient specialist firms would have similar order processing costs. If there are no entry/exit barriers in the market for trade executions, then only efficient specialist firms will survive in the long run and all specialist firms should have similar order processing costs. On the other hand, if we assume specialists are equally efficient, then two equally profitable specialist firms would have similar order processing costs. Therefore, the zero economic profit assumption for all specialist firms implies that there should not be differences in order processing costs due to differences in trading skill, organizational structure, or other attributes of the specialist firm. Jointly, under the equal efficiency and zero economic profit assumptions, the only source of differential order processing costs should be factors associated with the stock. The identity of the specialist firm should have no impact.

A rejection of **H2** would be important because differential order processing costs across specialist firms is consistent with costs attributable to the specialist firm affecting the costs to investors. A rejection of the hypothesis is a rejection of the joint hypotheses of equal efficiency and zero economic profit for specialist firms. Determining the relative importance of efficiency and profit in explaining the differences across specialist firms would require unavailable internal information about the costs and profits of specialist firms and is beyond the scope of this article. However, some insight into the relative impacts of efficiency and profit on order processing costs can be gained by asking whether there are differences in order processing costs for the stocks assigned to a single specialist firm.

From the specialist firm's perspective, the internal costs of completing a trade should be decreasing in trading volume as suggested by Stoll (1985) because of economies of scale in transactions. For a given stock, if there are no economies of scale in trading then the internal cost should be the same for all stocks assigned to the firm as each trade requires the same combination of inputs. If there are economies of scale in trading a given stock, then active stocks should have lower internal costs than inactive stocks. The internal costs of the specialist firm cannot be directly observed. However, order processing costs include all the internal costs to the firm along with the firms' gross profit. Therefore, under the joint hypotheses that there are no diseconomies of scale and profits are equal across stocks, **H3** is stated as:

H3: *Low trading frequency stocks should have per share order processing costs equal to or greater than high trading frequency stocks.*

A rejection of **H3** would be consistent either with diseconomies of scale within a specialist firm or with differences in profit among the stocks assigned to a specialist firm. Because diseconomies of scale are unlikely, we conclude that there are profit differences across stocks traded by a specialist firm. The presence of differential profits across stocks for NYSE specialist firms is explicit in the premise of Grossman and Miller (1988) and Easley, Kiefer, O'Hara, and Paperman (1996). They conjecture that specialist firms subsidize trading in inactive stocks with revenues from active ones. If there are profit differences across stocks within a specialist firm, then these differences may contribute to the rejection of **H2** as well. In Section V, we develop the implications of consumer subsidies for the market for trade executions on the NYSE and present evidence that such subsidies exist.

III. Data

A. Specialist Data

We use the NYSE *Specialist Directory* for April, 1993 to identify the NYSE listed security assigned to each specialist firm. The directory lists, by symbol, all stocks that were traded on the NYSE at the start of each quarter. Associated with each stock is a numeric code for each of the specialist firms used in this sample.

B. The Transactions Data

We use intraday transactions data for the period March 1, 1993 to May 31, 1993 to study the execution costs at the stock level. The initial transactions data consist of all trades and quotes for all NYSE stocks that exist on the Trade and Quote (TAQ) database. There are 1,811 common stocks on both the TAQ and *Specialist Directory* data sets. Trades and quotes flagged as opening, errors, nonstandard delivery trades, as well as all Best Bid/Offer (BBO) ineligible quotes are eliminated.[3]

We construct a subsample of available stocks by selecting those stocks that satisfy the following criteria. (i) There must be at least 26 valid weekly return observations in the Center for Research in Security Prices (CRSP) stocks files for the one-year period prior to March 1, 1993. (ii) Any stock delisted by the NYSE during the period from March 1 to May 31, 1993 is excluded from the sample. (iii) The average stock price from the CRSP stock files in the one-year period prior to March 1, 1993 is between \$3 and \$200.[4] (iv) Stocks with less than 300 transactions during the three months sample period are dropped. The application of criteria (i) and (ii) results in the elimination of 122 (6.7 percent) stocks, criteria (iii) and (iv) eliminate 29 (1.6 percent) and 116 (6.4 percent) of the initial stocks respectively. The final sample contains 1,544 stocks.

Panel A of Table I provides summary statistics organized by specialist firm for the total number of common stocks assigned to each firm, the number of these stocks in our sample, and summary statistics of several relevant factors including those for variables used in the analysis. On average, there are 53 common stocks assigned to each specialist firm of which 39 stocks remain in our sample. The smallest specialist firm in the sample has 7 of 14 common stocks remaining. Table I also reports the industry coverage measured by the number of two digit Standard Industrial Classification (SIC) codes for stocks assigned to the specialist firm, and a measure of excess industry concentration based on the first two digits of the SIC codes. The average number of industries represented in the sample for each specialist firm is 19. The average specialist firm is 10.2 percent more concentrated than the NYSE floor in its most heavily represented industry. Of the 40 firms, three have maximum concentration measures that are statistically significant at the 5 percent level. This suggests that specialist firms do not specialize in stocks of a certain industry. The stocks handled by each specialist firm are generally well diversified.

Panel B of Table I presents summary statistics for variables used in the analysis for the 1,544 sample stocks. A comparison of Panel B to the summary statistics for the 2,041 common stocks listed on the NYSE as of March 1, 1993 indicates that the sample is representative of all common stocks traded on the NYSE. For example, the NYSE averages for market value, shares outstanding, and average price for all common stocks are \$1,812 million, 53 million, and \$27.23, respectively. For our sample, the average market value, shares outstanding and share price are \$2,305 million, 64 million, and \$24.71, respectively.

[3] BBO-ineligible quotes are closing quotations, trading halts, preopening indications, and nonfirm quotations. Trades which are in sequence but are reported late are retained in the data set. The impact of these observations is expected to be small since only a tiny fraction of the observations (0.02 percent) in the sample falls into this category.

[4] For low price stocks, the minimum price increment of \$0.125 may distort the analysis. For high price stocks, the large quoted spread (over \$100 for Berkshire-Hathaway) may also create distortions. Therefore, we drop both high and low price stocks.

Table I

Trading Characteristics of the 1,544 New York Stock Exchange (NYSE) Stocks

Panel A presents summary statistics by specialist firm for the number of common stocks assigned, the number of stocks in our sample, market value, shares outstanding, fraction of regional trades, price, weekly standard deviation, number of trades, trade size, beta, industry coverage, and industry concentration for the 1,544 stocks in our sample. *Market Value* is the average market capitalization calculated as the product of the shares outstanding reported as of February 28, 1993 times the average daily price for the one-year period prior to March 1, 1993. *Regional* is the average fraction (%) of trades that were executed on exchanges other than the NYSE during the period from March 1 to May 31, 1993. *Price* is the average daily price in the one-year period prior to March 1, 1993. *SD* is the average weekly standard deviation of the stock returns for the one year period prior to March 1, 1993. *Daily Trades* is the average number of trades that occurred per assigned stock on the NYSE during the period from March 1 to May 31, 1993. *Trade Size* is the average NYSE share volume per trade. *Beta* is the average beta estimated from weekly stock returns using the market model. *Ind. Cov.* is the number of industries, from two digit SIC code classifications, covered by each specialist firm. *Ind. Con.* is the maximum excess industry concentration. For industry i and specialist firm j, the excess industry concentration is defined as $((\%\ of\ stocks\ in\ SIC_i)_j - (\%\ of\ stocks\ in\ SIC_i)_{NYSE})$. For each specialist firm, we report the largest excess industry concentration. The critical values of the test statistic for a null of no over concentration are based on simulations. We use a simulation to compute the p-value corresponding to the maximum excess concentration statistics for each of the specialist firms. In each round of the simulation, we preserve the number of NYSE stocks and the industry distribution of the NYSE population. Then, all 1,544 stocks are randomly assigned to all specialist firms, where the number of stocks assigned to a firm is preserved from the actual data. Finally, we calculate the maximum excess concentration statistic for each firm. By repeating the above procedure 10,000 times, we obtain the empirical distribution of the maximum excess concentration statistics and critical values for the test. The technique is similar to that of Stoll (1985). Panel B reports summary statistics for the 1,544 stocks.

	Total Common Stocks	Stocks in Sample	Market Value ($mil.)	Shares (mil.)	Regional (%)	Avg. Price ($)	SD (%)	Daily Trades	Trade Size (Shares)	Beta	Ind. Cov.	Ind. Con. (%)
Panel A: 40 Specialist Firms												
ABD-NY, Inc.	25	17	241	19	28.1	12.79	4.66	21	1923	0.86	9	20.6
Adler, Coleman & Co. L.P.	75	53	1664	53	28.0	22.29	4.30	57	2061	0.90	25	7.8
Bear Specialist/Hunter Specialist	56	44	1678	54	33.4	23.64	4.39	48	2458	1.20	23	6.3
Benjamin Jacobson & Sons	58	43	2991	84	27.5	27.43	4.36	84	2146	0.95	20	7.1
Benton, Corcoran, Leib & Co.	28	21	1172	52	36.1	20.99	2.74	36	1472	0.48	5	46.1**
Bocklet & Co.	40	28	1691	55	32.5	22.15	4.47	59	2012	1.14	13	8.9
Buttonwood Specialist, L.P.	21	14	709	30	35.3	18.37	4.70	40	1704	0.88	11	17.2
Corroon, Lichtenstein & Co.	39	29	1107	40	34.9	19.78	5.39	42	2511	1.30	18	9.6
Einhorn & Co.	31	21	2668	74	30.1	23.29	4.42	54	1997	1.19	15	7.9
Equitrade Partners	38	28	2528	61	27.3	27.01	4.00	59	2126	1.01	14	6.5
Ernst & Co./Ware & Keelips/Homans	46	37	4464	94	35.2	24.55	4.00	67	2088	0.80	20	4.8

Fagenson & Company, Inc.	63	46	2022	68	32.7	20.07	3.87	54	1522	0.82	23	5.2
Fernandez, Bartsch & Mirra	37	34	1928	48	28.5	22.20	4.32	52	1656	1.05	18	7.9
Foster, Marks, Natoli, Safir L.P.	34	23	2234	68	36.6	26.10	4.63	67	2069	1.04	14	7.5
Fowler, Rosenau & Geary L.P.	59	41	3861	82	29.2	31.21	4.09	69	2342	0.84	23	6.3
Gavin, Benton & Co.	52	35	947	35	34.4	19.92	4.21	41	1663	0.94	16	10.8
Henderson Brothers, Inc.	103	71	2038	57	28.6	26.63	4.07	60	1970	0.95	29	3.8
JJC Specialist Corp.	121	83	2443	57	31.8	24.26	3.93	44	1915	0.93	27	5.4
LaBranche & Company	100	72	2746	73	25.5	23.93	4.29	72	1999	0.96	30	3.3
Lawrence, O'Donnell, Marcus & Co.	63	46	2214	61	28.0	27.13	4.47	61	1917	1.01	24	4.7
Marcus, Schloss & Co., Inc.	22	15	3184	83	36.2	31.52	4.06	80	2657	0.93	10	6.1
Mercator Partners	83	56	2391	73	29.4	25.13	3.91	64	2084	1.01	31	16.5
Merrill Lynch Specialist, Inc.	85	60	3052	81	30.4	24.91	4.39	69	1520	1.06	31	4.9
MMS & N	81	64	2408	73	28.0	26.66	3.61	59	1922	0.83	26	4.4
M.J. Meehan & Co.	48	35	5089	151	34.1	29.06	3.99	99	2698	1.01	20	5.6
Nick, Lyden & Co.	40	25	1331	65	34.3	22.89	3.78	38	2287	0.88	15	7.4
Purcell, Graham/R. Adrian/Frost	14	7	2599	106	34.0	19.72	5.56	89	1600	1.37	6	26.7
RPM Specialist Corp.	87	65	3361	70	27.4	29.68	3.76	78	1667	0.89	29	4.0
RSF Partners	39	34	1341	41	28.4	20.60	4.31	40	1650	0.87	21	4.9
Scavone, McKenna, Cloud & Co.	37	23	1226	37	29.5	32.85	3.36	36	1512	0.75	17	6.2
Scholl & Levin Corporation	12	9	4609	103	40.5	36.40	2.36	85	1827	0.78	4	35.3**
Spear, Leeds & Kellogg	216	168	2117	59	31.0	25.57	4.15	55	1958	0.89	48	2.1
Stern Brothers	47	34	2914	82	29.8	28.68	4.49	63	2143	1.05	21	9.6
Stern & Kennedy	33	23	1611	44	32.3	22.98	5.77	50	2209	1.07	11	15.5
Stuart, Scotto, Cella Company	17	15	746	35	34.8	17.68	4.44	30	1817	0.85	11	11.1
Surnamer, Weissman & Co.	28	19	1587	49	30.8	20.94	3.42	54	2022	0.66	12	10.9
Wagner, Stott & Co.	47	37	3580	86	32.2	30.64	3.73	88	1627	0.88	18	8.4
Walter N. Frank & Co.	44	31	1193	46	34.0	20.33	4.22	42	2241	0.80	14	21.3**
Webco Securities, Inc.	33	21	825	43	30.9	14.49	4.78	34	1750	0.48	12	8.1
Weiskopf Silver/Oscar Gruss Inc.	25	17	373	18	31.1	17.77	4.28	26	1625	0.91	9	21.2
			Panel B: 1,544 Stocks									
Mean	NA	NA	2305	64	30.7	24.71	4.15	58	1967	0.93	NA	NA
Std. Dev.	NA	NA	5964	125	14.8	17.32	2.12	86	1115	0.72	NA	NA
Minimum	NA	NA	11	0.5	0.3	3.04	0.80	6	269	−3.42	NA	NA
Quartile 1	NA	NA	208	14	19.7	12.46	2.70	15	1205	0.41	NA	NA
Median	NA	NA	586	29	29.2	20.59	3.80	31	1740	0.85	NA	NA
Quartile 3	NA	NA	1914	67	40.4	32.16	5.27	66	2449	1.37	NA	NA
Maximum	NA	NA	75621	2299	82.5	192.32	18.03	1228	9450	5.41	NA	NA

** Indicate significance at the 5 percent level.
NA: not available.

IV. Estimation of the Spread and its Components

Recently, several microstructure models have been developed to model transaction prices and bid-ask quotes, e.g., Glosten and Harris (GH, 1988), George, Kaul, and Nimalendran (GKN, 1991), Madhavan, Richardson, and Roomans (MRR, 1994), and Huang and Stoll (1995). These models share a similar structure of the price dynamics and the decomposition of the bid-ask spreads. The differences among these models are in the assumptions about order flow and expected return.

Since the purpose of this article is to examine execution cost differences among NYSE specialist firms, we are concerned that the results might be sensitive to the choice of microstructure models. Therefore, while we have selected the GH model for the primary analysis, we use an extension of the MRR model as well as the GKN model to cross-validate our results. For ease of exposition, we present the results based on the GH model. The results from using the MRR and GKN models are similar and available from the authors on request. In the following section, we briefly discuss the GH model.

A. The Glosten and Harris Model

The GH model consists of a process of the expected value of the stock price and a process of the bid and ask prices. Consider the price and bid-ask quote generating process for one stock. Let x_t denote a trade indicator where $x_t = 1$ if the trade at t is buyer-initiated, -1 if seller-initiated, and 0 if both buyer- and seller-initiated. Further, let μ_t be the posttrade expectation of the value of the stock conditional on public information and the trade initiation variable x_t. The innovation in beliefs between $t - 1$ and t due to new public information is denoted by ε_t. Let p_t^a and p_t^b be the market maker's ask and bid prices at t, conditional on the trade initiation variable at t. The model with unitary volume can be summarized as:

$$\mu_t = \mu_{t-1} + \theta x_t + \varepsilon_t \tag{1}$$

$$p_t^a = \mu_t + \phi \qquad \text{if} \quad x_t = 1 \tag{2}$$

$$p_t^b = \mu_t - \phi \qquad \text{if} \quad x_t = -1. \tag{3}$$

In equation (1), θ is the sensitivity of the posttrade expectation to the order flow. In other words, θ measures the costs of information asymmetry on a per share basis. In equations (2) and (3), ϕ denotes the order processing cost per share charged by the market maker. It includes transaction costs, inventory costs, costs for bearing risk, and trading profit. If a trade is not executed at the bid or ask price, it is assumed to be executed at the middle of the bid and ask. Since the minimum price movement is \$1/8, the observed stock price contains rounding errors. To capture such rounding errors, we include an additional random variable ξ_t. Then, the price generating process can be written as:

$$p_t = \mu_{t-1} + \theta x_t + \phi x_t + \varepsilon_t + \xi_t. \tag{4}$$

Thus, the change in the price is given by:

$$p_t - p_{t-1} = (\phi + \theta)x_t - \phi x_{t-1} + \varepsilon_t + \xi_t - \xi_{t-1}. \tag{5}$$

There are two alternative definitions of the effective spread. The first, which Glosten and Harris call the effective spread, is defined as the absolute expected value of a round-trip price change for a sale that immediately follows a purchase or equivalently for a purchase that immediately follows a sale. The measure of the effective spread as the expected execution cost conditional on a purchase followed by a sale is $(1 - P(x_t = 0))(2\phi + \theta)$. If we ignore the possibility that $x_t = 0$ then the effective spread will be $2\phi + \theta$.

An alternative measure of the effective spread, often called the effective half spread, is defined as $|p_t - q_t|$ where p_t is the price at time t and q_t is the midpoint of the bid and ask quotes in effect at t. One advantage of the effective half spread is that it does not depend on any market microstructure model of the spread. Hence, the results from the effective half spread can be used to cross-validate the findings from the market microstructure models. The two measures differ in that the former measures the round-trip cost of trading from a purchase to a sale while the latter measures the cost of a transaction relative to the prevailing quote, without considering the potential price impact on the subsequent trade. As pointed out by Huang and Stoll (1994), the market maker does not realize the effective half spread ($|p_t - q_t|$). For a sequential public purchase and sale, the market maker's realization is reduced by the price impact of the initial trade on the subsequent spread.

B. Estimation

We use the Generalized Method of Moments (GMM) procedure of Hansen (1982) to estimate the parameters. In estimating equation (5) we include a constant term, α, on the right-hand side. For the GH model, θ and ϕ are components of the spread, and σ_ε^2 and σ_ξ^2 are variances of the two error terms. Specifically, let Θ be the vector of the five parameters of interest, $\Theta = (\alpha, \theta, \phi, \sigma_\varepsilon^2, \sigma_\xi^2)$ and define u_t as $u_t = p_t - p_{t-1} - (\phi + \theta)x_t + \phi x_{t-1} - \alpha$ for notational convenience. Consider the following GMM disturbance term

$$f_t(\Theta) \equiv \begin{pmatrix} u_t \\ u_t x_t \\ u_t x_{t-1} \\ u_t^2 - \sigma_\varepsilon^2 - 2\sigma_\xi^2 \\ u_t u_{t-1} + \sigma_\xi^2 \end{pmatrix}, \tag{6}$$

with the corresponding moment restrictions, $E[f_t(\Theta)] = 0$. This system is just identified because the number of parameters equals the number of restrictions.

Table II

Generalized Method of Moments (GMM) Estimates of the Glosten-Harris Model

This table reports cross-sectional distributions of the estimated parameters of the Glosten and Harris model for 1,544 firms. ϕ is the order processing cost per share. θ is the asymmetric information cost per share. The effective spread is the expected round trip cost of trading equal to $(1 - P(x_t = 0)) \cdot (2\phi + \theta)$ where $P(x_t = 0)$ is the probability of a trade executed at the middle of the bid and ask prices. The effective half spread is calculated as the average of $|p_t - q_t|$ where p_t is the price at time t and q_t is the midpoint of bid and ask quotes in effect at t. The implied spread is the difference between implied bid and ask prices and is equal to $2(\phi + \theta)$. The quoted spread is the spread observed from posted bid and ask prices. Panel A reports summary statistics for the 40 specialist firms. Panel B reports summary statistics for the 1,544 stocks.

	ϕ (cent)	θ (cent)	$\frac{\phi}{\text{Avg. price}}$ (%)	$\frac{\theta}{\text{Avg. price}}$ (%)	Effective Spread (cent)	2 × Effective Half Spread (cent)	Implied Spread (cent)	Quoted Spread (cent)
Panel A: 40 Specialist Firms								
Mean	5.2	1.9	0.33	0.10	9.7	13.4	14.0	21.0
Std. Dev.	0.3	0.3	0.07	0.03	0.6	1.0	0.8	1.7
Minimum	4.3	1.2	0.16	0.06	8.3	11.5	12.4	17.8
Quartile 1	4.9	1.7	0.28	0.09	9.3	12.7	13.4	19.6
Median	5.2	1.9	0.33	0.10	9.8	13.6	14.0	21.0
Quartile 3	5.3	2.2	0.38	0.11	10.4	14.0	14.6	22.1
Maximum	5.7	3.0	0.48	0.21	11.1	15.8	15.4	25.5
Panel B: 1,544 Stocks								
Mean	5.2	1.9	0.32	0.10	9.7	13.4	14.1	20.8
Std. Dev.	0.8	1.5	0.25	0.10	1.7	3.1	2.7	5.5
Minimum	0.8	0.0	0.03	0.00	4.6	7.0	7.3	12.5
Quartile 1	4.6	0.8	0.16	0.04	8.5	11.4	12.2	16.8
Median	5.2	1.6	0.25	0.07	9.5	12.5	13.4	19.9
Quartile 3	5.7	2.6	0.41	0.14	10.6	14.8	15.4	24.2
Maximum	7.8	13.3	1.76	1.15	18.7	35.2	32.0	52.2

V. Results

A. Parameter Estimates

The GMM estimates are presented in Table II. For Panel A, the parameter values for 1,544 stocks are first averaged across all stocks assigned to a specialist firm and summary statistics are then provided using the 40 specialist firm averages. The mean value of ϕ, the measure of order processing costs, is 5.2 cents per share, and ranges between 4.3 and 5.7 cents per share. For θ, the asymmetric information costs, the lowest value among 40 specialist firms is 1.2 and the highest value is 3.0 cents per share. The estimated mean is 1.9 cents per share. The mean estimate for the effective spread is 9.7 cents, with the range lying between 8.3 and 11.1 cents per share. While a 2.8 cents difference is economically significant, it is substantially smaller than the 21.6 cents difference between the NYSE and Nasdaq stocks reported by Huang and

Stoll (1996). Thus, the structural differences across markets appear to dwarf the differences within an auction market.

The effective half spread is calculated using the price and quote data from TAQ. For comparability, we report the effective half spread multiplied by two. The average of 2 × effective half spread is 13.4 cents, which is higher than the average effective spread, 9.7 cents, estimated from the GH model. Since a number of factors may affect the costs of trading a stock, we now turn to cross-sectional regressions to evaluate cost differences among specialist firms.

B. Importance of the Specialist Firm

Our analysis builds on cross-sectional studies of the spread (see Glosten and Harris (1988), Stoll (1989), Harris (1994), and Lin, Sanger, and Booth (1995)). Specifically, we regress measures of execution costs on specialist firm indicator variables and stock-specific characteristics. Since there are 40 specialist firms, we create 39 indicator variables to represent each specialist firm and choose Merrill Lynch Specialist, Inc. (henceforth Merrill Lynch), a large, well capitalized firm, as the benchmark. The effect of each specialist firm on execution costs is measured relative to the benchmark.[5]

The independent variables include trade size, average number of trades, relative trading frequency on regional exchanges, average stock price, and the volatility of the stock return. These factors have been identified to be important by previous empirical work, and also are very close to the four characteristics selected by the NYSE as part of its new *Near Neighbor Analysis* to assess specialist performance.[6] Including additional potential measures of risk, the market beta, book-to-market ratio, and asset-to-market ratio, does not affect the results. Another important factor is the specialist participation rate. Since it is not publicly available, we use explanatory variables found by Madhavan and Sofianos (1994) to be associated with specialist participation rates. The variables include block turnover, nonblock turnover, a dummy variable for whether the stock is traded on the Intermarket Trading System (ITS), and a dummy variable for whether the stock is a closed-end fund (CEF).

Next, we discuss the anticipated relationship between the measures of the effective spread and the explanatory variables. The effective spread is predicted to be negatively related to trade size and number of trades as the fixed costs of execution are spread over a larger number of shares or a larger number of trades for a stock. The quoted spread should decrease with regional trading activity since competition forces specialists to quote a tighter spread. However, the effective spread could either decrease due to competition, or increase due to increased order fragmentation, which reduces the probability of a crossing trade. Harris (1994) shows that the quoted spread increases with the price

[5] We also rotate the benchmark firm among the 40 specialist firms and find the results are similar.

[6] The NYSE selected characteristics are daily nonblock volume, daily price, market value of the number of shares available for trading that are not closely held (the float), and daily high-low range as a percent of opening price for a measure of volatility.

level. Since the spread measures are related, the two effective spread measures are also expected to be increasing with the price level. All three spreads should increase with the risk of a stock because the asymmetric information cost is higher for riskier stocks. Taking the specialist participation rate as a whole, a greater participation rate implies that a specialist is more aggressive in competing with limit orders. Therefore, the spread is negatively related to the participation rate. Madhavan and Sofianos (1994) show that nonblock turnover is positively associated with participation rates while block turnover, ITS, and CEF are negatively associated with participation rates. Therefore, nonblock turnover should be negatively associated with the spread and the coefficients on block turnover, ITS, and CEF should all be positive.

These predictions generally apply to the components of the spread but with two exceptions. First, order processing costs could be positively or negatively related to regional trading activity. Greater competition from regional exchanges could cause the specialist to be more efficient or reduce his profits and thus lower order processing costs. On the other hand, higher order processing costs on the NYSE may enable regional exchanges to attract more order flow. Second, order processing costs are not directly related to risk, so there is no prediction for standard deviation.

The regression model estimated is

$$Y_i = \alpha_0 + \sum_{k=1}^{39} \alpha_k I_{k,i} + \beta_1 \text{Log(Trade size)}_i + \beta_2 \text{Log(NTrade)}_i \qquad (7)$$

$$+ \beta_3 \text{Regional}_i + \beta_4 \text{Log(Price)}_i + \beta_5 SD_i + \beta_6 \text{Block}_i$$

$$+ \beta_7 \text{NonBlock}_i + \beta_8 \text{ITS}_i + \beta_9 \text{CEF}_i + \eta_i,$$

where the subscript i refers to the ith stock and

Y = order processing cost, effective spread, 2 × effective half spread, and quoted spread,
I_k = specialist firm indicator variable ($k = 1, 2, \ldots, 39$),
Log(Trade size) = the log of average share volume per trade executed on the NYSE,
Log(NTrade) = the log of the daily average number of trades on the NYSE,
Regional = the number of trades occurring on regional exchanges expressed as a fraction of the total number of trades,
Log(Price) = the log of the average trade price,
SD = the standard deviation of weekly stock returns from trade prices,
Block = the square root of the ratio of the daily volume of block trades relative to shares outstanding,
NonBlock = the square root of the ratio of the daily volume of nonblock trades relative to shares outstanding,

ITS = a 0/1 indicator variable for whether the stock is traded on the ITS system,
CEF = a 0/1 indicator variable for whether the stock is a closed-end fund.

The specialist firm indicator variable coefficients, α_k ($k = 1, 2, \ldots, 39$), are used to test the null hypothesis that there is no significant difference in order processing costs or the effective spread among 40 specialist firms. After controlling for factors that influence the spread and its components, we expect the α_k's to be equal if there is no difference in costs across specialist firms. The null hypothesis can be stated formally as:

$$H_0: \alpha_1 = \alpha_2 = \cdots = \alpha_{39}.$$

Table III provides a summary of the predicted and actual signs for each regression coefficient.

We now turn to the specific results. For order processing cost, Table IV shows that the null hypothesis of no difference in order processing costs among specialist firms (**H2**) is strongly rejected. The F-statistic is 8.37 with a p-value less than 0.01. The estimated coefficients for the specialist firm indicator variables range from -0.5 to 1.1 cents per share. There are 25 significant coefficients at the 5 percent level. The variations in the indicator coefficients between the 90th and 10th percentiles and the 75th and 25th percentiles are 0.86 cents (16.5 percent of the mean value) and 0.44 cents (8.5 percent) respectively, showing that the results are not driven by one or two firms.

The signs of the coefficients associated with order processing costs are consistent with the expectation except for number of trades. The most interesting result is the positive sign of the estimated coefficient for number of trades. The coefficient estimate is 0.31 and is significant at the 5 percent level. This indicates that order processing costs are higher for actively traded stocks than for thinly traded stocks. We pursue alternative explanations for this finding in Section V.E.[7]

The ordinary least squares (OLS) results for the effective spread show that the null hypothesis of no difference in the effective spread among 40 specialist firms (**H1**) is rejected. The F-statistic is 3.73 and the p-value is less than 0.01. Among 39 indicator coefficients, the difference between the 90th and 10th percentiles is 1.27 cents per share (13.1 percent of the mean value of the effective spread reported in Table II), and the difference between the 75th and 25th percentiles is 0.56 cents (5.8 percent). Thirty-one indicator coefficients are

[7] We do not consider inventory costs in this article. However, it is unlikely that inventory costs can explain the positive relationship between order processing costs and trading frequency. As argued by Ho and Stoll (1981), the number of trades should be negatively related to the inventory cost. Including inventory cost as one component of the spread will make the positive relationship between order processing costs and trading frequency stronger. On the other hand, Madhavan and Smidt (1991) and Hasbrouck and Sofianos (1993) suggest the impact of inventory on the spread is weak at the transaction level.

Table III

Summary of Predicted and Actual Signs for the Test of the Difference in Costs among 40 New York Stock Exchange (NYSE) Specialist Firms Controlling for Firm-Specific Factors and Specialist Participation Rates

This table provides the predicted and actual signs for each regression coefficient. The signs given in the parentheses are the predicted signs, whereas the others are the signs of the estimated coefficients. We use 0 to indicate that theory provides no prediction for the sign of the coefficient or that the estimated coefficient is not significantly different from 0. The equation to be estimated is given as:

$$Y_i = \alpha_0 + \sum_{k=1}^{39} \alpha_k I_{k,i} + \beta_1 \text{Log(Trade size)}_i + \beta_2 \text{Log(NTrade)}_i + \beta_3 \text{Regional}_i + \beta_4 \text{Log(Price)}_i$$

$$+ \beta_5 SD_i + \beta_6 \text{Block}_i + \beta_7 \text{NonBlock}_i + \beta_8 \text{ITS}_i + \beta_9 \text{CEF}_i + \eta_i$$

The subscript i refers to the ith stock. Y is the order processing cost (ϕ), effective spread, 2 × effective half spread, or quoted spread in cents. I_k is the indicator variable for the kth specialist firm ($k = 1, 2, \ldots, 39$). Log(Trade size) is the log of average share volume per trade executed on the NYSE. Log(NTrade) is the log of the daily average number of trades on the NYSE. Regional is the number of trades occurring on regional exchanges expressed as a fraction of the total number of trades. Log(Price) is the log of the average price. *SD* is the weekly standard deviation of stock returns. Block is the square root of the daily volume of block trades relative to shares outstanding. NonBlock is the square root of the daily volume of nonblock trades relative to shares outstanding. ITS is a dummy variable for whether the stock trades on the Intermarket Trading System. CEF is a dummy variable for whether the stock is a closed-end fund. The last four variables, Block, NonBlock, ITS, and CEF, are associated with the specialist participation rate.

Regressors	Order Processing Costs	Effective Spread	2 × Effective Half Spread	Quoted Spread
Log(Trade size)	(−) −	(−) −	(−) −	(−) −
Log(NTrade)	(−) +	(−) −	(−) −	(−) −
Regional	(0) +	(0) +	(0) −	(−) −
Log(Price)	(0) −	(+) 0	(+) +	(+) +
SD	(0) −	(+) −	(+) +	(+) +
Participation rate	(−) −	(−) −	(−) 0	(−) +

significant at the 5 percent level. Furthermore, the signs of the coefficients are as predicted except for standard deviation.

The results for the effective half spread are consistent with those for the effective spread. The F-test again rejects the null hypothesis (**H1**) that there is no difference among specialist firms in the effective half spread, with a p-value less than 0.01. The indicator coefficients show a larger variation across 40 specialist firms than those based on the effective spread, a 1.88 cents (14 percent) difference between the 90th and 10th percentiles, and a 1.21 cents (9 percent) difference between the 75th and 25th percentiles. As the effective half spread is not based on a microstructure model, the very similar results based on the GH model are not likely to be model driven. Since the test results for the effective half spread are similar to those for the effective spread, we use one measure, the effective spread, in subsequent tests.

For completeness, we estimate the model using the quoted spread as the dependent variable. For the specialist indicator variables, the F-statistic is 4.26 and the p-value is again less than 0.01. The coefficient for regional trading is particularly interesting. This result is consistent with the negative relationship between competition and quoted spreads found by McInish and Wood (1992) and the opposite from that obtained for the effective spread. One possible explanation is that competition forces the specialist to narrow the quoted spread to match the best quote available from other exchanges (Battalio, Greene, and Jennings (1995)) but the effective spread is increased by a reduction in crossing trades due to the diversion of order flow away from the NYSE.

C. *Pairwise Comparison*

In this section, we use a pairwise comparison rather than cross-sectional regression as an alternative approach to compare execution costs across 40 specialist firms.[8] Ideally, we would identify a subset of stocks whose characteristics (such as industry affiliation, firm size, average price, risk factors, etc.) are similar across 40 specialist firms, and test for different execution costs across specialist firms. Since there are relatively few stocks in our sample assigned to the smaller firms (for example, seven stocks to Purcell, Graham), we fail to find a meaningful subset of matched stocks across 40 specialist firms. Thus, stocks for a given specialist firm are matched to those for another specialist firm, which results in 1,560 firm pairs (40×39).[9]

We use matching variables similar to those of Huang and Stoll (1996), who compare the execution costs on Nasdaq and the NYSE by matching stocks from the two markets. The matching variables used are the firm size, stock price, the ratio of book to market equity and leverage. Our matching procedure is as follows.

1. Obtain the firm size, the book value of equity, the book value of assets at the end of 1992, and the average price of the stock in 1992. The information is from the CRSP stock files and the COMPUSTAT database. There are 1,269 stocks with data available from all sources.
2. For each stock i, which is assigned to specialist firm k, find the stocks assigned to the matching specialist firm k^* ($k^* \neq k$) whose price is within 20 percent of stock i. These stocks are identified as potential matches, subscripted j. If a match cannot be found, drop stock i.

[8] We are grateful to an anonymous referee for suggesting this approach.

[9] Matching stocks for a specialist firm A to those of another specialist firm B can produce different matched pairs than matching stocks for B to those of A.

Table IV

Test of the Difference in Costs among 40 New York Stock Exchange (NYSE) Specialist Firms Controlling for Firm-Specific Factors and Specialist Participation Rates (Sample Size: 1544 Stocks)

$$Y_i = \alpha_0 + \sum_{k=1}^{39} \alpha_k I_{k,i} + \beta_1 \text{Log(Trade size)}_i + \beta_2 \text{Log(NTrade)}_i + \beta_3 \text{Regional}_i + \beta_4 \text{Log(Price)}_i$$

$$+ \beta_5 SD_i + \beta_6 \text{Block}_i + \beta_7 \text{NonBlock}_i + \beta_8 \text{ITS}_i + \beta_9 \text{CEF}_i + \eta_i$$

The subscript i refers to the ith stock. Y is the order processing cost (ϕ), effective spread, 2 × effective half spread, or quoted spread in cents. I_k is the indicator variable for the kth specialist firm ($k = 1, 2, \ldots, 39$). Log(Trade size) is the log of average share volume per trade executed on the NYSE. Log(NTrade) is the log of the daily average number of trades on the NYSE. Regional is the number of trades occurring on regional exchanges expressed as a fraction of the total number of trades. Log(Price) is the log of the average price. SD is the weekly standard deviation of stock returns. Block is the square root of the daily volume of block trades relative to shares outstanding. NonBlock is the square root of the daily volume of nonblock trades relative to shares outstanding. ITS is a dummy variable for whether the stock trades on the Intermarket Trading System. CEF is a dummy variable for whether the stock is a closed-end fund. The null hypothesis of the F-test is H_0: $\alpha_1 = \alpha_2 = \cdots = \alpha_{39}$. Panel A presents the regression results. Panel B reports the number of indicator variable coefficients significant at the 5 percent level and the difference in cents between the 90th and 10th percentile and the 75th and 25th percentile indicator variable coefficients. Panel C presents results for a simulation of the distribution of the F-statistic and indicator variable coefficients. For the F-statistic and the other statistics for the indicator variable coefficients, we use a simulation similar to that of Stoll (1985) to obtain critical values. Preserving the number of NYSE stocks, the number of stocks assigned to each specialist firm, the values of the dependent and independent variables for each stock, and assigning a new specialist indicator, we run a regression to obtain the statistics for the indicator variables. From 10,000 replications, the empirical distribution of the F-statistics yields the 95 percent critical value. Similarly, we obtain the 95 percent critical values for the number of significant indicator coefficients, the difference between the 90th and 10th percentiles, and the difference between the 75th and 25th percentiles.

Regressors	ϕ (cent)	Effective Spread (cent)	2 × Effective Half Spread (cent)	Quoted Spread (cent)
Panel A: Regression Results				
Intercept	6.97**	15.67**	16.20**	18.01**
Log(Trade size)	−0.87**	−2.03**	−1.65**	−1.58**
Log(NTrade)	0.31**	−0.24**	−1.69**	−2.91**
Regional	0.68**	0.54**	−2.23**	−6.41**
Log(Price)	−0.23**	0.10	2.17**	5.48**
SD	−0.10**	−0.07**	0.17**	0.42**
Block	1.84**	3.27**	1.86**	−0.52
NonBlock	−1.45**	−2.58**	0.90	2.19**
ITS	0.04	−0.74	−0.44	−0.58
CEF	0.39**	0.94**	−0.76**	−3.84**
Adj. R^2	0.39	0.40	0.50	0.69

Table IV—Continued

Regressors	ϕ (cent)	Effective Spread (cent)	2 × Effective Half Spread (cent)	Quoted Spread (cent)
Panel B: Analysis of 39 Specialist Firm Indicator Coefficients				
No. of significant coefficients at 5% level	25	31	23	27
Difference between 90th and 10th percentiles (cent)	0.86	1.27	1.88	3.00
Difference between 75th and 25th percentiles (cent)	0.44	0.56	1.21	2.08
F-statistic	8.37	3.73	4.02	4.26
(p-value)	(<0.01)	(<0.01)	(<0.01)	(<0.01)
Panel C: Simulation Results				
Simulated 95% critical values:				
No. of significant coefficients	7	7	7	7
Difference between 90th and 10th percentiles (cent)	0.43	0.87	1.43	2.03
Difference between 75th and 25th percentiles (cent)	0.21	0.44	0.72	1.02
F-statistic	1.41	1.42	1.41	1.42

** Indicate significance at the 5 percent level.

3. For a potential matching stock j, use the following four matching variables to construct a score statistic:

$$score_{i,j} = \left(\frac{size_i - size_j}{(size_i + size_j)/2}\right)^2 + \left(\frac{price_i - price_j}{(price_i + price_j)/2}\right)^2 + \left(\frac{B/ME_i - B/ME_j}{(B/ME_i + B/ME_j)/2}\right)^2 + \left(\frac{A/ME_i - A/ME_j}{(A/ME_i + A/ME_j)/2}\right)^2 \quad (8)$$

   where *size* is firm size measured by market value, *price* is the average daily stock price, B/ME is the ratio of book to market value of equity, and A/ME is the ratio of book value of assets to market value of equity. Then, select the stock with the lowest score from potential matching stocks as the stock matched with stock i.

4. Repeat steps (2) and (3) for all stocks assigned to a given specialist firm.
5. Repeat steps (2), (3), and (4) for each specialist firm.

Table V reports the t-test results for the difference in order processing costs and the effective spread for each specialist firm using the pairwise comparison approach. There are 39 pairwise comparisons for each specialist firm and we report the number of significant t-statistics. For the difference in order processing costs (effective spread), there are an average of 10 t-tests that are significant at the 5 percent level. For both order processing costs and the

Table V

Pairwise Comparison Approach of the Difference in Trading Costs: *t*-Tests for Each Specialist Firm

We match stocks for a given pair of specialist firms. The matching variables are firm size, average price, the ratio of the book value of equity to market value of equity, and the ratio of the book value of assets to market value of equity. For each pair of specialist firms, we test the null hypothesis that there is no difference in order-processing costs (ϕ), or the effective spreads (Eff. Sprd.) between the matched pairs of stocks using the *t*-test. For each specialist firm, we perform 39 pairwise tests, and report the number of stocks available in the firm, the average number of matched stocks, and the number of significant *t*-statistics (at 5 percent level) among 39 pairwise comparisons for the order processing cost and the effective spread. We conduct a simulation similar to that of Stoll (1985). The result shows that the expected number of significant *t*-statistics for ϕ (effective spread) is 1.97 (2.03) in a random sample. The 95 percent level from the simulation is 3.22 (3.25).

			No. of Sig. *t*-Stats Among 39					No. of Sig. *t*-Stats Among 39	
Specialist Firm	No. of Stocks	Avg. No. of Matched Stocks	ϕ	Eff. Sprd.	Specialist Firm	No. of Stocks	Avg. No. of Matched Stocks	ϕ	Eff. Sprd.
ABD-NY	9	7	3	0	Marcus, Schloss	15	12	5	10
Adler, Coleman	43	23	11	9	Mercator	48	25	10	6
Bear/Hunter	34	21	8	16	Merrill Lynch	46	24	16	20
Benjamin Jacobson	35	22	6	8	MMS & N	50	25	9	10
Benton et al.	8	7	3	1	M.J. Meehan	32	19	7	8
Bocklet	24	17	7	9	Nick, Lyden	17	13	2	4
Buttonwood	13	10	6	5	Purcell, Graham	5	5	7	4
Corroon, et al.	24	17	24	11	RPM	58	26	10	13
Einhorn	16	12	6	16	RSF	28	18	30	10
Equitrade	22	16	6	16	Scavone et al.	18	14	8	12
Ernst	30	20	30	33	Scholl & Levin	8	7	5	4
Fagenson	39	22	16	7	Spear et al.	150	29	17	12
Fernandez et al.	30	20	21	28	Stern Brothers	30	19	11	4
Foster et al.	19	15	18	19	Stern & Kennedy	22	16	14	11
Fowler et al.	33	20	13	6	Stuart et al.	12	9	4	6
Gavin, Benton	25	18	8	9	Surnamer et al.	12	10	5	7
Henderson Brothers	66	27	6	9	Wagner, Stott	30	18	5	12
JJC	68	27	9	9	Walter N. Frank	21	16	9	6
LaBranche	61	26	9	13	Webco	14	10	8	6
Lawrence, et al.	42	23	8	6	Weiskopf Silver	12	10	7	10

effective spread, the number of significant *t*-statistics for each of the 40 specialist firms is much higher than the 95 percent critical value of 3 predicted by simulation. The only exceptions are the effective spreads for ABD-NY, Inc. and Benton, Corcoran, Leib & Co. Both firms are very small specialist firms with few stocks available for comparison testing.

Huang and Stoll (1996) argue that the difference in the costs between the matched pairs may still be attributable to the difference in the characteristics of the stocks if the match is not perfect. To address this problem, we perform another test that is based on the cross-sectional regression for matched pairs of stocks for a given specialist firm:

$$\Delta Y_i = \alpha + \beta_1 \Delta \text{Log(Trade size)}_i + \beta_2 \Delta \text{Log(NTrade)}_i + \beta_3 \Delta \text{Regional}_i + \beta_4 \Delta \text{Log(Price)}_i + \beta_5 \Delta SD_i + \eta_i, \quad (9)$$

where the subscript i refers to the ith stock managed by the specialist firm. Δ is the difference in the variable between the matched pairs of stocks and Y is the order processing cost (ϕ) or the effective spread. The remaining explanatory variables are defined for equation (7).[10] If the constant of the regression model is nonzero, it would provide further evidence that there is a difference in trading costs between the matched stocks. For a meaningful analysis, we require that there are at least seven matched stocks for each pair of specialist firms. Thus, some pairwise comparisons are not possible. There are on average 36 pairwise comparisons for each specialist firm. The result is similar to that reported in Table V and available upon request. For the difference in order processing cost (effective spread), there are an average of 10 (8) t-statistics that are significant at the 5 percent level.

Comparing Tables IV and V, the result of Table IV is much stronger than result of Table V. One potential explanation for the weaker results under the matched-sample approach is that the available number of matched pairs of stocks is small relative to the number of stocks available in the two matching firms. The average sample size (18 stocks) is small because many specialist firms manage only 20 to 30 common stocks.

D. Possible Explanations for Different Execution Costs among Specialist Firms

What might account for the difference in the order processing costs and effective spreads across specialist firms? We offer several conjectures including differences in efficiency, structure, and trading style or philosophy.

Efficiency refers to how the firm organizes its operations including back office functions and banking relationships. All else equal, a less efficient firm should have higher order processing costs. Investors trading with inefficient specialist firms would pay higher costs to complete their transactions.

Related to efficiency are cost differences that reflect differences in the structure of the specialist firms. Some specialist firms are small, privately held partnerships while others are large, well capitalized public corporations. For example, Merrill Lynch earns substantial amounts of interest from the cash balances on its short stock positions. It is able to do this more profitably than smaller firms because Merrill Lynch obtains the equity capital to margin its short stock position at a low cost from its parent company. Smaller specialist firms must finance large stock positions with more costly equity capital ob-

[10] The specialist participation rate variables have been dropped to avoid singularity.

tained either from borrowing or from investment by their partners/shareholders.

Differences in trading styles or philosophies among specialist firms are usually divided into two general categories. Some specialist firms essentially are tick traders and desire a flat book (zero inventory position) by the end of the day. Others are position traders, establishing large speculative inventory positions. Differences in trading styles imply differences in the nature of specialist participation not captured by participation rates. Tick trading firms will be active on both sides of the market but trading relatively small volumes, while position trading firms will be more active and provide greater depth on one side of the market than the other. Since specialist participation is related to execution costs, trading style may explain some of the observed differences.

E. Specialist Pricing and Intersecurity Subsidy

A feature of execution costs within a specialist firm is that order processing costs on a per share basis should be lower for active stocks than for inactive ones. Recall that order processing costs can be interpreted as the noninformational costs paid by investors. Hence, a positive relationship between order processing costs and trading frequency indicates that the costs to investors are higher in the stocks where demand for trade executions is higher.

To test (**H3**) we perform the following regression separately for each specialist firm:

$$\phi_i = \alpha + \beta_1 \text{Log(Trade size)}_i + \beta_2 \text{Log(NTrade)}_i + \beta_3 \text{Regional}_i + \beta_4 \text{Log(Price)}_i + \beta_5 SD_i + \eta_i \tag{10}$$

the subscript i refers to the ith stock for the specialist firm. The independent variables are as defined for equation (7) without those variables associated with specialist participation rates. Under the null hypothesis, the coefficient β_2 should be nonpositive for each specialist firm.

Table VI presents the OLS results. Since we are mainly interested in testing the relationship between trading frequency and order processing costs, we report the β_2 coefficients only. The estimated coefficients of the other explanatory variables are generally consistent with those reported in Table IV. The estimated β_2 coefficients are positive for 37 of the 40 specialist firms. For the 37 positive coefficients, 21 are significant at the 5 percent confidence level. The t-statistic for the mean of the β_2 coefficients is 7.46, which is significantly positive. The evidence suggests that, within each specialist firm, per share order processing costs for active stocks are higher than for inactive stocks.

These results indicate that there are higher costs to investors trading in stocks where there is a higher demand for trade executions. This does not imply that specialist firms act as profit maximizing monopolists. Our result does not indicate whether demand sensitive pricing arises from profit maximization by the specialist, from a natural tendency of trading to concentrate at one point, from regulatory restrictions to market entry, from the minimum

Table VI

Test for Intra-firm Subsidy: Regression for Each Specialist Firm

$$\phi_i = \alpha + \beta_1 \text{Log(Trade size)}_i + \beta_2 \text{Log(NTrade)}_i + \beta_3 \text{Regional}_i + \beta_4 \text{Log(Price)}_i + \beta_5 SD_i + \eta_i$$

ϕ is the order processing cost in cents. Log(Trade size) is the log of average share volume per trade executed on the New York Stock Exchange (NYSE). Log(NTrade) is the log of the daily average number of trades on the NYSE. Regional is the number of trades occurring on regional exchanges expressed as a fraction of the total number of trades. Log(Price) is the log of the average price. SD is the weekly standard deviation of stock returns. The subscripts refer to the ith stock managed by the specialist firm. The result is sorted by the magnitude of the coefficient β_2 and does not correspond to the order in any other table.

Specialist Firm	Log(NTrade)	(*P*-Value)	Specialist Firm	Log(NTrade)	(*P*-Value)
Purcell, Graham	−0.44	(0.17)	Adler, Coleman	0.30	(0.00)
Stuart et al.	−0.26	(0.50)	Merrill Lynch	0.34	(0.00)
Einhorn	−0.04	(0.88)	Bocklet	0.35	(0.04)
Walter N. Frank	0.01	(0.89)	Spear et al.	0.36	(0.00)
Stern Brothers	0.01	(0.96)	Lawrence, et al.	0.39	(0.02)
RSF	0.06	(0.74)	Equitrade	0.39	(0.00)
Marcus, Schloss	0.07	(0.69)	Wagner, Stott	0.40	(0.02)
JJC	0.08	(0.51)	Foster et al.	0.41	(0.12)
M.J. Meehan	0.15	(0.27)	Mercator	0.42	(0.01)
Fernandez et al.	0.16	(0.45)	Stern & Kennedy	0.43	(0.04)
Corroon, et al.	0.16	(0.42)	Ernst	0.44	(0.00)
Henderson Brothers	0.17	(0.07)	MMS & N	0.45	(0.00)
LaBranche	0.18	(0.03)	Scholl & Levin	0.47	(0.02)
Fowler et al.	0.18	(0.17)	Bear/Hunter	0.54	(0.00)
Webco	0.19	(0.29)	ABD-NY	0.54	(0.05)
Scavone et al.	0.22	(0.57)	Weiskopf Silver	0.57	(0.04)
Benjamin Jacobson	0.23	(0.15)	Nick, Lyden	0.60	(0.00)
RPM	0.24	(0.09)	Buttonwood	0.69	(0.02)
Fagenson	0.28	(0.01)	Benton et al.	0.70	(0.00)
Surnamer et al.	0.29	(0.13)	Gavin, Benton	0.71	(0.00)

price increment, or from other factors. However, the fact that specialist firms make markets in many stocks has important implications for the policy debate on increased competition to NYSE specialists.

In the theoretical literature, the existence of interproduct subsidization depends on the presence of strategic substitutes and compliments among the products (see Tirole (1988), p. 70). However, in a regulated market, the regulatory body may require cross-subsidization between products, which may be a desirable social outcome.[11] In the case of NYSE specialist firms, the regulations in question are the market quality measures of the NYSE. As Grossman and Miller (1988) argue, one goal of these criteria is to reduce the specialists' monopoly power in inactive stocks. If NYSE specialists are unable to cover their costs from inactive stocks, then high revenue stocks may subsidize low

[11] Baumol and Willig (1986) argue this point forcefully and show that welfare maximization does not imply the absence of cross-subsidization and vice versa.

revenue stocks. Finally, the presence of a cross-subsidy does not necessarily mean that the total cost to investors is higher than in a competitive market subject to regulatory constraints.

Faulhaber and Levinson (1981) describe two implications of subsidy-free pricing that apply to NYSE specialists. First, if prices are subsidy-free, then no new entrant can provide lower execution costs to a subset of stocks or trades. The NYSE has lost market share to trading alternatives that provide liquidity for small retail orders in active stocks. Recently, Battalio, Greene, and Jennings (1995) report that one alternative, Madoff Securities, is competing on cost. Second, trading in each stock and within each identifiable subset of trades is profitable to the specialist. However, Sofianos (1995) has shown that NYSE specialists do not trade inactive stocks profitably.

Cross-subsidization may also be related to the allocation process. This is because the Allocation Committee uses support for the allocation process as one criterion in allocating new listings. Specialist firms are expected to apply for all potential listings. Furthermore, the institutional culture of the NYSE discourages specialist firms requesting that unprofitable listings be reassigned.

The NYSE may choose to require the cross-subsidization of higher cost stocks for two reasons. First, cross-subsidization may build future demand for liquidity in the low volume stocks. Second, low trading costs for smaller firms may attract more new listings to the NYSE by demonstrating that the costs for investors wishing to trade their securities will be low. As specialist firms also benefit from increased demand for trade executions and from new listings, the goals of the NYSE and of specialist firms are compatible.

Formal tests for cross-subsidy, such as Palmer (1992), require internal cost data for the specialist firm rather than the sum of internal cost and profit estimated as order processing cost. Thus, we leave a rigorous analysis of the presence of a cross-subsidy for future work.

VI. Conclusion

In this article, we document a significant difference in execution costs across specialist firms after controlling for stock-specific characteristics. This result indicates that there may be differences in efficiency and/or profitability for NYSE specialist firms. However, the cost differences between specialist firms are small compared to the cost differences between the NYSE and Nasdaq. Furthermore, we find strong evidence that the order processing costs, which are a proxy for the noninformational costs of trading, are higher for the actively traded stocks assigned to that firm. This finding is consistent with a cross-subsidy from actively traded stocks to inactively traded stocks within a specialist firm.

The existence of specialist firms with relatively low execution costs has implications for the NYSE and regulatory agencies. For the NYSE, low cost specialists may be the most efficient. Less efficient specialists should not be protected from the consequences of being high cost providers of liquidity. From a regulatory perspective, the existence of differential liquidity costs implies that the market for trade executions both on and off the NYSE does not enforce uniform pricing. Furthermore, if active stocks subsidize inactive stocks, the welfare implications of the expansion of non-NYSE trading in active NYSE stocks warrant more careful analysis. An important area for future research is to identify the determinants of differences in execution costs among specialist firms.

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