1998

The Impact of Specialist and Multiple Dealer Market Structures on Intraday Price Formation and Bid-Ask Spread Components.

David Michael Michayluk
Louisiana State University and Agricultural & Mechanical College

THE IMPACT OF SPECIALIST AND MULTIPLE DEALER MARKET STRUCTURES ON INTRADAY PRICE FORMATION AND BID-ASK SPREAD COMPONENTS

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Interdepartmental Program in Business Administration

by

David Michael Michayluk
B.Comm.(Honours), Queen's University at Kingston, 1989
August 1998

UMI Number: 9902652

UMI
300 North Zeeb Road
Ann Arbor, MI 48103

DEDICATION

This body of work is dedicated to the people who influenced my life and who made me the person I am today. Be they family or friends, many individuals have affected the course of my journey. Witnessing my parent's hard work has inspired my own perseverance and efforts at finding challenges. I also share their appreciation for adventure. These two traits are each attributable to one set of grandparents. My paternal grandparents worked inconceivable hours farming and living off the land. My mother's parents were not content to retire from teaching and logging, and they subsequently volunteered to teach in Africa for what ended up being twelve years of adventure.

My wide circle of friends has given me much needed support at crucial steps in my life and for their assistance I am grateful. There are also those that provided indirect guidance by sharing their experiences and letting me learn from their mistakes. This dissertation is a product of those impressions as well.

The influence of religion has often been subtle, but various teachings have provided lighting along my path. Often the illumination has been the brightest when I have been farthest from the route I intended to take.

The culmination of my degree is this dissertation, but the journey itself has been the true reward. To everyone who has helped along the route and in the preceding trails, this dissertation is dedicated to you.

ACKNOWLEDGEMENTS

I am extremely grateful to Dr. Gary Sanger, the chairman of my dissertation committee and my supervisor while in the Ph.D. program at LSU. In a program that is so individually motivated, he has provided direction when needed and insight when requested. I aspire to have the same wisdom and high standards to be able to guide others.

My dissertation committee deserves special recognition in handling this volume of work. I appreciate and want to thank Dr. R. Carter Hill, Dr. Ji-Chai Lin, Dr. Cynthia McDonald, and Dr. Roger Hinson for their time and effort.

The data used in the dissertation was obtained directly from the Paris Bourse and I want to thank Mr. Didier Davydoff, director of research. Also, uploading the various CD-Roms took many hours and Malcolm McNaylor and the staff of the Frey Computing Center were extremely helpful.

My colleagues and friends have also been invaluable in initiating and critiquing research ideas and in retaining my sanity. I am thankful for the help of Jeff Anderson, Paul Brockman, John Broussard, Susan Duhe, Arman Kosedag, Doug Margach, Lynne Morrison, Joan Payne, Karyn Neuhauser, Stephanie Reiter and Sheryl Wirch.

TABLE OF CONTENTS

ABSTRACT

This dissertation investigates specialist and multiple dealer markets. In the first of four essays, simultaneous trading in two market structures on the Paris Bourse is used to evaluate intraday price formation. Specialists are found to exacerbate the end of day price rise. Stock volatility and bid-ask spreads are found to be larger when a specialist is present, in contrast to existing literature that compares market structures on different exchanges.

The second essay estimates the components of the bid-ask spread and trade execution costs on the Paris Bourse. Estimates of the adverse selection cost component do not resolve the conflicting findings in existing literature regarding the relative size of this component in different market structures. A larger inventory holding cost component is identified for stocks that trade with the aid of a specialist, confirming the specialists' cost of maintaining an inventory. Higher trading costs are found for those stocks that trade with the aid of a specialist in contrast to existing literature, suggesting previous findings are exchange-specific. Long-term inventory changes are investigated and the impact on the inventory holding cost component is found to be twice as large for those stocks with a specialist.

The third essay examines specialist firms on the New York Stock Exchange. Differences are observed in the bid-ask spread, volatility and bid and ask depths. Likewise, final transaction returns differ across specialist firms indicating that the end of day price rise may be a method used by specialist firms to manage end of day prices. This is corroborated by observing minimal differences within each specialist firm. Short-term changes in inventory are investigated and extreme inventory changes are shown to

have smaller bid-ask spreads. Depletion of inventory is associated with a larger bid-ask spread than a build-up.

Essay four investigates the change in the rules governing market on close orders on the New York Stock Exchange. The new rules require earlier submission of orders. Minimal differences in the end of day price rise are found between the period before and after the rule change, however, volatility levels are found to decline for nine of thirty-seven specialist firms.

CHAPTER 1

AN OVERVIEW

1.1. Introduction

The trading mechanism for stocks varies across exchanges with the individual specialist system on the New York Stock Exchange (NYSE) and the American Stock Exchange (ASE) and the multiple market maker arrangement on Nasdaq being two of the most common market structures. The relative merits of the two systems have been investigated in a number of ways both theoretically and empirically. Empirical tests include comparing the magnitude and the components of the bid-ask spread of stocks of firms on different exchanges or those firms that move their listings between exchanges. A finding of large bid-ask spreads on Nasdaq has even led to an investigation of possible collusion which culminated in some changes to that trading system. The question of how to structure trading is especially important given the competition between exchanges for new listings. Furthermore, the continued shift to a more competitively-based world economy will result in more trading in equities and an even greater emphasis on designing optimal structures for trading stocks.

This dissertation investigates market structures, focusing on comparing specialist versus multiple dealer markets and their impact on both intraday price formation and the components of the bid-ask spread. Intraday price formation is of interest following the finding of several empirical regularities in trading volume, volatility, bid-ask spreads and mean returns. The continued existence of patterns or regularities that are economically exploitable is of interest since this is contradictory to market efficiency. The theoretical components of the bid-ask spread are of interest in determining the composition of trading costs using different market structures.

The first essay (Chapter 3) examines data from the Paris Bourse where some stocks have multiple dealers while others also have an individually assigned market maker. This provides an opportunity to analyze how intraday price formation is affected by the different market structures. This unique dual market structure is also used to investigate the components of the bid-ask spread and execution costs. In the second essay (Chapter 4) Huang and Stoll's (1997) general bid-ask spread decomposition model and Bessembinder and Kaufman's (1997) empirical measures of trading costs are used to identify the components in both segments of this market.

Individual specialist firms may have different levels of risk aversion, skill or capitalization that manifest themselves in characteristics that are not easily observable. In the third essay (Chapter 5) the intraday patterns in price formation characteristics are compared across specialist firms.

In June 1995, the rule governing the handling of market on close orders was altered by the NYSE in an effort to reduce volatility at the end of the day. The effectiveness of the rule change in aggregate and across specialist firms is the focus of the fourth essay (Chapter 6). In addition, the impact of the rule change on end of day pricing is examined.

1.2. Market Structure and Intraday Price Formation

The first essay examines the effect of a specialist market structure on intraday price formation. Recent empirical research on equity markets has revealed intraday regularities in bid-ask spreads, volatility and measures of trading in a variety of institutional settings. A U-shaped pattern in intraday bid-ask spreads and volume is found for stocks on the specialist market of NYSE. A similar U-shaped pattern in

volume is found on the multiple dealer structure of Nasdaq; however, bid-ask spreads have a declining pattern, being widest immediately following the open and then decreasing throughout the day. The Paris Bourse is an order-driven market with multiple dealers similar to Nasdaq. However, for stocks in the continuously-traded lower-liquidity trading group, there is also one dealer acting as a market maker for each stock similar to the specialist structure of the NYSE. The simultaneous trading of stocks, some with an assigned market maker in addition to the multiple dealers and some with only multiple dealers, provides an excellent opportunity to examine the effect of market structure on intraday price formation. Using all of the securities continuously traded on the Paris Bourse during the last 84 trading days of 1995, intraday price formation is investigated both with and without the assigned market maker. This essay examines volume, volatility and bid-ask spread patterns as well as the day end effect.

1.3. Market Structure and the Components of the Bid-Ask Spread

On exchanges with a single trading system, higher bid-ask spreads are expected on lower liquidity stocks for a number of reasons. One potential explanation is that the possibility of an inventory imbalance over a long period of time influences the specialist to increase the bid-ask spread to compensate for the additional holding cost. Another explanation suggests the market power of the specialist causes the large spread. A third explanation is information-based and suggests that low volume stocks have a higher probability of informed trading with the increased bid-ask spread set to compensate for these anticipated losses.

The second essay uses Paris Bourse data to compare the components of the bid-ask spread of those firms with and without an assigned market maker. The impact of

assigned market makers to medium liquidity stocks on the Paris Bourse is examined via the general bid-ask spread decomposition model of Huang and Stoll (1997) and Bessembinder and Kaufman's (1997) empirical measures of trading costs. The various possible explanations are tested by comparing the estimated inventory, order processing and adverse selection components of the bid-ask spread and the execution costs between the groups of stocks with and without an assigned market maker. The inventory accumulation explanation of inventory holding costs is tested by examining the estimated inventory holding cost component across groups of stocks partitioned by the amount of inventory accumulated in the previous trading sessions.

1.4. Specialist Firms and Intraday Price Formation

In the third essay the intraday price formation is further investigated by examining differences across individual specialist firms on the NYSE. Some explanations of price formation patterns involve the impact of the specialist. For example, the specialist may be able to capitalize on traders' inelastic demand at various times during the day. Another possibility is that the specialist may allow window dressing more readily in certain stocks. These explanations assume that the specialist is in a key position to impact the price formation patterns. Each specialist's expertise, however, is not likely to be similar and this may result in differing impacts on price formation characteristics. Also, volume may impact price formation since it impacts on the profitability of trading stocks through the capture of bid-ask spreads. Different patterns may exist in low volume stocks since they may be less important in day to day income of the specialists. Finally, high volume/high price stocks may be prone to more attention because of institutional investors' interest in stocks with higher market capitalization. This chapter

investigates the differences among specialists in order to determine the impact on patterns in intraday price formation characteristics.

1.5. Market on Close Order Rule Change and Intraday Price Formation Across Specialist Firms

The fourth essay investigates the impact of the June 1995 NYSE rule change on the entering of market on close orders. The rule was intended to reduce volatility at the end of the trading day and prevent a last minute influx of orders from causing large shifts in prices. Effective June 5, 1995, the rule required that all stocks have market on close orders in ten minutes before the close (3:50 pm) on all days. This essay tests the effectiveness of this rule change by examining the volatility in the month before and the month after the rule change. The effectiveness of the rule change is also examined across specialist firms to determine the impact of the specialist on the implementation of the rule change. The impact on intraday price formation and especially end of day pricing is also examined and compared across specialist firms. Additionally, some stocks fall into a special category where all large order imbalances in the market on close orders are reported and additional compensating orders are allowed after the 3:50 pm cutoff time. The impact of this policy is examined by comparing the group of stocks that allow the order imbalance publication and additional subsequent orders with the group of stocks that do not permit this practice.

CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

2.1. Introduction

The stock market structure literature is examined first and detailed descriptions of the NYSE, Nasdaq and Paris Bourse are provided. Next, the extant theoretical and empirical literature regarding market structure is detailed. The intraday price formation literature which examines patterns in volume, volatility, bid-ask spreads and end of day pricing is reviewed. Finally, literature regarding the components of the bid-ask spread and differences across specialist firms is examined.

2.2. Stock Market Structures

Interest in the market structure for trading equities on various stock exchanges has increased as the volume of shares traded has increased and the competition among exchanges to procure new listings has risen. The debate about the competitive advantages of specialist versus dealer markets depends on the criteria used to measure optimality. Measures of optimality include operational efficiency and pricing efficiency, as well as the depth of the available number of shares to buy or sell at the prevailing quotes. Before examining the relevant literature a simple description of the major stock exchange structures in the United States is provided. Also, a description of the Paris Bourse market structure, the source of the data used in Chapters 3 and 4, is given.

2.2.1. New York Stock Exchange

The primary United States stock exchange in terms of market capitalization is the NYSE. The NYSE trading floor is organized so that an individual specialist is in charge of several stocks at the same time, all at the same post and panel. Each stock is traded at

one specific panel on one post. The individual specialist is a member of a specialist firm usually organized as a partnership with all members located at the same post on the floor of the exchange.

The specialist is charged with opening trading in his stocks at 9:30 am or as close thereafter as possible. This is done by the means of a call auction whereby all the orders placed before the open are matched. A clearing price is established such that the specialist draws on inventory or accumulates inventory (depending on the relative number of buy or sell orders). For the remainder of the day the specialist is responsible for maintaining an orderly flow of transactions without wide fluctuations in price. The specialist does this by matching buy and sell orders or by taking the opposite side of the transaction and placing stock into or taking stock out of inventory. This is done by providing quotes at a price at which the specialist is willing to sell shares (the ask price) and buy shares (the bid price). The specialist also indicates the depth of the shares available to be traded at these quotes. For example, the specialist may have a bid quote at $16.50 and a depth of 5 indicating a willingness to buy a maximum of 500 shares at a price of $16.50 per share. Simultaneously, the specialist may have an ask quote, of perhaps $16.75 with a depth of 30, indicating a willingness to sell a maximum of 3000 shares at a price of $16.75 per share. In this example, the bid-ask spread is $0.25 or 1.5%.

Orders are submitted electronically over the Super Designated Order Turnaround (DOT) system or handled by floor brokers. Market orders are executed against limit orders that were placed in the limit order book or against prevailing quotes provided by the specialist. Rules of price and time priority prevent the specialist from trading ahead

of any limit order at the same price. Undisclosed limit orders may be available from other brokers around the post and panel.

The execution of a market order is not automatic. The market order is exposed to other orders and the specialist or other brokers have the ability to better the standing quote or to let the order be executed against the standing quote. If the quote is bettered then the transaction occurs inside the quotes; hence, the effective spread may be lower than the posted spread. The effective spread may also be lower than the quoted spread if the specialist "stops the stock" whereby the specialist guarantees for that order a price at least as good as the prevailing quotes. When the stock is "stopped" the order remains unexecuted until another order comes in to take the opposite side of the transaction or the specialist executes the order into or out of inventory.

The trading day ends at 4:00 pm. Prior to June 5, 1995, trades could be placed until 3:59:59, including market on close (MOC) orders that will be the last executed trade of the trading day. The rules differed on the one day a month when standardized contracts expire ('expiration days'). On expiration days MOC orders are required to be submitted at 3:40 pm. On June 5 the rules were altered for non-expiration days. Orders can still be placed up to 3:59:59, but after June 5 MOC orders were required to be submitted ten minutes in advance of the close (by 3:49:59). Further details of these changes and their effect on volatility at the close are given in Chapter 6.

2.2.2. Nasdaq

The Nasdaq trading system consists of brokers and market makers that are linked via computers. Market makers post their best bid and ask quotes into the system and these quotes are electronically disseminated to all the other brokers. There is a wide

variety in the number of dealers for each individual stock with the number of dealers in an active stock often exceeding thirty. Unlike NYSE, the market makers are not required to maintain an orderly market and they can exit or enter the market on short notice.

Each dealer in an active stock is obligated to trade a minimum of 1,000 shares at his or her prevailing quotes. Incoming market orders are executed against the inside dealer quotes. Inside quotes are the best bid and the best offer quotes that are available; thus, the bid and ask quotes are not necessarily from the same dealer.

2.2.3. Paris Bourse

The new Paris Bourse is a nationwide electronic market merging the old floor-trading Paris Bourse with the operations of the regional Bourses. The modernization began in the late 1980s and now the trading system (under the name "Cotation Assistèe en Continu" or CAC) is fully-computerized and includes data dissemination, clearance and settlement. The system is operated using workstations installed at 135 member firms. On June 26, 1995, the CAC system was replaced with an even more efficient system appropriately named SUPERCAC. The Paris Bourse is unique in that its structure embodies various characteristics of other existing of securities markets. For instance, there is continuous as well as batch trading. Also, the market may be characterized as a dealership as well as an auction market.

There are two trading compartments on the Paris Bourse. The first is the official list which includes large French and foreign companies. This compartment requires that at least 25% of a firm's total equity must be offered to the public. The official list has two divisions: the "Règlement Mensuel" (RM) contains the most active stocks where settlement is made monthly and the "Comptant" contains the less active stocks where

settlement is on the cash basis. The other trading compartment is referred to as the second market or "Second Marchè". The second market is set up for medium-sized companies and requires only that 10% of a firm's equity be held by the public. Only a small number of foreign companies list on the second market.

For securities traded on the "Second Marchè" or the "Comptant", settlement is on a cash basis. This is effected three days after the trade. For stocks on the "Règlement Mensuel" settlement occurs monthly, six business days before the end of the month, with delivery of the security required five days later. To place an order in this market the full amount of the transaction does not have to be put up, only an initial margin deposit is required. This deposit may be satisfied with 20% cash, French Treasury bills or money market funds, with 25% in listed bonds, commercial paper or bond funds, or with 40% in listed shares or equity funds. On the settlement day investors who have not closed their positions may carry their positions over to the next account period through the "contango market". This special market occurs the day after the settlement day and determines the rate at which buyers can obtain the cash and sellers can buy the securities they need to meet their obligations at the end of the month and, thus, carry over to the settlement day of the following month.

Transactions that are reported on the Paris Bourse can occur on the exchange or off the exchange as prearranged trades between two customers of the same broker or between a customer and the broker acting as principal. Transactions off the exchange are called cross-trades or pass-throughs.

Electronic trading is performed by 135 member firms. The market's central order book is maintained by the SUPERCAC electronic trading system and order matching is

automatic. Cross-trades can be placed onto the system by an intermediary or by a member firm if they are acting as a principal. Orders are ranked by price limit as they enter the system; within each, limit orders are ranked chronologically. Clients can specify a date beyond which unexecuted orders are not valid, but if the order is entered into the system without a specified validity date it is considered "Good 'Til Canceled" (GTC or "rèvocation"). For securities traded on the cash market these GTC orders are valid until the last day of the current month. For securities traded on the monthly settlement market GTC orders remain valid until the next settlement month.

The Paris Bourse offers a number of different types of orders. Orders must either specify the execution price or be market orders. A market order placed before the open will be filled at the price set by the system during the opening stage. A market order during the remainder of the trading session will be executed at the best price on the opposite side of the market. If the entire quantity of the market order is not filled at the best price then the remaining shares from the market order are transformed into a limit order at the transaction price. Limit orders specify a price limit. "At best orders" were introduced in late 1995 and have no price limits. Such orders will match best prices until executed in full. If the total quantity can not be served at the time of its entry in the system then a trading halt will occur. "Fill or kill" orders can only be executed when entered into the system. If the order is not executed immediately, either wholly or partially, the whole or remaining quantity is automatically canceled. "Quantitè cachè" (or hidden) orders which are fractions of larger orders are allowed on the exchange, but the disclosed amount must be ten times the stock's usual trading lot. The hidden part loses time priority as disclosed orders at the same price are executed before the hidden

quantity. As the visible portion is executed a portion of the hidden order becomes visible. Hidden orders are typically used by investors who wish to trade a large quantity or shares with minimal market impact. They represent from 20% to 40% of the disclosed quantity for active stocks; therefore, actual market depth may be much greater than observed depth.

Securities are traded on a continuous basis begun with an opening batch auction or in batch auctions only. The continuously traded securities are classified as either "Continuous A" securities that have high liquidity or "Continuous B" securities that have average liquidity. From 8:30 am to 10:00 am the market for continuous securities is in its pre-opening phase and orders are accumulated in the centralized order book without any transactions taking place. The market opens at 10:00 am with a batch auction. The opening price is automatically calculated to be the price at which the largest number of bids and asks can be matched. From 10:00 am until 5:00 pm, trading takes place on a continuous basis and the arrival of a new order will trigger one or more transactions if matching orders exist on the centralized book.

Securities traded only in batch auctions are those securities with low liquidity that are on the official list or the second market. This group is classified as the "Fixing A" group since the price is fixed twice daily. Orders are managed through an order book that operates continuously from 8:30 am until 4:00 pm, with batch auctions occurring at 11:30 am and 4:00 pm.

Price fluctuations are limited in various ways depending on the trading group. For Continuous A stocks, the initial allowed price change is plus or minus 10% from the prior day's close with subsequent changes of plus or minus 5% permitted. If these limits

are reached then trading halts of fifteen minutes occur. The maximum change in any one day is arbitrarily set at +21.25% or -18.75% from the previous day's close. The Continuous B group has an initial change limited to plus or minus 5% and subsequent changes limited to plus or minus 2.5%. In this group, trading halts occur for 30 minutes if these triggers are reached. The maximum one day change is +10.25% or -9.65%. For the Fixing A group, the price at the 11:30 am fixing must be within 5% of the prior day's close, and similar restrictions apply to the 4:00 pm fixing relative to the 11:30 am price.

Member firms are authorized to offer brokerage activities as well as dealership activities. They can execute buy and sell orders for clients on the market or may act as principals and deal in net prices to clients within the framework of the central market. Principal trading can occur during or outside the trading session. If the principal trade occurs during the trading session then it is reported on the computer system at a price that must be within or at the existing spread. If the principal trade occurs outside the trading session then it must be carried out at a price that is within 1% of the best bid or offer existing at the close of the previous trading day.

In order to enhance the liquidity of certain medium-sized stocks special agreements were implemented in 1992. These special agreements known as "Trading Animation Contracts" or "contrats d'animation" apply to stocks in the Continuous B and Fixing A group. They allow member firms to act as market makers under certain conditions. To comply with the rules governing these contracts, a member firm must agree to quote spreads on the market's central order book and to stand ready to buy and sell a minimum quantity of shares for their own account. Furthermore, they are required to maintain a market presence in the fifteen minutes immediately prior to opening, (or

throughout the day for Continuous B shares), and in the 15 minutes preceding each fixing for the Fixing A group shares. The maximum relative spread that can be quoted is 5% and minimum quantities are FF 50,000 for the Continuous B shares and FF 20,000 for the Fixing A shares. A single assigned "animateur" (or market maker) is appointed for each security and investors are informed of participating securities through the press. Market makers also agree to execute, insofar as possible, orders that were partially or totally unmatched at the market's opening price. Having an assigned market maker does not preclude the interest of other dealers. In fact, the assigned market maker remains in competition with the other dealers that may have an interest in the stock.

Each category of stocks is partitioned into individual trading groups that reflect the characteristics of that group. Besides differences in whether there is an assigned market maker, the stocks are divided according to whether there is regular or cash trading, foreign stocks or French stocks, primary versus secondary issues and even an individual trading group for those stocks that comprise the CAC-40 index. Appendix A lists the various trading groups.

Block trading rules were also revised in 1994. Member firms are now allowed to buy and sell large blocks in a single transaction and with a set price. The transaction must be larger than the "Normal Market Size" which is a figure based on the average trade volume in that stock and must be no less that FF 1 million. The block trades must be carried out at a price which falls within a weighted average spread calculated by weighting all orders on the order book. All block trades must be immediately reported to the Paris Bourse by the brokerage firm. Disclosure to the market is immediate when a member firm acts as a broker between two clients. Otherwise, timing of the disclosure

depends on the transaction's size. Transactions less than five times the normal market size are disclosed within two hours of being reported. Transactions more than five times the normal market size are disclosed when the market opens on the following business day.

2.2.4. Theoretical Literature on Market Structure

The differences across markets using specialists and those using market makers are examined theoretically in a number of papers. Ho and Stoll (1981) show that competition among market makers leads to a more liquid market in the sense that the average bid-ask spread is smaller with competing market makers. Ho and Stoll (1983) model quote setting in a competing dealer market from an inventory perspective and compare their predictions to those of a model with a single specialist. Their model predicts that the bid-ask spread on multiple dealer markets will be higher than on specialist markets because the multiple dealer market has significantly greater depth. This greater market depth is also shown by Grossman and Miller (1988). They find that the depth is greater because inventory holdings are larger with multiple dealers. As a result of these larger inventories and competition from other market makers, individual market makers may not be able to experiment with prices to the same extent as specialists on the NYSE or ASE. However, Leach and Madhavan (1993) show that losses incurred by the specialist during the price discovery process will be recovered by later order flow. Glosten and Milgrom (1985) concur by suggesting that the specialist can average profits over time. This allows trading to continue in the specialist market even in the event of other traders who possess superior information. In contrast, a multiple dealer market may

shut down temporarily when there is an influx of new information possessed by other traders.

The liquidity in each market structure may vary based on order size. Seppi (1997) develops a model in which a specialist with market power competes against a competitive limit order book. He finds that a hybrid specialist/limit order market provides better liquidity to small orders, but a pure limit order market may offer better liquidity on mid-size orders.

2.2.5. Empirical Literature on Market Structure

A number of studies measure the cost of execution on a particular market, without comparing the costs across markets. For example, Roll (1984) develops a method for measuring the effective spread and provides such estimates for exchange-listed stocks. Christie and Schultz (1994) and Christie, Harris and Schultz (1994) find that odd-eighth quotes are absent in 70 out of 100 Nasdaq stocks. This minimum spread of two-eighths ($0.25) suggests that Nasdaq market makers may tacitly collude to maintain wide spreads. This hypothesis is supported by empirical findings that spreads fell by approximately 50% for some of these stocks shortly after the release of the first study in May 1994. However, additional studies have offered explanations other than implicit collusion. Godek (1996) suggests share preferencing is a possible explanation for the large bid-ask spreads. The Christie and Schultz findings are corroborated in a direct comparison between Nasdaq and NYSE by Huang and Stoll (1996). Huang and Stoll find that the execution costs[1] for their sample of Nasdaq stocks are twice as large as that of the NYSE sample. In addition, they suggest that the internalization and preferencing of order flow and the presence of an alternative interdealer trading system results in a

[1] Execution costs are measured by the quoted spread, the effective spread, the realized spread, the Roll (1984) implied spread and post-trade variability.

disincentive to reduce spreads. The incentive system has recently been altered by an adjustment in the treatment of limit orders as a result of the United States Department of Justice investigation following the Christie and Schultz papers.

A study by Affleck-Graves, Hedge and Miller (1994) is inconclusive as to whether the NYSE or Nasdaq market structure has lower total costs. In investigating the components of the bid-ask spread, they document lower order processing costs for NYSE, but higher adverse selection and possibly higher inventory holding costs. In contrast, Jones and Lipson (1997) document gradual price adjustments on Nasdaq and a larger adverse selection component than on NYSE. Lin, Sanger and Booth (1995b) suggest that the adverse selection component of the bid-ask spread should be higher on exchanges that have a specialist since the specialist is constrained from obtaining security analysis. Bessembinder and Kaufman (1997) find that effective bid-ask spreads are only slightly smaller on the NYSE, but realized bid-ask spreads are two to three times lower.

Other studies compare the cost of trading the same stocks on competing markets. Lee (1993) and Petersen and Fialkowski (1994) measure the costs of trading NYSE stocks on regional exchanges and Nasdaq. They find that costs on the competing markets are slightly higher than on the NYSE. Their results are similar to De Jong, Nijman and Röell (1995) who investigate stocks of French and German companies traded in their home country auction market and on the London dealer market. They find the bid-ask spreads on the London market to be consistently larger. Christie and Huang (1994) investigate firms that move from Nasdaq to the NYSE or ASE. They find that average costs fall 4.7 cents for transfers to the NYSE and 5.2 cents for transfers to the ASE. They find that the largest improvements in liquidity are for the less liquid stocks that become

listed. Blume and Goldstein (1997) find that most of the time, the NYSE quotes match or better the existing quotes on other exchanges; however, other factors such as payment for order flow explain the ability of other exchanges to attract order flow.

2.3. Intraday Patterns in Volume, Volatility, Bid-Ask Spreads and Prices

This section reviews the theoretical and empirical literature regarding the pattern in intraday pricing documented by Wood, McInish and Ord (1985). They find that average stock price volatility and volume are highest at the beginning and end of the trading day. Also, they find that average returns are highest at the opening and closing of trading. Also in this section the end of day pricing literature is reviewed.

2.3.1. Intraday Patterns: Theoretical Literature

Two papers develop models that show that information is incorporated into security prices through the strategic activities of informed traders. Admati and Pfleiderer (1988) predict that informed traders will concentrate their trades in periods where liquidity trading is concentrated. This presumably occurs at the open and close of trading when trading costs are the lowest. Foster and Viswanathan (1990) suggest that uninformed traders will avoid the open and close of trading since these periods are anticipated to have the largest amount of private information. Foster and Viswanathan (1993) show that the anticipated private information costs and return volatility are the highest at the open. Brock and Kleidon (1992) suggest that the specialist is the cause of wider bid-ask spreads near the close of trading.

2.3.2. Intraday Patterns: Empirical Literature

Berry and Howe (1994) suggest that patterns in intraday volume are related to public information arrival as measured by news releases. They find a systematic intraday

pattern in Reuter's news releases that explains the trading volume. Trading volatility is examined by Gerety and Mulherin (1994) who use forty years of hourly observations of the Dow Jones 65 Composite Index levels to show that transitory volatility declines steadily during the day. They suggest that this is consistent with the notion that trading aids price formation. A U-shaped volatility pattern is also observed on the futures market by Chang, Jain and Locke (1995) who find that the S & P 500 futures market has a U-shaped pattern after the close in underlying stock trading. Stoll and Whaley (1990) report evidence of greater volatility in NYSE stock returns at the open and close of trading than at other points during the trading day. Lin, Sanger and Booth (1995a) show that the information component during the day for NYSE firms is largest at the beginning of the day and lowest at the end of the day for all but the largest trades.

Finally, researchers have found intraday patterns in the bid-ask spread that differ across market structures. For example, McInish and Wood (1992), Brock and Kleidon (1992) and Lee, Mucklow and Ready (1993) document that the intraday width of bid-ask spreads for NYSE stocks follow a U-shaped pattern, where spreads are widest immediately following the open, and immediately preceding the close. This contrasts with the multiple market maker structure on Nasdaq where Chan, Christie and Schultz (1995) find that bid-ask spreads decline near the close.

2.3.3. End of Day Pricing

A general increase in prices on the last trade of the day results in a higher than average final transaction return. This result has puzzled researchers since it was first identified by Harris (1986) and Wood, McInish and Ord (1985) on NYSE. The pattern is also found on the Toronto Stock Exchange (McInish and Wood (1990)), on the ASE

(Gosnell (1995)) and on the Hong Kong Stock Exchange (Mok (1988), Ho and Cheung (1991) and Cheung (1995)).

Several explanations for these findings have been offered, but all appear to explain only a portion of the effect. Harris (1989) suggests that the tendency for a transaction to be at the ask price may be the reason for the price rise. However, he finds that this explains only approximately half of the effect. Porter (1992) investigates this issue, but again, finds that only a portion of the end-of-day price anomaly can be explained by a tendency to close at the ask. Keim and Stambaugh (1984) use bid-to-bid returns and still find the phenomenon present, indicating that the bid-ask spread is not the sole reason for the price rise. Even if the bid-ask spread could completely explain the end-of-day price anomaly, this would merely beg the question of *why* there is a tendency for transaction prices to move to the ask price at the end of the day.

Keim (1989) and Lakonishok and Maberly (1990) suggest that the price rise may be due to a systematic shift in buying and selling. Admati and Pfleiderer (1988) and (1989) suggest that informed traders and liquidity traders concentrate their buy and sell volume in distinct periods during the day. Each type of trader tends to favor activity at certain times, with the informed traders wanting to trade when the market is thick so their trading will have little effect. They suggest that if this is at the end of the day, then the informed traders would also try to trade at that time, thereby impounding information in the prices, which may account for the wider bid-ask spread. This, in turn, accounts for the price rise if there is a tendency to focus on the ask price.

The propensity for the number of buy transactions near the close to explain the end-of-day price change identified by Gosnell (1995) is another empirical explanation

that is subject to different interpretations. The increase in the number of buy transactions could be related to inelastic demand at the end of the day and the monopoly power of the specialist or to an attempt by traders to influence the closing price.

Brock and Kleidon (1992) hypothesize that the partial monopoly power of the specialist and the specialist's ability to capitalize on traders' inelastic demand at the end of the day results in wider bid-ask spreads. If the tendency to shift to the ask price is true, then this would increase the price. In the Brock and Kleidon model, investors, faced with the prospect of not being able to trade overnight, adjust their portfolios near the close, thereby creating inelastic demand. Hasbrouck and Sofianos (1993) also suggest that inelastic demand may be caused by speculators who prefer to "go home flat" rather than maintaining an unhedged position overnight. Speculators would face more risk holding an unhedged short position overnight (since there is an unlimited risk of loss) than an unhedged long position; hence, the greater impetus to cover short positions may explain the inelastic demand to purchase near the close of trading. Inelastic demand may also be generated by fund managers who want to trade at a price as near to the closing price as possible. This may be done in order that the trades be completed at prices close to the end of day net asset value used in assessing the market value of the portfolio.

A large number of buy transactions near the close may also be indicative of price manipulation. Harris (1989) indicates that the end-of-day price rise may be related to the turn-of-the-month anomaly, suggesting window-dressing may be the cause of the price rise. Since portfolio returns are often calculated using the closing prices there may be an incentive to engage in price manipulation.

Other explanations for the increase in price at the end of the day involve the actions of the specialist. Miller (1989) proposes that the specialist will attempt to raise the closing price if he expects that the price will rise overnight. The opening trade is usually large and any order imbalances must come out of the specialist's inventory. Thus, if exchange continuity requirements force the opening price to be lower than the equilibrium price, the specialist stands to lose money. Since prices tend to rise over the long term, the specialist may, on average, raise prices more frequently than lowering them in advance of the opening trade. A related explanation by Hatheway (1994) proposes that the specialist will raise the price at the end of the day to induce the maximum information release the next morning. By closing with a price increase, short sales and the information provided by short sales are not constrained at the open by the NYSE uptick rule that prevents short sales when prices are falling.

2.4. Components of the Bid-Ask Spread

Investors face a number of transaction costs: explicit costs such as commissions and implicit costs such as the spread between the bid and ask prices in the market. The bid-ask spread represents compensation to the market makers. Extant market microstructure literature identifies three components of the bid-ask spread: order processing costs, inventory holding costs and adverse selection costs. Tinic (1972) defines order processing costs to be those fees that are charged by market makers for matching buy and sell orders. These costs also include any fees or opportunity costs for time used to complete the transaction. Stoll (1978) and Ho and Stoll (1981) define inventory holding costs as the portion of the bid-ask spread that compensates dealers for holding inventories that are not well-diversified. The adverse selection component is defined by Copeland and Galai (1983) and Glosten and Milgrom (1985) as the

compensation for taking on the risk of dealing with traders that may possess superior information.

Stoll (1989) develops a model based on the Roll (1984) estimator that is used to infer the components of the bid-ask spread on Nasdaq. The components are estimated using slope coefficients from a regression of the serial covariance in the percentage price change series on the bid-ask spread. He finds that 43% of the quoted spread for Nasdaq stocks represents adverse selection costs, and that compensation for order processing and inventory control costs account for 47% and 10% of quoted spreads, respectively. George, Kaul and Nimalendran (1991) extend Stoll's methodology to allow for time-varying expected returns except they assume zero inventory costs. Affleck-Graves, Hedge and Miller (1994) also use this methodology and examine the impact of the agency/auction trading mechanism versus the use of competitive dealers. Using their full sample, they find that the order processing component is lower for stocks traded on the NYSE and the ASE. Using a matched sample design, they find smaller adverse selection costs for Nasdaq stocks. Conclusions about the inventory holding costs are limited[2]. It appears that any differences between exchanges may be due to differences in the characteristics of firms that choose to list on the exchange.

Contrary to Affleck-Graves, Hedge and Miller's (1994) conclusions about the adverse selection component, Jones and Lipson (1997) find that the adverse selection component is larger on Nasdaq. Krinsky and Lee (1996) also analyze bid-ask spreads around earnings releases. They find that the adverse selection component of the bid-ask spread increases around earnings announcements, but the other components decrease.

[2] Other research about inventory holding costs by Hasbrouck and Sofianos (1993) and Madhavan and Smidt (1993) indicates that it takes a specialist approximately one week to reduce inventory by one-half.

Foster and Viswanathan (1993) investigate intraday variation in the components of the bid-ask spread and find that the order processing cost component of the bid-ask spread varies little during the trading day. Alternatively, the adverse selection component varies within the day and across days and is usually larger when there is higher trading volume. Lin, Sanger and Booth (1995a) show that the adverse selection component is largest near the open and smallest near the close for all but the largest trades. They also find that the trade size affects the adverse selection component: the adverse selection component increases uniformly with trade size.

2.5. Differences Across Specialists

Differences in trading behavior across specialists may be associated with characteristics such as the skill or experience of the specialist, the risk of the specialist's portfolio, the degree of risk aversion, the number and characteristics of the stocks traded by the firm, the capital backing of the firm, and other businesses in which the firm is involved. These differences have been shown to manifest themselves in stock volatility (Barnea (1974)), inventory holding costs (Coughenour and Deli (1996)), and execution costs (Cao, Choe and Hatheway (1997)). Corwin (1996) tests for differences across specialist firms and finds no differences in specialist behavior in terms of quoted bid-ask spreads, but significant differences in other, less easily monitored performance areas such as transitory volatility, trading halt probability and trading halt duration. He concludes that specialist firms have a significant effect on both the amount of noise in security prices and the continuity of trading. He suggests that these effects are not completely eliminated by competition or NYSE's monitoring mechanisms.

Differences in specialist participation rates are found by Madhavan and Sofianos (1998). They find wide fluctuations from less than 10% to over 60% across specialists.

Differences are found to be related to the composition of volume and other stock-specific characteristics. They find participation rates are positively related to non-block volume, but negatively related to block volume. The likelihood of participation is larger for smaller trades and wider bid-ask spread. Furthermore, the specialist's purchases are found to increase (decrease) with low (high) inventory levels.

CHAPTER 3

ESSAY ONE:

MARKET STRUCTURE AND INTRADAY PRICE FORMATION

3.1. Introduction

No accepted explanation of patterns in intraday price formation has been universally accepted in finance. Intraday U-shaped patterns have been documented for volume, volatility and bid-ask spreads. These patterns are not, however, identical across different market structures. The U-shaped pattern has been found on the NYSE for volume, volatility and bid-ask spreads while bid-ask spreads on Nasdaq have been found to decline near the close.

End of trading day pricing also shows a pattern in a consistent, abnormally large final transaction return. This suggests that closing prices may not consistently represent stock values. This is particularly disturbing given the high degree of importance placed on closing prices, not only for valuation, but also for information dissemination and use in academic studies.

The Paris Bourse invites analysis of intraday price formation since it involves the simultaneous trading of some stocks with a single market maker acting as a specialist and multiple dealers and others with only multiple dealers. After the batch open, high liquidity stocks are purely order driven and trade in a multiple dealer market, while medium liquidity stocks have a single market maker standing ready to buy and sell a minimum quantity of shares for his own account. The market maker also executes orders that were partially or totally unmatched at the market's opening price.

Through the analysis of transactions data for September through December 1995, this chapter investigates whether the patterns in volume, volatility, bid-ask spreads and end of day pricing reported for other exchanges also hold for the unique institutional arrangements of the Paris Bourse. The simultaneous trading of one group of stocks supported by a single market maker and multiple dealers and another group of stocks supported by only multiple dealers allows a clean comparison of the effect of differences in markets structures to be identified. This avoids the possible confounding influence of regulatory or other operational differences between markets, such as those between the NYSE and Nasdaq. These findings have general implications regarding the efficiency of different institutional arrangements.

The remainder of this chapter is divided into four sections. Section 3.2. details the hypotheses to be tested. Section 3.3. describes the data and statistical tests. Section 3.4. discusses the results of these tests. Conclusions are offered in section 3.5.

3.2. Hypotheses

The unique institutional arrangement of the Paris Bourse invites a comparison between those stocks with and those without a single assigned market maker. Intraday price formation as evidenced by the pattern in volume, volatility, bid-ask spreads and end of day prices can be examined within the two groups. The specific hypotheses that can be applied to each of the price formation characteristics listed are as follows:

> $H1_0$: The price formation characteristic observed is the same in both the group with and the group without an assigned market maker.
>
> $H1_A$: The price formation characteristic observed in not the same in both the group with and the group without an assigned market maker.

As described in section 2.2.3., cross trades are those trades that occur off the exchange. If these cross-trade transactions are driving any price formation patterns or are

being used to influence the end of day pricing for window-dressing purposes then intraday price formation as evidenced by the pattern in volume, volatility, bid-ask spreads and end of day prices should be different across these two groups. The specific hypotheses that can be applied to each of the price formation characteristics listed are as follows:

> $H2_0$: The price formation characteristic observed is the same in both the group of cross trades and the group of transactions that occur on the exchange.

> $H2_A$: The price formation characteristic observed is not the same in both the group of cross trades and the group of transactions that occur on the exchange.

A specific test of the end of day price rise can be performed by including the timing of the final transaction. The proximity to the close may impact on the final transaction return since it is with those transactions near the close that there may be inelastic demand. The specific hypotheses are as follows:

> $H3_0$: The final transaction return is not affected by the proximity to the close of trading.

> $H3_A$: The final transaction return is larger when it has a closer proximity to the close of trading.

The window dressing explanation can be tested by observing the cross-trades that occur on month-ends as the effect may be more pronounced on these days. The specific hypotheses are as follows:

> $H4_0$: The end of day price rise is the same on month-end days as on any other day during the month.

> $H4_A$: The end of day price rise is larger on month-end days than on other day during the month.

Additionally, price formation patterns may be influenced by the day of the week. Friday returns have been shown to be larger than other days of the week[3]; a large end of day price increase could be the cause. Likewise, intraday volume, volatility or the bid-ask spread patterns identified by Wood, McInish and Ord (1985) may be influenced by the day of the week. Intraday price formation as evidenced by patterns in volume, volatility, bid-ask spreads and end of day prices can be examined across the days of the week. The specific hypotheses that can be applied to each of the price formation characteristics listed are as follows:

> $H5_0$: The price formation characteristic observed is the same across the days of the week.
>
> $H5_A$: The price formation characteristic observed in not the same across the days of the week.

$H5_0$ is written as a two-tailed test, however there may be situations in which a one-tail test may be appropriate. For example, in examining the bid-ask spread, Brock and Kleidon's (1992) model suggests inelastic demand may be greater on Friday and this could influence the size of the bid-ask spread. In this case, a one-tail test is more appropriate, with the alternative hypothesis stating that the bid-ask spread is larger at the Friday close.

The price of the stock may be a factor in any observed pattern in price formation characteristics. For example, a shift in the price from the bid to the ask at the end of the day would generate a larger return for low priced stocks. This could manifest itself in a larger end of day price increase, yet be merely a function of the price of the stock. Likewise, a lower priced stock may have a higher observed volatility due solely to the larger percentage bid-ask spread bounce. Intraday price formation as evidenced by the

[3] See Cross (1973), French (1980), Rogalski (1984), Harris (1986).

pattern in volume, volatility, bid-ask spreads and end of day prices can be examined across price levels. The specific hypotheses that can be applied to each of the price formation characteristics are as follows:

$H6_0$: The price formation characteristic observed is the same across price levels.

$H6_A$: The price formation characteristic observed in not the same across price levels.

3.3. Data and Statistical Tests

The data used in this research is supplied by the Paris Bourse. The price, time, number of shares traded, and a classification identifying if the trade was a cross-trade transaction that occurred outside the exchange are provided. There is also descriptive data that identifies the trading compartment of the stock. The trading period examined includes September 1995 through December 1995. In total, there are 3,189,976 transactions for 458 firms over this 84 trading day period. Only those securities that are in the continuously trading compartment are retained for the present analysis. Additionally, if there is no previous price then any return calculation is not possible and this observation is deleted. For all returns that exceed 50% or are less than negative 50% the individual transactions are examined for data errors and these observations are deleted.

Table 1 presents a summary of the number of firms listed daily, both on an overall basis, and divided into groups based upon whether the firm has a single assigned market maker or not. In Table 2 further division is made into two groups: one group of firms where the final transaction was on the exchange and one group where the final transaction was an off-exchange cross-trade. In Table 2, an additional variable is

Table 1 Summary statistics for the 84 trading days (September - December 1995) on the Paris Bourse. The summary statistics are calculated for each firm over the trading period and then averaged across all firms.

	mean	standard deviation	minimum	maximum
ALL FIRMS (458)				
number of firms trading per day	413.50	19.31	377	433
closing share price (FF)	493.18	676.39	1.27	5180.97
firm size (million FF)	24,272	67,681	5.1	680,431
daily volume (shares)	39,991.58	231,971.31	3	4,602,201
number of trades per day	80.88	195.67	1	1819.92
mean transaction size	233.27	342.18	3	3619.17
no assigned market maker (311)				
number of firms trading per day	282.83	16.73	255	301
closing share price (FF)	527.94	697.57	2.01	5180.97
firm size (million FF)	35,321	79,814	55.4	680,431
daily volume (shares)	57,860.21	279,762.15	58.94	4,602,201
number of trades per day	115.07	229.72	1.61	1819.92
mean transaction size	280.33	394.69	6.98	3619.97
assigned market maker (160)				
number of firms trading per day	130.67	4.22	122	140
closing share price (FF)	447.84	657.70	1.27	5053.75
firm size (million FF)	1,019	1,522	5.1	13,543
daily volume (shares)	2,421.88	11,181.21	3	139,973
number of trades per day	9.51	7.17	1	43.25
mean transaction size	138.21	147.86	3	1377.56

calculated, the frequency of occurrence when the cross trade is the last trade of the day. This occurs, on average, for 9.94 days during the sample period of 84 days for each firm, although the range of occurrences reported is 1 to 61. The true range is 0 to 61 since 18 firms do not have any days where the last trade is a cross trade.

Table 1 shows that firms with an assigned market maker appear to be smaller, have a lower stock price, a lower daily volume, a lower number of trades per day and a smaller transaction size. Table 2 partitions the sample into those firms with final transactions that occurred on and off the exchange. For each day, the final return is placed in one of the two categories based on the location of the final transaction. The

Table 2 Summary statistics for the 84 trading days (September - December 1995) on the Paris Bourse. The summary statistics are calculated for each firm over the trading period and then averaged across firms after partitioning the firms into based on if the last trade is on the exchange.

	mean	standard deviation	minimum	maximum
FIRMS WITH THE LAST TRADE OF THE DAY ON THE EXCHANGE				
all firms (458)				
number of firms trading per day	361.44	24.36	311	392
closing share price (FF)	493.43	676.79	1.27	5158.34
firm size (million FF)	24,255	67,538	5.1	679,171
daily volume (shares)	39,572.46	226,097.08	3	4,469,901
number of trades per day	80.61	194.01	1	1774.29
mean transaction size	226.71	338.19	3	3491.89
no assigned market maker (311)				
number of firms trading per day	253.30	20.83	213	281
closing share price (FF)	528.06	697.61	2.02	5158.34
firm size (million FF)	35,293	79,641	5.5	679,171
daily volume (shares)	57,201.88	272,603.61	65.42	4,469,901
number of trades per day	114.58	227.74	1.61	1774.29
mean transaction size	275.75	387.94	6.84	3,491.89
assigned market maker (160)				
number of firms trading per day	108.14	5.95	95	124
closing share price (FF)	448.30	658.81	1.27	5,065
firm size (million FF)	1,023	1,551	5.1	14,047
daily volume (shares)	2,494.10	12,336.66	3	154,657
number of trades per day	9.67	7.11	1	44.41
mean transaction size	127.40	151.16	3	1,504.15
FIRMS WITH THE LAST TRADE OF THE DAY A CROSS TRADE				
all firms (440)				
number of firms trading per day	52.06	9.57	27	70
freq last trade=cross trade per firm	9.94	8.23	1	61
closing share price (FF)	495.80	683.14	1.89	5348.50
firm size (million FF)	25,229	70,572	34.3	692,247
daily volume (shares)	47,538.73	325,752.09	1	6,421,329
number of trades per day	89.47	244.48	1	2447.25
mean transaction size	289.43	449.84	1	4382.81
no assigned market maker (301)				
number of firms trading per day	29.53	6.95	15	43
freq last trade=cross trade per firm	8.24	6.20	1	53
closing share price (FF)	535.35	704.68	1.89	5,348.50
firm size (million FF)	36,468	82,981	54.6	692,247
daily volume (shares)	68,741.73	392,238.85	11	6,421,329
number of trades per day	127.04	288.04	1.10	2,447.25
mean transaction size	324.22	502.77	3.17	4,382.81

(table con'd)

(Table 2 continued)

	mean	standard deviation	minimum	maximum
assigned market maker (151)				
number of firms trading per day	22.52	5.03	10	33
freq last trade=cross trade per firm	12.53	10.67	1	61
closing share price (FF)	442.56	663.98	6	5,050
firm size (million FF)	1,022	1,500	34.3	13,084
daily volume (shares)	1,940.57	3,051.14	1	20,859
number of trades per day	9.11	8.14	1	46.25
mean transaction size	219.11	305.98	1	2,198

observations are similar on an overall basis as well as in either of the groups as determined by location (on or off-exchange) of the final trade.

For each trading day and each security the last transaction return of the day is calculated as:

$$r_{i,t} = \frac{(P_{i,t} - P_{i,t-1})}{P_{i,t-1}}$$

where $r_{i,t}$ is the transaction return for firm i on trade t, and P_t and P_{t-1} are the prices of the trades at times t = last and t-1 = previous to last, respectively. The previous to last transaction must have occurred during the same trading day.

The return calculation is stated in simple percentage terms in order to provide a convenient interpretation of the magnitude of the return. Other researchers (Harris (1989) and others) use the natural log of the ratio of the last price over the penultimate price. For short return intervals and small price changes, the difference in methods is immaterial.

The end-of-day transaction returns will be classified on the basis of several calendar time and security characteristics. Statistical testing of differences between the means of the classified group returns will be done using an analysis of variance framework, whereby the total variance of a sample is partitioned into the variance within

each group and the variance between groups. The larger the variance between groups relative to the variance within groups, the greater the probability that the underlying population means are not equal.

The distributional assumptions underlying variance analysis may be questioned, thus non-parametric tests will also be presented. Specifically, the Wilcoxon rank sums test is performed whereby returns are ranked and these ranks are summed and compared to a distribution that has no difference in the means. The larger the differences, the greater the probability that the groups are not from the same population. When only two groups are present the same analysis is performed but the test itself is called a Wilcoxon scores test.

Comparisons are initially made using the entire sample of firms, but there is a large disparity in the volume as shown by Table 1. A sample of firms that are matched by volume level is created to facilitate a better comparison and obtain a reasonable sample size. Results using the reduced sample are similar to the full sample except for some reduction in significance for cross-trade transactions. The matched sample includes those firms that have total volume during the four-month period that is between 100,000 and 200,000 shares. This includes 57 firms: 25 firms that have no assigned market maker and 32 with an assigned market maker. In a parametric ANOVA test and a non-parametric Wilcoxon rank sums test there is no statistically significant difference between the group in terms of level of volume.

Table 3 presents summary statistics for the matched volume sample. The details are presented both on an overall basis for all 57 firms, and for each of the two groups based on the presence or absence of an assigned market maker. The closing share price for the group of stocks with an assigned market maker is about half the magnitude of the

Table 3 Summary statistics for the 84 trading days (September - December 1995) on the Paris Bourse. This table uses a matched sample of firms (Inclusion if total volume is in the range of 100,000 to 200,000 shares during September-December 1995). Summary statistics are calculated for each firm over the trading period and then averaged across firms.

	mean	standard deviation	minimum	maximum
ALL FIRMS (57)				
number of firms trading per day	54.93	1.26	53	57
closing share price (FF)	451.02	482.05	1.27	2,707.54
firm size (million FF)	23,167	92,832	5.1	680,431
daily volume (shares)	1,899	1,070	1,216	8,232
number of trades per day	14.98	8.99	3.04	43.25
mean transaction size	148.02	93.24	45.54	570.04
no assigned market maker (25)				
number of firms trading per day	24.35	0.50	23	25
closing share price (FF)	601.88	593.36	61.98	2,707.54
firm size (million FF)	51,085	136,581	322	680,431
daily volume (shares)	1,821.18	838.72	1,216	5,536
number of trades per day	18.38	8.51	5.68	40.40
mean transaction size	106.96	41.72	45.54	209.95
assigned market maker (32)				
number of firms trading per day	30.58	0.93	29	32
closing share price (FF)	333.16	338.38	1.27	1,867.27
firm size (million FF)	1,355	2,413	5.1	13,543
daily volume (shares)	1,960.36	1,231.09	1,228	8,232
number of trades per day	12.32	8.57	3.04	43.25
mean transaction size	180.11	109.25	61.04	570.04

group of stocks without an assigned market maker. The firm size variable also shows a difference between the two groups with the group of stocks without an assigned market maker approximately ten times larger. The daily volume is very similar between the two groups, but the number of trades is smaller and the average transaction size is larger for the group of stocks with an assigned market maker.

3.4. Results

Results are presented first for the end of day price rise, with other price formation characteristics in the following sections: intraday volume is examined in section 3.4.2.,

intraday volatility is examined in section 3.4.3., intraday bid-ask spreads are examined in section 3.4.4. and intraday returns are examined in section 3.4.5.

3.4.1. End of Day Price Rise

The final intraday transaction return is examined to determine if there is a difference between those stocks with an assigned market maker and those without an assigned market maker. Table 4 presents the overall final intraday transaction return. There are a total of 32,647 final intraday transaction returns in the sample: 28,964 occur on the exchange and 3,683 occur off the exchange as cross-trades. On average, the final intraday transaction is found to generate a return of 0.13%, which is significantly different than zero at the 1% level. This compares to a mean return of all transactions (excluding first and last transactions each day) of negative 0.0011%, which is significantly different than zero at the 1% level, for the 3,087,696 transactions[4] within trading days that occurred on the Paris Bourse in continuous trading groups during the sample period.

On average, the final intraday transaction return has a magnitude approximately one hundred times that of the average return within the trading day and is positive while the within day return is negative. The mean return of the final transaction in Harris' (1989) study of the last transaction return for all NYSE stocks during the period December 1, 1981 to January 31, 1985 is 0.05%. Similarly, Gosnell (1995) finds that the mean return on the NYSE and ASE for all closing transactions during the 1985 to 1991 period is 0.054%.

Over the calendar period studied, the Paris market experienced a return of -1.04% on the CAC-40 index and -0.68% on the SBF-120 index. Over the four month period

[4] Given the large number of observations, conventional significance levels may not be appropriate. The p-value of this return is 0.0001.

Table 4 Transaction to transaction returns (in percent) for the final transaction of the day are provided both on an overall basis and by dividing the returns into two groups based on if the stock has an assigned market maker. Additionally, returns are divided into those that occurred on the exchange and off the exchange as cross trades. Differences between the groups are tested by using parametric ANOVA and non-parametric Wilcoxon rank scores tests.

	Overall	On Exchange	Cross Trades	ANOVA (Wilcoxon)
mean	0.1271	0.0952	0.3780	
t-statistic	20.35***	14.72***	17.69***	206.35***
n	32647	28964	3683	
% positive	29.7	28.0	43.3	(279.45***)
% zero	46.6	47.8	36.7	
% negative	23.7	24.2	20.0	
without an assigned market maker				
mean	0.0539	0.0354	0.2182	
t-statistic	9.30***	5.96***	10.01***	90.81***
n	23168	20830	2338	
% positive	27.4	26.2	38.5	(135.20***)
% zero	48.7	49.5	41.7	
% negative	23.9	24.3	19.8	
with an assigned market maker				
mean	0.3063	0.2485	0.6557	
t-statistic	19.07***	14.46***	15.04***	78.95***
n	9479	8134	1345	
% positive	35.3	32.6	51.5	(113.60***)
% zero	41.3	43.5	28.0	
% negative	23.4	23.9	20.4	
tests of difference				
ANOVA	339.94***	220.64***	99.70***	
Wilcoxon	174.58***	100.27***	70.04***	

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

studied the mean compound return is -2.9% for all 458 firms. If final intraday transaction returns are excluded then the four month compound return is -8.5%.

The overall final intraday transaction return is also divided into subgroups based on the presence or absence of a single assigned market maker. The mean final intraday transaction return for the group of stocks with single market makers and multiple dealers is seven times larger in magnitude than that of the trading groups with only multiple dealers (0.2485% versus 0.0354%) for on exchange transactions. For cross-trade transactions the magnitude is three times larger (0.6557% versus 0.2182%). Using parametric and non-parametric two-tailed tests, hypothesis one (H1), that the means of the two groups are identical, is rejected for the final intraday transaction return at the one percent level. The final intraday transaction return is larger for those stocks with an assigned market maker both for on exchange and off exchange cross-trades.

The difference in magnitude does lend support to the suggestion that specialists do contribute to the effect. However, these initial results suggest that the end-of-day effect is present in both the trading groups with and without an assigned market maker. And it is present for trades that don't even occur on the exchange. This indicates that the hypotheses that center on the actions of the specialist do not fully explain the end-of-day return phenomenon. Further analysis is warranted to determine if the difference between the groups is due to factors other than the structure of the market (assigned dealer versus not) in which the stocks trade.

Table 5 reproduces these results using the reduced sample that is constrained to include only those securities that had total volume during the four-month period that is between 100,000 and 200,000 shares. Despite the reduced number of observations (4,608

Table 5 This table uses a matched sample of securities that had total volume during the September-December 1995 period that totaled 100,000 to 200,000 shares. Transaction to transaction returns (in percent) for the final transaction of the day are provided both on an overall basis and by dividing the returns into two groups based on if the stock has an assigned market maker. Additionally, returns are divided into those that occurred on the exchange and off the exchange as cross trades. Differences between the groups are tested by using parametric ANOVA and non-parametric Wilcoxon rank scores tests.

	Overall	On Exchange	Cross Trades	ANOVA (Wilcoxon)
mean	0.1534	0.1191	0.3984	
t-statistic	8.59***	6.39***	6.92***	26.5***
n	4608	4042	566	
% positive	29.8	27.3	47.3	(44.5***)
% zero	46.3	48.6	29.7	
% negative	23.9	24.1	23.0	
without an assigned market maker				
mean	0.0420	0.0188	0.2460	
t-statistic	2.03**	0.89	3.01***	11.08***
n	2044	1835	209	
% positive	27.5	25.1	48.8	(30.06***)
% zero	45.4	47.1	30.1	
% negative	27.1	27.8	21.1	
With an assigned market maker				
mean	0.2422	0.2025	0.4877	
t-statistic	8.84***	6.94***	6.29***	13.05***
n	2564	2207	357	
% positive	31.6	29.1	46.5	(15.44***)
% zero	47.0	49.9	29.4	
% negative	21.4	21.0	24.1	
Tests of difference				
ANOVA	31.22***	24.24***	4.13**	
Wilcoxon	29.96***	28.52***	0.96	

*significant at a level of α = 10%
**significant at a level of α = 5%
***significant at a level of α = 1%

versus 32,647), the same pattern, magnitudes and levels of significance are reported between all groups with only one exception. For cross-trades, the difference between the presence and absence of an assigned market maker is significant using a parametric test at a level of only five percent versus one percent for the entire sample, and the difference using a non-parametric Wilcoxon rank sums test is not statistically significant.

3.4.1.1. Location of Final Intraday Transaction

In Table 6, end of day institutional cross-trades are further examined in each trading group to determine if they have significantly different characteristics than on-exchange trades. Trades in each individual trading group are divided into subgroups based on whether the transaction is identified as a cross-trade, indicating the trade occurred off the exchange (also known as a pass-through). Cross-trades occurred with much less frequency than on exchange transactions, ranging from 1% of the secondary issues cash market trading group to 15% of the medium liquidity stocks that are traded on a cash basis. In total, 3,683 of the 32,647 final transactions in the sample are cross-trades. In eight of the ten trading groups examined, the cross trades have a higher mean return that was statistically more significant than exchange trades. There is a statistical difference in the mean of the final intraday transaction return between cross-trades and on exchange trades; therefore hypothesis two (H2) is rejected. This suggests that cross-trades may not be as competitive and may be used to influence end-of-day pricing for window dressing purposes. For example, outside sellers may be able to obtain higher prices near the close if the broker is interested in buying the shares to influence the price near the close. Another example may be a negotiated price for a small number of shares between two individuals that is reported through a broker.

Table 6 Transaction to transaction returns (in percent) for the final transaction of the day are reported for each trading group. The continuous trading groups are subdivided into two groups depending on whether the transaction was a cross-trade or not. Tests of differences are performed using parametric ANOVA and non-parametric Wilcoxon rank scores tests.

	Overall	Exchange trades	Cross-trades	Tests of Difference ANOVA (Wilcoxon)
Continuous A Règlement Mensuel (trading group 11): High liquidity stocks traded on the Règlement Mensuel				
Mean	0.0661	0.0465	0.2196	
t-statistic	8.49***	5.83***	7.74***	49.86***
# obs (# firms)	9482 (163)	8410 (163)	1072 (156)	
% positive	25.4	24.1	35.7	(55.43***)
% zero	54.1	55.1	46.6	
% negative	20.5	20.8	17.6	
Continuous A Règlement Mensuel (trading group 15): High liquidity stocks traded on the Règlement Mensuel (index component stocks)				
mean	0.0281	0.0225	0.0802	
t-statistic	3.02***	2.34**	2.36***	3.36*
# obs (# firms)	3865 (66)	3491 (66)	374 (26)	
% positive	21.4	21.0	25.4	(3.95**)
% zero	59.7	59.9	58.6	
% negative	18.8	19.1	16.0	
Continuous A Règlement Mensuel - foreign stocks (trading group 21): High liquidity foreign stocks traded on the Règlement Mensuel				
mean	0.0085	-0.0048	0.1623	
t-statistic	0.73	-0.41	2.81***	15.20***
# obs (# firms)	6475 (83)	5963 (83)	512 (81)	
% positive	33.2	31.6	50.8	(39.03***)
% zero	34.3	35.5	20.1	
% negative	32.6	32.9	29.1	
Continuous A cash market (trading group 16): High liquidity stocks traded on the cash market				
mean	0.1675	0.1231	0.4475	
t-statistic	6.92***	4.82***	6.33***	21.40***
# obs (# firms)	2369 (35)	2045 (35)	324 (32)	
% positive	30.4	28.6	42.3	(27.98***)
% zero	48.7	49.6	42.9	
% negative	20.9	21.8	14.8	

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

(table con'd)

(Table 6 continued)

	Overall	Exchange trades	Cross-trades	Tests of Difference ANOVA (Wilcoxon)
Continuous A cash market - foreign stocks (trading group 22): High liquidity foreign stocks traded on the cash market				
mean	-0.081	-0.1043	0.2145	
t-statistic	-2.24**	-2.97***	1.02	5.37**
# obs (# firms)	569 (9)	527 (9)	42 (8)	
% positive	25.3	23.9	42.9	2.23
% zero	42.9	44.6	21.4	
% negative	31.8	31.5	35.7	
Continuous A cash market secondary issues (trading group 31): High liquidity secondary issues traded on the cash market				
mean	0.5381	0.5240	2.7287	
t-statistic	1.99**	1.93*		0.42
# obs (# firms)	156 (4)	155 (4)	1 (1)	
% positive	19.2	18.7	100.0	(2.63)
% zero	68.0	68.4	0	
% negative	12.8	12.9	0	
Continuous A RM secondary issues (trading group 32): High liquidity secondary issues traded on the Règlement Mensuel				
mean	0.0913	0.0755	0.3825	
t-statistic	2.73***	2.22**	2.39**	4.18**
# obs (# firms)	252 (3)	239 (3)	13 (3)	
% positive	27.8	26.4	53.8	(3.98**)
% zero	48.4	49.4	30.8	
% negative	23.8	24.3	15.4	
Continuous B cash market (trading group 12): Medium liquidity stocks traded on the cash market				
mean	0.3251	0.2679	0.6620	
t-statistic	19.18***	14.69***	14.78***	67.12***
# obs (# firms)	8698 (147)	7434 (147)	1264 (138)	
% positive	35.9	33.2	51.7	(102.09***)
% zero	41.4	43.6	28.5	
% negative	22.7	23.2	19.8	
Continuous B cash market foreign (trading group 17): Medium liquidity stocks traded on the cash market				
mean	0.0959	0.0425	0.5572	
t-statistic	2.02**	0.89	2.94***	11.04***
# obs (# firms)	781 (13)	700 (13)	81 (13)	
% positive	28.8	26.6	48.1	(7.23***)
% zero	40.7	43.0	79.0	
% negative	30.5	30.4	30.9	

*significant at a level of α = 10%
**significant at a level of α = 5%
***significant at a level of α = 1%

3.4.1.2. Timing of the Final Transaction

Other researchers[5] have found that the larger final intraday returns occur during the last five minutes of trading. Tables 7, 8 and 9 further examine final intraday transaction returns by dividing the final intraday transaction returns into individual trading groups and into pre-4:55 pm and post-4:55 pm subgroups[6]. On the Paris Bourse, trading occurs from 10 am to 5 pm with the final trades in our sample recorded at two minutes after five. Individual minute by minute returns are calculated for each minute after 4:00 pm but are not shown here. Starting at 4:00 pm, no individual minute has a mean transaction return that is statistically different than zero at a level of significance greater than 1% until 4:42 pm. Then all minutes except 4:48, 4:49 and 4:54 maintain that level of significance. This is also true for 5:00, but then the level of significance falls for 5:01 and 5:02. For this first look at the different trading groups, the division into pre-4:55 pm and post-4:55 pm is consistent with other researchers. Of interest are the high returns in the two trading groups that have a single market maker, the Continuous B groups. These groups have the largest and third largest mean returns in the post-4:55 pm category, and the second largest and fourth largest mean returns in the overall category. Although the multiple dealer in the cash market for secondary issues (trading group 31) has a relatively high post-4:55 pm average return, the sample size is relatively small.

Many of the other trading groups have mean final intraday transaction returns that are significant. The division into pre-4:55 pm and post-4:55 pm groups shows that in most of the cases the significance is a result of the final few minutes of the trading day.

---

[5] See Gosnell (1987) and Harris (1989).

[6] Trades are time-stamped to the nearest second. All returns using last transactions occurring later than 4:54:59 are included in the post-4:55 pm subgroup.

Table 7 Transaction to transaction return (in percent) for the final transaction of the day are reported for each trading group. Returns are reported on an overall basis as well as divided into two groups dependent on whether the final transactions occurred before or after 4:55 pm. This table includes exchange and cross-trade transactions for continuously trading compartments of the Paris Bourse. Tests of difference are performed using parametric ANOVA tests and non-parametric Wilcoxon rank scores tests.

	Overall	Before 4:55pm	After 4:55pm	Tests of Difference ANOVA (Wilcoxon)
Multiple Dealer Continuous A Règlement Mensuel (trading group 11): High liquidity stocks traded on the Règlement Mensuel				
mean	0.0661	0.0430	0.0764	
t-statistic	8.49***	2.40**	9.63***	3.92**
# obs (# firms)	9482 (163)	2922 (130)	6560 (163)	
% positive	25.4	29.4	23.6	(3.31*)
% zero	54.1	44.1	58.6	
% negative	20.5	26.5	17.8	
Multiple Dealer Continuous A Règlement Mensuel (trading group 15): High liquidity stocks traded on the Règlement Mensuel (index component stocks)				
mean	0.0281	-0.0216	0.0426	
t-statistic	3.02***	-0.90	3.64***	8.32***
# obs (# firms)	3865 (66)	872 (54)	2993 (66)	
% positive	21.5	26.6	20.0	(2.11)
% zero	59.7	47.0	63.5	
% negative	18.8	26.4	16.6	
Multiple Dealer Continuous A Règlement Mensuel - foreign stocks (trading group 21): High liquidity foreign stocks traded on the Règlement Mensuel				
mean	0.0085	-0.0224	0.1297	
t-statistic	0.73	-1.78*	4.56***	27.98***
# obs (# firms)	6475 (83)	5163 (83)	1312 (83)	
% positive	33.2	31.6	39.3	(35.92***)
% zero	34.3	34.7	32.8	
% negative	32.6	33.7	28.0	
Multiple Dealer Continuous A cash market (trading group 16): High liquidity stocks traded on the cash market				
mean	0.1675	0.0864	0.2626	
t-statistic	6.92***	2.39**	6.51***	13.25***
# obs (# firms)	2369 (35)	1279 (35)	1090 (34)	
% positive	30.4	30.4	30.6	(16.45***)
% zero	48.7	43.9	54.3	
% negative	20.9	25.7	15.1	
Multiple Dealer Continuous A cash market - foreign stocks (trading group 22): High liquidity foreign stocks traded on the cash market				
mean	-0.081	-0.0885	0.0625	
t-statistic	-2.24**	-2.43**	0.30	0.85
# obs (# firms)	569 (9)	540 (9)	29 (8)	
% positive	25.3	24.6	37.9	(0.09)
% zero	42.9	43.9	24.2	
% negative	31.8	31.5	37.9	

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

(table con'd)

(Table 7 continued)

	Overall	Before 4:55pm	After 4:55pm	Tests of Difference ANOVA (Wilcoxon)
Multiple Dealer Continuous A cash market secondary issues (trading group 31): High liquidity secondary issues traded on the cash market				
mean	0.5381	0.6273	0.4577	
t-statistic	1.99**	1.17	2.61**	0.10
# obs (# firms)	156 (4)	74 (4)	82 (4)	
% positive	19.2	27.0	12.2	(0.72)
% zero	68.0	47.3	86.6	
% negative	12.8	25.7	1.2	
Multiple Dealer Continuous A RM secondary issues (trading group 32): High liquidity secondary issues traded on the Règlement Mensuel				
mean	0.0913	0.1062	0.0762	
t-statistic	2.73***	2.20**	1.64	0.20
# obs (# firms)	252 (3)	127 (3)	125 (3)	
% positive	27.8	27.6	28.0	(0.41)
% zero	48.4	44.1	52.8	
% negative	23.8	28.3	19.2	
Single Market Maker Continuous B cash market (trading group 12): Medium liquidity stocks traded on the cash market				
mean	0.3251	0.1895	0.6926	
t-statistic	19.18***	9.83***	20.42***	176.89***
# obs (# firms)	8698 (147)	6353 (147)	2345 (138)	
% positive	35.9	31.2	48.7	(250.62***)
% zero	41.4	43.4	35.9	
% negative	22.7	25.4	15.4	
Single Market Maker Continuous B cash market foreign (trading group 17): Medium liquidity stocks traded on the cash market				
mean	0.0959	0.0302	0.3432	
t-statistic	2.02**	0.58	3.14***	7.25***
# obs (# firms)	781 (13)	617 (13)	164 (13)	
% positive	28.8	27.7	32.9	(4.17**)
% zero	40.7	40.7	40.9	
% negative	30.5	31.6	26.2	

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

Table 8 Transaction to transaction return (in percent) for the final transaction of the day is reported for each trading groups. Returns are reported on an overall basis as well as divided into two groups dependent on whether the final transactions occurred before or after 4:55 pm. This table includes only on exchange transactions for stocks traded in a continuous compartment. Cross trades are deleted. Differences are tested by parametric ANOVA and non-parametric Wilcoxon rank scores tests.

	Overall	Before 4:55pm	After 4:55pm	Tests of Difference ANOVA (Wilcoxon)
Multiple Dealer Continuous A Règlement Mensuel (trading group 11): High liquidity stocks traded on the Règlement Mensuel				
mean	0.0465	0.0263	0.0560	
t-statistic	5.83***	1.47	6.89***	3.03*
# obs (# firms)	8410 (163)	2697 (128)	5713 (163)	
% positive	24.1	28.0	22.3	(2.77*)
% zero	55.1	45.5	59.6	
% negative	20.8	26.5	18.1	
Multiple Dealer Continuous A Règlement Mensuel (trading group 15): High liquidity stocks traded on the Règlement Mensuel (index component stocks)				
mean	0.0225	-0.0225	0.0365	
t-statistic	2.34**	-0.91	3.64***	6.78***
# obs (# firms)	3491 (66)	828 (54)	2663 (66)	
% positive	21.0	26.0	19.5	(1.78)
% zero	59.9	47.8	63.6	
% negative	19.1	26.2	16.9	
Multiple Dealer Continuous A Règlement Mensuel - foreign stocks (trading group 21): High liquidity foreign stocks traded on the Règlement Mensuel				
mean	-0.0048	-0.0246	0.0784	
t-statistic	-0.41	-1.95*	2.81***	12.41***
# obs (# firms)	5963 (83)	4816 (83)	1147 (82)	
% positive	31.6	30.5	36.5	(20.44***)
% zero	35.5	35.7	34.7	
% negative	32.9	33.8	28.8	
Multiple Dealer Continuous A cash market (trading group 16): High liquidity stocks traded on the cash market				
mean	0.1231	0.0497	0.2194	
t-statistic	4.82***	1.35	6.51***	10.87***
# obs (# firms)	2045 (35)	1160 (35)	885 (34)	
% positive	28.6	28.5	28.6	(12.48***)
% zero	49.6	45.4	55.1	
% negative	21.8	26.0	16.3	
Multiple Dealer Continuous A cash market - foreign stocks (trading group 22): High liquidity foreign stocks traded on the cash market				
mean	-0.1043	-0.1027	-0.1445	
t-statistic	-2.97***	-2.85***	-1.01	0.05
# obs (# firms)	527 (9)	507 (9)	20 (6)	
% positive	23.9	23.7	30.0	(0.11)
% zero	44.6	45.2	30.0	
% negative	31.5	31.3	40.0	

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

(table con'd)

(Table 8 continued)

	Overall	Before 4:55pm	After 4:55pm	Tests of Difference ANOVA (Wilcoxon)
Multiple Dealer Continuous A cash market secondary issues (trading group 31): High liquidity secondary issues traded on the cash market				
mean	0.5240	0.6273	0.4296	
t-statistic	1.93*	1.17	2.45**	0.13
# obs (# firms)	155 (4)	74 (4)	81 (4)	
% positive	18.7	27.0	11.1	(0.57)
% zero	68.4	47.3	87.7	
% negative	12.9	25.7	1.2	
Multiple Dealer Continuous A RM secondary issues (trading group 32): High liquidity secondary issues traded on the Règlement Mensuel				
mean	0.0755	0.1009	0.0484	
t-statistic	2.22**	2.05**	1.04	0.60
# cbs (# firms)	239 (3)	123 (3)	116 (3)	
% positive	26.4	26.8	25.9	(0.08)
% zero	49.4	45.5	53.4	
% negative	24.3	27.7	20.7	
Single Market Maker Continuous B cash market (trading group 12): Medium liquidity stocks traded on the cash market				
mean	0.2679	0.1428	0.6592	
t-statistic	14.69***	7.05***	16.80***	150.13***
# obs (# firms)	7434 (147)	5633 (147)	1801 (135)	
% positive	33.2	29.0	46.3	(197.55***)
% zero	43.6	45.5	37.6	
% negative	23.2	25.5	16.1	
Single Market Maker Continuous B cash market foreign (trading group 17): Medium liquidity stocks traded on the cash market				
mean	0.0425	-0.0193	0.2943	
t-statistic	0.89	-0.37	2.45**	6.83***
# obs (# firms)	700 (13)	562 (13)	138 (13)	
% positive	26.6	25.3	31.9	(4.45**)
% zero	43.0	43.1	42.8	
% negative	30.4	31.6	25.3	

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

Table 9 Transaction to transaction return (in percent) for the final transaction of the day divided into trading groups. Returns are reported on an overall basis as well as divided into two groups dependent on whether the final transactions occurred before or after 4:55 pm. This table includes only cross-trades for those stocks traded in a continuous trading compartment. Tests of difference are performed using parametric ANOVA and non-parametric Wilcoxon rank scores tests.

	Overall	Before 4:55pm	After 4:55pm	Tests of Difference ANOVA (Wilcoxon)
Multiple Dealer Continuous A Règlement Mensuel (trading group 11): High liquidity stocks traded on the Règlement Mensuel				
mean	0.2196	0.2428	0.2134	
t-statistic	7.74***	2.73***	7.88***	0.18
# obs (# firms)	1072 (156)	225 (87)	847 (143)	
% positive	35.7	46.7	32.8	(1.01)
% zero	46.6	28.0	51.6	
% negative	17.6	25.3	15.6	
Multiple Dealer Continuous A Règlement Mensuel (trading group 15): High liquidity stocks traded on the Règlement Mensuel (index component stocks)				
mean	0.0802	-0.0049	0.0916	
t-statistic	2.36***	-0.04	2.59**	0.84
# obs (# firms)	374 (26)	44 (26)	330 (26)	
% positive	25.4	38.6	23.6	(0.00)
% zero	58.6	31.8	62.1	
% negative	16.0	29.6	14.3	
Multiple Dealer Continuous A Règlement Mensuel - foreign stocks (trading group 21): High liquidity foreign stocks traded on the Règlement Mensuel				
mean	0.1623	0.0084	0.4861	
t-statistic	2.81***	0.13	4.31***	15.32***
# obs (# firms)	512 (81)	347 (81)	165 (58)	
% positive	50.8	47.3	58.2	(15.66***)
% zero	20.1	20.5	19.4	
% negative	29.1	32.2	22.4	
Multiple Dealer Continuous A cash market (trading group 16): High liquidity stocks traded on the cash market				
mean	0.4475	0.4444	0.4493	
t-statistic	6.33***	3.09***	6.03***	0.01
# obs (# firms)	324 (32)	119 (28)	205 (27)	
% positive	42.3	47.9	39.0	(0.01)
% zero	42.9	29.4	50.7	
% negative	14.8	22.7	10.3	
Multiple Dealer Continuous A cash market - foreign stocks (trading group 22): High liquidity foreign stocks traded on the cash market				
mean	0.2145	0.1304	0.5227	
t-statistic	1.02	0.60	0.89	0.58
# obs (# firms)	42 (8)	33 (8)	9 (5)	
% positive	42.9	39.4	55.6	(0.07)
% zero	21.4	24.2	11.1	
% negative	35.7	36.4	33.3	

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

(table con'd)

(Table 9 continued)

	Overall	Before 4:55pm	After 4:55pm	Tests of Difference ANOVA (Wilcoxon)
Multiple Dealer Continuous A cash market secondary issues (trading group 31): High liquidity secondary issues traded on the cash market				
mean	2.7287		2.7287	
t-statistic				
# obs (# firms)	1 (1)		1 (1)	
% positive	100.0		100.0	
% zero	0		0	
% negative	0		0	
Multiple Dealer Continuous A RM secondary issues (trading group 32): High liquidity secondary issues traded on the Règlement Mensuel				
mean	0.3825	0.2673	0.4336	
t-statistic	2.39**	0.94	2.15*	0.22
# obs (# firms)	13 (3)	4 (3)	9 (3)	
% positive	53.8	50.0	55.5	(0.39)
% zero	30.8	0	44.5	
% negative	15.4	50.0	0	
Single Market Maker Continuous B cash market (trading group 12): Medium liquidity stocks traded on the cash market				
mean	0.6620	0.5551	0.8034	
t-statistic	14.78***	9.28***	11.98***	7.58***
# obs (# firms)	1264 (138)	720 (135)	544 (108)	
% positive	51.7	48.1	56.6	(16.42***)
% zero	28.5	27.4	30.0	
% negative	19.8	24.5	13.4	
Single Market Maker Continuous B cash market foreign (trading group 17): Medium liquidity stocks traded on the cash market				
mean	0.5572	0.5358	0.6025	
t-statistic	2.94***	2.13**	2.31***	0.03
# obs (# firms)	81 (13)	55 (10)	26 (8)	
% positive	48.1	52.7	38.4	(0.07)
% zero	79.0	16.4	30.8	
% negative	30.9	30.9	30.8	

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

These results indicate that the end-of-day effect is pervasive across the trading groups, but that the effect is a function of the proximity of the last trade to the close and to the presence of a single market maker. This is confirmed on an overall basis as well as when dividing the transactions into on-exchange and off exchange cross-trades as shown in Tables 8 and 9. This rejects (H2) and the alternative hypothesis that the final intraday transaction return is larger when it has closer proximity to the close of trading is accepted.

Table 10 presents the mean final intraday transaction returns categorized by the time of the final transaction. The timing of the final transaction is divided into hourly periods as well as quarterly-hour periods within the trading day. The only fifteen minute periods with transaction returns that are significantly different from zero at a high level of significance are those that occur after 4:30 pm.

Intuition would suggest that relatively few firms would have last trades that occur before 2:00 pm, with a high concentration of final transactions in the final hour of trading. This indicates a relatively high degree of liquidity or frequency of trading. It is interesting to note that when the final return occurs during the first hours of the trading day, average returns are negative. However, only the fifteen minute intervals from 10:30 am-10:44 am and from 11:30 am-11:44 am are significantly different than zero. Analysis of variance and non-parametric tests are performed to test the significance of the differences in mean returns among the fifteen minute intervals. When all the intervals are included the hypothesis that the means of the groups are identical is rejected both parametrically (with an F test of 9.36) and non-parametrically with a Wilcoxon rank sums test (with a chi-square equal to 252.8). Both tests are significant at the 1% level. In order

Table 10 Transaction to transaction return (in percent) for the final transaction of the day. All cross-trades are deleted. The time of the last trade is specified classified by hour of the trading day (10AM - 5PM). The transactions are also divided into fifteen minute intervals within each hour. Tests for significant differences are performed across all the fifteen minute trading intervals both including and deleting the last three fifteen minute periods.

	ALL	10am-11	11-12	12-1pm	1-2	2-3	3-4	4-5	after 5
mean	0.0952	-0.0924	-0.0578	0.0458	-0.163	0.0068	0.0287	0.1545	0.0706
t-stat	14.72***	-1.36	-1.10	0.77	-2.43**	0.18	1.32	16.84***	8.54***
N	28964	519	797	634	501	1334	3203	14938	7038
%pos.	28.0	25.6	23.8	29.2	22.8	28.9	27.9	32.6	18.9
% zero	47.8	43.6	46.4	44.8	42.7	43.6	42.2	41.4	66.0
%neg.	24.2	30.8	29.8	26.0	34.5	27.5	29.9	26.0	15.1
first fifteen minutes (:00-:14)									
mean	0.0446	-0.0600	-0.0661	-0.0993	0.0465	0.0118	-0.0861	0.0124	0.0706
t-stat	4.90***	-0.41	-0.57	-1.00	0.27	0.11	-1.48	0.42	8.54***
N	9758	117	171	204	89	213	541	1385	7038
%pos.	21.1	21.4	21.6	28.9	29.2	30.5	25.3	27.7	18.9
% zero	59.6	51.3	49.7	40.7	42.7	41.8	42.5	41.9	66.0
%neg.	19.3	27.3	28.7	30.4	28.1	27.7	32.2	30.3	15.1
second fifteen minutes (:15-:29)									
mean	0.0177	-0.1020	0.0798	0.0399	-0.2564	0.0423	0.0315	0.0242	
t-stat	0.81	-0.82	0.62	0.33	-1.71*	0.55	0.64	0.89	
N	3438	120	180	163	106	290	644	1935	
%pos.	27.8	21.7	30.6	27.0	21.7	27.9	29.5	27.8	
% zero	42.5	51.6	34.4	46.6	43.4	44.8	42.9	41.8	
%neg.	29.7	26.7	35.0	26.4	34.9	27.3	27.6	30.4	
third fifteen minutes (:30-:44)									
mean	0.0433	-0.2511	-0.2459	0.1011	-0.1283	-0.0498	0.0447	0.0947	
t-stat	2.63***	-1.84*	-2.61***	0.79	-0.87	-0.77	1.15	5.06***	
N	4897	143	219	151	128	382	894	2980	
%pos.	29.0	26.6	20.1	29.8	21.1	27.2	29.3	30.2	
% zero	42.9	40.5	49.8	47.0	44.5	42.4	40.6	42.9	
%neg.	28.1	32.9	30.1	23.2	34.4	30.4	30.1	26.9	
last fifteen minutes (:45-:59)									
Mean	0.1886	0.0520	0.0210	0.2372	-0.2366	0.0295	0.0697	0.2270	
t-stat	16.80***	0.39	0.24	1.68*	-2.51**	0.46	1.92*	18.65***	
n	10871	139	227	116	178	449	1124	8638	
%pos.	33.7	31.7	23.8	31.9	21.3	30.1	27.0	35.3	
% zero	41.2	33.1	50.2	46.5	41.0	44.8	42.9	40.7	
%neg.	25.1	35.3	26.0	21.6	37.6	25.2	30.1	24.0	

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

(table con'd)

(Table 10 continued)

H_O: the mean value of the last transaction return is the same for all of the 29 fifteen minute intervals during the trading day
H_1: at least one of the fifteen minute intervals does not have the same mean

F-value for ANOVA test	9.36***
Chi-square approximation for Wilcoxon rank sums non-parametric test	252.8***

H_O: the mean value of the last transaction return is the same for all of the 26 fifteen minute intervals during the trading day before 4:30pm
H_1: at least one of the fifteen minute intervals during the trading day before 4:45pm does not have the same mean

F-value for ANOVA test	1.69**
Chi-square approximation for Wilcoxon rank sums non-parametric test	33.0

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1%

to test if there is any differences for those intervals before the end of the day the last three fifteen minute intervals are excluded and the parametric and non-parametric tests are performed again. With the reduced period of 26 intervals, the same tests fail to find significant differences among the groups. The parametric test has a significance level of 5%, but the non-parametric test fails conventional significance levels. These results indicate that the proximity to the close is still important, even with the cross-trades removed. This rejects hypothesis three (H3) and confirms that the end of day price rise is due largely to last returns occurring within the last fifteen minutes of trading, with some effect also occurring in the previous fifteen minutes. Interestingly, trades reported within the first few minutes following the close have a significant positive return, yet a disproportionate proportion of zero returns.

3.4.1.3. Window Dressing

The window dressing hypothesis is tested in Table 11 by examining final intraday transaction returns on month-ends since there may be a greater incentive to affect the

Table 11 Transaction to transaction return (in percent) for the final transaction of the day is provided for non-month end and month end days on an overall basis and by dividing the returns into two groups based on if the transaction occurred with or without an assigned market maker. Tests of difference between the groups are done using parametric ANOVA and non-parametric Wilcoxon rank scores tests.

	Overall	No Assigned Market Makers	Assigned Market Maker	ANOVA (Wilcoxon)
mean	0.1271	0.0539	0.3063	
t-statistic	20.35***	9.30***	19.07***	339.94***
n	32647	23168	9479	
% positive	29.7	27.4	35.3	(174.58***)
% zero	46.6	48.7	41.3	
% negative	23.7	23.9	23.4	
non-month end days				
mean	0.1247	0.0516	0.3042	
t-statistic	19.66***	8.78***	18.59***	
n	31111	22097	9014	329.55***
% positive	29.7	27.4	35.3	
% zero	46.4	48.6	41.1	(165.61***)
% negative	23.9	24.0	23.6	
month end days				
mean	0.1749	0.1008	0.3455	
t-statistic	5.28***	3.17***	4.27***	
n	1536	1071	465	11.58***
% positive	30.2	28.1	35.1	
% zero	49.8	51.6	45.6	(8.47***)
% negative	20.0	20.3	19.3	
tests of difference				
ANOVA	2.98*	3.19*	0.38	
Wilcoxon	5.28**	4.78**	1.17	

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

price at the close of trading on these days. The results show that there is a statistically significant difference between non-month end day's final intraday transaction return and month end day's final intraday transaction return (0.1749% versus 0.1247%). This, however, occurs only for multiple dealers where the month-end return is twice as large as non-month end day's final intraday transaction return (0.1008% versus 0.0516%). The month-end explanation is also tested in Table 12 by dividing the return into exchange trades and cross-trades. Within each of these groups there is modest statistical difference between the final intraday transaction return at month end and the final intraday transaction return on other days.

Based on the results of the two tests there appears to be little difference on month-end days within the group of stocks with assigned market makers, within the group of cross-trades and within the group of on exchange trades. It is only for the group of multiple market makers with no assigned dealer where the final intraday transaction return on month-end days is statistically different from non-month-end-days both parametrically and non-parametrically. Hypothesis four (H4) fails to be rejected and the end of the day price rise is concluded to be the same on month-end days as on any other day during the month.

3.4.1.4. Day of the Week

Table 13 examines the relationship between the magnitude of the final intraday transaction return and the day of the week. Harris (1989) fails to find any differences in weekday final transaction returns, while Gosnell (1987) observes significant differences in the final returns across the days of the week. Specifically, Gosnell finds that final transaction returns are higher on Friday due to an increase in the number of buy orders on

Table 12 Transaction to transaction return (in percent) for the final transaction of the day is reported for the last trading day of the month both on an overall basis and by dividing the returns into two groups based on if the transaction occurred on the exchange or as a cross-trade. Tests of difference between the groups are done using parametric ANOVA and non-parametric Wilcoxon rank scores tests.

	Overall	On Exchange	Cross-Trade	ANOVA (Wilcoxon)
mean	0.1271	0.0952	0.3780	
t-statistic	20.35***	14.72***	17.69***	206.35***
n	32647	28964	3683	
% positive	29.7	28.0	43.3	(279.45***)
% zero	46.6	47.8	36.7	
% negative	23.7	24.2	20.0	
non-month end days				
mean	0.1247	0.0938	0.3690	
t-statistic	19.66***	14.26***	17.04***	
n	31111	27610	3501	188.86***
% positive	29.7	28.0	43.3	
% zero	46.4	47.6	36.6	(266.63***)
% negative	23.9	24.4	20.1	
month end days				
mean	0.1749	0.1244	0.5508	
t-statistic	5.28***	3.65***	4.78***	
n	1536	1354	182	17.47***
% positive	30.2	28.5	42.8	
% zero	49.8	51.3	38.5	(12.57***)
% negative	20.0	20.2	18.7	
tests of difference between the two groups				
ANOVA	2.98*	0.99	3.40*	
Wilcoxon	5.28**	5.69**	0.55	

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

Table 13 Final intraday transaction returns are reported across the days of the week. The returns are also divided into transactions that occurred before and after 4:55 pm. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are performed to test the hypothesis that the means across the days of the week are equal. Parametric ANOVA and non-parametric Wilcoxon ranks scores tests are performed to test the hypothesis that the means in both subperiods are equal.

	All Days	Monday	Tuesday	Wednesday	Thursday	Friday	F test (Wilcoxon)
Overall							
mean	0.0952	0.0977	0.0712	0.0965	0.0949	0.1149	1.204
t-statistic	14.72***	6.65***	5.00***	6.82***	6.56***	7.83***	
n	28964	5520	5840	5503	5891	6210	(7.66)
% positive	28.0	28.0	27.6	28.2	26.9	29.2	
% zero	47.8	48.1	47.1	47.2	49.4	47.4	
% negative	24.2	23.9	25.3	24.6	23.7	23.5	
Overall - Trading Groups Without Market Makers							
mean	0.0354	0.0427	0.0206	0.0447	0.0163	0.0527	1.48
t-statistic	5.96***	3.10***	1.53	3.54***	1.23	3.98***	
n	20830	3999	4214	3954	4215	4448	(6.81)
% positive	26.2	26.5	26.1	26.9	24.4	27.0	
% zero	49.5	49.8	48.5	48.5	51.2	49.5	
% negative	24.3	23.8	25.4	24.6	24.4	23.5	
Overall - Trading Groups With Market Makers							
mean	0.2485	0.2423	0.2023	0.2288	0.2925	0.2720	0.87
t-statistic	14.46***	6.23***	5.42***	5.96***	7.71***	6.94***	
n	8134	1521	1626	1549	1676	1762	(6.45)
% positive	32.6	32.0	31.3	31.6	33.2	34.8	
% zero	43.5	43.6	43.7	43.8	44.8	41.8	
% negative	23.9	24.4	25.0	24.6	22.0	23.4	
test for difference between trading groups:							
F test	68.91***	37.02***	32.95***	34.42***	75.09***	45.67***	
Wilcoxon	106.31***	13.28***	12.91***	10.18***	44.47***	27.06***	

* significant at a level of $\alpha = 10\%$, ** significant at a level of $\alpha = 5\%$, *** significant at a level of $\alpha = 1\%$

(table con'd)

(Table 13 continued)

	All Days	Monday	Tuesday	Wednesday	Thursday	Friday	ANOVA (Wilcoxon)
Before 4:55PM							
mean	0.0483	0.0626	0.0202	0.0670	0.0511	0.0429	0.77
t-statistic	5.09***	2.83***	1.00	3.23***	2.29**	2.07**	
n	16400	3144	3375	3166	3232	3483	(3.21)
% positive	28.8	28.9	28.4	29.2	27.0	30.1	
% zero	42.6	43.3	41.9	42.2	44.6	41.4	
% negative	28.6	27.8	29.7	28.6	28.4	28.5	
Before 4:55PM - Trading Groups Without Market Makers							
mean	-0.0001	0.0241	-0.0296	0.0192	-0.0174	0.0052	1.09
t-statistic	-0.02	1.00	-1.40	0.93	-0.74	0.24***	
n	10205	1949	2117	1962	1994	2183	(5.09)
% positive	28.8	29.3	28.7	29.6	26.5	29.9	
% zero	41.0	41.8	39.8	40.4	42.9	40.5	
% negative	30.2	28.9	31.5	30.0	30.6	29.6	
Before 4:55PM - Trading Groups With Market Makers							
mean	0.1281	0.1253	0.1042	0.1449	0.1615	0.1064	0.34
t-statistic	6.73***	2.93***	2.57	3.40***	3.66***	2.50**	
n	6195	1195	1258	1204	1238	1300	(0.54)
% positive	28.7	28.3	28.0	28.6	27.9	30.5	
% zero	45.2	45.8	45.4	45.0	47.3	42.9	
% negative	26.1	25.9	26.6	26.4	24.9	26.5	
tests for difference between trading groups in the before 4:55pm subgroup:							
ANOVA	43.09***	4.94**	10.34***	8.69***	15.25***	5.57**	
Wilcoxon	18.69***	1.69	4.32**	1.83	9.49***	3.38*	

*significant at a level of $\alpha = 10\%$, **significant at a level of $\alpha = 5\%$, ***significant at a level of $\alpha = 1\%$

(table con'd)

(Table 13 continued)

	All Days	Monday	Tuesday	Wednesday	Thursday	Friday	ANOVA (Wilcoxon)
After 4:55PM							
Mean	0.1565	0.1442	0.1409	0.1365	0.1481	0.2069	2.61**
t-statistic	18.87***	8.19***	7.30***	7.61***	8.70***	10.23***	
N	12564	2376	2465	2337	2659	2727	(7.93*)
% positive	27.0	26.8	26.3	26.9	26.8	27.9	
% zero	54.6	54.4	54.3	54.0	55.2	55.0	
% negative	18.4	18.9	19.4	19.1	18.0	17.1	
After 4:55PM - Trading Groups Without Market Makers							
Mean	0.0696	0.0604	0.0712	0.0698	0.0466	0.0986	1.71
t-statistic	10.39***	4.33***	4.37***	4.81***	3.39***	6.18***	
n	10625	2050	2097	1992	2221	2265	(3.47*)
% positive	23.6	23.8	23.4	24.2	22.6	24.1	
% zero	57.7	57.4	57.2	56.5	58.6	58.4	
% negative	18.7	18.9	19.4	19.2	18.8	17.5	
After 4:55PM - Trading Groups With Market Makers							
Mean	0.6332	0.6712	0.5376	0.5216	0.6626	0.7379	1.25
t-statistic	16.90***	7.61***	6.17***	6.12***	9.27***	8.58***	
N	1939	326	368	345	438	462	(6.29*)
% positive	45.3	45.7	42.7	42.0	48.2	46.8	
% zero	38.0	35.6	37.8	39.7	38.1	38.5	
% negative	16.7	18.7	19.6	18.3	13.7	14.7	
tests for difference between trading groups in the after 4:55pm subgroup:							
ANOVA	632.90***	151.63***	76.54***	82.66***	193.24***	148.21***	
Wilcoxon	328.05***	54.08***	38.88***	38.91***	113.18***	91.55***	

* significant at a level of $\alpha = 10\%$, ** significant at a level of $\alpha = 5\%$, *** significant at a level of $\alpha = 1\%$

Friday rather than to a shift in the equilibrium prices. Using the Paris Bourse data, there are no differences across the days of the week for the overall final intraday transaction return. Both parametric and non-parametric tests fail to reject the null hypothesis that the mean of the final intraday transaction return is the same across the days of the week. When the transaction returns are subdivided into those that occurred in trading groups with an assigned market maker and those without an assigned market maker, the mean transaction return does not differ significantly across the days of the week for either grouping. However, there are very significant differences between the trading groups, with the means of the group with a single market maker five to fifteen times larger, depending on the day of the week being examined. Thus, the end of day price rise on the Paris Bourse is not due to peculiarities on a single day of the week.

The timing of the last trade is addressed by examining last trades that occur before 4:55 pm and those that occur after 4:55 pm across the days of the week. Tests for a difference in means across the days of the week fail to find any significant differences for stocks with final transactions that occurred before 4:55 pm, but there are marginally significant differences in the post-4:55 pm group. For these trades, the Friday mean return (0.207%) is somewhat higher than the final transaction return on the other days which is (approximately 0.14%). The level of significance is 5% for the parametric test and 10% for the non-parametric test.

The final day-of-the-week test examines pre-4:55 pm and post-4:55 pm final trades for those stocks with versus those without an assigned market maker. The means in each group fail to show any significant differences across the days of the week. A comparison between stocks with an assigned market maker versus those without an

assigned market maker shows generally significant differences across all days of the week. Furthermore, the magnitude of the difference between the groups is much more pronounced in the post-4:55 pm subgroup. For the transactions that occurred after 4:55 pm, the hypothesis that the group with an assigned market maker and the group without an assigned market maker have the same mean is rejected each day of the week with a parametric analysis of variance F-test statistic ranging from 76.54 to 193.24 and a non-parametric Chi-square test statistic ranging from 38.88 to 113.18. The pre-4:55 pm transactions also reject the hypothesis that stocks with an assigned market maker and those without an assigned market maker have identical means. For this hypothesis the parametric analysis of variance F-test statistics range from 4.94 to 15.25 and the non-parametric Chi-square test statistics range from 1.69 to 9.49. In sum, this analysis confirms that the final intraday transaction return anomaly is robust across days of the week on the Paris Bourse. This does not reject hypothesis five (H5) and it is concluded that the end of the day price rise observed is the same across the days of the week.

3.4.1.5. Price Groupings

One hypothesis advanced to explain the high final intraday transaction return is that there is a shift to the ask price at the end of the day. This would suggest that low price stocks (with relatively high percentage bid-ask spreads) will exhibit a larger effect. Harris (1989) and Gosnell (1987) both divide transactions into price groups to investigate whether low priced securities could be driving the overall results. They find that the effect is slightly larger for low-priced firms, but is present for all price levels. Table 14 addresses this issue on the Paris Bourse by dividing transactions into several price level groupings. Each stock is assigned to a price level group based upon its price at the

Table 14 Final transaction return reported for price level groups and divided into subperiods before and after 4:55 pm. Returns are also divided into those with and without an assigned market maker. All cross-trades are deleted. Tests of difference used are the parametric ANOVA and the non-parametric Wilcoxon rank sums (in parentheses) tests.

	<FF 100	100-250	250-400	400-600	600-900	900-1500	>1500	Tests of Diff.
Overall								
mean	0.0858	0.1185	0.0882	0.1294	0.0824	0.0674	0.0048	3.39^{***}
t-statistic	4.02^{***}	7.59^{***}	6.76^{***}	8.82^{***}	5.74^{***}	3.39^{***}	0.26	
n	3910	6815	6427	4785	3547	1933	1547	(26.3^{***})
% pos.	28.1	28.6	27.7	29.2	26.8	26.6	26.6	
% zero	45.8	46.7	46.9	49.0	51.6	50.0	46.3	
% neg.	26.1	24.7	25.4	21.8	21.6	23.4	27.1	
Overall -Trading Groups Without An Assigned Market Makers								
mean	0.0181	0.0328	0.0195	0.0719	0.0489	0.0428	-0.0010	2.09^{*}
t-statistic	0.97	2.22^{**}	1.46	5.42^{***}	4.00^{***}	2.73^{***}	-0.05	
n	2957	4548	4259	3639	2739	1341	1347	(22.09^{***})
% pos.	27.2	26.3	26.0	27.2	24.3	24.7	26.5	
% zero	45.5	48.9	47.6	51.2	54.6	53.8	47.1	
% neg.	27.3	24.8	26.4	21.6	21.1	21.5	26.4	
Overall - Trading Groups With Market Makers								
mean	0.2957	0.2904	0.2232	0.3118	0.1957	0.1232	0.0437	2.22^{**}
t-statistic	4.53^{***}	8.04^{***}	7.89^{***}	7.08^{***}	4.15^{***}	2.27^{**}	0.72	
n	953	2267	2168	1146	808	592	200	(14.73^{**})
% pos.	30.6	33.3	31.0	35.7	35.5	31.1	27.5	
% zero	46.9	42.3	45.5	42.1	41.7	41.4	41.0	
% neg.	22.5	24.4	23.4	22.2	22.8	27.5	31.5	
test for difference between the trading groups with and without an assigned market maker:								
ANOVA	31.49^{***}	60.99^{***}	54.91^{***}	49.23^{***}	18.50^{***}	3.47^{*}	0.66	
Wilcoxon	13.94^{***}	32.40^{***}	28.86^{***}	20.73^{***}	17.18^{***}	0.19	0.15	

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

(table con'd)

(Table 14 continued)

	<FF 100	100-250	250-400	400-600	600-900	900-1500	>1500	Tests of Diff.
BEFORE 4:55pm								
Mean	0.0067	0.0741	0.0449	0.1086	0.0527	0.0152	-0.0505	2.85***
t-statistic	0.27	3.25***	2.50**	4.49***	2.01**	0.51	-1.83*	
N	2749	3922	3956	2290	1574	1063	846	(20.0***)
% pos.	26.1	29.6	28.6	30.6	29.9	28.6	27.8	
% zero	45.7	41.2	41.8	43.7	42.6	43.2	39.6	
% neg.	28.2	29.2	29.6	25.7	27.5	28.2	32.6	
BEFORE 4:55pm - Trading Groups Without an Assigned Market Maker								
Mean	-0.0163	-0.0001	-0.0304	0.0373	0.0527	0.0500	-0.0573	1.60
t-statistic	-0.73	-0.00	-1.46	1.56	2.02**	1.74*	-1.86*	
N	1998	2175	2255	1491	1000	606	680	(14.54**)
% pos.	26.7	30.0	29.2	29.2	29.0	30.2	27.8	
% zero	44.1	38.5	37.8	44.0	43.0	43.1	39.6	
% neg.	29.2	31.5	33.0	26.8	28.0	26.7	32.6	
BEFORE 4:55pm - Trading Groups With an Assigned Market Maker								
Mean	0.0680	0.1665	0.1446	0.2417	0.0526	-0.0308	-0.0229	1.86*
t-statistic	0.97	4.27***	4.63***	4.58***	0.95	-0.53	-0.37	
N	751	1747	1701	799	574	457	166	(15.31**)
% pos.	24.5	29.1	27.7	33.2	31.4	26.5	27.7	
% zero	49.7	44.6	47.1	43.1	42.0	43.3	39.8	
% neg.	25.8	26.3	25.2	23.7	26.7	30.2	32.5	
test for difference between the trading groups with and without an assigned market maker before 4:55pm:								
ANOVA	2.20	13.24***	23.42***	16.31***	0.00	1.78	0.25	
Wilcoxon	0.15	7.23***	12.85***	7.64***	0.37	2.84*	0.03	
AFTER 4:55pm								
Mean	0.2728	0.1787	0.1576	0.1484	0.1061	0.1312	0.0716	5.40***
t-statistic	6.92***	8.98***	8.77***	8.61***	7.02***	5.32***	3.10***	
N	1161	2893	2471	2495	1973	870	701	(13.3**)
% pos.	32.7	27.2	26.3	28.0	24.4	24.3	25.2	
% zero	46.2	54.3	55.1	53.9	58.8	58.3	54.5	
% neg.	21.1	18.5	18.9	18.1	16.8	17.4	20.3	
AFTER 4:55pm - Trading Groups Without an Assigned Market Maker								
mean	0.0897	0.0630	0.0756	0.0959	0.0468	0.0369	0.0564	1.35
t-statistic	2.70***	4.35***	4.77***	6.35***	3.87***	2.29**	2.54**	
n	959	2373	2004	2148	1739	735	667	(8.33)
% pos.	28.4	22.8	22.4	25.8	21.6	20.1	25.2	
% zero	48.2	58.5	58.7	56.2	61.2	62.6	54.9	
% neg.	23.4	18.7	18.9	18.0	17.2	17.3	19.9	
AFTER 4:55pm - Trading Groups With an Aassigned Market Maker								
mean	1.1423	0.7067	0.5092	0.4732	0.5469	0.6448	0.3686	4.66***
t-statistic	7.69***	8.31***	7.97***	5.97***	6.42***	5.21***	2.01*	
n	202	520	467	347	234	135	34	(26.51***)
% pos.	53.5	47.3	43.0	41.5	45.7	46.7	26.5	
% zero	36.6	34.8	39.6	39.8	41.0	34.8	47.0	
% neg.	9.9	17.9	17.4	18.7	13.3	18.5	26.5	
test for difference between the trading groups with and without an assigned market maker in the after 4:54pm subgroup:								
ANOVA	112.16***	163.12***	92.62***	58.64***	121.48***	87.72***	8.55***	
Wilcoxon	72.76***	98.83***	59.72***	26.38***	60.17***	26.35***	0.01	

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

beginning of the sample period. On an overall basis, using both parametric and non-parametric tests, there are noticeable and significant differences between the different price groups. As the price increases the mean return of the final transaction generally declines, with the most notable differences for stocks priced above FF 900 (approximately US $180 in the sample period).

Again, transactions are divided into groups based upon the presence or absence of an assigned market maker. The group without an assigned market maker rejects the hypothesis that the mean of the final transaction return is equal across all the price groups. The level of significance is alpha = 5% for the parametric test and alpha = 1% for the non-parametric test. However, there is no clear relationship between price level and the magnitude of the final transaction return. The group with the assigned market maker also rejects this hypothesis, but at a lower significance level of 10% for both the parametric and non-parametric tests. For this group, there is a decline in the magnitude of the final intraday transaction return for high priced stocks.

Next, the hypothesis that the means of the trading groups (with versus without an assigned market maker) are identical is examined within each price level group. The difference between the two trading groups is significant in all but the largest price grouping. In each case, the group with an assigned market maker has a larger mean final return than the comparison group without an assigned market maker. This multiple ranges from three times larger for the largest price range (>FF 1500) to fifteen times larger for the second smallest price range (FF 100-249).

All transactions are grouped based on the time of the transaction (before 4:55 pm or after 4:55 pm) and the hypothesis that the mean of all the price groups is identical

within each time period is tested. The hypothesis is rejected both parametrically and non-parametrically in each time period. Comparing the magnitude of the means shows that the high final intraday transaction return is affected by the proximity to the end of the trading day for all price level groups. In each price group the mean of the returns of the transactions that occurred before 4:55 pm is smaller than the mean in the comparable price group of transactions that occurred after 4:55 pm.

Finally, the groups based upon the time of the transaction are further subdivided into groups based on the presence or absence of an assigned market maker. For the time period before 4:55 pm, there is a significant difference between groups with an assigned market maker and groups without an assigned market maker only for the second (FF 100-250), third (FF 250-400) and fourth (FF 400-600) price ranges. By contrast, for the after 4:55 pm time period, the difference between groups with and without an assigned market maker is highly significant, with all but the largest (>FF 1500) price range having large parametric and non-parametric test statistics. For the price group over FF 1500 the non-parametric test does not find a difference in the means, but the parametric tests indicate the means are statistically significantly different.

The differences between stocks with an assigned market maker and those without an assigned market maker indicates that the effect of the assigned market maker is to exacerbate the end-of-day effect regardless of price level or the time of the last transaction. The price groupings indicate that the low price groups do indeed have larger final transaction returns, but the differences between the pre-4:55 pm and post-4:55 pm means indicate that the end-of-day effect is influenced by the timing of transactions along with the price of the stock. Finally, the largest end-of-day transaction returns (1.1591%)

are observed for those stocks with assigned market maker that have low stock prices and last trades occurring after 4:55 pm. This rejects hypothesis six (H6) that the magnitude of the final transaction return is the same across price levels and results in the acceptance of the alternative hypothesis that the magnitude of the final transaction return decreases with an increase in the price of the stock.

3.4.1.6. Volume Groupings

In order to determine the effect of the level of volume on the final intraday transaction return five groups are created by dividing the stocks based on mean daily volume. Table 15 reports that the large final intraday return is present and statistically significant in all volume groups on an overall basis. This is also true for the individual volume groups with and without an assigned market maker except for both the low volume group for stocks without an assigned market maker and the high volume group for stocks with an assigned market maker.

The magnitude is larger for the lower volume groups on an overall basis, as well as for those stocks with an assigned market maker. For those stocks without an assigned market maker the pattern is an inverse-U shape. In each of the volume groups, except for the high volume group, there is a statistically significant difference (both parametrically and non-parametrically) between the mean final intraday return for those stocks with an assigned market maker and those without an assigned market maker. The stocks with an assigned market maker have magnitudes three to four times larger than those stocks without an assigned market maker.

This differences across volume levels is also tested by examining final intraday transaction returns that occur on and off the exchange. The final intraday return of those

Table 15 The final intraday transaction return across average volume levels. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are performed to test the hypothesis that the means across the volume groups are equal. Parametric ANOVA and non-parametric Wilcoxon ranks scores tests are performed to test the hypothesis that the means in both trading groups are equal.

	low volume	medium low volume	medium volume	medium high volume	high volume	ANOVA (Wilcoxon)
Overall						
mean	0.2452	0.1741	0.1419	0.0828	0.0271	32.10***
t-statistic	10.14***	11.25***	10.22***	8.52***	3.83***	
n	4786	6653	7210	7478	6520	(57.76***)
% positive	34.6	34.5	31.0	29.5	20.1	
% zero	37.9	39.1	44.9	47.2	61.7	
% negative	27.5	26.4	24.1	23.3	18.2	
Overall - Trading Groups Without an Assigned Market Maker						
mean	-0.0186	0.0622	0.0826	0.0716	0.0276	6.45***
t-statistic	-0.49	3.63***	6.19***	7.41***	3.90***	
n	1708	3073	5077	6848	6462	(27.10***)
% positive	31.6	32.8	29.6	29.2	20.1	
% zero	35.4	36.8	45.7	47.3	61.8	
% negative	33.0	30.4	24.7	23.5	18.1	
Overall - Trading Groups With an Assigned Market Maker						
mean	0.3916	0.2701	0.2829	0.2044	-0.0274	4.23***
t-statistic	12.65***	10.98***	8.24***	4.31***	-0.26	
n	3078	3580	2133	630	58	(6.43)
% positive	36.2	35.9	34.1	32.2	24.1	
% zero	39.4	41.1	43.0	46.4	44.9	
% negative	24.4	23.0	22.9	21.4	31.0	
test for difference between trading groups:						
ANOVA	66.90***	45.13***	43.63***	14.42***	0.54	
Wilcoxon	56.61***	45.52***	24.10***	6.12***	1.06	
Overall - Trading Groups Where Last Trade is On-Exchange						
mean	0.1736	0.1512	0.1004	0.0583	0.0204	6.45***
t-statistic	6.77***	9.29***	6.96***	5.84***	2.84***	
n	4105	5957	6325	6692	5885	(27.10***)
% positive	31.3	32.9	28.9	28.1	19.6	
% zero	40.3	40.1	46.5	48.0	62.1	
% negative	28.4	27.0	24.6	23.9	18.3	
Overall - Trading Groups Where Last Trade is a Cross-Trade						
mean	0.6770	0.3697	0.4386	0.2918	0.0886	4.23***
t-statistic	9.88***	7.51***	9.66***	8.16***	3.14***	
n	681	696	885	786	635	(6.43)
% positive	54.5	48.3	46.1	41.0	24.7	
% zero	23.9	30.6	33.0	40.3	57.6	
% negative	21.6	21.1	20.9	18.7	17.7	
test for difference between trading groups:						
ANOVA	66.90***	45.13***	43.63***	14.42***	0.54	
Wilcoxon	56.61***	45.52***	24.10***	6.12***	1.06	

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1%

transactions that occur off the exchange as cross-trades is at a magnitude that is two to five times larger than on-exchange returns. Both groups show an inverse relationship between volume and return, with statistically significant differences from zero in all groups.

Table 16 analyzes only those stocks where the final trade was on the exchange. For stocks without an assigned market maker there are significant final intraday transaction returns for all volume groups except the low volume group. The magnitude is about the same for the middle three groups with an average return of approximately 0.05 percent. The high volume stocks have a slightly lower average return of approximately

Table 16 The final intraday transaction return across average volume levels. Parametric ANOVA and non-parametric Wilcoxon ranks sums tests are performed to test the hypothesis that the means across the volume groups are equal. Parametric ANOVA and non-parametric Wilcoxon ranks scores tests are performed to test the hypothesis that the means in both trading groups are equal. Only those trading groups are included when the final trade is on the exchange.

	low volume	medium low volume	medium volume	medium high volume	high volume	ANOVA (Wilcoxon)
Trading Groups Without an Assigned Market Maker						
mean	-0.0175	0.0414	0.0544	0.0471	0.0197	2.84**
t-statistic	-0.45	2.36**	3.96***	4.78***	2.73***	
n	1557	2808	4503	6129	5833	(18.53***)
% positive	29.8	31.5	27.8	27.9	19.6	
% zero	37.0	37.6	46.8	48.0	62.2	
% negative	33.2	30.9	25.4	24.1	18.2	
Trading Groups With an Assigned Market Maker						
mean	0.2904	0.2492	0.2140	0.1803	0.0997	1.08
t-statistic	8.63***	9.44***	5.85***	3.58***	1.12	
n	2548	3149	1822	563	52	(3.08)
% positive	32.1	34.2	31.3	30.7	26.9	
% zero	42.4	42.3	46.1	47.3	46.2	
% negative	25.5	23.5	22.6	22.0	26.9	
test for difference between trading groups:						
ANOVA	34.20***	40.89***	25.23***	13.78***	1.08	
Wilcoxon	28.04***	38.31***	16.35***	4.86**	0.00	

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

0.02 percent. There is a statistically significant difference between the various volume groups both parametrically and non-parametrically. The statistically significant difference between the groups does not hold for the stocks with assigned market makers. For these stocks the magnitude of the average return is between 0.2 and 0.3 percent for all but the high volume group, with no statistical difference among groups either parametrically or non-parametrically. Tests of difference are also performed within each volume group between the stocks with and without an assigned market maker. For all except the high volume stocks the difference between the two groups is statistically significant both parametrically and non-parametrically.

Table 17 examines the final intraday transaction return for those stocks where the final trade is an off-exchange cross-trade. The magnitude of the returns is much larger for cross-trades than for the on-exchange trades. For stocks without an assigned market maker the range of final intraday transaction returns is 0.1 to 0.3 percent for all the groups excluding the lowest volume group. The range is 0.4 to 0.9 percent, excluding the high volume group, for the stocks with an assigned market maker. In both groups there are statistically significant differences both parametrically and non-parametrically across the volume groups. Differences across the stocks with and without assigned market makers are not statistically significant for the medium low volume group and the medium high volume group, but are statistically significant parametrically and non-parametrically for the other three volume groups.

The mean final intraday returns across the volume groups show that the differences between the groups with and without assigned market makers is not solely due to volume and is robust to different levels of volume.

Table 17 The final intraday transaction return across average volume levels. Parametric ANOVA and non-parametric Wilcoxon ranks sums tests are performed to test the hypothesis that the means across the volume groups are equal. Parametric ANOVA and non-parametric Wilcoxon ranks scores tests are performed to test the hypothesis that the means in both trading groups are equal. Only those trading groups are included when the final trade is an off-exchange cross-trade.

	low volume	medium low volume	medium volume	medium high volume	high volume	ANOVA (Wilcoxon)
Trading Groups Without an Assigned Market Maker						
mean	-0.0301	0.2832	0.3042	0.2811	0.1002	5.96***
t-statistic	-0.20	4.68***	6.48***	7.62***	3.61***	
n	151	265	574	719	629	(28.35***)
% positive	49.7	47.5	43.7	40.6	25.0	
% zero	19.2	28.7	37.3	40.5	57.9	
% negative	31.1	23.8	19.0	18.9	17.1	
Trading Groups With an Assigned Market Maker						
mean	0.8784	0.4230	0.6866	0.4066	-1.1291	7.30***
t-statistic	11.71***	6.31***	7.28***	2.92***	-2.37*	
n	530	431	311	67	6	(20.58***)
% positive	55.8	48.7	50.5	44.8	0	
% zero	25.3	31.8	25.1	38.8	33.3	
% negative	18.9	19.5	24.4	16.4	66.7	
test for difference between trading groups:						
ANOVA	31.68***	1.90	16.46***	0.96	18.23***	
Wilcoxon	17.07***	2.25	7.15***	1.29	9.35***	

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

3.4.1.7. Subsequent Overnight Returns

One final set of tests regarding returns is performed in order to gain a further understanding of the end-of-day effect. Specifically, overnight returns are examined in order to determine if there is a systematic continuation or reversal after the large price rise at the end of the day. Table 18 shows the overnight return following the final intraday transaction return averages -0.0487%. The final intraday transaction return is divided into two groups based on the median final return of all stocks on that trading day. The overnight return is shown to be 0.0529% for the lower half of the final transaction

Table 18 Close to open return (in percent) for the overnight period is provided both on an overall basis and by dividing the returns into two groups based whether the final transaction return was above or below that day's median return for all firms. Tests of difference between the groups is done using parametric ANOVA and non-parametric Wilcoxon rank scores tests.

	Overall	On Exchange	Cross Trades
mean	-0.0487	-0.0310	-0.2070
t-statistic	-4.32***	-2.57***	-5.90***
n	32191	28508	3246
% positive	40.1	40.7	35.0
% zero	17.1	16.8	19.4
% negative	42.8	42.5	45.6
closing return below the median day's return			
mean	0.0529	0.0878	-0.1160
t-statistic	3.91***	5.86***	-2.18**
n	21555	16640	1791
% positive	43.3	44.6	36.1
% zero	17.3	16.8	19.0
% negative	39.4	38.6	44.9
closing return above the median day's return			
mean	-0.2545	-0.1974	-0.3190
t-statistic	-12.61***	-10.01***	-7.45***
n	10636	11868	1455
% positive	33.8	35.2	33.7
% zero	16.6	16.7	19.8
% negative	49.6	48.0	46.5
tests of difference			
ANOVA	165.61***	137.35***	8.31***
Wilcoxon	417.99***	369.40***	6.04***

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

returns and -0.2545% for the larger half of the final transaction returns. The positive close to open return observed for smaller final intraday transaction returns may indicate a slower adjustment to information near the end of the trading day.

The negative means observed for all final intraday transaction returns when the final intraday transaction is a cross-trade indicates that the cross-trades may be reversed overnight. Somewhat more of the cross-trade final intraday transaction return is reversed, on average, than for on-exchange final intraday transaction returns. For cross-trades, the final intraday transaction return is 0.3780% (from Table 4) and the reversal during the subsequent overnight period is 0.2070%. For on-exchange transactions, the final intraday transaction return is 0.0952% (from Table 4) with a reversal of 0.0310% during the subsequent overnight period. This represents a reversal of 55% for cross-trades but only 33% for on-exchange transactions.

Table 19 further examines the overnight return by dividing the transactions into two groups based on the timing of the final transaction. If the transaction occurs before 4:55 pm then the delayed response explanation may be more valid since this indicates the liquidity of the stock may contribute to the effect. When the final transaction return occurs before 4:55 pm on exchange transactions are significantly positive with a mean overnight return of 0.0358% that is significantly different than zero. For on exchange transactions that occur after 4:55 pm there is an overnight return of negative 0.1167%. For off exchange cross-trades, the overnight return is negative and there is no statistical difference between those transactions that occur before or after 4:55 pm. The observation that when the final transaction is a cross-trade the subsequent overnight return is on average negative, irrespective of the time of the cross-trade, suggests window dressing may be a valid explanation (see section 3.4.1.3.).

Table 19 Close to open return (in percent) for the overnight period is provided both on an overall basis and by dividing the returns into two groups based whether the final transaction return was before or after 4:55 pm. Tests of difference between the groups is done using parametric ANOVA and non-parametric Wilcoxon rank scores tests.

	Overall	On Exchange	Cross Trades
mean	-0.0487	-0.0310	-0.2070
t-statistic	-4.32***	-2.57***	-5.90***
n	32191	28508	3246
% positive	40.1	40.7	35.0
% zero	17.1	16.8	19.4
% negative	42.8	42.5	45.6
closing return before 4:55 pm			
mean	0.0143	0.0358	-0.1897
t-statistic	0.90	2.15**	-3.35***
n	17942	16020	1675
% positive	41.0	41.7	35.0
% zero	19.2	18.9	21.7
% negative	39.8	39.4	43.3
closing return after 4:55 pm			
mean	-0.1280	-0.1167	-0.2254
t-statistic	-8.11***	-6.78***	-5.62***
n	14249	12488	1571
% positive	39.0	39.4	35.0
% zero	14.4	14.1	16.9
% negative	46.7	46.6	48.1
tests of difference between the two groups			
ANOVA	39.40***	39.66***	0.26
Wilcoxon	84.26***	86.12***	0.66

*significant at a level of α = 10%
**significant at a level of α = 5%
***significant at a level of α = 1%

In summary, for cross-trades, there is a subsequent overnight reversal of the final intraday transaction return for the group of stocks with an average final intraday return both above and below the median return for that day. This reversal represents approximately 55% of the final intraday transaction return. For on-exchange final intraday transactions the subsequent overnight reversal is only observed in those stocks with returns above the median final intraday return for that day. On average, the subsequent overnight return for these stocks represents a 33% reversal of the final intraday transaction return.

3.4.2. Intraday Volume

Intraday volume is examined to determine if there is a difference between those stocks with an assigned market maker and those stocks without an assigned market maker. The total volume traded for stocks with an assigned market maker is approximately one tenth the volume traded for the stocks without an assigned market maker. Table 20 reports the mean volume in terms of number of shares and the mean number of transactions for each thirty minute time interval during the trading day. Also, the mean percentage of each day's volume is also reported for each interval. The results show that volume follows a reverse-J pattern during the day, with the first interval (10:00-10:30[7]) having the largest amount of volume both in number of transactions and in total number of shares traded. This is true for both the group of stocks with an assigned market maker and those without an assigned market maker. In terms of the number of shares, the stocks without an assigned market maker had 22.2% of the day's volume during the first interval, while the stocks with an assigned market maker had

[7] The precise timing of the interval is from 10:00:00 to 10:29:59.

31.0% of the day's volume during this period. The difference between the stocks with and without an assigned market maker in terms of percentage of day's volume during the half-hour is statistically significant in all half-hour periods except for 11:00-11:30 am and 11:30-12:00 am. During these two half-hour periods the non-parametric Wilcoxon rank sums test is still statistically significant at a level of one percent, however, the parametric ANOVA test has no or little statistical significance.

Table 20 also examines volume across half-hour periods for on-exchange and off-exchange cross-trades. On-exchange trades have a similar reverse-J pattern in terms of the mean number of transaction, the mean total share volume, and the mean percentage of the day's volume in each half-hour period. Cross-trades exhibit a similar pattern across the half-hour periods, however, the transactions that occur after 5 pm are larger, proportionally, than on-exchange transactions. This could be the result of an inability to trade on the exchange, an attempt to influence the closing price or an agreement to transact after the close[8].

Table 21 also investigates intraday volume, but uses the reduced sample of firms that had a total volume during the period of 100,000 to 200,000 shares. There are considerably fewer mean number of transactions during each period and the total mean volume each period is also lower. The same pattern in relative volume each period, as a percentage of the day's total volume, is apparent with the same reverse-J shape. This indicates that the differences between the group of stocks with and without assigned market makers are not due to differences in overall level of volume.

[8] An agreement to transact after the close may be especially appealing to mutual fund managers that use closing prices as the basis for fund redemptions and purchases.

Table 20 This table reports volume that occurs within each thirty-minute time interval during the trading day. The mean number of transactions, the mean total share volume and the mean percentage of each day's total share volume are reported. This is done on an overall basis as well as for those stocks with and without an assigned market maker.

Overall	overall	10:00-10:30	10:30-11:30	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
mean # trans.	9.5	14.9	5.6	5.3	4.7	3.5	2.3	2.0	2.4	3.0	4.0	4.3	5.0	5.0	7.1	2.0
mean total volume	4546	5355	2732	2614	2485	1910	1267	1179	1217	1376	2004	2262	2571	2852	3872	266
mean % of day's volume		25.1	8.0	7.5	6.7	4.9	3.0	2.3	2.7	3.7	5.3	5.9	6.7	6.9	10.3	0.8
Stocks without an assigned market maker:																
mean # trans.	6.7	20.8	8.0	7.6	6.7	5.1	3.3	2.9	3.5	4.2	5.7	6.1	7.2	7.2	10.1	2.8
mean total volume	3305	7851	3993	3825	3353	2808	1866	1744	1801	2023	2926	3323	3787	4183	5689	391
mean % of day's volume		22.2	7.8	7.4	6.8	5.0	3.2	2.6	3.0	3.9	5.7	6.2	7.3	7.4	10.7	0.9
Stocks with an assigned market maker:																
mean # trans.	0.7	2.8	0.8	0.7	0.6	0.5	0.3	0.2	0.2	0.3	0.4	0.5	0.5	0.5	1.0	0.3
mean total volume	158	296	179	162	126	94	55	35	36	64	137	116	110	159	196	11
mean % of day's volume		31.0	8.5	7.7	6.6	4.7	2.6	1.8	2.1	3.4	4.6	5.3	5.5	5.9	9.7	0.6
Transactions that occur on the exchange:																
mean # trans.	4.7	15.0	5.6	5.3	4.7	3.5	2.3	2.0	2.4	2.9	4.0	4.2	5.0	5.0	7.1	1.9
mean total volume	2007	5112	2491	2190	2153	1607	1085	978	1079	1229	1744	1969	2216	2441	3557	264
mean % of day's volume		25.5	7.9	7.4	6.7	4.9	3.0	2.3	2.8	3.8	5.3	5.8	6.6	6.8	10.4	0.8
Transactions that occur off the exchange as cross-trades:																
mean # trans.	0.2	0.4	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.3
mean total volume	575	680	564	901	725	647	395	425	311	333	571	644	773	888	752	14
mean % of day's volume		17.7	8.1	7.2	6.5	4.8	3.1	2.7	2.6	3.7	5.4	7.0	7.4	7.9	12.7	3.1

Table 21 This table uses a reduced sample of only those firms with total volume between 100,000 and 200,000 shares over the sample period September-December 1995. This table reports volume that occurs within each thirty-minute time interval during the trading day. The mean number of transactions, the mean total share volume and the mean percentage of each day's total share volume are reported. This is done on an overall basis as well as for those stocks with and without an assigned market maker.

Overall	overall	10:00-10:30	10:30-11:30	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
mean # trans.	2.7	4.1	1.1	1.0	1.1	0.7	0.4	0.3	0.4	0.5	0.7	0.7	0.9	0.9	1.4	0.5
mean total volume	329	353	146	155	126	100	53	53	38	50	102	102	141	149	185	13
mean % of day's volume		28.0	8.0	7.5	7.9	4.9	2.6	2.0	2.3	3.2	4.8	5.2	6.1	6.7	10.1	0.9
Stocks without an assigned market maker:																
mean # trans.	1.2	5.0	1.4	1.3	1.2	0.8	0.5	0.4	0.5	0.6	0.9	0.9	1.2	1.0	1.7	0.7
mean total volume	115	404	129	136	114	115	58	38	54	55	93	93	120	133	164	18
mean % of day's volume		27.6	7.6	7.5	6.5	5.0	2.7	2.2	2.9	3.2	5.1	5.2	7.1	6.5	9.7	1.2
Stocks with an assigned market maker:																
mean # trans.	0.8	3.4	0.9	0.9	1.0	0.5	0.3	0.2	0.2	0.4	0.5	0.5	0.6	0.8	1.2	0.3
mean total volume	120	313	159	169	137	89	50	64	26	45	110	109	157	162	202	8
mean % of day's volume		28.3	8.2	7.5	9.0	4.8	2.5	1.8	1.8	3.1	4.6	5.2	5.3	6.9	10.3	0.6
Tests of difference																
ANOVA		313	159	169	137	89	50	64	26	45	110	109	157	162	202	8
Wilcoxon		28.3	8.2	7.5	9.0	4.8	2.5	1.8	1.8	3.1	4.6	5.2	5.3	6.9	10.3	0.6

3.4.3. Intraday Volatility

Differences in volatility between those stocks with assigned market makers and those stocks without assigned market makers are tested using several definitions of volatility. Volatility is measured both by the difference between the high and the low transaction prices as a percentage of the mean price and by the standard deviation of intraday return as measured on successive midpoints of the bid-ask spread. Table 22 reports these measures within half-hour intervals during the trading day.

The average difference between the high and the low price each interval is largest at the open and close and follows a U-shaped pattern throughout the day. This is true on an overall basis as well as for both the stocks with an assigned market maker and the stocks without an assigned market maker. The magnitude of this measure is 34% to 82% greater for stocks without an assigned market maker as compared to the stocks with an assigned market maker during all half-hour periods during the trading day except after 5:00 pm. The difference is statistically significant at a level of one percent in all periods except after 5:00 pm using both parametric and non-parametric tests (not shown).

The standard deviation of the returns based on successive midpoints between the bid and the ask prices are also reported in aggregate and for stocks both with and without an assigned market maker. On an overall basis, the standard deviation is higher during the first half-hour (10:00-10:30) of trading than at any other half-hour during the trading day. Stocks without an assigned market maker have a standard deviation that is approximately one-half of the standard deviation of those stocks with assigned market

Table 22 Volatility is reported for each thirty-minute time interval during the trading day. The volatility is reported as the difference between the high and low prices (divided by the mean price of the stock and reported in percent) during each interval, as well as the standard deviation (in percent) of the transaction return based on successive midpoints of the bid-ask spread. This is done on an overall basis as well as for those stocks with and without an assigned market maker.

	Overall	10:00-10:30	10:30-11:30	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
Overall:																
high minus low price	0.433	0.635	0.517	0.470	0.418	0.347	0.277	0.249	0.282	0.313	0.378	0.398	0.422	0.431	0.613	0.288
stdard dev. midpoint	0.219	0.508	0.236	0.212	0.198	0.167	0.153	0.154	0.149	0.169	0.178	0.183	0.189	0.186	0.232	0.101
Stocks without an assigned market maker:																
high minus low price	0.459	0.731	0.559	0.503	0.445	0.369	0.286	0.261	0.296	0.331	0.400	0.426	0.456	0.458	0.649	0.285
stdard dev. midpoint	0.179	0.442	0.181	0.164	0.152	0.139	0.128	0.132	0.131	0.142	0.152	0.151	0.160	0.150	0.192	0.086
Stocks with an assigned market maker:																
high minus low price	0.319	0.415	0.346	0.325	0.292	0.229	0.209	0.151	0.177	0.205	0.262	0.255	0.250	0.290	0.485	0.312
stdard dev. midpoint	0.516	0.816	0.546	0.491	0.503	0.398	0.463	0.468	0.404	0.455	0.408	0.441	0.434	0.472	0.462	0.330

makers during the first half-hour of trading (0.442 percent versus 0.816 percent). For those stocks without an assigned market maker the standard deviation drops in the second half-hour to 0.181 percent, while the stocks with an assigned market maker drop to 0.546 percent. The stocks without an assigned market maker exhibit a reverse-J shape in terms of magnitude of standard deviation, with a slight increase in the 4:30-5:00 pm half-hour approaching the magnitude of the 10:30-11:00 am half-hour. Stocks with an assigned market maker also have standard deviations with a reverse-J shape, however, the pattern is less noticeable with magnitudes ranging from 0.398 to 0.546 percent. The volatility, as measured by the standard deviation of midpoint returns, differs between the stocks with and without assigned market makers and this differences is statistically significant at a level of one percent in each of the half-hour periods both parametrically and non-parametrically.

The two measures of volatility appear to contradict each other with respect to which group of stocks has the higher volatility. Table 23 uses the reduced sample of firms that have a total volume during the four-month period that is between 100,000 and 200,000 shares. For these stocks the volatility using both of the measures exhibits a reverse-J pattern and is larger in magnitude for the group of stocks with an assigned market maker. This is true for all subperiods using the standard deviation measure and for nine of the subperiods for the mean difference measure. Statistical significance of the difference between the two measures is present for all subperiods for the standard deviation measure using the parametric ANOVA test and for ten of the fifteen subperiods using the non-parametric Wilcoxon rank sums test. For the mean difference measure there is no statistical significance in any of the parametric tests. The non-parametric

Table 23 This table uses a reduced sample of only those firms with total volume between 100,000 and 200,000 shares over the sample period September - December 1995. Volatility is reported for each thirty-minute time interval during the trading day. The volatility is reported as the difference between the high and low prices (divided by the mean price of the stock and reported in percent) during each interval, as well as the standard deviation (in percent) of the transaction return based on successive midpoints of the bid-ask spread. This is done on an overall basis as well as for those stocks with and without an assigned market maker.

	Overall	10:00-10:30	10:30-11:30	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
Overall:																
high minus low price	0.395	0.646	0.527	0.478	0.226	0.340	0.287	0.261	0.293	0.323	0.387	0.405	0.432	0.264	0.603	0.290
stdard dev. midpoint	0.345	0.644	0.339	0.342	0.326	0.269	0.257	0.287	0.224	0.299	0.286	0.315	0.291	0.273	0.325	0.197
Stocks without assigned market maker:																
high minus low price	0.321	0.486	0.338	0.296	0.293	0.234	0.181	0.138	0.212	0.217	0.267	0.293	0.332	0.289	0.468	0.280
stdard dev. midpoint	0.254	0.538	0.206	0.225	0.179	0.192	0.152	0.192	0.194	0.244	0.242	0.240	0.241	0.193	0.262	0.147
Stocks with an assigned market maker:																
high minus low price	0.336	0.507	0.319	0.326	0.293	0.235	0.196	0.148	0.164	0.190	0.271	0.263	0.272	0.259	0.530	0.293
stdard dev. midpoint	0.497	0.786	0.525	0.500	0.527	0.394	0.474	0.533	0.305	0.419	0.374	0.447	0.397	0.419	0.418	0.306

Wilcoxon rank sums test is also used to test the means of the two groups. For the nine subperiods that had a higher mean difference measure for the stocks with an assigned market maker, four (six) subperiods had statistically significant differences at a level of one (five) percent. For the five subperiods that had a higher mean difference in the group of stocks without assigned market makers, the non-parametric tests all were significant at a level of one percent. These five periods that have higher mean differences in stocks without assigned market makers are all between 1:30 and 4:30, with only the 2:30-3:00 subperiod not in this group.

3.4.4. Intraday Bid-Ask Spread

The intraday bid-ask spread is examined to determine if there is a difference between those stocks with and those stocks without an assigned market maker. The average absolute and percentage bid-ask spread are provided for each half-hour during the trading day. These averages are determined by computing the bid-ask spreads that is outstanding at the beginning of the half-hour period and weighting this and every new bid-ask spread quote by the number of seconds outstanding during the half-hour period. The period after 5 pm is treated differently, as trading technically ceases at 5 pm, but there are quotes reported after this time. The average outstanding bid-ask spread up to the final quote is computed for the period after 5 pm. Additionally, the number of quote revisions during each period is also reported.

In Table 24, the mean percentage bid-ask spread is 1.62% while the mean absolute bid-ask spread is FF 6.58. When the stocks are divided into those with an assigned market maker and those without an assigned market maker, the magnitude of the means is significantly greater for those stocks with an assigned market maker. The mean

Table 24 This table reports the bid-ask spread that occurs within each thirty-minute time interval during the trading day. The time-weighted bid-ask spread is reported on an absolute and a proportional basis. Also, the number of quote revisions is also reported. This is done on an overall basis as well as for those stocks with and without an assigned market maker.

Overall

	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
absolute bid-ask sp.	6.58	6.96	6.87	6.72	6.58	6.50	6.51	6.50	6.52	6.52	6.50	6.49	6.45	6.47	6.55	6.55
% bid-ask spread	1.62	1.70	1.68	1.65	1.61	1.59	1.59	1.60	1.60	1.61	1.60	1.61	1.60	1.61	1.62	1.62
# of quote revisions	8.65	10.50	9.68	9.24	8.42	7.15	6.02	5.65	6.25	6.70	8.42	8.69	10.04	9.68	11.85	7.57

Stocks without an assigned market maker:

	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
absolute bid-ask sp.	4.88	5.26	5.13	4.95	4.81	4.75	4.78	4.77	4.82	4.83	4.82	4.83	4.78	4.81	4.90	4.90
% bid-ask spread	1.14	1.23	1.19	1.15	1.12	1.10	1.11	1.11	1.13	1.13	1.13	1.14	1.13	1.14	1.16	1.16
# of quote revisions	10.09	12.98	11.74	11.13	10.01	8.25	6.72	6.25	6.93	7.63	9.75	10.11	11.76	11.28	14.34	8.06

Stocks with an assigned market maker:

	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
absolute bid-ask sp.	9.90	10.28	10.26	10.16	10.04	9.92	9.88	9.87	9.84	9.81	9.78	9.74	9.71	9.71	9.76	9.75
% bid-ask spread	2.55	2.63	2.64	2.61	2.58	2.56	2.54	2.55	2.54	2.54	2.53	2.52	2.52	2.52	2.53	2.52
# of quote revisions	2.17	2.67	2.37	2.25	2.13	1.93	1.71	1.52	1.64	1.78	1.97	2.10	2.05	2.11	2.51	3.22

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

percentage bid-ask spread is 2.55% for those stocks with an assigned market maker, versus 1.14% for those stocks without an assigned market maker. The mean absolute bid-ask spread is FF 9.90 for those stocks with an assigned market maker, versus FF 4.88 for those stocks without an assigned market maker. Using a t-test, the means have a difference that is statistically significant at a level of 1%.

Analyzing the mean bid-ask spread during each half-hour shows that both the percentage bid-ask spread and the absolute bid-ask spread demonstrate a reverse-J pattern. This is similar to the U-shaped pattern on the NYSE observed by Wood, McInish and Ord (1985), Brock and Kleidon (1992) and Lee, Mucklow and Ready (1993). This does not match the pattern observed by Chan, Christie and Schultz (1995) on Nasdaq where there is a declining bid-ask spread near the close.

The reverse-J pattern does not differ in shape between stocks on the Paris Bourse that trade with and without an assigned market maker. The magnitudes, however, are significantly different. The stocks with an assigned market maker have percentage and absolute bid-ask spreads that are approximately twice as large as those stocks without an assigned market maker. A parametric t-test compares the means in each of the two groups within each individual half-hour time period and the difference is statistically significant at a level of 1%.

The number of quote revisions in each period follows a U-shaped pattern. This is true on an overall basis, as well as for those stocks with and without an assigned market maker. For stocks without an assigned market maker the number of quote revisions is approximately five times larger than for those stocks with an assigned market maker. This difference is statistically significant at a level of 1% on an overall basis and within

each of the half-hour periods. In the period after 5 pm, the multiple between the two stock groups differs. For stocks without an assigned market maker, the number of quote revisions falls from 14.34 in the previous half-hour (4:30-5:00) to 8.06. For stocks with an assigned market maker the number of quote revisions increases from 2.51 in the previous half-hour (4:30-5:00) to 3.22. This represents a decrease in the multiple from five in each of the half-hours during the day to less than three after 5 pm. The lower multiple than average for quotes after 5 pm indicates that those stocks with an assigned market maker have more activity, proportionally, at the end of the trading day. This may be due to the assigned market makers adjusting the closing prices, or may be a result of increased attention by traders at the end of the trading day. An increase in volume does not appear to explain this phenomenon since Table 20 shows that volume for stocks with an assigned market maker falls from 9.7% (in the previous half-hour) to 0.6% while the volume for stocks without an assigned market maker falls from 10.7% to 0.9%.

The difference between the stocks with an assigned market maker and those without an assigned market maker may be partially due to the difference between the stocks in each of the categories. One such difference may be a stock's price since this impacts on the percentage bid-ask spread and the absolute bid-ask spread. In order to facilitate an improved comparison, stocks are divided into seven groups based on their price at the beginning of the period.

Table 25 examines the percentage bid-ask spread across the price groups. The percentage bid-ask spread is expected to decline as the price of the stock increases because of the fixed priced component of transaction costs. Including all stocks, on an overall basis and in each of the half-hour periods, there is a monotonic decline in the

Table 25 This table reports the time-weighted percentage bid-ask spread that occurs across price levels within each thirty-minute time interval during the trading day. This is done on an overall basis as well as for those stocks with and without an assigned market maker.

Overall

price	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
< FF 100	2.26	2.35	2.34	2.29	2.26	2.24	2.25	2.25	2.25	2.24	2.24	2.23	2.23	2.24	2.26	2.26
100 - 250	1.78	1.87	1.84	1.81	1.76	1.74	1.75	1.76	1.76	1.76	1.76	1.77	1.77	1.78	1.80	1.79
250-400	1.57	1.64	1.60	1.57	1.54	1.52	1.52	1.52	1.55	1.57	1.57	1.59	1.57	1.57	1.59	1.59
400-600	1.44	1.53	1.53	1.49	1.46	1.44	1.42	1.42	1.43	1.43	1.42	1.42	1.41	1.41	1.42	1.42
600-900	1.07	1.14	1.13	1.10	1.07	1.05	1.05	1.05	1.05	1.05	1.04	1.04	1.05	1.04	1.07	1.07
900-1500	1.61	1.69	1.66	1.64	1.61	1.60	1.61	1.61	1.60	1.60	1.60	1.60	1.59	1.59	1.60	1.61
>1500	1.04	1.11	1.11	1.07	1.05	1.04	1.04	1.03	1.03	1.02	1.01	1.01	1.00	1.00	1.02	1.01

Stocks without an assigned market maker:

	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
< FF 100	1.62	1.71	1.69	1.63	1.61	1.59	1.62	1.63	1.63	1.60	1.59	1.59	1.59	1.60	1.64	1.64
100 - 250	1.23	1.32	1.27	1.23	1.19	1.16	1.18	1.19	1.21	1.21	1.22	1.24	1.23	1.25	1.27	1.27
250-400	1.12	1.19	1.14	1.10	1.06	1.04	1.04	1.05	1.09	1.13	1.15	1.18	1.13	1.14	1.17	1.17
400-600	1.13	1.22	1.21	1.17	1.13	1.11	1.10	1.10	1.11	1.12	1.11	1.12	1.10	1.10	1.11	1.11
600-900	0.75	0.83	0.80	0.78	0.76	0.74	0.74	0.74	0.74	0.73	0.73	0.72	0.73	0.73	0.75	0.76
900-1500	0.82	0.90	0.86	0.83	0.80	0.80	0.82	0.82	0.82	0.81	0.81	0.80	0.80	0.81	0.83	0.83
>1500	0.92	0.99	0.99	0.95	0.93	0.92	0.93	0.92	0.92	0.91	0.90	0.90	0.89	0.90	0.92	0.90

Stocks with an assigned market maker:

	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
< FF 100	3.50	3.58	3.58	3.56	3.51	3.48	3.47	3.46	3.47	3.50	3.50	3.48	3.46	3.47	3.46	3.45
100 - 250	2.71	2.79	2.80	2.78	2.74	2.71	2.69	2.71	2.71	2.69	2.67	2.67	2.67	2.68	2.68	2.68
250-400	2.28	2.35	2.34	2.31	2.31	2.29	2.28	2.27	2.26	2.26	2.25	2.24	2.25	2.26	2.26	2.25
400-600	2.11	2.20	2.21	2.17	2.14	2.12	2.11	2.10	2.09	2.08	2.07	2.07	2.05	2.06	2.07	2.08
600-900	2.05	2.13	2.15	2.08	2.07	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.03	2.01	2.05	2.04
900-1500	3.04	3.10	3.11	3.10	3.06	3.06	3.04	3.03	3.01	3.02	3.02	3.01	3.01	3.01	3.00	3.00
>1500	1.43	1.54	1.51	1.51	1.48	1.44	1.43	1.43	1.44	1.41	1.41	1.40	1.37	1.37	1.38	1.39

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

percentage bid-ask spread as the price rises for all stocks priced below FF 900. The percentage bid-ask spread for the group of stocks priced between FF 900-1500 is larger than those stocks priced lower and higher than the group. In fact, the percentage bid-ask spread for stocks priced between FF 900-1500 is larger than all other price grouping except those stocks priced below FF 250.

In order to examine this phenomenon in more detail, stocks are divided into groups with and without assigned market makers in order to determine if the pattern is robust across the groups. For stocks without an assigned market maker, the pattern across price levels is U-shaped with the lowest percentage bid-ask spread for those stocks priced between FF 600-900. For stocks with an assigned market maker the pattern is similar to the overall pattern, with a monotonic decline in the percentage bid-ask spread as the stock's price increases, except for those stocks priced between FF 900-1500. The two groups have a large difference in magnitude, with the group of stocks with an assigned market maker having a mean percentage bid-ask spread that is approximately twice as large as the group of stocks without an assigned market maker.

The pattern across half-hour intervals exhibits a reverse-J pattern. For those stocks with an assigned market maker, the end of day increase in the percentage bid-ask spread is less pronounced than for those stocks without an assigned market maker. The lack of increase in the percentage bid-ask spread at the end of the day for those stocks with an assigned market maker may be because the stocks with an assigned market maker already have a large percentage bid-ask spread. Another possibility is that the assigned market maker can simply shift the entire bid-ask spread to adjust for inventory with a minimal effect on the percentage bid-ask spread. If this were the case there would likely

be a noticeable increase in volatility at the end of the day for these stocks. As shown in Table 22, this is not the case. Volatility as measured by the standard deviation of the midpoint does not noticeably increase at the end of the day, while volatility as measured by the high minus the low price increases, but only in a similar proportion to both the group of stocks with an assigned market maker and the group of stocks without an assigned market maker.

The absolute bid-ask spread is also examined across price groupings. Table 26 shows the monotonic increase in the absolute bid-ask spread as price increases on an overall basis and across groups of stocks with and without an assigned market maker. The magnitude of the difference between the two stock groups is consistent with that observed when examining the percentage bid-ask spread. The absolute bid-ask spread is approximately twice as large for those stocks with an assigned market maker. For stocks priced under FF 100, the magnitude is approximately three times larger for the absolute bid-ask spread, but since there is a large range of stock prices in this group, a direct comparison of the absolute bid-ask spread is not as relevant as when using the percentage bid-ask spread.

Examining the pattern across half-hour intervals shows a U-shaped pattern on an overall basis, with the absolute bid-ask spread near the beginning of the day larger than at the end of the day. This is consistent with the percentage bid-ask spread pattern. Examining stocks with and without an assigned market maker also shows that the same overall pattern is observed for both groups of stocks. Those stocks with an assigned market maker do, however, show a gradual decline during the day, with no increase in the bid-ask spread at the end of the day. This is consistent with the percentage bid-ask spread patterns as well.

Table 26 This table reports the time-weighted absolute bid-ask spread that occurs across price levels within each thirty-minute time interval during the trading day. This is done on an overall basis as well as for those stocks with and without an assigned market maker.

price	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
<u>Overall</u>																
< FF 100	1.35	1.40	1.38	1.36	1.34	1.34	1.35	1.35	1.35	1.34	1.33	1.34	1.33	1.34	1.35	1.35
100 - 250	2.87	3.01	2.95	2.89	2.82	2.78	2.80	2.82	2.84	2.84	2.84	2.86	2.85	2.87	2.91	2.90
250-400	4.96	5.19	5.06	4.96	4.87	4.81	4.80	4.82	4.89	4.97	4.99	5.04	4.96	4.99	5.05	5.04
400-600	6.45	6.86	6.84	6.66	6.50	6.41	6.36	6.36	6.38	6.38	6.37	6.37	6.29	6.32	6.35	6.38
600-900	7.26	7.79	7.69	7.48	7.33	7.16	7.17	7.16	7.14	7.10	7.09	7.06	7.12	7.10	7.24	7.26
900-1500	18.01	18.80	18.51	18.23	17.93	17.89	18.04	18.00	17.90	17.87	17.87	17.78	17.72	17.76	17.90	17.97
>1500	28.84	31.05	30.66	29.89	29.26	28.90	28.91	28.68	28.85	28.50	28.23	27.97	27.69	27.72	28.26	28.12
<u>Stocks without an assigned market maker:</u>	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
< FF 100	0.69	0.72	0.72	0.69	0.68	0.67	0.69	0.69	0.69	0.68	0.67	0.67	0.67	0.67	0.70	0.69
100 - 250	2.07	2.22	2.12	2.05	1.98	1.94	1.98	1.99	2.03	2.05	2.06	2.10	2.08	2.12	2.17	2.16
250-400	3.54	3.77	3.58	3.47	3.34	3.27	3.26	3.31	3.45	3.59	3.63	3.74	3.60	3.63	3.71	3.72
400-600	5.21	5.62	5.57	5.39	5.22	5.11	5.08	5.08	5.13	5.16	5.14	5.16	5.08	5.10	5.12	5.14
600-900	5.30	5.84	5.65	5.51	5.34	5.23	5.23	5.23	5.21	5.15	5.16	5.10	5.15	5.16	5.28	5.32
900-1500	9.43	10.33	9.87	9.48	9.17	9.12	9.42	9.40	9.38	9.28	9.25	9.20	9.19	9.24	9.50	9.63
>1500	22.79	24.50	24.36	23.36	22.87	22.76	22.96	22.64	22.78	22.56	22.30	22.12	21.92	22.04	22.50	22.27
<u>Stocks with an assigned market maker:</u>	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
< FF 100	2.63	2.70	2.68	2.66	2.63	2.62	2.61	2.61	2.61	2.62	2.62	2.62	2.60	2.63	2.62	2.62
100 - 250	4.21	4.34	4.35	4.31	4.25	4.20	4.18	4.21	4.20	4.18	4.15	4.13	4.15	4.15	4.15	4.15
250-400	7.21	7.45	7.42	7.32	7.29	7.23	7.22	7.20	7.17	7.16	7.13	7.09	7.12	7.14	7.16	7.12
400-600	9.09	9.47	9.52	9.34	9.21	9.14	9.07	9.05	9.00	8.95	8.94	8.95	8.83	8.90	8.95	8.98
600-900	13.37	13.89	14.05	13.65	13.52	13.19	13.22	13.18	13.17	13.18	13.14	13.18	13.27	13.15	13.38	13.32
900-1500	33.43	33.97	34.06	33.96	33.68	33.65	33.54	33.48	33.22	33.32	33.36	33.18	33.04	33.07	32.98	32.94
>1500	50.66	54.64	53.31	53.43	52.26	51.03	50.39	50.48	50.74	49.95	49.65	49.05	48.50	48.24	49.03	49.21

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

The number of quote revisions across price groups is shown in Table 27. The number of quote revisions does not appear to have a relationship with the price grouping. On an overall basis, the number of quote revisions is approximately nine per period. For the low priced stocks (below FF 100) the number of quote revisions per half-hour appears slightly lower at 6.51, while the high priced stocks also appear slightly lower with a mean of 7.48. Parametric and non-parametric tests find that there is a difference within each half-hour period across the price groups that is significant at a level of 1%.

The pattern across price levels is also examined for those stocks with and without an assigned market maker. For those stocks without an assigned market maker, there are some differences across the price groups, with the mean number of quote revisions slightly lower for those stocks priced below FF 100 and above FF 1500. This is not as apparent, however, in the stocks with an assigned market maker. For these stocks, the magnitude of quote revisions is much lower, as expected based on the lower liquidity of the stocks placed in this group.

Parametric ANOVA tests and non-parametric Wilcoxon rank sums tests are performed to tests the differences across the price groups. For the stocks without an assigned market maker, in each of the half-hour periods the differences between the price groups are statistically significant at a level of 1% using both parametric and non-parametric tests. For the stocks with an assigned market maker, there are differences that are statistically significant at a level of 1% for all half-hour periods except 1:00-1:30 and 1:30-2:00. For the 1:00-1:30 period, the parametric test is significant at a level of 5%, while the non-parametric test is significant at a level of 1%. In the 1:30-2:00 period the

Table 27 This table reports the number of quote revisions that occur across price levels within each thirty-minute time interval during the trading day. This is done on an overall basis as well as for those stocks with and without an assigned market maker.

Overall

price	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
< FF 100	6.51	8.39	7.91	7.67	6.91	5.56	4.32	4.12	4.67	5.62	6.02	6.39	6.87	6.64	7.31	6.87
100 - 250	9.62	11.73	10.85	10.39	9.47	8.07	6.58	6.07	6.78	7.49	9.55	9.74	11.34	10.85	12.80	8.63
250-400	9.00	10.08	9.65	9.31	8.56	7.27	6.20	5.75	6.44	6.88	8.87	9.09	11.32	10.45	12.80	7.98
400-600	8.12	9.97	8.95	8.36	7.80	6.53	5.82	5.43	6.01	6.14	7.94	8.21	9.21	9.07	11.38	6.93
600-900	9.43	12.12	10.70	10.16	9.11	7.66	6.39	5.97	6.69	7.05	8.79	9.43	10.45	10.47	14.12	7.97
900-1500	9.15	11.28	9.79	9.53	8.54	7.52	6.83	6.63	7.22	6.84	9.05	9.36	10.48	10.27	13.09	6.67
>1500	7.48	9.29	9.01	8.18	7.33	6.79	5.67	5.58	5.51	6.05	7.32	7.18	8.02	8.18	9.27	4.63

Stocks without an assigned market maker:

	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
< FF 100	7.33	9.87	9.18	8.86	7.82	6.18	4.67	4.47	5.09	6.25	6.72	7.21	7.70	7.44	8.43	7.29
100 - 250	11.47	15.00	13.55	12.97	11.68	9.51	7.43	6.75	7.56	8.67	11.28	11.46	13.52	12.90	16.01	9.31
250-400	11.00	13.19	12.43	11.79	10.73	8.79	7.19	6.59	7.36	8.11	10.76	11.13	13.87	12.66	16.29	8.58
400-600	9.45	12.23	10.72	9.93	9.18	7.52	6.52	6.08	6.78	7.02	9.19	9.58	10.77	10.59	13.62	7.32
600-900	10.51	14.20	12.30	11.54	10.31	8.50	6.88	6.37	7.15	7.66	9.79	10.46	11.72	11.71	16.29	8.37
900-1500	10.80	14.26	11.99	11.79	10.26	8.70	7.81	7.31	7.96	7.86	10.49	10.89	12.65	12.20	16.30	7.07
>1500	8.18	10.49	10.16	9.14	8.12	7.38	6.04	5.89	5.84	6.53	8.03	7.90	8.73	8.96	10.24	4.76

Stocks with an assigned market maker:

	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
< FF 100	1.96	2.30	2.13	2.08	2.16	1.85	1.55	1.31	1.61	1.65	1.78	1.90	1.84	1.99	2.03	3.88
100 - 250	1.92	2.32	2.08	2.04	1.91	1.72	1.54	1.52	1.54	1.56	1.78	1.81	1.86	1.84	2.12	2.47
250-400	2.23	2.71	2.46	2.30	2.12	1.96	1.74	1.54	1.73	1.86	2.07	2.22	2.06	2.20	2.63	3.59
400-600	2.63	3.30	2.84	2.63	2.56	2.22	2.07	1.66	1.73	2.07	2.31	2.51	2.59	2.56	3.32	4.26
600-900	2.06	2.71	2.27	2.29	1.91	1.79	1.57	1.50	1.55	1.78	1.70	1.94	1.76	1.86	2.49	2.50
900-1500	2.13	2.61	2.39	2.19	2.17	2.10	1.68	1.52	1.66	1.87	2.12	2.12	2.07	2.06	2.18	1.52
>1500	2.08	2.80	2.38	2.21	2.02	1.97	1.57	1.42	1.55	1.55	1.84	1.96	1.94	2.08	2.20	1.24

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1%

parametric test is not significantly different, while the non-parametric test shows that the difference is statistically significant at a level of 10%.

On an overall basis, the pattern across the half-hour periods exhibits a well-defined U-shape, with the mean number of quote revisions lowest during the 1:00-1:30 half-hour period. For the most part, the mean number of quote revisions in the final full half-hour of trading is larger than during the first half-hour of trading. This does not hold for the group of stocks with prices below FF 100 and prices above FF 1500. For these groups the mean number of quote revisions is larger in the first half-hour of trading.

For stocks without an assigned market maker, the pattern across the half-hour periods is well-defined. Again, the minimum mean number of quote revisions is in the 1:00-1:30 period, and the mean number of quote revisions in the final full half-hour of trading is larger than the first half-hour for all price groups except those with prices below FF 100 and above FF 1500. The pattern is similar for those stocks that have an assigned market maker, however, the relative mean number of quote revisions at the beginning and end of the day differs. For stocks with an assigned market maker, the mean number of quote revisions in the final full half-hour of trading is less than the mean in the first half-hour of trading for all price groups except those stocks with prices between FF 400 - 600. For this group, the mean number of quote revisions is the same in the two periods.

The number of quote revisions that occur after trading differs between those stocks with and without an assigned market maker. For those stocks without an assigned market maker, the mean number of quote revisions is approximately half the number in the after 5:00 period as compared to the final full half-hour of trading. For those stocks

with an assigned market maker that are priced below FF 600 there is an increase in the number of quote revisions after 5 pm. Those stocks priced between FF 600-900 have approximately the same number of mean quote revisions, and those stocks above FF 900 have a slightly smaller number of quote revisions after 5 pm. The difference in mean number of quote revisions after 5:00 pm may indicate that the stocks with an assigned market maker garner more attention because of the presence of an assigned market maker. This is consistent with explanations involving the specialist-like market maker influencing the closing prices. It also may indicate that the assigned market maker adjusts prices to take advantage of the after-hours trading, since it is likely that the assigned market maker will have more of this trading than any other market maker, and thus has more of an incentive to influence the closing quotes.

3.4.5. Intraday Return

Table 28 examines the intraday return over half-hour intervals. Returns are calculated using the final transaction within each half-hour period. Including all stocks, the intraday half-hour returns are negative for all half-hours except the two half-hours after 4:30. The first two half-hours have the highest magnitude of negative return during the day. A parametric ANOVA test (F = 109.7) and a non-parametric Wilcoxon rank sums test (chi-square = 1,547.4) show significant differences between the half-hour intervals during the day. When the last two periods are excluded, the tests are repeated and the parametric and non-parametric tests remain statistically significant at a level of one percent, however, the values drop to 7.6 and 146.6, respectively. When the first two half-hours and the last two half-hours are removed, the statistical significance of tests across the remaining half-hour periods stays at one percent, but the value of the

Table 28 Intraday returns within each thirty minute time interval are calculated for transactions on the Paris Bourse during the period September-December 1995. Returns are calculated using the last transaction within each half-hour period.

	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
Overall																
return	-0.0065	-0.0780	-0.0552	-0.0600	-0.0325	-0.0105	-0.0122	-0.0176	-0.0461	-0.0370	-0.0320	-0.0336	-0.0167	-0.0035	0.2668	0.1510
t-stat	-2.8***	-7.8***	-6.1***	-7.1***	-4.2***	-1.4	-1.5	-2.1**	-5.9***	-5.0***	-4.3***	-4.6***	-2.2**	-0.5	28.4***	15.4***
n	259007	31132	20792	19966	19364	16662	12782	11202	12646	14933	16738	17470	18030	17965	20968	8357
%pos.	36.0	38.8	34.8	33.8	34.2	34.4	34.5	34.2	32.7	33.7	34.0	34.8	36.5	36.0	46.5	34.1
% zero	26.6	16.4	26.4	27.5	29.0	30.6	30.6	29.4	29.9	29.6	28.0	26.7	25.5	26.0	21.1	43.0
%neg.	37.4	44.8	38.8	38.7	36.8	35.0	34.9	36.4	37.4	36.7	38.0	38.5	38.0	38.0	32.4	22.9
Stocks without an assigned market maker:																
	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
return	-0.0021	-0.0630	-0.0353	-0.0312	-0.0054	0.0107	-0.0037	-0.0128	-0.0327	-0.0335	-0.0188	-0.0218	-0.0024	-0.0024	0.1688	0.1099
t-stat	-0.9	-5.3***	-4.7***	-4.1***	-0.8	1.4	-0.5	-1.7*	-4.4***	-4.7***	-2.7***	-3.1***	-0.3	-0.4	20.0***	12.3***
n	215562	22122	17004	16554	16126	14226	11288	10063	11288	12984	14305	14886	15321	15247	16626	7522
%pos.	36.9	41.2	36.3	34.9	35.4	35.6	35.3	35.0	33.5	34.8	35.2	36.1	37.9	37.1	45.5	33.1
% zero	25.2	11.9	24.8	26.3	27.6	29.4	29.5	28.3	29.0	27.9	26.1	24.8	23.7	24.1	19.9	43.3
%neg.	37.9	46.9	38.9	38.8	37.0	35.0	35.2	36.7	37.5	37.3	38.7	39.1	38.4	38.7	34.6	23.6
Stocks with an assigned market maker:																
	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
return	-0.0286	-0.1146	-0.1443	-0.1999	-0.1675	-0.1348	-0.0765	-0.0597	-0.1575	-0.0602	-0.1097	-0.1020	-0.0967	-0.0093	0.6419	0.5210
t-stat	-3.5***	-6.3***	-4.9***	-6.0***	-5.9***	-4.5***	-1.7*	-1.2	-3.8***	-1.9*	-3.7***	-3.6***	-3.3***	-0.3	20.6***	9.7***
n	43445	9010	3788	3412	3238	2436	1494	1139	1358	1949	2433	2584	2709	2718	4342	835
%pos.	31.6	33.0	28.1	28.5	28.2	27.8	28.4	27.4	26.4	26.5	27.3	27.5	28.6	30.0	50.4	43.0
% zero	33.5	27.2	33.5	33.3	35.8	37.3	38.6	38.7	38.0	40.6	38.9	37.2	35.4	36.4	25.8	40.5
%neg.	34.9	39.8	38.4	38.2	36.0	34.9	33.0	33.9	35.6	32.9	33.8	35.3	36.0	33.6	23.8	16.5
Tests of difference:																
ANOVA	18.3***	5.5**	21.7***	56.0***	62.7***	43.6***	7.9***	2.7*	23.6***	1.5	18.6***	15.4***	19.7***	0.1	425.6***	162.3***
Wilc.	31.9***	1.0	37.2***	28.4***	29.7***	29.0***	5.6**	5.3**	12.0***	4.8**	8.0***	14.2***	20.1***	2.0	314.8***	78.4***

*significant at a level of $\alpha = 10\%$ **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

parametric and non-parametric test are at 49 and 60.5, respectively. This indicates that the beginning and end of the day exacerbate much of the variation during the day.

Table 28 also divides stocks into those with an assigned market maker and those without an assigned market maker. For both groups the pattern is negative returns for all periods except the final two, however, the magnitude of the final two periods differs. The stocks with an assigned market maker have returns that are approximately five times larger than the returns for stocks without an assigned market maker. During the day, the stocks with an assigned market maker have negative returns that have a higher magnitude than the returns for the stocks of firms without assigned market makers. In eight of the thirteen half-hour periods (excluding the final two periods) both parametric and non-parametric tests show statistically significant differences at a level of 1 percent.

Table 29 shows the intraday return using the reduced sample of firms that have a total volume during the sample period of 100,000 to 200,000 shares. Each half-hour return for the entire reduced sample is negative except for the final two half-hour periods. When the stocks are divided into those with and without an assigned market maker, there are significant differences for only six of the half-hour periods. The most significant differences are for the final full half-hour period (4:30-5:00), where both the parametric and non-parametric tests are significant at a level of 1%.

3.5. Conclusion

The end-of-day effect first observed in the U.S. is also evident on the Paris Bourse. The contributions of this essay toward a further understanding of the end-of-day effect are: (1) The existence of a significantly higher magnitude of the final intraday transaction return is found for securities that have an assigned market maker versus those

Table 29 This table uses a reduced sample of only those firms with total volume between 100,000 and 200,000 shares over the sample period September-December 1995. Intraday returns within each thirty minute time interval are calculated for transactions on the Paris Bourse during the period September-December 1995. Returns are calculated using the last transaction within each half-hour period.

	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
Overall																
return	-0.0105	-0.0391	-0.0531	-0.0830	-0.0695	-0.0999	-0.0439	-0.1070	-0.1079	-0.0723	-0.0298	-0.1604	-0.0456	-0.0144	0.4636	0.1525
t-stat	-1.1	-1.4	-1.7*	-2.2**	-2.4**	-2.9***	-1.2	-2.3**	-2.7***	-2.1**	-0.9	-5.2***	-1.3	-0.5	10.9***	3.0***
n	24288	4049	2053	1962	1901	1451	922	755	911	1170	1429	1550	1674	1614	2293	554
%pos.	32.7	39.5	30.7	28.8	29.8	27.9	28.4	26.4	27.1	29.4	29.2	27.6	32.4	30.6	46.5	32.5
% zero	31.6	19.0	32.7	33.1	36.2	36.7	38.6	41.3	35.7	36.1	36.4	34.2	30.6	33.0	25.0	48.4
%neg.	35.7	41.5	36.6	38.1	34.0	35.4	33.0	32.3	37.2	34.5	34.4	38.2	37.0	36.4	28.5	19.1
Stocks without an assigned market maker:																
	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
return	-0.0033	0.0004	0.0187	-0.1014	0.0164	-0.0126	-0.0051	-0.0334	-0.0928	-0.0687	0.0195	-0.1630	0.0177	0.0347	0.1975	0.1337
t-stat	-0.3	0.0	-0.6	-2.8***	0.5	-0.3	-0.2	-0.6	-2.0**	-1.8*	0.5	-4.4***	0.4	1.0	5.6***	2.9***
n	13577	2000	1148	1117	1070	835	547	453	561	678	825	895	992	931	1175	350
%pos.	34.0	43.0	32.2	29.2	30.7	29.5	30.0	30.2	27.8	32.7	31.2	29.9	35.9	34.6	42.8	30.6
% zero	29.5	14.3	31.2	31.8	36.7	35.8	38.2	38.6	33.9	31.4	32.7	30.5	26.6	28.4	23.4	52.0
%neg.	36.5	42.7	36.6	39.0	32.6	34.7	31.8	31.2	38.3	35.9	36.1	39.6	37.5	37.0	33.8	17.4
Stocks with an assigned market maker:																
	overall	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30	4:30-5:00	after 5:00
return	-0.0196	-0.0776	-0.0967	-0.0586	-0.1800	-0.2184	-0.1005	-0.2174	-0.1320	-0.0772	-0.0972	-0.1568	-0.1376	-0.0831	0.7433	0.1847
t-stat	-1.1	-1.8*	-1.7*	-0.8	-3.6***	-3.7***	-1.3	-2.7***	-1.8*	-1.3	-1.6	-2.9***	-2.1**	-1.5	9.5***	1.7*
n	10711	2049	905	845	831	616	375	302	350	492	604	655	682	683	1118	204
%pos.	31.1	36.2	28.8	28.4	28.6	25.8	26.1	20.5	26.0	24.8	26.5	24.4	27.4	25.2	50.4	35.8
% zero	34.1	23.7	34.7	34.9	35.4	37.8	39.2	45.4	38.6	42.5	41.4	39.2	36.4	39.2	26.7	42.2
%neg.	34.8	40.1	36.5	36.7	36.0	36.4	34.7	34.1	35.4	32.7	32.1	36.4	36.2	35.6	22.9	22.0
tests of difference:																
ANOVA	0.7	1.9	1.6	0.3	11.0***	8.9***	1.7	3.7*	0.2	0.0	2.8*	0.0	4.7**	3.5*	42.0***	0.2
Wilc.	3.1*	2.3	2.1	0.0	5.4**	5.4**	2.2	6.8***	0.1	0.7	0.7	0.3	4.7**	4.9**	59.5***	0.5

*significant at a level of α 10% **significant at a level of $\alpha = 5\%$ ***significant at a level of $\alpha = 1\%$

that do not have an assigned market maker. This is robust across subdivisions based on time of day, day of the week as well as the price level of the stock. (2) The existence of an impact on the final intraday transaction return by the price of the stock is in addition to the assigned market maker effect, suggesting that the hypothesis regarding the tendency to switch to the ask price may have some validity. (3) The proximity of the last transaction to the close of trading has a significant effect on the magnitude of the final intraday transaction return, regardless of price level or market structure. (4) The end of month effect is not observed on the final intraday transaction return for the group of stocks with an assigned market maker suggesting the assigned market makers are not involved in window dressing at month end. (5) The final intraday transaction return is partially reversed overnight with a magnitude that is proportional to the final intraday transaction return suggesting a portion of the price rise may be temporary. This explanation is also consistent with Hatheway's (1994) explanation that the price rise at the end of the day could be used to induce information from short sales the following morning. Future research should be directed towards understanding the causes for these observed effects.

This essay also finds that volume follows a reverse-J intraday pattern for stocks traded with and without an assigned market maker. When cross-trades are examined separately, they show the same pattern during the day, however, in trades reported after 5 pm, there is a larger percentage of cross-trades than in on-exchange transactions. This may be a result of an inability to trade on the exchange or may be an attempt to influence the closing price.

Volatility as measured by a high minus low price definition is found to follow a U-shaped pattern during the day. When the standard deviation of changes in successive

midpoints is used as the definition then the pattern resembles a reverse-J. Using the full sample the two measures appear to contradict each other with respect to whether the group of stocks with or without an assigned market maker has a larger volatility. When a reduced sample matched on level of volume is used the magnitude of volatility is larger for the group of stocks with an assigned market maker.

This chapter shows that the intraday bid-ask spread is larger in magnitude for stocks with an assigned market maker, even when controlling for price. The percentage and absolute bid-ask spread exhibit a reverse-J pattern during the trading day for stocks with and without an assigned market maker. The number of quote revisions throughout the day follows a U-shaped pattern with stocks without an assigned market maker having approximately five times more quote revisions, likely reflecting the differences in liquidity. The differences are not uniform since after 5 pm the multiple drops from five to three, indicating a proportional increase in the attention paid to stocks with an assigned market maker in the period near the market close.

The intraday return over half-hour intervals is examined and the beginning and end of the trading day are shown to be responsible for most of the variation during the trading day. There are differences between the group of stocks with and without an assigned market maker. For stocks with an assigned market maker the intraday return in the final two periods has a magnitude approximately five times larger than the group of stocks without an assigned market maker. The return observed intraday also has a magnitude that is larger for those stocks with an assigned market maker.

The direct comparability of these findings with studies on other exchanges must consider the different incentives that exist on the Paris Bourse compared to the US exchanges that are the focus of much of the research in this area. Principal trading on the

Paris Bourse may be carried out by member firms during or outside the trading session. During the trading session the trade must be at a price within or at the existing spread, but if the principal trade occurs outside the trading session then it must be carried out within the spread or at a price plus or minus 1% of the best bid or best offer existing at the close of the previous trading day. These differing incentives which affect the closing price may impair cross-exchange comparability.

Subsequent to the sample period and notification of these results to researchers at the Paris Bourse, the end of day procedures have been altered by introducing a batch auction at the close for all continuously traded securities. Under the new rule instituted in May 1996 all trading ceases at 4:55 pm and market orders are accumulated but not executed. At 5:00 pm the electronic system matches the orders in a batch auction similar to the open and this price is the closing price for the day. The new procedure may eliminate concerns that may be created from observing an end of day transaction price anomaly on the Paris Bourse.

CHAPTER 4

ESSAY TWO:

MARKET STRUCTURE AND THE CCOMPONENTS OF THE BID-ASK SPREAD

4.1. Introduction

The rapid structural change in the securities industry caused by expanding international markets, technological advances and intermarket competition encourages further analysis of the differences in execution costs between different market structures. Execution costs can be divided into direct commissions and indirect fees such as the bid-ask spread and market impact. The bid-ask spread is the difference between the price at which the market maker is willing to sell and the price at which the market maker is willing to buy. This compensation to the market maker has been decomposed into three theoretical components: inventory holding costs, order processing costs and adverse information costs. The inventory holding cost is the compensation charged by the market maker for holding a sub-optimal portfolio. The order processing costs are those fees that are charged to compensate for the processing charges involved in a transaction. The adverse information (or adverse selection) costs are those costs that compensate the market maker for transacting with investors that are better informed.

The relative merits of alternative trading systems have been questioned in the theoretical and empirical literature. Theoretically, the efficiency of the specialist market organization is argued by Glosten (1989) and Leach and Madhavan (1993). The ability of the monopolist to suffer losses on individual trades encourages competition among informed traders and permits the market to stay open where under other circumstances it would be forced to close because of the competitive conditions. Benveniste, Marcus and

Wilhelm (1992) show that the specialist can induce information release by penalizing brokers that attempt to exploit the information. This model of the specialist's behavior suggests that the specialist is most valuable when there is a tendency for informed trading. Additionally, the specialist market has limit orders that can be thought of as providing competition to the specialist (see Harris and Hasbrouck (1996)). Similarly, Laux (1997) shows that institutional investors provide outside competition in a dealer market, and this can affect the bid-ask spread.

Empirical examinations of the bid-ask spread have compared the speed of adjustment to new information and the relative size on different exchanges. Kim, Lin and Slovin (1997) show that information is impounded in prices in less trading time after the open on NYSE/ASE stocks compared to Nasdaq stocks. This supports Madhavan's (1992) finding that call auctions are more efficient than a dealer system. Conversely, Masulis and Shivakumar (1997) find that Nasdaq stocks react faster than NYSE/ASE stocks to intraday equity offering announcements.

The size of the bid-ask spread has been the focus of recent studies. Christie and Schultz (1994) and Christie, Harris and Schultz (1994) note a tendency for bid-ask spreads on Nasdaq to be larger than spreads on NYSE because of an avoidance of odd-eighth prices. Godek (1996), however, suggests that the larger bid-ask spreads are justifiable economic results of the market structure and the incentive structure. Statistical models of spread components have also been used to compare single dealer and multiple dealer markets. Contradictory results have been found in assessing the components of the bid-ask spread across exchanges. Widely divergent estimates of the adverse selection component have been produced. Glosten and Harris (1988) use 250 NYSE stocks and

estimate that about 20% of the total spread is due to adverse information. Stoll (1989) finds that the adverse selection component accounts for approximately 43% of the total spread for a sample of 900 Nasdaq stocks.

Direct comparisons of bid-ask spread components or trade execution costs are also made by Affleck-Graves, Hedge and Miller (1994), Lin, Sanger and Booth (1995b), Huang and Stoll (1996), Porter and Weaver (1996), Jones and Lipson (1997) and Bessembinder and Kaufman (1997). Affleck-Graves, Hedge and Miller (1994) find that order processing costs are lower for NYSE/ASE stocks and adverse selection costs are lower for Nasdaq. Conversely, Jones and Lipson (1997) indicate that the adverse selection cost component is larger on Nasdaq. They find effective[9] bid-ask spreads to be only slightly smaller on NYSE, while realized bid-ask spreads are two to three times lower. Bessembinder and Kaufman (1997) update Huang and Stoll's (1996) finding of larger execution costs on Nasdaq compared to the NYSE. Bessembinder and Kaufman find a smaller differential than Huang and Stoll and this may reflect the timing of the sample (1994 versus 1991). They find average effective spreads to be approximately 25% larger for large firms, and approximately twice as large for medium and small firms.

The Paris Bourse provides a unique structure that is well suited to comparing different market structures since two market structures coexist: some stocks trade using multiple dealers while other stocks also each have an assigned market maker. The price effects of trading and the components of the bid-ask spread have been studied on the Paris Bourse by De Jong, Nijman and Röell (1996). They do not, however, compare the two market structures on the Paris Bourse. Using the Glosten (1994) model, extended to

[9] All alternate measures of the bid-ask spread are defined in section 4.3.2.

include order processing costs, they find that the adverse selection component of the bid-ask spread comprises 30-45% of the total spread, with the remainder accounted for by order processing costs. They use two different models to estimate the price impacts and find that using the Glosten (1994) model generates estimates of the price impact that vary from 25% of the bid-ask spread for small transactions to 60% for large transactions. Using a vector autoregression model, they provide estimates of the permanent price impact that vary from 40% to 115% of the total bid-ask spread.

In this chapter, the general decomposition model of Huang and Stoll (1997) is used to decompose the bid-ask spreads of stocks traded on the Paris Bourse and a comparison is made across the two market structures that coexist. The Huang and Stoll model is a reconciliation of existing covariance and trade indicator models. They show that their trade indicator model fully decomposes the bid-ask spread into the three components: inventory holding costs, adverse selection costs and order processing costs. This chapter will add to the De Jong, Nijman and Röell (1996) findings by using a model that decomposes the bid-ask spread into all its components. Furthermore, the data set used in this chapter encompasses a larger time period (84 days versus 44 days), is more current (September-December 1995 versus May 25 - July 25 1991) and is larger (454 firms versus ten firms).

This chapter also employs the procedures used by Bessembinder and Kaufman (1997) to calculate the execution costs of trading on the Paris Bourse and compares these estimates across the two market structures that coexist. The Bessembinder and Kaufman (1997) method provides a direct measure of trade execution costs. This is beneficial since it does not rely on the assumptions of a theoretical model.

4.2. Hypotheses

The unique arrangement of the Paris Bourse, with two market structures operating simultaneously, provides an opportunity to test for differences in the components of the bid-ask spread. The inconclusive findings regarding the relative sizes of the adverse selection component on NYSE and Nasdaq make prediction difficult. A higher adverse selection component may be more likely when one dealer is required to stay in the market. This is especially true if that dealer is constrained from information gathering by its research division through rules such as 'Chinese walls' that prohibit communication between the research division and the dealer. In conjunction to this, Easley, Kiefer, O'Hara and Paperman (1996) find that higher volume stocks have a lower probability of information-based trading. This may subject the assigned market maker on the Paris Bourse to a higher adverse selection component since these stocks have, on average, lower volume than stocks without an assigned market maker. The lower volume stocks do not necessarily ensure higher adverse selection costs, since the timing of intraday volume may also be important. Foster and Viswanathan (1993) find that high adverse selection costs are found at times of the day when there is higher trading volume. Intraday fluctuations in adverse selection costs are not specifically examined, however, an overall comparison is made to determine the relative size of this component across the two market structures.

The specific hypotheses are as follows:

$H1_O$: The adverse selection component is the same for stocks with and without an assigned market maker.

$H1_A$: The adverse selection component is not equal for stocks with and without an assigned market maker.

This requires a two-tailed test. As suggested by the literature, the volume of a stock may impact on the size of the adverse selection component and this may confound tests across market structures. Volume levels can be used to rank and group stocks and then comparisons across market structures may be more informative. Hypothesis one (H1) is revisited controlling for these volume differences. Additionally, testing of the adverse selection component's variation with volume within each market structure may indicate if the level of volume is a valid explanatory factor. The hypotheses are as follows:

> $H2_O$: The adverse selection component of stocks with or without an assigned market maker is the same across volume levels.
>
> $H2_A$: The adverse selection component of stocks with or without an assigned market maker differs across volume levels.

The inventory holding cost component is likely nontrivial for those stocks with an assigned market maker since the assigned market maker is required to maintain a positive inventory and may be more sensitive to inventory changes. Thus, those stocks with an assigned market maker may have a higher inventory holding cost component. This suggests the following hypotheses to test this proposition:

> $H3_O$: The inventory holding cost component is the same for stocks with and without an assigned market maker.
>
> $H3_A$: The inventory holding cost component is larger for stocks with an assigned market maker than for those stocks without an assigned market maker.

This requires a one-tailed test.

The order processing cost component was found by Affleck-Graves, Hedge and Miller (1994) to be smaller for those stocks that traded on NYSE/ASE. This may be a function of the individual stocks under examination or may be a reflection of the different costs across exchanges. The Paris Bourse data can be used to identify the source of the

difference since any differences are a reflection of the stocks or the market structure and not the exchange itself. This suggests the following hypotheses:

> $H4_O$: The order processing cost component is the same for stocks with and without an assigned market maker.
>
> $H4_A$: The order processing cost component is smaller for stocks with an assigned market maker than for stocks without an assigned market maker.

This also requires a one-tailed testing procedure.

The inventory holding cost component may be considered to be a function of the accumulation of inventory. Furthermore, assigned market makers may be more likely to be affected by inventory changes since they have to maintain a presence in the market. The effect of inventory changes is tested by dividing the period under study. In the first period buy and sell transactions are netted to create a summation of the accumulated inventory change, and the total inventory changes are ranked and placed in quintiles. Then, in the subsequent period, the estimated inventory holding cost component is compared across the inventory accumulation quintiles. If there are statistically significant differences across inventory accumulation quintiles, then this demonstrates that inventory accumulation can be considered to be an explanatory variable in determining the inventory holding costs. The specific hypotheses are as follows:

> $H5_O$: The inventory holding cost component is the same for groups of stocks determined by the inventory change in the previous period.
>
> $H5_A$: The inventory holding cost component differs across group of stocks determined by the inventory change in the previous period.

Furthermore, a comparison between stocks with and without an assigned market maker will determine if the effect of a large inventory change may be more noticeable for those stocks with an assigned market maker since the assigned market maker is required to

maintain a presence in the market. Hypothesis three (H3) will be revisited to test if the difference between the group of stocks with and without an assigned market maker within each of the groups of stocks determined by the inventory change in the previous period.

Since trades are often executed at prices inside the quotes direct trade execution costs are examined using a number of measures[10] following Bessembinder and Kaufman (1997). In each of the measures, the difference between the group of stocks with and without an assigned market maker provides further information about the performance of the alternate trading systems. The hypotheses that are tested are as follows:

> $H6_O$: The trade execution cost measure is the same for stocks with and without an assigned market maker.
>
> $H6_A$: The trade execution cost measure is not equal for stocks with and without an assigned market maker.

4.3. Data and Method of Testing

The data used in this research is supplied by the Paris Bourse. It contains the price, time, number of shares traded, and a classification identifying whether the trade was a pass-through transaction that occurred outside the exchange. Quote data is also provided that details the best limit orders that were in the system at all times. There is also descriptive data that identifies the trading compartment of the stock. Trading compartments are described in Appendix A. Trading is examined over the period September through December, 1995. In total, there are 3,189,976 transactions and 3,301,090 quotes for 458 firms over this 84 trading day period. Only those securities that are traded on a continuous basis during the day after the open are retained for the present

[10] The measures are defined in section 4.3.2.

analysis. To ensure trades are only matched with quotes that preceded the trades, any quotes must have been outstanding for at least five seconds. This was originally suggested by Lee and Ready (1991), specific to the floor of the NYSE, however, it is also applicable for the Paris Bourse as a conservative measure of ensuring that trades and quotes are reported in the proper causal order. Since it is unlikely that traders react within five seconds to a new quote, ensuring quotes are outstanding for five seconds forces those trades that occur within five seconds of a quote revision to be measured against earlier quotes that likely were in force when the decision to trade occurred.

Simple statistics are provided in Table 1. A summary of the number of firms listed daily is provided on an overall basis, as well as divided into groups based on whether the firm has an assigned market maker.

Two methods are used in this chapter to examine the properties of trading costs on the Paris Bourse. Estimation of Huang and Stoll's (1997) general decomposition model is used to test hypotheses one to five. This method is explained in section 4.3.1. The trade execution costs measured in Bessembinder and Kaufman (1997) are used to test hypothesis six. This is explained in sections 4.3.2.

4.3.1. Huang and Stoll's (1997) General Decomposition Model

The bid-ask spread decomposition model of Huang and Stoll (1997) involves the estimation of two equations. The first equation is the conditional expectation of the trade indicator at time t-1, given the trade indicator at time t-2.

$$E(Q_{t-1} | Q_{t-2}) = (1-2\pi)\, Q_{t-2} \qquad (1)$$

where the subscript t refers to time and π refers to the probability that the trade at t-1 is opposite in sign to the trade at t-2. Q_t is defined to be the buy-sell trade indicator variable

for the transaction price, P_t. It equals +1 (-1) if the transaction is buyer-initiated (seller-initiated) and occurs above (below) the midpoint of the bid-ask spread. It equals 0 if the transaction occurs at the midpoint.

The second equation estimates the components of the spread directly from the quote-change equation:

$$\Delta M_t = (\alpha + \beta) \frac{S_{t-1}}{2} Q_{t-1} - \alpha(1-2\pi) \frac{S_{t-2}}{2} Q_{t-2} + e_t \qquad (2)$$

where M_t is the bid-ask spread midpoint at time t, S_{t-1} is the observed posted bid-ask spread at time t-1, α is the proportion of the half-spread attributable to adverse selection, and β is the proportion of the half-spread attributable to inventory holding costs. The error term, e_t, is a serially uncorrelated public information shock that contains rounding errors.

These components are estimable because of assumptions about behavior following each transaction. As inventory is accumulated, inventory models assume that market makers adjust prices relative to fundamental values in order to induce inventory equilibrating trades. This would suggest that following a transaction there should be a reversal of the direction of trade to compensate for inventory costs. This is induced by a market maker that lowers (raises) prices following a purchase (sale). Therefore the component of the bid-ask spread attributable to inventory holding costs, β, can be estimated by observing how the midpoint changes following a transaction.

The adverse selection costs, α, are also confounded with the estimate of inventory holding costs since following a purchase (sale) market makers would lower (raise) prices in order to reflect the potential information content of the trade. They are differentiated in Huang and Stoll's model by using the negative serial covariance induced by inventory

adjustments. The probability of a reversal, π, increases when quotes adjust for inventory purposes, but not for adverse selection purposes. In the Huang and Stoll model, the order processing component of the bid-ask spread is calculated as the remainder following the estimation of the inventory and adverse selection cost components.

Huang and Stoll (1997) estimate the two equations using a generalized method of moments (GMM) procedure. This is done in order to impose weak distributional assumptions on the data which is particularly important since the error term includes rounding errors due to discreteness in the price data. Furthermore, the GMM procedure accommodates conditional heteroskedasticity of an unknown form and serial correlation in the residuals.

Before the GMM estimation is done a simpler non-linear least squares (NLLS) estimation procedure is used in this chapter and the error terms are examined in order to test if the estimation procedure is appropriate. The second equation contains lagged versions of the buy-sell trade indicator variable (Q_{t-1} and Q_{t-2}) that can be considered to be predetermined. This system of equations can be estimated using non-linear least squares and the residuals from this estimation procedure should have a zero mean and a positive definite covariance matrix. If the residuals are autocorrelated then the standard errors may be incorrect. If the residuals are heteroskedastic, then estimation using some weighting can be used, or alternatively, without knowing the proper weighting, the GMM procedure can be used. Both a GMM and NLLS estimation are used to estimate the coefficients. Additionally, the residuals of the GMM procedure are examined to determine if they exhibit autocorrelation and heteroskedasticity, since evidence of these two potential problems casts some doubt as to the appropriateness of the NLLS estimation.

4.3.2. Bessembinder and Kaufman's (1997) Trade Execution Cost Estimates

Bessembinder and Kaufman (1997) estimate the quoted, effective and realized bid-ask spreads. The quoted half-spread is measured as follows:

$$\text{Quoted Half-Spread}_{it} = 100*(A_{it} - B_{it})/2M_{it}), \quad (3)$$

where A_{it} is the posted ask price for security i at time t, B_{it} is the posted bid price for security i at time t, and M_{it} is the quote midpoint or mean of A_{it} and B_{it}. This measures one-half of a round-trip execution costs in percent if trades are executed at the quotes. The conventional method of reporting is to use a one-way measure as reported by half of the quoted percentage spread.

The effective half-spread measures trading costs, accounting for the fact that trades may occur inside the quoted spread. This is calculated as follows:

$$\text{Effective Half-Spread}_{it} = 100D_{it}(P_{it} - M_{it})/M_{it}, \quad (4)$$

where P_{it} is the transaction price for security i at time t, and D_{it} is a dummy variable that equals one for customer buy orders and negative one for customer sell orders. M_{it} is the midpoint of the most recently posted bid and ask quotes for security i (interpreted as a proxy for the pre-trade value of the asset). The two components of the effective spread are the price impact and the realized half-spread. The price impact is defined as follows:

$$\text{Price Impact}_{it} = 100D_{it}(P_{it+n} - M_{it})/M_{it}, \quad (5)$$

where P_{it+n} is the first trade observed at least thirty minutes or one day after the trade for which price impact is measured. The price impact represents the private information content that is conveyed by the trade. The realized half-spread is defined as follows:

$$\text{Realized Half-Spread}_{it} = 100D_{it}(P_{it} - P_{it+n})/M_{it} \quad (6)$$

The realized half-spread represents the profit net of adverse selection but prior to order processing and inventory costs. This can be considered to be the net revenue.

Bessembinder and Kaufman (1997) recognize that the large number of data observations creates some difficulties arising from data processing limitations. They circumvent the problems by calculating mean monthly trade execution cost measures, and then averaging across stocks. They use a weighted least-squares regression procedure (with the weights being the number of observations) where a dummy variable (representing the exchange) is regressed on the mean trade execution cost. They use the residuals in a bootstrap procedure consisting of 500 estimates using random sampling of 300 firm's residuals to come up with p-values that test the difference between NYSE and Nasdaq stocks.

In this chapter, a two-stage computational procedure is also used. Daily averages are first calculated for each stock. This is similar to Bessembinder and Kaufman (1997), and has the added benefit of ensuring that higher frequency stocks do not dominate any calculations of overall means. Means are provided globally as well as after dividing stocks into groups with and without an assigned market maker. Differences between the two groups are calculated using a parametric ANOVA test and a non-parametric Wilcoxon rank scores test. All stocks are also divided into price quintiles based on the first price of each stock during the period. Testing of the difference between the group of stocks with and without an assigned market maker is done in each of these price quintiles.

4.4. Bid-Ask Spread Component Results

In this section the Huang and Stoll (1997) general decomposition model is used to estimate the components of the bid-ask spread. A simple NLLS estimation procedure is used in addition to the GMM procedure employed by Huang and Stoll as explained in

section 4.3.1. In order to determine the reliability of the NLLS estimates, the residuals from the GMM method are examined to determine if the simpler estimation procedure is appropriate. The NLLS procedure is considered appropriate if the residuals from the GMM estimation are without serial correlation and heteroskedasticity.

The residuals indicate that serial correlation is present for a majority of the stocks. Table 30 reports that of the 454 stocks, 452 have usable GMM estimates and residuals. Statistically significant serial correlation is found in 339 stocks. The measure of heteroskedasticity is performed in two ways. White's asymptotically consistent covariance matrix is used to test the residuals and statistically significant heteroskedasticity is found in 293 stocks. The Goldfeldt-Quandt method is also employed, where the residuals are divided into two groups based on the magnitude of an instrumental variable. Statistically significant heteroskedasticity is found in 384, 364 and 358 stocks, depending on the instrumental variable used to divide the residuals. The instrumental variables are chosen following Huang and Stoll (1997). The three instrumental variables used are the lagged half-spread multiplied by the lagged buy-sell indicator variable, the second lagged half-spread multiplied by the second lagged buy-sell indicator variable and the second lagged buy-sell indicator variable.

The overall observance of the presence of serial correlation and heteroskedasticity suggests that the GMM method employed by Huang and Stoll (1997) to correct for these problems is appropriate with this data. Both the NLLS and GMM methods of estimation are used and both sets of coefficient estimates are provided in all testing. Estimates are individually obtained for 452 stocks using the GMM procedure.

Table 30 This table reports summary statistics for tests of serial correlation and heteroskedasticity. The Huang and Stoll (1997) model, shown as equations (1) and (2), are estimated using a GMM procedure for each stock on the Paris Bourse during the period September-December 1995. Residuals are analyzed to determine if serial correlation and heteroskedasticity are present. The correlation test used is the Pearson correlation coefficient of the residual on the lag of the residual. Two heteroskedasticity tests are used. Estimation of White's aymptotically consistent covariance matrix is used to estimate the significance of heteroskedasticity. Additionally, the Goldfeldt-Quant test is used where the residuals are divided into two groups based on one of the instrumental variables and the ratio of the sum or squared errors is computed and compared to the probability of an F-test distribution.

	Total Firms	Reject at 1%	Reject at 5%	Reject at 10%	Fail to Reject
PANEL A All Observations					
Serial Correlation					
Pearson Correlation Coefficient					
	452	264	48	27	113
Heteroskedasticity					
White's Test	452	178	78	37	159
Goldfeldt-Quant					
#1	452	325	39	20	68
#2	452	298	39	27	88
#3	452	275	53	30	94
PANEL B Observations with Bunching					
Serial Correlation					
Pearson Correlation Coefficient					
	387	248	33	19	87
Heteroskedasticity					
White's Test	387	149	59	29	150
Goldfeldt-Quant					
#1	387	216	45	22	104
#2	387	187	46	25	129
#3	387	219	45	20	103

A bunching procedure is also used where successive transactions at identical prices are combined into one larger trade. This bunching is used by Huang and Stoll (1997) in order to account for large trades that are negotiated at a single price, but may be reported in a series of smaller trades. This is a potential source of positive serial correlation and affects the estimates of the parameters. Bunching reduces the sample size of transactions from 2,454,828 by 1,276,597 to 1,178,231. When bunching is employed there are 355 stocks with coefficient estimates using the GMM estimation procedure. Some of the individual coefficients estimates are outside economically meaningful ranges. One reason is due to an insufficient number of observations. To ensure the estimates obtained are at the global minimum, a grid search is performed with starting values within the bounds of the empirical predictions. Additionally, an increase in the maximum number of iterations is also attempted in order to obtain estimates that converge and are economically meaningful.

The serial correlation and heteroskedasticity measures are re-calculated for using the bunched observations and reported on Table 30. Of the 387 firms with estimates using the GMM procedure, 300 firms exhibit statistically significant serial correlation. The tests for heteroskedasticity also show a large percentage of firms with statistically significant estimates. Using White's test, 337 firms show statistically significant heterskedasticity. When the Goldfeldt-Quant test and each of the three instrumental variables are used, statistically significant heteroskedasticity is found in 296, 271 and 297 firms. These results confirm that serial correlation and heteroskedasticity are present in the observations both with and without the bunching procedure.

The estimates are averaged across firms and reported on an overall basis, as well as for each group of stocks with and without an assigned market maker. Tests of difference are done between the two groups using a parametric ANOVA test and a non-parametric Wilcoxon rank scores test.

In the following sections the individual hypotheses are tested and results are presented. While estimates of only one component are required to test each of the hypotheses outlined, all are estimated simultaneously and are reported in the resulting tables. In all cases, the adverse selection component (α), the inventory holding cost component (β) and the probability of reversal (π) are presented. The order processing component is not shown since it is a remainder, but the exception is in Table 16 where the order processing costs are reported in order to test hypotheses four (H4).

4.4.1. Overall Bid-Ask Spread Component Estimates

In this section the individual components of the bid-ask spread are estimated and hypotheses are tested that involve comparisons across stocks with and without an assigned market maker.

4.4.1.1. Adverse Selection Cost Component

Table 16 shows the bid-ask spread component estimates for all transactions and those transactions using the bunching procedure in which successive transactions at identical prices are combined into a larger trade. The estimates for the adverse selection component, α, all have non-positive mean values irrespective of the method of estimation. The overall estimates and the estimates for the group of stocks without an assigned market maker are all significantly different than zero. The group of firms with an assigned market maker have estimates that are not significantly different than zero.

Table 31 This table reports estimates of bid-ask spread components. This table uses a NLLS and GMM estimation procedure to estimate the Huang and Stoll (1997) model, shown as equations (1) and (2), for each firm on the Paris Bourse during the September - December 1995 period. Results are shown on an overall basis, as well as for each group of stocks that trade with and without an assigned market maker. Panel A presents the results using all observations in the regression, while panel B uses a bunching procedure in which successive transactions at identical prices are combined into one larger trade. A parametric ANOVA test and a non-parametric Wilcoxon rank sums test are used to test differences between the means in the two groups.

	α	SD	β	SD	Π	SD
PANEL A — All Observations						
Overall						
NLLS	-0.0105***	0.0837	0.0682***	0.0788	0.2661***	0.0485
GMM	-0.0078***	0.0541	0.0607***	0.0472	0.1767***	0.0505
Firms Without An Assigned Market Maker						
NLLS	-0.0125***	0.0630	0.0616***	0.0594	0.2609***	0.0421
GMM	-0.0099***	0.0436	0.0576***	0.0415	0.1756***	0.0458
Firms With An Assigned Market Maker						
NLLS	-0.0064	0.1146	0.0813***	0.1066	0.2765***	0.0581
GMM	-0.0037	0.0706	0.0669***	0.0564	0.1789***	0.0590
Tests of Difference	ANOVA	Wilcoxon	ANOVA	Wilcoxon	ANOVA	Wilcoxon
NLLS	0.53	0.21	6.35***	7.38***	10.58***	25.32***
GMM	1.34	0.31	3.91**	4.94**	0.45	2.06
PANEL B — Observations with Bunching						
Overall						
NLLS	-0.0437**	0.3450	0.1366***	0.3391	0.4662***	0.0768
GMM	-0.0486***	0.2597	0.1479***	0.2523	0.4562***	0.1215
Firms Without An Assigned Market Maker						
NLLS	-0.0508**	0.3044	0.1332***	0.3012	0.4731***	0.0807
GMM	-0.0549***	0.2447	0.1471***	0.2418	0.4693***	0.1234
Firms With An Assigned Market Maker						
NLLS	-0.0284	0.4201	0.1440***	0.4101	0.4513***	0.0657
GMM	-0.0353	0.2899	0.1494***	0.2745	0 4281***	0.1126
Tests of Difference	ANOVA	Wilcoxon	ANOVA	Wilcoxon	ANOVA	Wilcoxon
NLLS	0.33	0.33	0.08	0.05	6.30**	3.94**
GMM	0.44	0.21	0.01	0.06	9.09***	9.44**

*significant at a level of α = 10%
**significant at a level of α = 5%
***significant at a level of α = 1%

(table con'd)

(Table 31 continued)

	$1-\alpha-\beta$	SD
PANEL A — All Observations		
Overall		
NLLS	0.9423***	0.0541
GMM	0.9471***	0.0484
Firms Without An Assigned Market Maker		
NLLS	0.9509***	0.0485
GMM	0.9523***	0.0426
Firms With An Assigned Market Maker		
NLLS	0.9251	0.0604
GMM	0.9368	0.0571
Tests of Difference	ANOVA	Wilcoxon
NLLS	24.04***	34.02***
GMM	10.54***	14.49***
PANEL B — Observations with Bunching		
Overall		
NLLS	0.9070***	0.0719
GMM	0.9008***	0.0663
Firms Without An Assigned Market Maker		
NLLS	0.9176***	0.0599
GMM	0.9077***	0.0577
Firms With An Assigned Market Maker		
NLLS	0.8844	0.0887
GMM	0.8859	0.0799
Tests of Difference	ANOVA	Wilcoxon
NLLS	17.17***	20.13***
GMM	8.55***	6.63***

*significant at a level of α = 10%
**significant at a level of α = 5%
***significant at a level of α = 1%

In order to test hypothesis one (H1) and determine if the estimates for the adverse selection component differ between the group of stocks with and without an assigned market maker, a parametric ANOVA test and a non-parametric Wilcoxon rank scores test are performed on the means. For all the GMM and NLLS estimates with or without bunching, neither the parametric nor the non-parametric test is significant. These results indicate that the null hypothesis for hypothesis one (H1) that the adverse selection component is the same for those stocks with and without an assigned market maker is not rejected.

4.4.1.2. Inventory Holding Cost Component

Hypothesis three (H3) investigates whether the inventory holding cost component, β, is larger for stocks with an assigned market maker. Table 16 shows that, without bunching, the inventory cost component is larger for stocks with an assigned market maker. The mean coefficient estimate is approximately 7-8% for those stocks with an assigned market maker versus 6% for those stocks without an assigned market maker. The difference is significant at a level of 1% for both the parametric and non-parametric tests when using the NLLS estimates. When using the GMM estimates, the difference is significant at a level of 5% using both tests of difference.

These estimation results differ when the bunching procedure is used. Without bunching, the null of hypothesis three (H3) is rejected, suggesting that stocks with an assigned market maker are compensated for the requirement to maintain inventory. When bunching is used, the coefficient estimates increase to approximately 13-15%, however, there is no statistically significant difference between the coefficient estimates of stocks with and without an assigned market maker. This suggests that the difference apparent when bunching is not used may be due to the frequency of similar trades. The

splitting of orders could increase the positive serial correlation. The estimation technique may over-emphasize continuations instead of reversals, hence increasing the positive serial correlation.

4.4.1.3. Order Processing Cost Component

The order processing cost component can be calculated as the remainder from one after deducting the adverse selection cost component and the inventory holding cost component. Table 16 reports the order processing cost component estimates using the GMM and NLLS estimation methods calculated using all the observations with and without bunching. The table also reports the mean estimates on an overall basis and divided into groups based on if the stock is traded with or without an assigned market maker.

The order processing cost component of the bid-ask spread is calculated to be 94.71% of the bid-ask spread when the GMM procedure is used and 94.23% when the NLLS procedure is used. With bunching, this falls to 90.08% and 90.70%, respectively. In all cases, when the two groups of firms with and without an assigned market maker are compared, the stocks with an assigned market maker have order processing cost components that are smaller than those for the firms that do not have an assigned market maker. This is likely due to the increase in the inventory holding cost component that was noted in section 4.4.3. The difference between the group of firms with and without an assigned market maker is statistically significant for all parametric and non-parametric tests at a level of 1%.

For hypothesis four (H4) the null hypothesis is rejected. This finding of a smaller order processing component confirms earlier studies that found the order processing

component was smaller on NYSE as compared to Nasdaq. This finding, however, is not exchange specific and conclusions about the relative size are related to individual stocks and the market structure and not to differences particular to the exchanges.

4.4.2. Controlling For Differences in Volume

In this section, differences in volume are controlled by group stocks based on the total number of shares traded during the entire sample period.

4.4.2.1. Adverse Selection Cost Component Controlling For Volume

Hypothesis one (H1) is re-tested when controlling for differences in volume. Volume quintiles are determined by using all stocks with and without an assigned market maker and ranking stocks based on the total volume for each stock. Without using bunching, Table 32 reports coefficient estimates using the GMM method of estimation while Table 34 reports the estimates using the NLLS method of estimation. Using the bunching procedure, Table 33 reports coefficient estimates for the GMM method of estimation and Table 35 reports coefficient estimates for the NLLS method of estimation. The number of firms in each quintile differs between these tables because the NLLS estimation procedure requires a lower number of observations than the GMM estimation procedure.

The number of firms in each quintile shown in Table 32 differs between the groups of stocks with and without an assigned market maker, with the number of firms in the group of stocks with an assigned market maker being concentrated in the quintiles with lower volume. There are no stocks with an assigned market maker in the largest volume quintile. For the group of firms without an assigned market maker, the two largest volume quintiles have statistically significant adverse selection component

Table 32 This table reports estimates of bid-ask spread components across volume quintiles. This table uses a GMM estimation procedure to estimate the Huang and Stoll (1997) model, shown as equations (1) and (2), for each firm on the Paris Bourse during the September - December 1995 period. Results are shown on an overall basis, as well as for each group of stocks that trade with and without an assigned market maker. This table presents the results without using a bunching procedure in which successive transactions at identical prices are combined into one larger trade. Individual stocks are assigned into one of five groups based on the number of transactions that occur during the period. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are performed to test differences across volume quintiles and across groups of stocks with and without an assigned market maker. The non-parametric test is reported in parentheses.

		Overall			**without an assigned market maker**				**with an assigned market maker**				**tests of difference**		
number of obs.	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	α	β	Π
39-489	90	0.0013	0.0729***	0.1820***	27	-0.0071	0.0859***	0.1755***	63	0.0049	0.0674***	0.1848***	0.32	1.17	0.38
		(0.0912)	(0.0745)	(0.0659)		(0.0847)	(0.0740)	(0.0609)		(0.0942)	(0.0745)	(0.0658)	(0.92)	(0.36)	(0.38)
494-969	91	-0.0042	0.0620***	0.1830***	32	-0.0032	0.0506***	0.1811***	59	-0.0047	0.0682***	0.1816***	0.02	2.37	0.00
		(0.0550)	(0.0525)	(0.0577)		(0.0688)	(0.0653)	(0.0665)		(0.0465)	(0.0435)	(0.0537)	(0.51)	(2.90*)	(0.15)
975-2240	90	-0.0127**	0.0610***	0.1787***	65	-0.0076	0.0588***	0.1836***	25	-0.0259**	0.0668***	0.1658***	2.70	0.80	2.37
		(0.0478)	(0.0381)	(0.0498)		(0.0476)	(0.0413)	(0.0505)		(0.0464)	(0.0284)	(0.0455)	(1.56)	(1.56)	(2.33)
2268-5281	91	-0.0082***	0.0521***	0.1716***	87	-0.0092***	0.0526***	0.1736***	4	0.0144	0.0412**	0.1292**	3.01*	0.65	4.52**
		(0.0266)	(0.0277)	(0.0416)		(0.0265)	(0.0279)	(0.0387)		(0.0213)	(0.0232)	(0.0802)	(3.10*)	(0.41)	(1.63)
5304-104027	90	-0.0156***	0.0557***	0.1698***	90	-0.0156***	0.0557***	0.1698***	0						
		(0.0169)	(0.0212)	(0.0291)		(0.0169)	(0.0212)	(0.0291)							
Differences Across Volume Quintiles															
Parametric test		1.39	2.57**	1.13		0.64	3.89***	1.02		1.24	0.29	1.63			
Non-parametric test		(6.45)	(6.57)	(8.15*)		(6.87)	(4.46)	(5.78)		(3.70)	(1.70)	(4.93)			

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1%

Table 33 This table reports estimates of bid-ask spread components across volume quintiles. This table uses a GMM estimation procedure to estimate the Huang and Stoll (1997) model, shown as equations (1) and (2), for each firm on the Paris Bourse during the September - December 1995 period. Results are shown on an overall basis, as well as for each group of stocks that trade with and without an assigned market maker. This table presents the results using a bunching procedure in which successive transactions at identical prices are combined into one larger trade. Individual stocks are assigned into one of five groups based on the number of transactions that occur during the period. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are performed to test differences across volume quintiles and across groups of stocks with and without an assigned market maker. The non-parametric test is reported in parentheses.

	Overall				without an assigned market maker				with an assigned market maker				tests of difference		
number of obs.	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	α	β	Π
16-289	77	-0.0188	0.1453***	0.4125***	23	0.0213	0.0879	0.3558***	54	-0.0358	0.1698***	0.4367***	0.61	1.32	4.80**
		(0.2933)	(0.2866)	(0.1520)		(0.3373)	(0.3227)	(0.1649)		(0.2740)	(0.2694)	(0.1408)	(0.43)	(0.98)	(6.78***)
290-564	78	-0.0306	0.1316***	0.4352***	28	-0.0642	0.1435***	0.4347***	50	-0.0119	0.1249***	0.4355***	0.51	0.07	0.00
		(0.3092)	(0.3033)	(0.1090)		(0.2643)	(0.2652)	(0.1208)		(0.3328)	(0.3251)	(0.1031)	(0.36)	(0.00)	(0.64)
565-1266	77	-0.0901**	0.1849***	0.4584***	61	-0.0537	0.1476***	0.4623***	16	-0.2291**	0.3272***	0.4438***	3.36*	3.81*	0.64
		(0.3461)	(0.3338)	(0.0822)		(0.3521)	(0.3372)	(0.0877)		(0.2918)	(0.2866)	(0.0569)	(3.45*)	(3.64*)	(0.44)
1273-2644	78	-0.0459	0.1318***	0.4701***	76	-0.0514	0.1365***	0.4717***	2	0.1645	-0.0495	0.4124*	0.90	0.68	1.35
		(0.3175)	(0.3137)	(0.0714)		(0.3189)	(0.3157)	(0.0713)		(0.2021)	(0.1841)	(0.0604)	(1.76)	(1.68)	(1.22)
2651-39094	77	-0.0041	0.1008***	0.5349***	77	-0.0041	0.1008***	0.5349***	0						
		(0.2623)	(0.2593)	(0.1279)		(0.2623)	(0.2593)	(0.1279)							
Differences Across Volume Quintiles															
Parametric test		0.89	0.79	13.07***		0.56	0.35	13.92***		2.52*	2.27*	0.05			
Non-parametric test		(5.17)	(3.79)	(46.47***)		(3.89)	(2.29)	(42.05***)		(7.26*)	(6.74*)	(1.15)			

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1%

Table 34 This table reports estimates of bid-ask spread components across volume quintiles. This table uses a NLLS estimation procedure to estimate the Huang and Stoll (1997) model, shown as equations (1) and (2), for each firm on the Paris Bourse during the September - December 1995 period. Results are shown on an overall basis, as well as for each group of stocks that trade with and without an assigned market maker. This table presents the results without using a bunching procedure in which successive transactions at identical prices are combined into one larger trade. Individual stocks are assigned into one of five groups based on the number of transactions that occur during the period. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are performed to test differences across volume quintiles and across groups of stocks with and without an assigned market maker. The non-parametric test is reported in parentheses.

		Overall			**without an assigned market maker**				**with an assigned market maker**				**tests of difference**		
number of obs.	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	α	β	Π
39-489	91	-0.0103	0.0912***	0.2855***	27	-0.0002	0.0963***	0.2843***	64	-0.0146	0.0890***	0.2860***	0.16	0.06	0.01
		(0.1548)	(0.1299)	(0.0622)		(0.1153)	(0.0921)	(0.0518)		(0.1693)	(0.1434)	(0.0665)	(0.70)	(0.21)	(0.38)
494-969	91	-0.0014	0.0735***	0.2741***	32	-0.0078	0.0707***	0.2726***	59	0.0021	0.0750***	0.2749***	0.26	0.05	0.03
		(0.0884)	(0.0856)	(0.0602)		(0.1100)	(0.1076)	(0.0671)		(0.0750)	(0.0720)	(0.0567)	(0.01)	(0.64*)	(0.35)
975-2240	90	-0.0192***	0.0715***	0.2684***	65	-0.0161*	0.0690***	0.2734***	25	-0.0272***	0.0779***	0.2555***	0.56	0.34	3.35*
		(0.0629)	(0.0650)	(0.0420)		(0.0678)	(0.0655)	(0.0388)		(0.0480)	(0.0647)	(0.0477)	(0.50)	(1.05)	(2.70)
2268-5281	91	-0.0101**	0.0520***	0.2550***	87	-0.0109**	0.0520***	0.2571***	4	0.0064	0.0523*	0.2091**	0.76	0.00	5.33**
		(0.0387)	(0.0337)	(0.0416)		(0.0388)	(0.0338)	(0.0370)		(0.0344)	(0.0359)	(0.0984)	(1.09)	(0.02)	(0.57)
5304-104027	90	-0.0169***	0.0519***	0.2444***	90	-0.0169***	0.0519***	0.2444***	0						
		(0.0206)	(0.0241)	(0.0244)		(0.0206)	(0.0241)	(0.0244)							
Differences Across Volume Quintiles															
Parametric test		1.39	2.57**	1.13		0.48	4.07***	8.55***		0.42	0.28	3.12**			
Non-parametric test		(6.45)	(6.57)	(8.15*)		(2.25)	(8.75*)	(50.28***)		(2.93)	(0.97)	(11.96***)			

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1%

Table 35 This table reports estimates of bid-ask spread components across volume quintiles. This table uses a NLLS estimation procedure to estimate the Huang and Stoll (1997) model, shown as equations (1) and (2), for each firm on the Paris Bourse during the September - December 1995 period. Results are shown on an overall basis, as well as for each group of stocks that trade with and without an assigned market maker. This table presents the results using a bunching procedure in which successive transactions at identical prices are combined into one larger trade. Individual stocks are assigned into one of five groups based on the number of transactions that occur during the period. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are performed to test differences across volume quintiles and across groups of stocks with and without an assigned market maker. The non-parametric test is reported in parentheses.

	Overall				**without an assigned market maker**				**with an assigned market maker**				**tests of difference**		
number of obs.	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	α	β	Π
16-289	72	-0.0309	0.1497***	0.4366***	22	0.0362	0.0917**	0.4033***	50	-0.0604	0.1752***	0.4512***	1.03	0.80	5.07**
		(0.3728)	(0.3640)	(0.0855)		(0.2222)	(0.1996)	(0.0971)		(0.4211)	(0.4156)	(0.0764)	(0.77)	(0.61)	(7.43***)
290-564	78	-0.0111	0.1226***	0.4547***	26	-0.0614	0.1503**	0.4517***	52	0.0141	0.1088*	0.4563***	0.61	0.19	0.08
		(0.4023)	(0.3965)	(0.0683)		(0.3015)	(0.3241)	(0.0818)		(0.4448)	(0.4304)	(0.0613)	(0.08)	(0.01)	(2.39)
565-1266	76	-0.1447***	0.2275***	0.4647***	58	-0.1199**	0.2016***	0.4665***	18	-0.2246**	0.3110***	0.4589***	0.98	1.13	0.31
		(0.3914)	(0.3826)	(0.0504)		(0.3937)	(0.3796)	(0.0551)		(0.3835)	(0.3909)	(0.0315)	(0.45)	(0.71)	(0.04)
1273-2644	74	-0.0494	0.1237***	0.4686***	72	-0.0577	0.1309***	0.4694***	2	0.2518	-0.1383	0.4368**	1.65	1.27	0.95
		(0.3376)	(0.3344)	(0.0468)		(0.3373)	(0.3351)	(0.0469)		(0.2431)	(0.2204)	(0.0405)	(2.25)	(1.96)	(0.87)
2651-39094	80	-0.0848**	0.1616***	0.5096***	80	-0.0848**	0.1616***	0.5096***	0						
		(0.3112)	(0.3121)	(0.0905)		(0.3112)	(0.3121)	(0.0905)							
Differences Across Volume Quintiles															
Parametric test		0.89	0.79	13.07***		0.96	0.60	10.80***		1.75	1.41	0.13			
Non-parametric test		(5.17)	(3.79)	(46.47***)		(4.11)	(2.13)	(37.92***)		(4.42)	(4.10)	(1.84)			

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1%

estimates. For the group of firms with an assigned market maker, only the middle quintile has a statistically significant estimate. The parametric and non-parametric tests of difference indicate that there is no statistical difference between the two groups for the three lower volume quintiles. The second largest volume quintile has 87 firms in the group without an assigned market maker and has an adverse selection component coefficient estimate that is -0.0092 and is statistically significant at a level of 1%. The group with an assigned market maker contains four firms and has an adverse selection component mean estimate that is slightly positive but not significantly different than zero. The parametric ANOVA test comparing the two means has a test statistic of 3.01 that is significant at a level of 10%. The parametric Wilcoxon rank scores test has a test statistic of 3.10 that is also significant at a level of 10%. The importance of this significance is somewhat lessened by the small number of firms in the group of stocks with an assigned market maker.

Table 34 uses a NLLS method of estimation for the bid-ask spread components. In each volume quintile there is no statistically significant difference in the estimates of the adverse selection component for those stocks with and without an assigned market maker, confirming Table 32. There is also no statistically significant differences across the volume quintiles and on an overall basis nor within the group of stocks with and without an assigned market maker. The pattern of statistical significance of the individual quintile estimates in Table 34 mirrors Table 32. For those stocks with an assigned market maker, only those stocks in the middle volume quintile have an adverse selection component estimate that is significantly significant. On an overall basis and for those stocks without an assigned market maker, only the larger volume quintiles have statistically significant adverse selection component estimates.

Tables 32 and 34 show that the adverse selection component estimates are not significantly different from each other when the group of stocks with and without an assigned market maker are compared. The adverse selection component coefficient estimates that are significant indicate the estimate is negative, which is economically not meaningful. This finding of negative adverse selection component coefficients is also made by Huang and Stoll (1997). They also perform their estimation procedures using a bunching procedure where successive transactions at identical prices are combined into one larger trade. They do this in order to correct for the splitting up of large trades that could affect the estimation procedures. By bunching identical transactions the estimates of the adverse selection component by Huang and Stoll go from 19 of 20 stocks with negative coefficients to only 2 of 20 with negative coefficients. Using the Paris Bourse data, the bunching procedure is performed and the GMM estimates are reported in Table 17B and the NLLS estimates are reported in Table 17D. Using the bunching procedure, the percentage of individual stocks with positive estimates increases from 152/452 (168/453) to 171/387 (168/380) for the GMM (NLLS) estimates. The bunching procedure reduces the number of observations by decreasing the number of stocks for which estimates are obtainable.

Using the bunching procedure and examining the individual groups with and without an assigned market maker, the coefficient estimates for the adverse selection component, α, have only one volume quintile with a coefficient that is statistically significant for the GMM estimation (Table 33) and three volume quintiles with coefficients that are statistically significant for the NLLS estimation (Table 35). The

GMM estimates have one quintile that has a statistically significant difference between the group of stocks with and without an assigned market maker. In the middle quintile, the parametric and non-parametric tests both indicate that the difference between the two groups is significant at a level of 10%. For the NLLS estimates in Table 35 there is no statistically significant differences between the group of stocks with and without an assigned market maker in any of the volume quintiles. Even with the bunching procedure, the coefficient estimates fail to reject the null of hypothesis one (H1) that the coefficient estimates for the adverse selection component are the same for those stocks with and without an assigned market maker.

4.4.2.2. Inventory Holding Cost Component Controlling For Volume

One way to explain the conflicting results when comparing estimation with and without bunching is to control for volume differences since different volume stocks may have different amounts of bunching. For example, small volume stocks may have more splitting of orders due to a smaller depth at the inside quotes. Tables 32-35 show the tests of difference between the group of stocks with and without an assigned market maker. No observations are in the largest volume quintile for those stocks with an assigned market maker. For the other four quintiles, there is very limited statistical significance. Only in the middle quintile in Table 33, using the GMM estimation procedure with bunching, is there statistically significant differences in both parametric and non-parametric tests of difference. And the level of significance in that quintile is at a level of 10%. This suggests that the difference between the group of stocks with and without an assigned market maker shown in Table 31 and discussed in section 4.3.1. may be due to differences that are reduced when the volume is controlled. Based on this finding,

hypothesis three (H3) fails to be rejected and no difference is found in the inventory holding cost component between stocks with and without an assigned market maker.

4.4.3. Adverse Selection Across Volume Levels

The literature suggests that larger trades may convey more information and those larger trades may have a higher adverse selection component. The effect of the overall volume on the adverse selection component is not as clear. Larger volume stocks may provide a greater incentive for informed traders to invest in the stock and consequently there may be a larger adverse selection component for these firms. Alternatively, for low volume stocks the likelihood of a trade containing information may be higher since low volume stocks may exclude some traders. Hypothesis two (H2) tests whether the adverse selection component is the same across volume quintiles.

Table 32 provides the GMM estimates across volume quintiles. Parametric and non-parametric tests on the mean coefficient estimates of the adverse selection component indicate that there is no difference across the volume quintiles on an overall basis, nor within either the group of firms with or without an assigned market maker. This finding is shared by the NLLS estimates in Table 34.

Tables 33 and 35 use the bunching procedure where successive transactions at identical prices are combined into one larger trade. Table 33 reports that for those stocks with an assigned market maker, the GMM coefficient estimates for the adverse selection component differ across the volume quintiles. This is confirmed both parametrically and non-parametrically at levels of significance of 10%. The pattern, however, does not support rejecting the null of hypothesis two (H2) since only one of the quintiles has a mean that is statistically significant. The NLLS estimates in Table 35 have no significant

differences across the volume quintiles, both parametrically and non-parametrically. Based on these results, the null of hypothesis two (H2) is not rejected.

4.4.4. Inventory Accumulation Quintiles

In this section, the effect of inventory accumulation is examined on the components of the bid-ask spread. Madhavan and Sofianos (1998) suggest specialists are more likely to buy when their inventory is low and sell when their inventory is high. In this section, the examination encompasses a long term approach. First, the direction of trade is classified using the Lee and Ready (1991) procedure and then the inventory changes are accumulated for the months of September and October 1995. The inventory changes are then ranked and placed into five groups and estimates for the components of the bid-ask spread are made using the months of November and December 1995. The ranking of the inventory change groups is done in two ways: First, the ranking is done on an overall basis and these results are reported for the GMM estimates in Table 36 and the NLLS estimates in Table 38. Second, the ranking is done within the group of firms with or without an assigned market maker. These results are reported in Table 37 for the GMM estimates and in Table 39 for the NLLS estimates. This is a measure of the long-term effect of inventory changes.

The effect of inventory changes on the inventory holding cost component, β, is reported in Tables 36-39. There is no statistically significant differences across inventory accumulation quintiles for the group of stocks with an assigned market maker. This indicates that the null of hypothesis five (H5) that the inventory holding cost component is the same for the inventory accumulation quintiles is not rejected.

In Tables 36-39, there are some statistically significant differences in the

Table 36 This table reports estimates of bid-ask spread components across inventory change quintiles. This table uses a GMM estimation procedure to estimate the Huang and Stoll (1997) model, shown as equations (1) and (2), for each firm on the Paris Bourse during the November - December 1995 period. Results are shown on an overall basis, as well as for each group of stocks that trade with and without an assigned market maker. This table presents the results without using a bunching procedure in which successive transactions at identical prices are combined into one larger trade. Individual stocks are assigned into one of five groups based accumulated inventory change during the September - October 1995 period. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are performed to test differences across inventory change quintiles and across groups of stocks with and without an assigned market maker. The non-parametric test is reported in parentheses.

	Overall				**without an assigned market maker**				**with an assigned market maker**				**tests of difference**		
inv. change group (average change)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	α	β	Π
0 (smallest)	84	-0.0154***	0.0514***	0.1747***	68	-0.0126***	0.0510**	0.1753***	16	-0.0273	0.0533***	0.1722***	1.38	0.06	0.10
	-168,711	(0.0453)	(0.0351)	(0.0351)	-198,630	(0.0283)	(0.0294)	(0.0343)	-41,554	(0.0871)	(0.0544)	(0.0396)	(0.10)	(0.52)	(0.24)
1	84	0.0084	0.0642***	0.1743***	37	0.0134	0.0535***	0.1724***	47	0.0045	0.0727***	0.1759***	0.39	1.69	0.06
	-5,664	(0.0648)	(0.0676)	(0.0632)	-5,478	(0.0624)	(0.0571)	(0.0600)	-5,810	(0.0670)	(0.0743)	(0.0662)	(0.01)	(1.51)	(0.16)
2	84	-0.0068	0.0597***	0.1744***	45	-0.0016	0.0515***	0.1781***	39	-0.0130	0.0692***	0.1702***	0.24	0.83	0.27
	446	(0.1050)	(0.0885)	(0.0695)	381	(0.0697)	(0.0638)	(0.0625)	520	(0.1356)	(0.1105)	(0.0773)	(0.12)	(0.64)	(0.10)
3	84	-0.0118	0.0557***	0.1779***	61	-0.0102	0.0567***	0.1750***	23	-0.0161	0.0528***	0.1855***	0.13	0.07	0.52
	12,748	(0.0679)	(0.0601)	(0.0593)	14,271	(0.0608)	(0.0537)	(0.0529)	8,707	(0.0855)	(0.0758)	(0.0743)	(0.49)	(0.10)	(0.50)
4 (largest)	84	-0.0125***	0.0547***	0.1652***	82	-0.0126***	0.0546***	0.1651***	2	-0.0113	0.0617	0.1718**	0.00	0.16	0.07
	501,407	(0.0319)	(0.0246)	(0.0362)	510,358	(0.0323)	(0.0247)	(0.0366)	134,439	(0.0036)	(0.0226)	(0.0084)	(0.15)	(0.25)	(0.01)
Differences Across Inventory Change Quintiles															
Parametric test		1.65	0.57	0.64		2.22*	0.17	0.75		0.41	0.31	0.19			
Non-parametric test		(14.85***)	(1.68)	(3.29)		(9.54**)	(2.70)	(3.09)		(4.32)	(1.36)	(0.57)			

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1%

Table 37 This table reports estimates of bid-ask spread components across inventory change quintiles. This table uses a GMM estimation procedure to estimate the Huang and Stoll (1997) model, shown as equations (1) and (2), for each firm on the Paris Bourse during the November - December 1995 period. Results are shown on an overall basis, as well as for each group of stocks that trade with and without an assigned market maker. This table presents the results using a bunching procedure in which successive transactions at identical prices are combined into one larger trade. Individual stocks are assigned into one of five groups based accumulated inventory change during the September - October 1995 period. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are performed to test differences across inventory change quintiles and across groups of stocks with and without an assigned market maker. The non-parametric test is reported in parentheses.

	Overall				**without an assigned market maker**				**with an assigned market maker**				**tests of difference**		
inv. change group (average change)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	α	β	Π
0 (smallest)	83	-0.0183***	0.0545***	0.1756***	58	-0.0137***	0.0508***	0.1752***	25	-0.0289*	0.0631***	0.1768***	1.61	1.41	0.03
	-170,080	(0.0502)	(0.0436)	(0.0415)	-230,180	(0.0274)	(0.0279)	(0.0338)	-30,648	(0.0816)	(0.0674)	(0.0563)	(0.37)	(0.83)	(0.60)
1	84	0.0086	0.0597***	0.1701***	59	0.0064	0.0502***	0.1686***	25	0.0138	0.0822***	0.1737***	0.25	5.33**	0.12
	-6,067	(0.0610)	(0.0597)	(0.0617)	-6,224	(0.0611)	(0.0515)	(0.0573)	-5,697	(0.0615)	(0.0719)	(0.0722)	(1.76)	(4.87**)	(0.03)
2	85	-0.0023	0.0590***	0.1853***	59	-0.0030	0.0567***	0.1908***	26	-0.0005	0.0644***	0.1729***	0.02	0.17	1.62
	1,570	(0.1891)	(0.0788)	(0.0600)	2,871	(0.0749)	(0.0693)	(0.0597)	-1,382	(0.1169)	(0.0983)	(0.0601)	(0.18)	(0.02)	(0.67)
3	85	-0.0107	0.0578***	0.1669***	59	-0.0097*	0.0551***	0.1659***	26	-0.0132	0.0638***	0.1693***	0.04	0.31	0.07
	27,315	(0.0773)	(0.0656)	(0.0540)	38,896	(0.0383)	(0.0358)	(0.0379)	1,035	(0.1291)	(0.1069)	(0.0803)	(0.13)	(0.01)	(0.15)
4 (largest)	83	-0.0158***	0.0546***	0.1686***	58	-0.0158***	0.0551***	0.1618***	25	-0.0157	0.0535***	0.1844***	0.00	0.02	3.47*
	490,965	(0.0503)	(0.0431)	(0.0516)	694,499	(0.0286)	(0.0209)	(0.0392)	18,,766	(0.0819)	(0.0728)	(0.0713)	(0.01)	(0.07)	(1.96)
Differences Across Inventory Change Quintiles															
Parametric test		2.21*	0.14	1.60		1.91	0.25	3.45***		0.69	0.37	0.17			
Non-parametric test		(19.49***)	(0.34)	(5.71)		(12.31**)	(2.34)	(7.89*)		(6.33)	(2.72)	(0.39)			

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1%

Table 38 This table reports estimates of bid-ask spread components across inventory change quintiles. This table uses a NLLS estimation procedure to estimate the Huang and Stoll (1997) model, shown as equations (1) and (2), for each firm on the Paris Bourse during the November - December 1995 period. Results are shown on an overall basis, as well as for each group of stocks that trade with and without an assigned market maker. This table presents the results without using a bunching procedure in which successive transactions at identical prices are combined into one larger trade. Individual stocks are assigned into one of five groups based accumulated inventory change during the September - October 1995 period. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are performed to test differences across inventory change quintiles and across groups of stocks with and without an assigned market maker. The non-parametric test is reported in parentheses.

		Overall			without an assigned market maker				with an assigned market maker				tests of difference		
inv. change group	number of firms avg. $ change.	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms	α (s.d.)	β (s.d.)	Π (s.d.)	α	β	Π
0 (smallest)	84	-0.0185**	0.0617***	0.2694***	68	-0.0150***	0.0545***	0.2674***	16	-0.0335	0.0922**	0.2779***	0.94	2.54	1.45
	-168,711	(0.0687)	(0.0860)	(0.0315)	-198,630	(0.0453)	(0.0488)	(0.0293)	-41,554	(0.1290)	(0.1704)	(0.0396)	(3.08*)	(4.39**)	(0.42)
1	84	0.0043	0.0794***	0.2736***	37	0.0172	0.0619***	0.2680***	47	-0.0059	0.0932***	0.2780***	0.88	1.70	0.57
	-5,664	(0.1121)	(0.1100)	(0.0598)	-5,478	(0.1120)	(0.1073)	(0.0496)	-5,810	(0.1123)	(0.1112)	(0.0670)	(0.35)	(2.44)	(1.86)
2	84	-0.0119	0.0738***	0.2755***	45	-0.0103	0.0617***	0.2787***	39	-0.0137	0.0877***	0.2718***	0.01	0.70	0.25
	446	(0.1622)	(0.1421)	(0.0626)	381	(0.1070)	(0.1026)	(0.0505)	520	(0.2102)	(0.1776)	(0.0748)	(0.00)	(1.00)	(0.01)
3	84	-0.0158	0.0652***	0.2743***	61	-0.0133	0.0609***	0.2700***	23	-0.0225	0.0766***	0.2858***	0.12	0.44	1.49
	12,748	(0.1053)	(0.0969)	(0.0528)	14,271	(0.0965)	(0.0946)	(0.0456)	8,707	(0.1279)	(0.1039)	(0.0684)	(0.28)	(1.46)	(2.40)
4 (largest)	84	-0.0105**	0.0497***	0.2498***	82	-0.0102*	0.0494***	0.2493***	2	-0.0211	0.0619	0.2697**	0.10	0.27	0.77
	501,407	(0.0481)	(0.0333)	(0.0325)	510,358	(0.0486)	(0.0334)	(0.0327)	134,439	(0.0207)	(0.0328)	(0.0123)	(0.15)	(0.42)	(1.31)
Differences Across Inventory Change Quintiles															
Parametric test		0.58	1.10	3.92***		1.14	0.34	4.75***		0.12	0.07	0.17			
Non-parametric test		(6.36)	(1.41)	(25.77***)		(5.98)	(1.55)	(18.87***)		(2.33)	(0.10)	(1.08)			

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1%

Table 39 This table reports estimates of bid-ask spread components across inventory change quintiles. This table uses a NLLS estimation procedure to estimate the Huang and Stoll (1997) model, shown as equations (1) and (2), for each firm on the Paris Bourse during the November - December 1995 period. Results are shown on an overall basis, as well as for each group of stocks that trade with and without an assigned market maker. This table presents the results using a bunching procedure in which successive transactions at identical prices are combined into one larger trade. Individual stocks are assigned into one of five groups based accumulated inventory change during the September - October 1995 period. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are performed to test differences across inventory change quintiles and across groups of stocks with and without an assigned market maker. The non-parametric test is reported in parentheses.

	Overall				**without an assigned market maker**				**with an assigned market maker**				**tests of difference**		
inv. change group	number of firms avg. $ change.	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms avg. $ change.	α (s.d.)	β (s.d.)	Π (s.d.)	number of firms avg. $ change.	α (s.d.)	β (s.d.)	Π (s.d.)	α	β	Π
0 (smallest)	83	-0.0240***	0.0671***	0.2703***	58	-0.0161***	0.0543***	0.2669***	25	-0.0425*	0.0967***	0.2781***	2.14	3.75*	1.26
	-170,080	(0.0761)	(0.0929)	(0.0417)	-230,180	(0.0416)	(0.0448)	(0.0286)	-30,648	(0.1232)	(0.1530)	(0.0625)	(3.71*)	(4.34**)	(3.37*)
1	84	0.0035	0.0731***	0.2689***	59	0.0064	0.0583***	0.2651***	25	-0.0030	0.1080***	0.2779***	0.14	4.64**	0.95
	-6,067	(0.1052)	(0.0987)	(0.0548)	-6,224	(0.1041)	(0.0920)	(0.0473)	-5,697	(0.1095)	(0.1071)	(0.0699)	(0.00)	(3.62*)	(1.46)
2	85	-0.0073	0.0710***	0.2847***	59	-0.0118	0.0661***	0.2881***	26	-0.0029	0.0820**	0.2771***	0.19	0.25	0.83
	1,570	(0.1445)	(0.1360)	(0.0513)	2,871	(0.1205)	(0.1213)	(0.0476)	-1,382	(0.1905)	(0.1669)	(0.0593)	(0.64)	(0.07)	(0.05)
3	85	-0.0094	0.0601***	0.2612***	59	-0.0087	0.0522***	0.2575***	26	-0.0109	0.0781**	0.2697***	0.01	1.24	1.09
	27,315	(0.1139)	(0.0990)	(0.0497)	38,896	(0.0530)	(0.0519)	(0.0325)	1,035	(0.1926)	(0.1620)	(0.0758)	(0.00)	(0.87)	(2.79*)
4 (largest)	83	-0.0155*	0.0584***	0.2573***	58	-0.0126**	0.0510***	0.2456***	25	-0.0223	0.0755***	0.2845***	0.28	2.94*	11.97***
	490,965	(0.0767)	(0.0603)	(0.0500)	694,499	(0.0460)	(0.0293)	(0.0362)	18,766	(0.1226)	(0.0997)	(0.0657)	(0.23)	(2.52)	(13.20***)
Differences Across Inventory Change Quintiles															
Parametric test		0.77	0.35	3.79***		0.70	0.38	9.21***		0.35	0.24	0.16			
Non-parametric test		(9.43*)	(0.80)	(17.50***)		(8.10*)	(1.96)	(27.47***)		(3.75)	(0.69)	(0.33)			

*significant at a level of α = 10% **significant at a level of α = 5% ***significant at a level of α = 1

inventory holding cost component estimates between those firms with and those without an assigned market maker within individual inventory accumulation quintiles. When comparing across groups with and without assigned market makers, Tables 36 and 38 use all the observations in determining the ranking of individual stocks into quintiles. As reported in Table 38, when the NLLS estimation procedure is used, the inventory holding cost component differs statistically between the two groups of stocks with and without an assigned market maker only in the smallest quintile with the most negative change in inventory accumulation. For this category, the inventory holding cost component is almost twice as large for those stocks with an assigned market maker and this difference is statistically significant at a level of 5% using a non-parametric Wilcoxon rank scores test. This significance does not show up in any other quintile using the NLLS estimation method nor in any quintile using the GMM estimation method.

In Tables 37 and 39 the quintiles were formed within each group of stocks with and without an assigned market maker. As shown in Table 37, when using the GMM estimation procedure, a significantly larger inventory cost component estimate is found for firms with an assigned market maker in the second most negative inventory change quintile. The significance of the difference is at a level of 5% for the parametric and non-parametric tests. As shown in Table 39, when NLLS estimates are used there are statistically significant estimates found in the two extreme change quintiles as well as the second most negative inventory change quintile. The two most negative inventory change quintiles have parametric and non-parametric tests that are statistically significant at levels of 1% and 5% in each quintile. The most negative inventory accumulation

quintile has the parametric test of difference significant at a level of 1% while the non-parametric test is significant at a level of 5%. The opposite levels of significance are found in the second most negative inventory change quintile. The most positive inventory change quintile has a significance that is only at a level of 10% for the parametric test.

In all three of these quintiles the coefficient estimate for the inventory holding cost is larger for the stocks with an assigned market maker. This indicates that there is a higher cost for firms with an assigned market maker that is especially noticeable when there are large changes in inventory, particularly when inventory is depleted. This difference again rejects hypothesis three (H3) but it adds some information, indicating that the inventory changes (particularly depletion) may impact on stocks with an assigned market maker since the market maker is required to maintain a presence in the market at all times.

From these tables it is also interesting to note that the adverse selection component coefficient estimates are statistically significantly different than zero only for those stocks without an assigned market maker and only at the extreme quintiles. This is intuitively appealing since it is in these quintiles where the value of information may be more important since the inventory levels are changing. Unfortunately it is in these quintiles with the significant adverse selection component coefficients where the coefficient is negative and not economically meaningful.

4.4.5. Summary

The GMM method of estimation is shown to be more appropriate than the NLLS method of estimation since the residuals exhibit serial correlation and heteroskedasticity. The GMM estimation procedure has the effect of correcting for heteroskedasticity that

may be caused by discrete price data. The market structure hypotheses are tested by comparing the coefficient estimates of the bid-ask spread components across the two market structures. The resulting coefficient estimates indicate that the adverse selection component does not differ between the group of stocks that trade with and without an assigned market maker either on an overall basis or when controlling for differences in volume. No differences across coefficient estimates for the adverse selection component are found across the volume levels, indicating that even when controlling for market structure, volume as a whole does not impact on the adverse selection component. The lack of cross-sectional difference on the effect of the total volume of a stock indicates that large or small volume stocks do not give a predisposition to higher adverse selection costs. This suggests that earlier literature on cross-sectional differences may be measuring trade-specific adverse selection.

The inventory holding cost component has contradictory results that are dependent on the use of the bunching procedure where successive transactions at identical prices are condensed into one larger trade. When bunching is not used then the group of stocks with an assigned market maker has a larger inventory holding cost component, suggesting that the assigned market maker is compensated for holding inventory. With bunching, however, the overall estimate of the inventory holding cost component increases, but for these estimates there is no statistically significant difference between the group of stocks with and without an assigned market maker. This can be explained by controlling for volume. When volume is controlled and the bunching is not performed, no statistical difference is found between the group of stocks with and without an assigned market maker. There is some limited statistical difference between the two

groups in the middle volume quintile when the bunching procedure is used. Although intuitively pleasing, there is only limited evidence that the inventory holding cost component is larger for those stocks with an assigned market maker.

The order processing cost component is found to be smaller for those stocks that have an assigned market maker. This overall finding is consistent with extant literature that finds that the order processing cost component is smaller on NYSE compared to NASDAQ. The finding in this chapter suggests that the differences are not due to exchange costs. The results suggest that the differences may be a result of the different market structures. Another possibility is that the results are a result of the stocks that trade in those two structures.

Inventory accumulation is calculated over a two-month period and there are some statistically significant differences in the inventory holding cost component in the subsequent two months across quintiles formed from the initial two-month inventory accumulation. When all stocks are used in the inventory accumulation rankings, a difference is found in the most negative inventory accumulation quintile where the inventory holding cost component is almost twice as large for the group of stocks with an assigned market maker. When the ranking is done within each group of stocks with or without an assigned market maker, then the inventory cost component coefficient is larger for those firms with an assigned market maker and there are statistically significant differences in the extreme quintiles. This indicates that inventory changes (especially depletion) may impact on stocks with an assigned market maker to a greater extent than the other stocks. This may be because the assigned market maker is required to stay in the market.

4.5. Execution Cost Results

Four measures of (one-way) trade execution costs are estimated and reported in Table 40. These include quoted bid-ask half-spread, effective bid-ask half-spread (which accounts for execution inside the quotes), the price impact (which measures trades' average information content) and realized bid-ask half-spread (which measures average price reversals after trades and market-making revenue net of information costs). These measures are explained fully in section 4.3.2. These estimates are shown on an overall basis as well as in each group of stocks with and without an assigned market maker. Since the hypothesis that trading costs equal zero is of little practical interest, standard errors or t-statistics for the individual estimates are not reported. As explained in section 4.3.2., a two-stage estimation procedure is used to calculate the execution costs. First, daily mean execution costs are calculated for each stock. Comparisons on an overall basis and between groups of stocks with and without an assigned market maker use these daily means in a parametric ANOVA test and a non-parametric Wilcoxon rank scores test. A bunching procedure, where successive transactions at identical prices are combined into one larger trade, is also used and estimates and tests of differences are also provided after performing this procedure. Following the overall analysis, each individual trade execution measure is analyzed across price groups. The price groups are determined by using the first transaction price in the trading period and then ranking the stocks into five groups.

4.5.1. Quoted Half-Spread

The quoted half-spread is a measure of one-half of the round-trip execution costs if trades are executed at the quotes. As shown in Table 40, using all observations, the

Table 40 This table reports estimates of trade execution costs. This table estimates the Bessembinder and Kaufman (1997) trade execution costs, shown in equations (3), (4), (5), and (6), for each firm on the Paris Bourse during the September - December 1995 period. The mean results are presented both on an overall basis and for stocks with and without an assigned market maker. A bunching procedure in which successive transactions at identical prices are combined into one larger trade is used in Panel B but is not used in Panel A. A parametric ANOVA test and Wilcoxon rank scores test is used to test the difference in means between the groups of stocks with and without an assigned market maker.

	Overall	without an assigned MM	with an assigned MM	ANOVA	Wilcoxon
PANEL A — All Observations					
Quoted Half-Spread	0.7558	0.5775	1.2342	6248.3***	5665.4***
Effective Half-Spread	0.3731	0.1629	0.5138	1649.5***	2011.1***
Price Impact	0.0962	0.0759	0.1878	60.1***	35.4***
Realized Half-Spread	0.2769	0.0870	0.3260	416.8***	343.9***
PANEL B — Observations with deletions due to Bunching					
Quoted Half-Spread	0.7637	0.3008	1.0789	6207.1***	5662.0***
Effective Half-Spread	0.3605	0.1619	0.4946	1640.2***	2004.0***
Price Impact	0.0597	0.0582	0.1144	17.4***	0.1
Realized Half-Spread	0.3009	0.1037	0.3802	487.1***	412.8***

*significant at a level of α = 10%
**significant at a level of α = 5%
***significant at a level of α = 1%

mean quoted half-spread is 0.7558%. When the group of stocks with and without an assigned market maker are compared, the quoted half-spread of the stocks with an assigned market maker is approximately twice as large (1.2342% versus 0.5775%). Parametric and non-parametric tests of difference are significant at a level of 1%. When the bunching procedure is performed, the mean quoted half-spread increases slightly to 0.7637% and the difference between stocks with and without an assigned market maker remains at a multiple slightly greater than two (1.2456% versus 0.5868%, respectively).

Since the two groups of stocks have different characteristics, the effect of the stock's price level is analyzed in Table 41. On an overall basis, the quoted half-spread declines as the price of the stock increases. This occurs for all stocks, as well as in the group of stocks without an assigned market maker. The group of stocks with an assigned market maker has a monotonically decreasing quoted half-spread except for the largest price group. This pattern is present with and without bunching. In all price groups, the quoted half-spread is approximately two and one-half times larger for the stocks with an assigned market maker versus those without an assigned market maker. Using parametric and non-parametric tests, the difference between the means is statistically significant at a level of 1% in all the price groups. For hypothesis six (H6), the null is rejected for the quoted half-spread trade execution cost measure. On an overall basis, and in each price group, the quoted half-spread is larger for those stocks with an assigned market maker by a multiple of approximately two and one-half.

4.5.2. Effective Half-Spread

The effective half-spread measure may be expected to be less than the quoted half-spread since trades can occur inside the quoted bid and ask prices and the measure

Table 41 This table reports estimates of trade execution costs for quoted half-spreads across price groups. This table estimates the quoted half-spread, shown in equation (3), for each firm on the Paris Bourse during the September - December 1995 period. The mean results are presented both on an overall basis and for stocks with and without an assigned market maker. Each stock is assigned into one of five price groups based on the price of the stock at the beginning of the period. A bunching procedure in which successive transactions at identical prices are combined into one larger trade is used in Panel B but is not used in Panel A. A parametric ANOVA test and Wilcoxon rank scores test is used to test the difference in means between the groups of stocks with and without an assigned market maker.

	average price	Overall	without an assigned MM	with an assigned MM	ANOVA	Wilcoxon
PANEL A	All Observations					
Group 0 – smallest price	61.15	1.0003	0.7390	1.7144	1896.6***	1362.0***
Group 1	183.85	0.8350	0.6047	1.3647	1579.2***	1565.5***
Group 2	311.70	0.7964	0.6173	1.1592	941.6***	967.1***
Group 3	466.39	0.6382	0.5560	0.8762	456.0***	634.6***
Group 4 - largest price	1384.85	0.5263	0.4030	1.0162	1848.6***	1301.6***
PANEL B	Observations with deletions due to Bunching					
Group 0 - smallest price	61.07	1.0076	0.7483	1.7260	1887.6***	1357.6***
Group 1	184.77	0.8486	0.6262	1.3781	1492.7***	1504.3***
Group 2	312.56	0.7942	0.6048	1.1740	1045.2***	1055.5***
Group 3	466.57	0.6523	0.5738	0.8836	419.4***	588.5***
Group 4 - largest price	1385.10	0.5330	0.4109	1.0239	1821.5***	1285.8***

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

itself is a function of the post-trade price. As shown on an overall basis in Table 40, the effective half-spread is similar with and without bunching. Without bunching, the effective half-spread is 0.3731%, while with bunching, the effective half-spread is 0.3605%. When the stocks are split into those with and without an assigned market maker, the stocks without an assigned market maker have an effective half-spread that is approximately 0.29% with or without bunching. The stocks with an assigned market maker have an effective half-spread that is twice as large at approximately 0.58% as the effective spread of the stocks without an assigned market maker. This difference is statistically significant at a level of 1% using parametric and non-parametric tests of difference.

The stocks are also divided into price quintiles based on the price of the first transaction in the trading period. These estimates are reported in Table 42. Using all observations without bunching, the effective half-spread measure is monotonically decreasing from 0.4809% to 0.2629%. This pattern is also present when the bunching procedure is performed.

Table 42 also shows that the group of stocks with an assigned market maker has an effective half-spread that is consistently more than twice as large as the effective half-spread for the group of stocks without an assigned market maker. The pattern across the price quintiles differs slightly between the groups of stocks with and without an assigned market maker. For those stocks with an assigned market maker, there is a monotonic decline in the effective half-spread, for all the price quintiles except for the largest price quintile. This pattern is the same irrespective of the use of the bunching procedure. For the group of firms without an assigned market maker, there is a monotonic decline in all

Table 42 This table reports estimates of trade execution costs for the effective half-spreads across price groups. This table estimates the effective half-spread, shown in equation (4), for each firm on the Paris Bourse during the September - December 1995 period. The mean results are presented both on an overall basis and for stocks with and without an assigned market maker. Each stock is assigned into one of five price groups based on the price of the stock at the beginning of the period. A bunching procedure in which successive transactions at identical prices are combined into one larger trade is used in Panel B but is not used in Panel A. A parametric ANOVA test and Wilcoxon rank Scores test is used to test the difference in means between the groups of stocks with and without an assigned market maker.

	average price	**Overall**	**without an assigned MM**	**with an assigned MM**	**ANOVA**	**Wilcoxon**
<u>PANEL A</u>	<u>All Observations</u>					
Group 0 - smallest price	61.15	0.4809	0.3636	0.8017	435.2***	477.4***
Group 1	183.85	0.4141	0.2958	0.6864	497.4***	692.9***
Group 2	311.70	0.3899	0.3201	0.5314	173.9***	304.3***
Group 3	466.39	0.3256	0.2871	0.4372	158.1***	239.5***
Group 4 - largest price	1384.85	0.2629	0.2127	0.4625	395.8***	329.0***
<u>PANEL B</u>	<u>Observations with deletions due to Bunching</u>					
Group 0 - smallest price	61.07	0.4646	0.3534	0.7726	417.2***	448.1***
Group 1	184.77	0.4038	0.2934	0.6665	454.2***	652.0***
Group 2	312.56	0.3725	0.2989	0.5203	203.7***	331.6***
Group 3	466.57	0.3167	0.2790	0.4280	159.4***	253.2***
Group 4 - largest price	1385.10	0.2525	0.2031	0.4512	399.5***	344.1***

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

the price quintiles except for the second price quintile. This pattern, too, is similar whether bunching is or is not used.

The mean effective half-spread is approximately twice as large for the group of stocks with an assigned market maker in each of the price quintiles. This difference is statistically significant at a level of 1% using both parametric and non-parametric tests. For hypothesis six (H6) the null is rejected for the effective half-spread trade execution cost measure. On an overall basis, and in each price quintile, the effective half-spread is twice as large for those stocks with an assigned market maker.

4.5.3. Price Impact

Price impact provides a measure of trades' information content thirty minutes after the trade. Since stocks with an assigned market maker that is required to maintain a presence in the market may be more susceptible to informed traders, they may be compensated with larger bid-ask spreads. This difference will be more visible using the price impact measure, since the effect is measured after the trade. Table 40 provides an overall estimate of the price impact to be 0.0962% using all observations and 0.0597% when the bunching procedure is used. When the bunching procedure is not used, the stocks with an assigned market maker have a mean price impact of 0.1527% which is approximately two times larger than the mean price impact of 0.0752% for those stocks without an assigned market maker. When the bunching procedure is used the stocks with an assigned market maker have a mean price impact of 0.0906% which is also approximately two times larger than the mean price impact of 0.0483% for those stocks without an assigned market maker. Without using the bunching procedure, the difference between the means in the two groups is statistically significant at a level of 1% using both

parametric and non-parametric tests of difference. When the bunching procedure is used the parametric test remains statistically significant at a level of 1%, however, the non-parametric test shows no statistically significant difference between the two groups.

Table 43 reports the price impact across price quintiles. The mean price impact is largest for those stocks in the smallest price quintile, and smallest for those stocks in the largest price quintile, but the middle three quintiles are very similar. Without using the bunching procedure, the mean price impact is two and one-half times larger for the smallest price group, but this multiple declines to only one and one-half times larger for the largest price group. The statistical significance between the group of stocks with and without an assigned market maker is at a level of 1% for the smallest three price quintiles, but this level is not maintained for the larger price quintiles. The second largest price quintile has statistically significant differences at a level of 5% using the parametric test and at a level of 10% using the non-parametric test. When using the parametric test, the largest price quintile has no statistically significant difference, while the non-parametric test is significant only at a level of 10%.

When the bunching procedure is used, there is very little statistically significant differences between the means of the groups of stocks with and without an assigned market maker. None of the price quintiles have significant non-parametric test statistics. The smallest price quintile has a parametric test statistic that is significant at a level of 1%. Also, the middle quintile has a parametric test statistic that is significant at a level of 10%.

For hypothesis six (H6) the null is not rejected for the price impact trade execution cost measure. Although there are some statistically significant differences in

Table 43 This table reports estimates of trade execution costs for the price impact across price groups. This table estimates the price impact, shown in equation (5), for each firm on the Paris Bourse during the September - December 1995 period. The mean results are presented both on an overall basis and for stocks with and without an assigned market maker. Each stock is assigned into one of five price groups based on the price of the stock at the beginning of the period. A bunching procedure in which successive transactions at identical prices are combined into one larger trade is used in Panel B but is not used in Panel A. A parametric ANOVA test and Wilcoxon rank scores test is used to test the difference in means between the groups of stocks with and without an assigned market maker.

	average price	**Overall**	**without an assigned MM**	**with an assigned MM**	**ANOVA**	**Wilcoxon**
PANEL A	All Observations					
Group 0 - smallest price	61.15	0.1461	0.1048	0.2589	26.3***	8.4***
Group 1	183.85	0.0995	0.0762	0.1531	11.1***	8.4***
Group 2	311.70	0.1067	0.0829	0.1547	10.9***	10.1***
Group 3	466.39	0.0841	0.0749	0.1110	4.2**	3.4*
Group 4 - largest price	1384.85	0.0475	0.0426	0.0673	2.1	3.0*
PANEL B	Observations with deletions due to Bunching					
Group 0 - smallest price	61.07	0.0983	0.0723	0.1703	9.9***	0.1
Group 1	184.77	0.0548	0.0473	0.0725	1.2	1.0
Group 2	312.56	0.0726	0.0587	0.1004	3.7*	0.4
Group 3	466.57	0.0530	0.0464	0.0726	2.2	0.0
Group 4 - largest price	1385.10	0.0219	0.0216	0.0229	0.0	0.0

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

the small price quintiles, this significance is not present in the large price quintiles nor when the bunching procedure is used.

4.5.4. Realized Half-Spread

The realized half-spread is equivalent to the effective half-spread less the price impact. It measures the price reversals after trades and represents the market-making revenue net of losses to better informed traders. Table 40 reports that the overall realized half-spread is 0.2769% when the bunching procedure is not used and 0.3009% with bunching. The realized half-spread is approximately two times larger for those stocks with an assigned market maker compared to those stocks without an assigned market maker. The difference between the stocks with and without assigned market makers is statistically significant using both parametric and non-parametric tests.

Table 44 reports the realized half-spread across price quintiles. On an overall basis, the realized half-spread is monotonically declining with price irrespective of whether the bunching procedure is used. These patterns are mirrored in each individual group of stocks with and without an assigned market maker, except for the largest price quintile for stocks with an assigned market maker. For the stocks with an assigned market maker, the realized half-spread in the largest price quintile is slightly larger than the mean in the second largest quintile.

Examining those observations with and without the bunching procedure shows that the difference between the mean realized half-spread in the groups with and without an assigned market maker in all ten price quintiles is statistically significant at a level of 1% using both parametric and non-parametric tests. For hypothesis six (H6) the null is rejected for the realized half-spread trade execution cost measure. On an overall basis,

Table 44 This table reports the estimates of trade execution costs for the realized half-spreads across price groups. This table estimates the realized half-spread, shown in equation (6), for each firm on the Paris Bourse during the September - December 1995 period. The mean results are presented both on an overall basis and for stocks with and without an assigned market maker. Each stock is assigned into one of five price groups based on the price of the stock at the beginning of the period. A bunching procedure in which successive transactions at identical prices are combined into one larger trade is used in Panel B but is not used in Panel A. A parametric ANOVA test and Wilcoxon rank scores test is used to test the difference in means between the groups of stocks with and without an assigned market maker.

	average price	Overall	without an assigned MM	with an assigned MM	ANOVA	Wilcoxon
PANEL A	All Observations					
Group 0 - smallest price	61.15	0.3348	0.2587	0.5428	84.4***	80.1***
Group 1	183.85	0.3146	0.2196	0.5332	149.3***	151.8***
Group 2	311.70	0.2833	0.2372	0.3766	35.3***	41.2***
Group 3	466.39	0.2415	0.2123	0.3262	37.6***	41.0***
Group 4 - largest price	1384.85	0.2154	0.1701	0.3952	144.5***	55.5***
PANEL B	Observations with deletions due to Bunching					
Group 0 - smallest price	61.07	0.3663	0.2811	0.6023	95.6***	102.2***
Group 1	184.77	0.3490	0.2461	0.5941	160.7***	154.7***
Group 2	312.56	0.2999	0.2402	0.4198	57.2***	60.6***
Group 3	466.57	0.2637	0.2326	0.3554	39.5***	48.4***
Group 4 - largest price	1385.10	0.2306	0.1814	0.4283	163.9***	70.9***

*significant at a level of $\alpha = 10\%$
**significant at a level of $\alpha = 5\%$
***significant at a level of $\alpha = 1\%$

and in each price group, the realized half-spread is larger for those stocks with an assigned market maker by a multiple of approximately two.

4.5.5. Summary

Four measures of execution costs are estimated following Bessembinder and Kaufman (1997). A two-stage estimation process is used whereby daily means are calculated for each stock and then these means are used to calculate overall means and means for the group of stocks with and without an assigned market maker. The difference between these two groups is then tested with a parametric ANOVA test and a non-parametric Wilcoxon rank scores tests.

All four trade execution cost measures are larger for stocks with an assigned market maker and show a difference between the groups. When the bunching procedure is not used, the average quoted bid-ask half-spread is 66 basis points larger (1.2342% versus 0.5775), the effective bid-ask half-spread is 30 basis points larger (0.5885% versus 0.2930%) and the price impact is 8 basis points larger (0.1527% versus 0.0752%). The realized bid-ask half-spread is also larger by 22 basis points (0.4357% versus 0.2178%).

The null hypotheses of a similar trade execution cost measure in the group of stocks with and without an assigned market maker is rejected for three of the four measures. The hypothesis is not rejected for the price impact measure. Although there are some differences, when the price impact is examined across stock price quintiles, there is limited statistical difference for the measure in the largest two price quintiles. Additionally, there is very little statistically significant difference for price impact in any price quintile when the bunching procedure is used.

These results do not confirm the findings of Huang and Stoll (1996) and Bessembinder and Kaufman (1997). These two articles attributed differences between NYSE and Nasdaq to the market structure. Comparisons between groups of stocks with and without an assigned market maker on the Paris Bourse are much cleaner since other unassigned market makers are present in both groups. This allows a better comparison than between NYSE and Nasdaq, since the effect of the assigned market maker is determined without the institutional differences inherent in a comparison of a specialist market with a multiple dealer market. The results show that quoted, effective and realized half-spreads are all larger for stocks that trade with an assigned market maker.

4.6. Conclusion

This essay examines estimates of the components of the bid-ask spread and trade execution costs across two trading systems that coexist on the Paris Bourse. Literature regarding the adverse selection component is contradictory: Affleck-Graves, Hedge and Miller (1994) find lower adverse selection costs on Nasdaq, while Jones and Lipson (1997) find a higher adverse selection component. Bessembinder and Kaufman (1997) find no difference in their measure of adverse selection, the price impact measure, when comparing the NYSE and Nasdaq. Data from the Paris Bourse is unable to clarify the contradictory findings with respect to the adverse selection component. In estimates of the bid-ask spread components, the adverse selection component is found to be similar in the group with and without an assigned market maker. In estimates of the execution costs, the price impact measure is also found to be similar for the group of stocks with and without an assigned market maker.

The actual estimate of the adverse selection component varies from being insignificantly different from zero to negative five percent. While a negative adverse

selection component is economically questionable, it does suggest that adverse selection plays a minor role in determining the bid-ask spread. These estimates are much lower than those by De Jong, Nijman and Röell (1996). Their findings were based on a small sample of stocks during a much earlier time period before the reforms on the Paris Bourse. Additionally, they use models with two component spread decompositions that ignore inventory holding costs and this may affect the determination of the adverse selection component.

The inventory holding cost component is found to be larger for those firms with an assigned market maker when bunching of successive transactions with identical prices into one larger trade is not done. This indicates that the assigned market maker faces an identifiable cost of maintaining an inventory and adding liquidity by standing ready to buy and sell the stock. This larger inventory holding cost component is a partial justification of the larger trade execution costs that are found for those stocks with an assigned market maker. Bessembinder and Kaufman (1997) suggest that higher volatility on (size-matched) Nasdaq firms versus NYSE firms may also contribute to higher inventory holding costs. This higher volatility for stocks with an assigned market maker was confirmed on the Paris Bourse in chapter three (essay one) of this dissertation. On average, stocks with an assigned market maker face trade execution costs that are much larger than for stocks without an assigned market maker.

The third theoretical component of the bid-ask spread is the order processing costs, and, as a percentage, these costs were lower on stocks with an assigned market maker. Since this is the remainder from the other components, it is not surprising there is a difference given the larger inventory holding cost component for stocks with an assigned market maker.

The inventory holding cost component difference is further analyzed by looking at the prior period inventory buildup. A difference is found between the groups of firms with and without an assigned market maker only in the group of stocks with the largest decline in inventory. For this group, the inventory cost component is found to be twice as large for those stocks with an assigned market maker. This is intuitively pleasing since in this situation the assigned market maker would be more likely to manage inventory compared to market makers that can exit and cease trading. The inventory accumulation procedure is further validated by noting that the adverse selection component is statistically significant in only those extreme quintiles where the largest inventory changes occurred in the prior period.

Trade execution cost results indicate that larger average trading costs are faced by those traders of stocks with an assigned market maker. Quoted, effective and realized half-spreads are all approximately twice as large for stocks with an assigned market maker. This is in contrast to the findings by Huang and Stoll (1996) and Bessembinder and Kaufman (1997) that showed Nasdaq stocks (with multiple market makers) generally had larger trading costs than those facing traders of NYSE stocks (with a single specialist). The estimates and comparison across groups of stocks with and without an assigned market maker on the Paris Bourse avoids the institutional differences that are inherent in the comparison by Huang and Stoll (1996) and Bessembinder and Kaufman (1997). The specialist on NYSE is the only market maker, and with the NYSE rule enforcement procedures and close monitoring, those specialists may be held more accountable than if there were other market makers on the same exchange competing for order flow. This comparison using Paris Bourse data involves stocks that all have unassigned market makers that are free to enter or exit trading. Thus, the effect on the

assigned market maker (or specialist) is cleaner since it is not mitigated by a lack of competing market makers. The results show that stocks traded with an assigned market maker face higher trade execution costs on the Paris Bourse.

CHAPTER 5

ESSAY THREE:

SPECIALIST FIRMS AND INTRADAY PRICE FORMATION

5.1. Introduction

Some of the most puzzling empirical findings are intraday patterns in volume, volatility, bid-ask spreads and prices (see Wood, McInish and Ord (1985), Stoll and Whaley (1990), McInish and Wood (1992), Brock and Kleidon (1992) and Lee, Mucklow and Ready (1993)). Patterns are puzzling since they appear to contradict the efficient market hypothesis in that they provide exploitable risk-free profit opportunities. On the NYSE, a U-shaped pattern has been found for volume, volatility, and bid-ask spreads. Also, there exists a systematically large end of day price rise and large final transaction return. One potential explanation involves the specialist's ability to capitalize on trader's inelastic demand at the end of the day. This may contribute to the higher volume, volatility, bid-ask spread and price. Another explanation is the suggestion that the end of day price rise may be due to window-dressing. According to these explanations the specialist is in a key role to take advantage of the inelastic demand and/or to allow a last minute price change.

These explanations can be tested by examining differences across specialists. Expertise in assessing inelastic demand may enable the specialist to seize the opportunity to profit in these situations. This expertise is not likely to be similar across specialist firms since specialist firms have been found to have differences that manifest themselves in transitory volatility, trading continuity, execution costs and inventory holding costs[11].

---

[11] See Corwin (1996), Barnea (1974), Coughenour and Deli (1996) and Cao, Choe and Hatheway (1997).

In this chapter, the price formation characteristics of volume, volatility, the bid-ask spread, end of day returns and depth are examined across specialist firms. Differences across individual specialists within a specialist firm may also provide clues to the reasons for any patterns in price formation characteristics. Depth has not been examined in detail in existing literature and is one characteristic that the specialist can alter that may affect the patterns in prices, volume, volatility and bid-ask spread. Patterns in depth changes may differ when specialists use different strategies and these patterns may be related to individual specialists and/or specialist firms.

The volume of a stock may impact on that stock's importance to a specialist because of the effect on the specialist's revenue. The specialist may treat stocks differently depending on volume and this may manifest itself in patterns in price formation characteristics. This could have implications on whether stocks of a certain volume level are positively or negatively affected by listing on an exchange that uses specialists. Madhavan and Sofianos (1998) find that specialist participation on the NYSE varies from less than 10% to over 60%. They find specialist trading rises with non-block trading but declines with block trading. Furthermore, they find specialists are more active in smaller trades and are more likely to provide liquidity when the spread widens.

Inventory accumulation may also affect price formation characteristics. Specialists may react differently to inventory accumulation or depletion and this may be discernible in price formation characteristics.

These issues are investigated in order to better explain the role and impact of specialists on price formation patterns. Hypotheses are developed in Section 5.2. and the sample and methodology are detailed in Section 5.3. The results are explained in Section 5.4. and conclusions are given in Section 5.5.

5.2. Hypotheses

Intraday price formation, as evidenced by patterns in volume, volatility, bid-ask spreads, depth and returns at the end of the day, should be uniform under the null hypothesis of a random walk or sub-martingale, if they are unrelated to characteristics of the specialists or if the specialists are all operating similarly. This suggests that differences among specialist firms may result in differing patterns in the price formation characteristics. Testing of similarity or difference can be carried out for each of these characteristics and the hypotheses can be expressed as follows:

> $H1_O$: The price formation characteristic observed is the same for all the specialist firms.
>
> $H1_A$: The price formation characteristic observed is not the same for all the specialist firms.

To further examine this issue, the differences within specialist firms can be considered. Some firms have many individual specialists while others have only a few individual specialists. The post and panel location can be used to determine the individual specialist that is assigned to each stock. If characteristics of the specialist firm, such as capitalization or risk tolerance, influence the price formation characteristics then there should be no differences between individual specialists that are members of the same firm. If the expertise of the individual specialist influences the price formation characteristic then there should be differences between individual specialists that are members of the same firm. Individual prospective specialists learn the procedures first by working behind the panel in clerical support positions similar to an apprentice. It is only after much training and membership in the specialist partnership as well as membership on the exchange that the specialist will become active. This long period

before trading where the specialist firm procedures are learned suggests individual specialists in the same firm will possess similar trading mannerisms. The specific hypotheses are as follows:

> $H2_O$: The price formation characteristic observed is the same for all individual specialists in each specialist firm.
>
> $H2_A$: The price formation characteristic observed is not the same for all individual specialists in each specialist firm.

Some specific stocks may be more profitable than others and as such they may garner more attention from each specialist. This, in turn, may indicate that these stocks are more likely to be of interest to the specialist and to be affected by differences between specialists even though the actual participation rate may be lower due to higher volume. Profitability is likely related to volume since higher volume stocks represent more opportunities to capture the bid-ask spread. If the patterns differ between stocks based on volume then this may indicate the volume of a stock influences the resulting price formation characteristics. If a price formation characteristic is larger for low volume stocks then this may be the natural result of compensating for not being able to capture large quantities of the bid-ask spread. Conversely, larger price formation characteristics for high volume stocks may indicate that the price formation characteristics are a result of the high volume and ability of the specialist to capitalize on that volume. This may indicate that there exists some cross-subsidization from the more active to less active stocks[12]. No systematic differences between high and low volume stocks would indicate that volume is not a factor that influences the behavior or ability of the specialist to impact on the price formation characteristics. The hypotheses are as follows:

---

[12] Easley, Kiefer, O'Hara and Paperman (1996) identify an understanding on the NYSE that frequently traded stocks will subsidize infrequently traded stocks.

$H3_O$: Patterns in price formation characteristics observed in stocks of each specialist firm are not affected by the level of volume in the stocks.

$H3_A$: Patterns in price formation characteristics observed in stocks of each specialist firm are affected by the level of volume in the stocks.

The next hypothesis involves the end of day price rise. If specialists are influencing the end-of-day price rise then the quotes will likely adjust in advance of the final transaction. This ability to adjust the bid-ask spread may be apparent in those specialist firms with expertise in assessing inelastic demand. The hypotheses is as follows:

$H4_O$: Adjustment of the bid-ask quotes in advance of the final transaction of the day is similar across specialist firms.

$H4_A$: Adjustment of the bid-ask quotes in advance of the final transaction of the day differs across specialist firms.

The accumulation of share inventory during the day may also play a role in the intraday price formation since some specialist firms may be better able to withstand inventory accumulations (because of lower risk aversion or higher capitalization). This ability may be evidenced in price formation characteristics. The hypotheses are as follows:

$H5_O$: Price formation characteristics are affected by inventory accumulation during the trading day.

$H5_A$: Price formation characteristics are not affected by inventory accumulation during the trading day.

5.3. Sample and Method of Testing

Patterns in intraday price formation characteristics are examined through the use of the New York Stock Exchange's (NYSE) Trades and Quotes (TAQ) database. The May 1995 CD-ROM is used to extract prices and quotes throughout the day. All trades

and quotes with non-positive prices or volume/depth are deleted. All trades with an error or correction code are deleted. All transactions with a 50% price change as compared to the previous price are deleted. Only those stocks that are defined as common stocks or preferred stocks are included in the analysis.

Specialist data is obtained from the *NYSE Specialist Directory* for May 1995. The Directory is a monthly report prepared by the NYSE, listing specialist firms operating on the Exchange and specialist assignments for all NYSE-listed securities. The directory includes the security, specialist firm, and the post and panel location of each security. There are 37 specialist firms operating in May 1995, handling 2,439 securities. One additional specialist firm was operating in May 1995 but is excluded because there are a limited number of observations and that specialist firms ceased operations in June 1995.

In order to compare the end of day price rise across trading groups, simple statistics will be used to obtain the mean returns. As in chapter 3, the return calculation will be shown in simple percentage terms so that the magnitude of the return can be easily interpreted. The time-weighted bid-ask spread and depth are weighted by the number of seconds the quotes are outstanding during each half-hour interval. The opening quotes are usually from a prior period, except in the case of the first half-hour period, where no quotes are used until the first quote after the opening transaction. For the interval after 4:00, the final quotes of the day are considered to be outstanding for only one second.

Price formation characteristics will be tested across groups under both a parametric and non-parametric framework. A simple analysis of variance framework will provide the method of testing that breaks the total variance of the sample into that

attributable to within and that attributable to between groups. This method of testing relies on assessing the difference in size between the groups and within the groups to determine if the underlying population means are equal. The non-parametric method of testing will be performed using the Wilcoxon rank sums test whereby returns are ranked and these ranks are summed and compared to a distribution that has no difference in the means. Again, the larger the difference the more likely the two groups are not from the same population.

5.4. Results

The differences across and within specialist firms are examined by observing numerous price formation characteristics. The results of these tests are organized by hypothesis.

5.4.1. Differences Across Specialist Firms

The null of hypothesis one (H1) is that the price characteristic is the same for all the specialist firms. In the following subsections volume, volatility, the bid-ask spread, end of day returns, and depth are used to test the hypothesis. With the exception of the end of day returns, each of the price characteristics may vary during the day, and in order to better identify the impact of the specialist firms, the price formation characteristics examined are both reported on an overall basis and by isolating the characteristic within each half-hour interval during the trading day.

5.4.1.1. Volume

Trading volume is examined and reported in Table 45. The mean number of transactions each half-hour is 2.6, with an average volume of 598,900 shares (reported as 5,989 hundred-lot shares). The trading day is broken down into half-hour intervals and

Table 45 This table reports the volume within each thirty minute interval across specialist firms. The mean number of transactions, the mean total share volume (in hundred-lots) and the mean percentage of each day's total share volume are reported in aggregate and for each specialist firm. A parametric ANOVA test and a non-parametric Wilcoxon rank sums test are conducted to test for differences across specialist firms and across trading intervals.

Overall	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
mean # trans.	2.6	3.0	3.3	3.1	3.0	2.6	2.4	2.1	2.0	2.2	2.5	2.7	3.1	3.5	0.5
mean tot. vol.	5,989	7,035	7,904	7,386	6,932	5,891	5,760	4,984	4,599	4,973	5,504	6,008	6,819	7,953	2,109
mean % day's vol.		6.4	7.5	7.5	7.8	7.2	6.8	6.1	5.9	6.4	7.4	8.0	9.2	11.2	2.9
<u>**Specialist #**</u>															
20															
mean # trans.	2.8	3.2	3.4	3.5	3.4	2.9	2.6	2.2	2.4	2.4	2.8	3.1	3.5	3.8	0.5
mean tot. vol.	6,542	6,693	8,655	8,650	8,394	6,022	6,476	4,720	5,862	4,627	6,395	6,204	7,440	9,056	2,394
mean % day's vol.		6.5	8.0	7.7	8.4	7.0	6.9	5.8	6.7	5.9	7.3	7.4	9.2	10.4	2.8
34															
mean # trans.	1.9	2.1	2.4	2.3	2.1	1.9	2.1	1.6	1.5	1.5	1.9	2.0	2.2	2.6	0.4
mean tot. vol.	5,590	6,419	6,479	6,397	8,315	4,965	9,142	4,788	3,581	4,912	4,373	4,301	5,880	7,029	1,676
mean % day's vol.		6.3	8.0	7.5	7.8	6.8	8.1	6.1	5.8	5.8	7.1	8.3	9.0	10.6	2.7
104															
mean # trans.	1.6	1.7	1.9	1.7	1.8	1.6	1.5	1.2	1.3	1.4	1.6	1.7	1.9	2.2	0.3
mean tot. vol.	2,729	3,125	3,097	3,148	2,947	2,644	2,567	2,607	2,641	2,117	2,768	2,818	3,473	3,446	803
mean % day's vol.		6.3	6.7	6.7	7.6	7.5	7.1	5.8	6.2	6.4	8.3	8.4	9.5	11.2	2.4
137															
mean # trans.	3.9	5.0	4.9	4.8	4.5	4.0	3.7	3.1	3.0	3.3	3.7	4.1	4.6	5.1	0.6
mean tot. vol.	9,635	12,741	12,220	12,344	11,565	10,034	8,921	7,267	7,721	7,861	8,420	9,949	10,637	12,165	3,040
mean % day's vol.		7.2	7.7	8.0	8.3	6.6	6.7	5.8	6.0	5.9	7.5	8.3	8.6	10.4	2.9
202															
mean # trans.	2.9	3.6	3.8	3.6	3.3	3.0	2.8	2.4	2.2	2.5	2.9	3.1	3.5	3.9	0.6
mean tot. vol.	7,961	9,592	9,861	11,694	9,119	7,585	7,052	6,034	5,874	6,616	6,853	7,862	8,991	11,002	3,324
mean % day's vol.		7.1	8.1	8.0	7.8	6.5	6.5	5.4	5.4	6.8	7.0	7.8	8.9	11.7	3.0
210															
mean # trans.	3.2	3.9	4.3	3.9	3.8	3.3	3.0	2.6	2.5	2.7	3.2	3.4	3.9	4.3	0.5
mean tot. vol.	7,764	9,424	10,941	10,357	8,681	6,968	7,392	6,843	5,347	5,501	7,627	8,343	8,457	10,137	2,684
mean % day's vol.		7.1	8.0	8.1	7.9	7.0	6.6	5.6	5.4	6.5	7.2	8.2	8.9	10.7	2.7

(table con'd)

(Table 45 continued)

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Specialist #															
215															
mean # trans.	2.7	2.9	3.4	3.2	3.0	2.8	2.5	2.1	2.0	2.4	2.6	2.8	3.3	3.7	0.5
mean tot. vol.	5,654	5,704	7,223	6,835	6,919	5,998	5,321	4,642	4,358	5,132	5,093	5,888	6,371	8,129	1,535
mean % day's vol.		6.2	7.6	7.7	7.5	7.2	6.9	6.0	6.2	7.0	7.4	7.8	9.0	11.2	2.5
240															
mean # trans.	1.6	1.9	2.0	1.9	2.0	1.6	1.5	1.3	1.3	1.6	1.5	1.6	1.8	2.3	0.4
mean tot. vol.	3,494	4,121	4,895	4,288	3,959	3,182	3,416	2,616	3,085	3,222	3,462	3,652	3,291	4,742	989
mean % day's vol.		5.5	6.7	7.6	8.2	6.8	7.2	6.1	5.8	7.0	8.0	8.0	9.2	10.9	2.9
298															
mean # trans.	3.5	4.0	4.5	4.2	4.0	3.6	3.3	2.8	2.8	3.0	3.4	3.6	4.0	4.5	0.6
mean tot. vol.	8,978	10,316	12,538	11,590	10,540	8,928	9,093	7,818	6,186	7,707	8,221	8,641	9,728	11,074	3,305
mean % day's vol.		6.1	7.6	7.8	8.2	7.7	6.6	6.6	5.6	6.6	6.8	7.9	8.5	10.9	3.0
364															
mean # trans.	1.9	2.1	2.3	2.3	2.0	2.1	1.9	1.5	1.5	1.5	1.8	2.1	2.5	2.5	0.4
mean tot. vol.	3,783	4,411	3,815	3,950	4,522	2,990	5,714	2,671	4,320	2,986	2,798	4,380	4,676	4,175	1,553
mean % day's vol.		6.6	7.2	6.7	6.2	5.9	7.6	6.2	7.4	7.5	5.5	9.7	10.9	9.6	2.9
403															
mean # trans.	3.1	3.5	3.9	3.6	3.6	3.2	2.9	2.5	2.4	2.7	3.0	3.2	3.8	4.2	0.5
mean tot. vol.	6,143	7,110	7,921	7,305	7,292	5,870	5,654	5,013	4,800	5,097	5,787	6,076	7,702	8,567	1,802
mean % day's vol.		5.7	7.5	7.3	8.3	7.5	6.9	6.2	5.6	6.2	8.0	7.9	9.9	10.2	2.8
501															
mean # trans.	2.9	3.4	3.8	3.5	3.3	3.0	2.7	2.3	2.4	2.5	2.9	3.2	3.6	3.9	0.5
mean tot. vol.	6,701	8,120	8,693	7,838	7,646	6,964	6,239	5,641	5,481	5,292	6,316	6,786	7,750	8,521	2,530
mean % day's vol.		6.2	7.5	7.4	7.6	7.3	6.8	5.9	6.1	6.1	7.6	7.9	9.3	11.3	3.0
520															
mean # trans.	2.5	3.0	3.3	3.0	2.9	2.6	2.3	1.9	1.9	2.1	2.4	2.7	3.0	3.3	0.5
mean tot. vol.	5,462	5,824	7,237	6,603	5,839	5,070	4,584	4,347	4,446	4,611	4,929	6,308	7,370	6,925	2,380
mean % day's vol.		6.3	7.2	7.1	7.3	6.3	6.3	5.4	5.3	6.4	7.8	8.1	9.6	13.0	3.9

(table con'd)

(Table 45 continued)

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Specialist #															
551															
mean # trans.	2.7	3.3	3.5	3.2	3.1	2.7	2.4	2.0	2.1	2.3	2.7	2.9	3.3	3.6	0.4
mean tot. vol.	5,966	7,968	8,659	7,900	6,675	5,521	5,082	5,116	4,267	5,168	5,514	5,713	6,228	7,882	1,834
mean % day's vol.		6.6	7.1	7.2	7.9	7.6	7.0	5.5	5.9	6.4	7.5	8.0	9.9	11.2	2.2
1010															
mean # trans.	1.9	1.8	2.3	2.3	2.3	2.1	1.8	1.5	1.5	1.7	1.9	2.0	2.4	2.7	0.3
mean tot. vol.	4,426	5,268	5,984	5,112	7,043	6,439	3,188	3,607	3,438	3,502	2,709	3,320	5,332	5,700	1,319
mean % day's vol.		4.5	5.6	6.1	7.6	7.8	5.6	6.5	5.9	7.7	9.5	8.3	10.8	11.6	2.3
1027															
mean # trans.	2.0	2.4	2.5	2.3	2.3	1.9	1.7	1.6	1.7	1.8	2.1	1.9	2.3	2.8	0.4
mean tot. vol.	4,782	6,622	7,144	4,803	5,328	4,699	4,004	3,011	4,192	5,386	5,537	3,575	4,079	5,999	2,571
mean % day's vol.		6.9	8.8	7.3	8.2	6.4	5.8	6.4	7.0	5.8	7.2	7.3	7.5	11.4	3.9
1034															
mean # trans.	0.9	1.0	1.1	1.0	1.0	1.1	0.8	0.7	0.7	0.8	0.9	1.0	1.1	1.4	0.2
mean tot. vol.	1,527	1,642	1,759	1,554	1,448	2,053	1,758	943	1,257	1,328	1,393	1,468	1,369	2,955	453
mean % day's vol.		5.9	6.2	7.0	6.3	8.5	6.3	6.6	5.3	5.9	7.2	7.9	9.3	15.2	2.5
1148															
mean # trans.	1.8	2.0	2.3	2.1	2.1	1.8	1.6	1.4	1.4	1.4	1.7	1.9	2.1	2.6	0.4
mean tot. vol.	3,545	4,011	4,605	4,142	3,887	3,632	3,052	2,638	2,903	3,044	3,171	3,969	4,181	5,084	1,314
mean % day's vol.		6.4	7.8	8.1	7.8	7.2	5.3	5.9	5.6	6.4	7.6	8.2	9.7	11.0	3.1
1225															
mean # trans.	2.2	2.7	2.9	2.7	2.5	2.2	2.1	1.7	1.7	1.8	2.2	2.3	2.5	3.0	0.4
mean tot. vol.	5,440	6,216	7,322	6,073	6,358	5,885	6,375	3,963	4,316	5,131	4,662	5,836	5,496	6,957	1,572
mean % day's vol.		6.5	7.6	7.7	8.0	7.3	7.2	6.3	6.4	6.0	6.7	8.3	8.6	11.3	2.1
1227															
mean # trans.	2.0	2.3	2.5	2.3	2.2	2.0	1.8	1.6	1.5	1.7	1.9	2.2	2.4	2.7	0.5
mean tot. vol.	4,553	5,634	6,152	5,275	5,527	4,384	4,315	4,090	3,215	3,798	4,087	4,728	5,515	5,674	1,350
mean % day's vol.		6.6	7.6	7.4	7.5	7.0	6.5	6.1	5.6	6.1	7.4	8.4	9.2	11.3	3.1

(table con'd)

(Table 45 continued)

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Specialist #															
1229															
mean # trans.	1.1	1.0	1.3	1.3	1.5	1.1	1.1	1.0	0.8	1.1	1.1	1.2	1.4	1.6	0.3
mean tot. vol.	2,286	2,456	2,468	3,165	2,271	2,227	1,930	1,884	2,095	2,301	1,922	1,906	3,748	2,968	663
mean % day's vol.		5.5	6.9	7.1	7.9	6.5	6.8	6.5	5.7	7.8	7.9	8.4	9.0	11.5	2.4
1266															
mean # trans.	2.7	3.4	3.6	3.2	3.2	2.8	2.6	2.2	2.2	2.4	2.6	2.8	3.2	3.8	0.5
mean tot. vol.	5,681	6,657	6,599	6,858	6,555	5,211	5,771	4,873	4,463	5,324	5,169	5,368	6,401	8,486	1,798
mean % day's vol.		6.7	7.7	8.2	7.1	7.2	6.1	5.5	6.5	7.6	8.2	6.9	8.4	11.2	2.7
1280															
mean # trans.	1.6	1.7	2.1	2.0	1.9	1.7	1.5	1.4	1.2	1.4	1.7	1.8	2.0	2.4	0.4
mean tot. vol.	2,883	2,601	3,319	3,069	3,459	2,894	2,463	2,803	2,181	2,732	2,622	3,604	3,152	4,577	892
mean % day's vol.		5.7	7.9	8.8	7.8	7.8	6.1	6.2	5.4	6.7	6.5	8.7	8.9	10.8	2.7
1341															
mean # trans.	2.3	2.9	3.1	2.8	2.6	2.4	2.2	1.8	1.8	2.0	2.2	2.5	2.7	3.2	0.5
mean tot. vol.	5,321	6,762	7,924	5,608	5,664	4,909	5,124	3,938	4,820	5,310	4,897	5,406	4,835	7,058	2,241
mean % day's vol.		6.1	7.3	7.0	8.1	6.8	6.8	5.7	6.0	6.2	7.6	8.3	7.9	12.4	3.8
1418															
mean # trans.	3.2	4.0	4.3	4.0	3.7	3.3	3.0	2.6	2.5	2.9	3.0	3.4	3.8	4.3	0.6
mean tot. vol.	8,653	11,058	11,753	10,234	9,444	8,601	7,868	8,522	6,087	6,477	7,401	9,611	9,093	11,729	3,271
mean % day's vol.		7.5	8.6	7.4	7.5	7.1	6.8	6.2	5.4	6.3	6.8	8.0	8.2	10.6	3.7
1679															
mean # trans.	2.3	2.5	2.6	2.6	2.6	2.4	2.2	2.0	1.7	1.9	2.3	2.4	2.8	3.2	0.4
mean tot. vol.	6,752	8,637	8,878	7,886	7,724	7,295	6,738	6,615	5,103	5,722	6,012	5,818	7,616	8,469	2,017
mean % day's vol.		5.6	6.5	6.9	7.4	7.3	6.9	7.2	5.6	5.9	7.3	7.8	10.9	11.8	2.8
1687															
mean # trans.	2.0	2.3	2.5	2.4	2.3	2.1	1.9	1.6	1.6	1.7	1.9	2.3	2.4	2.8	0.4
mean tot. vol.	5,240	5,815	6,757	6,415	5,731	5,477	5,683	4,148	3,637	4,474	4,657	5,129	5,823	7,782	1,837
mean % day's vol.		5.7	6.8	7.2	7.5	7.5	7.5	6.3	5.8	6.2	7.7	9.2	8.8	10.7	3.0

(table con'd)

(Table 45 continued)

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Specialist #															
1726															
mean # trans.	3.1	3.0	3.7	3.8	3.7	3.2	3.0	2.5	2.5	2.7	3.1	3.4	3.8	4.4	0.6
mean tot. vol.	7,674	7,206	9,782	9,627	8,800	7,814	7,595	6,284	7,665	6,280	6,624	8,465	8,353	10,166	2,773
mean % day's vol.		5.7	7.6	7.7	7.9	7.1	7.3	5.8	6.3	6.5	7.5	7.7	8.6	11.3	2.9
1746															
mean # trans.	1.6	1.9	2.1	2.0	1.9	1.8	1.6	1.3	1.3	1.4	1.5	1.7	1.8	2.3	0.5
mean tot. vol.	3,769	4,776	5,085	4,775	4,333	4,409	3,884	3,332	2,419	3,238	3,364	3,191	3,289	5,294	1,381
mean % day's vol.		6.9	8.2	7.5	7.3	7.9	6.9	5.8	5.1	5.4	6.5	8.7	7.9	11.9	3.8
1903															
mean # trans.	2.5	2.9	3.0	2.8	2.9	2.4	2.4	2.2	1.9	2.0	24	2.6	3.4	3.4	0.4
mean tot. vol.	4,929	5,844	6,066	5,235	5,584	4,518	4,786	5,174	3,778	3,795	4,631	4,525	7,238	5,701	2,135
mean % day's vol.		6.5	6.9	6.5	7.4	6.8	6.8	7.4	5.8	5.9	7.2	7.8	11.3	11.0	2.7
1910															
mean # trans.	0.8	0.8	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.8	0.9	0.9	1.3	0.3
mean tot. vol.	1,279	1,376	1,419	1,291	1,367	1,577	1,501	1,029	1,118	1,015	1,216	1,120	1,296	1,783	804
mean % day's vol.		5.7	7.1	6.9	7.1	7.0	6.3	6.7	6.0	6.3	7.7	7.9	8.5	12.7	4.1
1941															
mean # trans.	2.9	3.4	3.7	3.5	3.4	2.9	2.6	2.2	2.3	2.4	2.8	3.2	3.5	3.9	0.5
mean tot. vol.	6,706	7,166	9,472	9,015	7,839	6,032	6,114	4,934	4,599	5,865	6,265	6,732	7,210	10,156	2,490
mean % day's vol.		6.9	8.0	8.0	7.5	6.9	7.0	5.6	5.5	6.2	7.8	7.8	8.7	11.3	2.9
1966															
mean # trans.	2.6	3.1	3.5	3.2	3.0	2.8	2.4	2.1	2.0	2.2	2.5	2.8	3.2	3.5	0.5
mean tot. vol.	7,888	9,978	11,111	9,711	8,843	7,291	6,768	6,622	5,662	6,426	7,990	7,490	8,956	10,460	3,131
mean % day's vol.		6.3	6.8	7.2	7.1	7.9	7.0	7.3	6.2	7.1	7.6	7.2	8.7	10.6	3.0
2022															
mean # trans.	2.3	2.6	3.0	2.9	2.7	2.2	2.2	1.8	1.7	1.9	2.2	2.6	2.8	3.1	0.5
mean tot. vol.	4,970	4,969	7,465	5,974	5,771	4,267	4,697	3,717	3,280	4,271	5,335	4,666	6,075	7,009	2,080
mean % day's vol.		5.5	6.9	7.6	8.4	6.3	6.5	6.3	6.0	5.9	6.8	8.5	9.0	12.0	4.4

(table con'd)

(Table 45 continued)

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Specialist #															
2090															
mean # trans.	2.3	2.7	2.8	2.7	2.6	2.4	2.2	1.9	1.8	2.1	2.3	2.4	2.7	3.3	0.5
mean tot. vol.	5,473	7,072	7,572	6,336	6,141	4,610	5,484	3,738	4,208	4,751	5,295	5,410	6,154	7,751	2,104
mean % day's vol.		7.2	8.0	7.3	7.5	7.8	6.7	5.8	5.7	6.5	7.0	7.5	8.6	11.8	2.5
3011															
mean # trans.	1.2	1.2	1.5	1.3	1.4	1.3	1.1	1.0	1.0	1.0	1.1	1.2	1.4	1.7	0.3
mean tot. vol.	2,400	2,244	3,046	2,583	2,442	2,842	2,527	2,031	1,838	2,220	2,671	2,443	2,800	3,300	616
mean % day's vol.		6.0	7.7	7.3	7.3	8.2	6.5	6.6	6.7	6.5	6.8	8.2	8.7	11.0	2.9
3174															
mean # trans.	2.7	3.2	3.5	3.3	3.0	2.7	2.5	2.2	2.2	2.4	2.7	2.9	3.3	3.5	0.5
mean tot. vol.	5,756	7,257	7,501	7,721	5,872	5,553	4,906	4,048	4,360	5,328	5,336	5,674	7,273	7,518	2,235
mean % day's vol.		6.8	7.6	7.9	8.3	7.3	6.5	5.6	5.9	6.9	6.5	7.9	9.0	10.7	3.0
Tests of Difference of Mean % Day's Volume Across Specialist Units															
ANOVA		2.8***	2.1***	1.7***	1.2	1.5**	1.3	2.0***	1.4*	1.6**	1.7***	1.0	2.9***	1.8***	3.2***
Wilcoxon		428.5***	370.4***	333.6***	283.2***	210.3***	255.4***	212.1***	297.1***	290.8***	217.5***	183.1***	189.9***	128.2***	581.5***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

the mean number of transactions and mean total volume is reported for each interval. Additionally, the mean percentage of the day's volume is reported for each interval. Since the average volume differs across specialist firms, this measure allows a more appropriate comparison across specialist firms. The mean percentage is calculated by dividing the number of shares traded each half hour by the total volume each day for each stock and then averaging the percentage across all stocks within an individual specialist firm.

First, on an overall basis, each half-hour interval is examined and a J-shaped pattern in volume is found. The interval with the largest mean percentage of day's volume is the 3:30-4:00 interval, immediately preceding the close. There is some volume reported after the close, but this amount is very small.

Each specialist firm is examined to determine if the intradaily J-shaped pattern occurs consistently across the specialist firms. Of the 37 specialist firms detailed in Table 45, 35 have the 3:30-4:00 half-hour as the interval with the largest mean percentage of the day's volume, ranging from 10.4% to 15.2%. For the other two specialist firms, numbers 364 and 1903, the 3:00-3:30 interval has the largest mean percentage of the day's volume.

The first half-hour interval (9:30-10:00) has a slightly smaller mean percentage of the day's volume as compared to the second half-hour interval (10:00-10:30). This is true on an overall basis, as well as for each of the 37 specialist firms. This may be partially due to the opening procedures followed by the NYSE, since the opening trade of the stock may be delayed. On an overall basis, this pattern also holds for the mean

volume in the first two half-hour intervals. For individual specialist firms, 33 of the 37 have the same pattern in mean volume.

When the number of transactions and actual volume are examined across the trading day, similar patterns are observed as when the mean percentage of the day's volume is examined with one exception. The rise in the percentage of the day's volume at the end of the day is much larger than the number of transactions or the volume in these periods might indicate. This suggests that the rise in percentage at the end of the day may be driven by stocks with lower volume, that perhaps have a majority of their trading during that period in the day. For stocks with low volume, a few more shares traded at the end of the day will not impact the mean number of transactions and mean volume as much as they will impact the mean percentage of the day's volume.

The mean percentage volume is examined across the specialist firms in each half-hour interval and tests of difference show that, while a similar pattern exists, the actual percentage volume differs significantly between the specialist firms. In all fourteen half-hour intervals during the trading day, the non-parametric Wilcoxon rank sums tests indicate that the differences in the mean percentage of the day's volume across specialist firms is statistically significant at a level of 1%. The parametric ANOVA test for each of the fourteen half-hours indicates that in only nine of the individual half-hours do the specialist firms have a mean percentage of the day's volume that is significantly different at a level of 1%. These half-hours are concentrated at the beginning (first three half-hours) and end (last three half-hours) of the trading day with the intervals within the 11:00 until 3:00 time period with varying levels of significance and three half-hour intervals with no statistically significant differences.

These results indicate that hypothesis one (H1) for volume is rejected and that volume as a percentage of the day's volume differs among the specialist firms. This is especially true during the beginning and the end of the trading day and specifically during the first three and last three half-hour trading intervals. The differences may be attributable to stock characteristics, however, the lack of differences during the middle of the day suggest that during the beginning and end of the day the specialists may manage their volume in different way. For example, specialists may alter the bid-ask spread and this may have an effect on when the transactions are filled.

5.4.1.2. Volatility

Volatility is examined in Table 46 by using two measures. One measure of volatility is the high minus the low share price of transactions divided by the mean share price during each trading interval. A second measure is the standard deviation of changes in successive midpoints of the bid-ask spread. First, on an overall basis, the patterns across the half-hour intervals of the trading day are similar but not identical. The high minus low (HML) measure and the standard deviation (STD) measure both have reverse-J shapes during the day. The change in volatility between successive intervals is much less pronounced for the STD measure, with the exception of the change between the first two and the last two trading intervals. The HML measure peaks in the 3:30-4:00 interval, and then is very small in the 4:00-4:30 interval, while the STD measure has a large rise from the 3:30-4:00 interval to the 4:00-4:30 interval peak. For the STD measure, there is a large drop from the 9:30-10:00 interval to the 10:00-10:30 interval. Since these two measures are similar but not identical, both measures are used to examine the differences among specialist firms.

Table 46 This table reports volatility within each thirty minute interval across specialist firms. Volatility is reported (in percent) using two measures. One measure calculates volatility as the difference between the high and the low share prices divided by the mean share price (H-L)/P for each half-hour. Volatility is also reported as the standard deviation of the change in successive midpoints of the bid-ask spread. This is done on an overall basis as well as for each specialist firm. A parametric ANOVA test and a non-parametric Wilcoxon rank sums test are conducted to test if there is a difference between the specialist firms and trading intervals.

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Overall															
(H-L)/P	0.325	0.460	0.423	0.377	0.353	0.328	0.302	0.271	0.262	0.276	0.300	0.318	0.343	0.402	0.025
standard dev.	0.310	0.442	0.342	0.313	0.290	0.284	0.273	0.273	0.262	0.262	0.270	0.267	0.269	0.277	0.384
Specialist #															
20															
(H-L)/P	0.283	0.375	0.343	0.336	0.310	0.302	0.255	0.228	0.228	0.244	0.262	0.276	0.322	0.343	0.034
standard dev.	0.227	0.307	0.253	0.232	0.216	0.205	0.203	0.200	0.200	0.197	0.207	0.200	0.211	0.213	0.255
34															
(H-L)/P	0.314	0.429	0.353	0.378	0.337	0.298	0.301	0.268	0.221	0.262	0.348	0.294	0.315	0.428	0.042
standard dev.	0.341	0.433	0.358	0.332	0.324	0.314	0.321	0.304	0.321	0.315	0.330	0.300	0.286	0.384	0.432
104															
(H-L)/P	0.284	0.381	0.368	0.314	0.287	0.295	0.272	0.258	0.237	0.277	0.274	0.257	0.289	0.338	0.020
standard dev.	0.311	0.416	0.323	0.338	0.271	0.281	0.295	0.280	0.266	0.267	0.285	0.274	0.296	0.283	0.373
137															
(H-L)/P	0.424	0.666	0.508	0.474	0.494	0.399	0.366	0.394	0.365	0.343	0.374	0.427	0.473	0.506	0.048
standard dev.	0.331	0.503	0.358	0.294	0.311	0.280	0.314	0.289	0.273	0.297	0.299	0.265	0.281	0.294	0.451
202															
(H-L)/P	0.307	0.406	0.399	0.362	0.348	0.308	0.293	0.282	0.243	0.278	0.286	0.312	0.319	0.352	0.017
standard dev.	0.243	0.324	0.262	0.250	0.223	0.219	0.223	0.225	0.210	0.210	0.218	0.211	0.227	0.227	0.297
210															
(H-L)/P	0.333	0.451	0.445	0.372	0.352	0.327	0.306	0.280	0.278	0.291	0.307	0.336	0.341	0.440	0.020
standard dev.	0.270	0.345	0.286	0.285	0.260	0.268	0.245	0.247	0.236	0.233	0.259	0.243	0.250	0.244	0.301
215															
(H-L)/P	0.313	0.426	0.406	0.404	0.331	0.323	0.284	0.256	0.248	0.253	0.282	0.293	0.330	0.421	0.008
standard dev.	0.291	0.399	0.417	0.346	0.251	0.245	0.253	0.243	0.215	0.223	0.246	0.232	0.253	0.260	0.376
240															
(H-L)/P	0.343	0.762	0.518	0.400	0.301	0.337	0.324	0.215	0.279	0.301	0.297	0.325	0.326	0.342	0.021
standard dev.	0.721	1.019	0.846	0.680	0.700	0.640	0.581	0.453	0.413	0.627	0.910	0.718	0.673	0.550	0.922

(table con'd)

(Table 46 continued)

Specialist #	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
298															
(H-L)/P	0.327	0.463	0.437	0.400	0.358	0.331	0.326	0.284	0.260	0.288	0.305	0.300	0.345	0.372	0.030
standard dev.	0.294	0.376	0.317	0.310	0.287	0.273	0.281	0.275	0.260	0.262	0.259	0.263	0.247	0.277	0.350
364															
(H-L)/P	0.319	0.476	0.443	0.414	0.357	0.296	0.229	0.194	0.312	0.306	0.276	0.305	0.330	0.404	0.032
standard dev.	0.257	0.341	0.293	0.274	0.253	0.254	0.235	0.233	0.232	0.219	0.229	0.217	0.232	0.223	0.291
403															
(H-L)/P	0.326	0.450	0.401	0.378	0.383	0.354	0.292	0.275	0.254	0.281	0.293	0.320	0.356	0.396	0.026
standard dev.	0.228	0.329	0.247	0.235	0.217	0.222	0.205	0.200	0.202	0.191	0.198	0.196	0.206	0.208	0.267
501															
(H-L)/P	0.316	0.466	0.413	0.369	0.341	0.333	0.278	0.249	0.260	0.262	0.296	0.316	0.336	0.404	0.023
standard dev.	0.289	0.419	0.304	0.285	0.268	0.276	0.255	0.261	0.247	0.244	0.250	0.269	0.261	0.277	0.319
520															
(H-L)/P	0.335	0.483	0.452	0.425	0.404	0.347	0.327	0.248	0.305	0.258	0.281	0.320	0.347	0.384	0.016
standard dev.	0.495	1.140	0.450	0.447	0.335	0.269	0.412	0.588	0.391	0.341	0.265	0.405	0.276	0.386	0.704
551															
(H-L)/P	0.248	0.358	0.313	0.289	0.264	0.234	0.237	0.204	0.214	0.203	0.237	0.231	0.253	0.325	0.016
standard dev.	0.206	0.286	0.219	0.221	0.196	0.188	0.186	0.186	0.184	0.174	0.172	0.187	0.181	0.184	0.264
1010															
(H-L)/P	0.346	0.507	0.425	0.413	0.396	0.341	0.301	0.302	0.264	0.266	0.306	0.336	0.403	0.422	0.047
standard dev.	0.338	0.434	0.346	0.332	0.349	0.323	0.291	0.313	0.283	0.266	0.308	0.319	0.309	0.312	0.479
1027															
(H-L)/P	0.274	0.360	0.396	0.286	0.297	0.248	0.220	0.163	0.261	0.261	0.268	0.265	0.295	0.372	0.020
standard dev.	0.230	0.309	0.258	0.233	0.260	0.244	0.216	0.183	0.174	0.189	0.207	0.212	0.209	0.216	0.240
1034															
(H-L)/P	0.299	0.523	0.416	0.389	0.293	0.328	0.193	0.238	0.170	0.194	0.244	0.249	0.298	0.425	0.071
standard dev.	0.283	0.334	0.358	0.298	0.238	0.252	0.266	0.227	0.225	0.237	0.231	0.303	0.208	0.275	0.374
1148															
(H-L)/P	0.458	0.709	0.651	0.530	0.553	0.459	0.483	0.324	0.379	0.310	0.365	0.414	0.483	0.549	0.021
standard dev.	0.652	0.947	0.717	0.719	0.604	0.564	0.499	0.653	0.537	0.559	0.559	0.529	0.565	0.568	0.804

(table con'd)

(Table 46 continued)

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Specialist #															
1225															
(H-L)/P	0.280	0.440	0.388	0.323	0.292	0.267	0.264	0.226	0.213	0.223	0.261	0.266	0.283	0.343	0.015
standard dev.	0.324	0.467	0.341	0.307	0.290	0.283	0.273	0.288	0.283	0.287	0.255	0.271	0.290	0.303	0.462
1227															
(H-L)/P	0.327	0.426	0.439	0.373	0.355	0.327	0.311	0.277	0.281	0.270	0.323	0.326	0.343	0.398	0.026
standard dev.	0.288	0.390	0.325	0.289	0.272	0.277	0.253	0.254	0.239	0.247	0.251	0.239	0.251	0.252	0.373
1229															
(H-L)/P	0.339	0.348	0.352	0.380	0.318	0.322	0.334	0.345	0.273	0.329	0.361	0.382	0.384	0.386	0.071
standard dev.	0.323	0.469	0.364	0.315	0.319	0.285	0.265	0.267	0.239	0.259	0.255	0.278	0.289	0.250	0.473
1266															
(H-L)/P	0.386	0.519	0.561	0.377	0.382	0.373	0.367	0.338	0.287	0.285	0.365	0.378	0.445	0.563	0.018
standard dev.	0.305	0.541	0.319	0.304	0.245	0.246	0.254	0.275	0.244	0.216	0.234	0.248	0.231	0.249	0.438
1280															
(H-L)/P	0.322	0.414	0.434	0.364	0.344	0.346	0.303	0.286	0.172	0.308	0.311	0.290	0.333	0.431	0.016
standard dev.	0.282	0.377	0.318	0.282	0.289	0.345	0.239	0.227	0.217	0.220	0.209	0.242	0.245	0.244	0.259
1341															
(H-L)/P	0.414	0.586	0.499	0.491	0.434	0.461	0.392	0.337	0.399	0.356	0.339	0.406	0.456	0.502	0.019
standard dev.	0.298	0.370	0.317	0.302	0.283	0.307	0.282	0.291	0.253	0.261	0.266	0.278	0.270	0.286	0.340
1418															
(H-L)/P	0.379	0.552	0.505	0.436	0.384	0.378	0.361	0.317	0.286	0.335	0.363	0.420	0.376	0.469	0.025
standard dev.	0.351	0.495	0.364	0.403	0.330	0.323	0.315	0.316	0.311	0.304	0.284	0.296	0.320	0.307	0.414
1679															
(H-L)/P	0.264	0.340	0.311	0.270	0.276	0.267	0.252	0.274	0.229	0.236	0.258	0.244	0.297	0.336	0.022
standard dev.	0.279	0.337	0.315	0.302	0.283	0.263	0.265	0.253	0.246	0.253	0.248	0.244	0.253	0.251	0.320
1687															
(H-L)/P	0.291	0.361	0.358	0.316	0.273	0.293	0.268	0.265	0.279	0.245	0.261	0.294	0.338	0.376	0.028
standard dev.	0.328	0.408	0.358	0.344	0.316	0.296	0.286	0.302	0.321	0.322	0.302	0.302	0.304	0.310	0.333

(table con'd)

(Table 46 continued)

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Specialist #															
1726															
(H-L)/P	0.341	0.472	0.470	0.410	0.397	0.372	0.311	0.270	0.255	0.321	0.321	0.317	0.327	0.424	0.032
standard dev.	0.269	0.373	0.290	0.288	0.265	0.257	0.242	0.231	0.236	0.240	0.237	0.232	0.233	0.247	0.330
1746															
(H-L)/P	0.330	0.488	0.380	0.401	0.324	0.355	0.328	0.289	0.221	0.274	0.283	0.324	0.339	0.435	0.035
standard dev.	0.363	0.598	0.381	0.365	0.321	0.288	0.317	0.329	0.304	0.311	0.352	0.331	0.285	0.343	0.367
1903															
(H-L)/P	0.305	0.447	0.381	0.313	0.356	0.315	0.290	0.259	0.221	0.266	0.292	0.309	0.322	0.358	0.017
standard dev.	0.302	0.497	0.312	0.277	0.267	0.276	0.254	0.245	0.241	0.252	0.247	0.245	0.262	0.251	0.418
1910															
(H-L)/P	0.203	0.305	0.246	0.199	0.214	0.203	0.182	0.138	0.186	0.147	0.175	0.188	0.214	0.316	0.023
standard dev.	0.325	0.384	0.384	0.348	0.315	0.326	0.319	0.311	0.279	0.289	0.292	0.267	0.294	0.288	0.357
1941															
(H-L)/P	0.341	0.479	0.465	0.381	0.383	0.304	0.319	0.279	0.260	0.278	0.310	0.363	0.393	0.422	0.032
standard dev.	0.320	0.562	0.368	0.298	0.293	0.286	0.262	0.232	0.240	0.239	0.228	0.244	0.253	0.267	0.490
1966															
(H-L)/P	0.292	0.407	0.380	0.348	0.303	0.292	0.279	0.247	0.230	0.238	0.313	0.297	0.324	0.344	0.018
standard dev.	0.276	0.341	0.300	0.256	0.295	0.254	0.250	0.232	0.247	0.250	0.255	0.248	0.248	0.259	0.354
2022															
(H-L)/P	0.316	0.500	0.462	0.413	0.332	0.276	0.263	0.326	0.199	0.256	0.274	0.275	0.359	0.419	0.008
standard dev.	0.414	0.572	0.532	0.354	0.449	0.461	0.373	0.357	0.378	0.342	0.356	0.323	0.313	0.348	0.494
2090															
(H-L)/P	0.466	0.596	0.629	0.582	0.564	0.484	0.506	0.360	0.381	0.426	0.402	0.426	0.425	0.533	0.051
standard dev.	0.418	0.562	0.512	0.417	0.403	0.388	0.378	0.317	0.307	0.323	0.353	0.347	0.375	0.344	0.588
3011															
(H-L)/P	0.323	0.420	0.448	0.368	0.368	0.307	0.304	0.268	0.271	0.283	0.294	0.316	0.314	0.382	0.022
standard dev.	0.358	0.417	0.372	0.352	0.333	0.361	0.313	0.342	0.319	0.342	0.337	0.356	0.357	0.353	0.381

(table con'd)

(Table 46 continued)

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Specialist #															
3174															
(H-L)/P	0.261	0.384	0.324	0.306	0.267	0.270	0.225	0.193	0.220	0.238	0.238	0.270	0.281	0.326	0.025
standard dev.	0.241	0.306	0.282	0.240	0.210	0.210	0.203	0.211	0.302	0.224	0.205	0.204	0.191	0.238	0.289
Tests of Difference															
(H-L)/P															
ANOVA	49.1***	5.1***	5.5***	5.7***	7.1***	4.0***	5.6***	4.3***	4.1***	3.0***	3.1***	5.1***	5.1***	5.9***	1.9***
Wilcoxon	2649.5***	274.1***	282.1***	296.4***	326.3***	263.9***	217.9***	209.5***	210.8***	231.2***	186.5***	265.8***	273.6***	229.1***	75.5***
standard dev.															
ANOVA	128.4***	25.5***	9.4***	8.2***	10.2***	9.3***	8.1***	8.3***	5.1***	8.6***	12.2***	9.3***	8.2***	8.9***	15.9***
Wilcoxon	5341.4***	998.8***	625.2***	417.0***	415.4***	369.4***	385.3***	384.3***	432.0***	364.1***	436.4***	382.7***	411.8***	464.2***	651.4***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

For the HML measure, the dramatic decline from the 3:30-4:00 interval to the 4:00-4:30 interval is robust across all 37 specialist firms. This is likely due to the small number of transactions that are reported after the close. The large rise in the STD measure between the same two intervals is exhibited in all 37 specialist firms. This may indicate that the quotes reported after the close have a midpoint that differs greatly from that occurring before the close. Since the quotes are reported after trading, the specialist does not have to honor these quotes and this measure of volatility in this interval may not be accurate. This phenomenon may then be best explained as being related to the end of day price rise or end-of-day effect.

When the two measures of volatility are examined within each specialist firm there are statistically significant differences found across the half-hour trading intervals in most of the specialist firms. Only two specialist firms, specialist numbers 240 and 3011, do not have statistically significant differences across the STD measure when using a parametric ANOVA test. For both of these specialist firms, the non-parametric Wilcoxon rank sums test is statistically significant at a level of 1%. The differences across the specialist firms are examined within each half-hour trading interval using both measures of volatility. In all cases, the parametric ANOVA and the non-parametric Wilcoxon rank sums tests are statistically significant. The level of significance is at a levels of 1% .

These results indicate that hypothesis one (H1) for volatility is rejected and that volatility using either measure differs among the specialist firms. The patterns are found to be similar between the two measures, but not identical. The STD measure peaks in the 4:00-4:30 interval, while the HML measure peaks during the 3:30-4:00 interval. Over the entire trading day, the STD measure is shown to have less pronounced successive

changes between half-hour intervals when compared to the HML measure. The exception is the first two intervals and last two intervals that have very large differences when the STD measure is used.

5.4.1.3. Bid-Ask Spread

The percentage bid-ask spreads across half-hour intervals and across specialist firms are reported in Table 47. On an overall basis, each successive half-hour period during the trading day has a declining bid-ask spread except for the last two half-hour intervals that exhibit a slight increase. The individual half-hour periods have mean percentage bid-ask spreads that are statistically significantly different both parametrically and non-parametrically at significance levels of 1%.

Examining the pattern in each specialist firm shows that the percentage bid-ask spread in the first interval of the day (9:30-10:00) is the largest of all the half-hour intervals for all 37 specialist firms. The same conclusion can not be made at the end of the day. In the final two intervals, the 3:30-4:00 interval and the 4:00-4:30 interval contain the larger percentage bid-ask spread for 22 and 15 specialist firms, respectively. The final two intervals do not necessarily contain the peak late afternoon percentage bid-ask spread. In some cases the 2:30-3:00 or the 3:00-3:30 interval has a larger percentage bid-ask spread. While the percentage bid-ask spread at the beginning of the day is consistently large, the pattern near the end of the trading day is not robust across specialist firms.

The percentage bid-ask spread is compared in each half-hour interval across the specialist firms and found to be statistically significantly different in all the intervals using both parametric and non-parametric tests. The larger percentage bid-ask spreads at

Table 47 This table reports the bid-ask spread within each thirty minute interval across specialist firms. The time-weighted percentage bid-ask spread (% BAS) is reported within each thirty minute interval. This is done on an overall basis as well as for each specialist firm. Parametric ANOVA tests and non-parametric Wilcoxon rank sums tests are conducted to test for differences across specialist firms and across trading intervals.

		overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Overall																
	% BAS	2.468	3.152	2.796	2.597	2.508	2.458	2.414	2.379	2.349	2.335	2.328	2.324	2.319	2.335	2.353
Specialist #																
20																
	% BAS	1.726	2.160	1.953	1.816	1.791	1.717	1.682	1.645	1.635	1.619	1.615	1.610	1.612	1.600	1.778
34																
	% BAS	2.840	3.550	3.170	2.962	2.843	2.837	2.804	2.750	2.739	2.723	2.699	2.625	2.619	2.659	2.882
104																
	% BAS	2.912	3.751	3.332	3.078	2.976	2.896	2.862	2.768	2.753	2.752	2.766	2.766	2.703	2.765	2.721
137																
	% BAS	2.628	3.277	2.869	2.712	2.683	2.590	2.526	2.526	2.502	2.516	2.534	2.503	2.479	2.528	2.636
202																
	% BAS	2.247	2.832	2.499	2.338	2.250	2.220	2.186	2.138	2.139	2.127	2.154	2.134	2.145	2.187	2.193
210																
	% BAS	2.080	2.563	2.336	2.197	2.115	2.087	2.063	2.030	1.992	1.980	1.965	1.956	1.976	1.979	1.950
215																
	% BAS	2.543	3.329	2.963	2.665	2.561	2.532	2.487	2.453	2.431	2.404	2.430	2.407	2.416	2.389	2.256
240																
	% BAS	2.657	3.449	2.996	2.752	2.751	2.647	2.671	2.620	2.508	2.493	2.449	2.470	2.496	2.509	2.505
298																
	% BAS	2.416	2.959	2.674	2.520	2.487	2.421	2.399	2.366	2.344	2.318	2.274	2.278	2.270	2.288	2.311
364																
	% BAS	2.481	3.394	2.857	2.540	2.473	2.474	2.388	2.327	2.317	2.322	2.293	2.312	2.316	2.343	2.506
403																
	% BAS	2.512	3.171	2.839	2.595	2.503	2.488	2.461	2.433	2.413	2.395	2.392	2.382	2.387	2.393	2.417
501																
	% BAS	2.523	3.143	2.839	2.672	2.567	2.540	2.494	2.454	2.423	2.393	2.398	2.398	2.375	2.371	2.349

(table con'd)

(Table 47 continued)

Specialist #		overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
520	% BAS	2.485	3.019	2.752	2.583	2.500	2.477	2.425	2.388	2.381	2.416	2.360	2.366	2.361	2.394	2.443
551	% BAS	1.883	2.471	2.142	2.026	1.918	1.863	1.838	1.794	1.784	1.761	1.768	1.768	1.746	1.764	1.812
1010	% BAS	1.595	2.156	1.848	1.663	1.622	1.568	1.530	1.527	1.516	1.488	1.458	1.458	1.480	1.485	1.616
1027	% BAS	1.618	2.212	1.909	1.730	1.665	1.625	1.606	1.560	1.531	1.516	1.518	1.474	1.428	1.500	1.466
1034	% BAS	2.793	3.599	3.016	2.873	2.802	2.770	2.732	2.766	2.721	2.736	2.621	2.735	2.690	2.906	2.255
1148	% BAS	3.791	4.978	4.256	3.962	3.820	3.740	3.677	3.621	3.612	3.607	3.558	3.563	3.542	3.605	3.707
1225	% BAS	2.092	2.762	2.347	2.179	2.100	2.011	1.990	2.010	2.004	2.018	1.990	1.958	1.956	1.995	2.072
1227	% BAS	2.736	3.484	3.179	2.913	2.821	2.724	2.677	2.647	2.591	2.557	2.544	2.567	2.579	2.562	2.572
1229	% BAS	2.347	3.089	2.768	2.481	2.470	2.361	2.277	2.207	2.152	2.129	2.169	2.205	2.179	2.183	2.305
1266	% BAS	2.603	3.542	2.979	2.791	2.664	2.642	2.547	2.558	2.502	2.379	2.358	2.463	2.371	2.365	2.420
1280	% BAS	2.320	3.065	2.630	2.445	2.384	2.316	2.268	2.248	2.183	2.145	2.107	2.130	2.164	2.125	2.386
1341	% BAS	2.400	3.188	2.732	2.590	2.464	2.379	2.331	2.229	2.228	2.259	2.258	2.249	2.316	2.318	2.179
1418	% BAS	2.842	3.602	3.184	2.964	2.920	2.837	2.805	2.741	2.720	2.760	2.742	2.698	2.747	2.705	2.470
1679	% BAS	1.976	2.558	2.348	2.173	2.044	1.998	1.925	1.904	1.861	1.826	1.838	1.824	1.816	1.844	1.793
1687	% BAS	2.042	2.726	2.417	2.161	2.088	2.000	1.988	1.948	1.912	1.911	1.921	1.926	1.903	1.917	1.886

(table con'd)

(Table 47 continued)

Specialist #	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
1726															
% BAS	2.373	3.074	2.709	2.485	2.390	2.320	2.279	2.242	2.199	2.218	2.221	2.263	2.242	2.243	2.438
1746															
% BAS	3.052	3.908	3.500	3.293	3.106	3.111	3.017	2.930	2.861	2.852	2.792	2.729	2.755	2.878	3.134
1903															
% BAS	2.250	2.781	2.539	2.362	2.310	2.257	2.218	2.182	2.151	2.142	2.152	2.136	2.129	2.140	2.086
1910															
% BAS	2.460	3.368	2.894	2.611	2.520	2.441	2.366	2.311	2.328	2.243	2.269	2.262	2.266	2.323	2.377
1941															
% BAS	3.218	4.267	3.653	3.424	3.242	3.186	3.108	3.104	3.005	3.019	2.971	2.987	2.960	3.026	3.252
1966															
% BAS	2.038	2.470	2.251	2.116	2.036	2.020	2.010	1.989	1.983	1.979	1.969	1.978	1.943	1.989	1.863
2022															
% BAS	2.737	3.386	3.020	2.850	2.734	2.715	2.677	2.680	2.666	2.638	2.614	2.581	2.567	2.641	2.637
2090															
% BAS	2.981	4.061	3.361	3.152	3.024	3.011	2.885	2.806	2.791	2.748	2.787	2.805	2.835	2.754	2.879
3011															
% BAS	2.799	3.473	3.169	3.004	2.841	2.807	2.755	2.707	2.663	2.677	2.688	2.611	2.657	2.709	2.532
3174															
% BAS	1.715	2.163	1.943	1.800	1.749	1.712	1.656	1.665	1.638	1.638	1.627	1.627	1.617	1.609	1.642
Tests of Difference															
ANOVA		26.1***	23.5***	22.7***	21.3***	21.4***	21.5***	21.1***	20.8***	21.2***	20.5***	20.5***	20.7***	22.0***	26.9***
Wilcoxon		1926.1***	1923.5***	1878.2***	1884.0***	1901.9***	1888.8***	1817.8***	1784.4***	1797.5***	1784.6***	1793.8***	1743.3***	1851.6***	2201.9***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

the beginning of the day suggest that all specialist firms face more uncertainty at that point than later in the trading day, possibly because of the lack of trading overnight and the risk of adverse information.

These results indicate that hypothesis one (H1) for the percentage bid-ask spread is rejected and the pattern is not similar across specialist firms. The overall percentage bid-ask spread across half-hour trading intervals is larger at the beginning of the day with a gradual decline during the trading day. Generally, the intraday pattern is similar across specialist firms, but is not identical at the end of the day. Some specialist firms have a peak in the final trading interval while others have a peak in the second-last trading interval. In a few other specialist firms the peak is slightly earlier in the trading day. The tests of difference across the specialist firms show statistically significant differences across each of the half-hour periods, but this may be partially explained as a function of the characteristics of stocks held by the specialist firm since a stock's price impacts on the percentage bid-ask spread. Nevertheless, the patterns differ across the specialist firms and it can be concluded that the percentage bid-ask spread is not the same for all the specialist firms.

5.4.1.4. End of the Trading Day Returns

The final return across specialist firms is reported in Tables 48 and 49. Table 48 examines the final return irrespective of the timing of the final two transactions. Table 49 requires that the final transaction occur after 3:45 pm while the previous transaction price used to calculate the return is the last transaction that occurred before 3:45 pm.

The overall final transaction return reported in Table 48 is 0.0785% and is statistically significant at a level of 1%. Of the 37 specialist firms, 28 are statistically

Table 48 This table reports the final intraday transaction return across specialist firms. Mean final intraday transaction returns (in percentages) are reported for May 1995 for each specialist firm. Parametric ANOVA tests and non-parametric Wilcoxon rank sums tests are conducted to test for differences across specialist firms.

Specialist	Return
20	0.0608***
34	0.0908*
104	0.0296
137	0.0958**
202	0.0461***
210	0.0753***
215	0.0883***
240	0.0180
298	0.0730***
364	0.1701***
403	0.0272*
501	0.0833***
520	-0.0166
551	0.0463*
1010	-0.0109
1027	0.0263
1034	0.0898
1148	0.1143**
1225	0.0489***
1227	0.0953***
1229	0.1523**
1266	0.2520***
1280	0.1281***
1341	0.0386*
1418	0.1011***
1679	0.0733***
1687	0.0482*
1726	0.0941***
1746	0.0427
1903	0.0458
1910	0.1648**
1941	0.1814***
1966	0.0376
2022	0.1305***
2090	0.1259**
3011	0.1328***
3174	0.0649***
overall	0.0785***
ANOVA	2.2***
Wilcoxon	53.8**

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

Table 49 This table reports the final fifteen minute return across specialist firms. Final fifteen minute return (in percent) is reported for May 1995 for each specialist firm. Parametric ANOVA tests and non-parametric Wilcoxon rank sums tests are conducted to test for differences across specialist firms.

Specialist	Return
20	0.0589**
34	0.1495***
104	0.0774**
137	0.0264
202	0.0776***
210	0.1057***
215	0.0952***
240	0.0062
298	0.0702***
364	0.1445**
403	0.0527***
501	0.0748***
520	0.0506
551	0.0775**
1010	0.0434
1027	0.0483
1034	0.3601***
1148	0.1212*
1225	0.0591**
1227	0.0739**
1229	0.0561
1266	0.3274***
1280	-0.0224
1341	0.0422*
1418	0.0607
1679	0.0750***
1687	0.1130***
1726	0.1329***
1746	0.0662
1903	0.0606**
1910	0.1610*
1941	0.1237***
1966	0.1160***
2022	0.1624***
2090	0.1670**
3011	0.0723
3174	0.0858***
overall	0.0851***
ANOVA	1.9***
Wilcoxon	47.4*

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

significant with positive means. There are 18 specialist firms that have significance levels of 1%, five with significance levels of 5% and five with significance levels of 10%.

Tests of difference across the specialist firms show that the final transaction returns are statistically significantly different using both parametric and non-parametric tests. The non-parametric test is significant at a level of 5% while the parametric test is statistically significant at a level of 1%.

When the final fifteen minute return is examined, on an overall basis, the mean return is 0.0851% and this is statistically significant at a level of 1%. Of the 37 specialist firms, 16 are positive and statistically significantly different from zero at a level of 1%. Positive means are also found for eight specialist firms with a statistical significance of 5% and three specialist firms with a statistical significance of 10%. The differences across the specialist firms is slightly less than that for the final transaction return in Table 48. The non-parametric test is statistically significant at a level of 10%, while the statistical significance of the parametric test remains at a level of 1%.

These results indicate that hypothesis one (H1) for the final transaction return is rejected both for the final transaction return irrespective of the timing of the final transaction and for the final fifteen minute return. In all cases, when the individual return for a specialist firm is significantly different from zero, it is positive. The final transaction return is not the same across the specialist firms. This suggests that some specialist firms may be undertaking actions that result in a positive and significant final transaction return, while others do not. This suggests that whatever is causing the positive final transaction return may be related to specialist firm characteristics.

5.4.1.5. Depth

The time-weighted depth of the bid and ask quotes is examined across specialist firms and reported in Table 50. On an overall basis, the mean ask depth is 40.5, or 4,050 shares and the mean bid depth is 43.1 or 4,310 shares. For 12 of the specialist firms, the overall ask depth is larger than the bid depth. For 24 specialist firms the reverse is true, and for one specialist firm the mean bid and ask depth are equal. On an overall basis, when the half-hour intervals during the trading day are examined, the bid depth is larger than the ask depth in each half-hour interval throughout the day. This is not true for the individual specialist firms. For the 12 specialist firms with overall means that have a larger mean ask depth, most of the half-hour intervals also have a larger mean ask depth. But in a few individual half-hour periods have larger mean bid depths. This general consistency is also true for the 24 firms that have a larger mean bid depth.

The overall intradaily pattern of mean ask and bid depths shows a low ask and bid depth at the beginning of the day. The depth levels increase during the day and peak immediately before the close. A test of the difference among the means across the individual half-hour trading intervals shows that the depths across the half-hour intervals are statistically significantly different using both parametric and non-parametric tests. This is confirmed for both the ask and the bid depth.

The ask and bid depths are also examined individually across half-hour intervals for each individual specialist firm. Of the 37 specialist firms, 36 have ask depths that are statistically significant (both parametrically and non-parametrically at a level of 1%) across the half-hour intervals. For the bid depths, there are 35 specialist firms that have statistically significant (both parametrically and non-parametrically at a level of 1%)

Table 50 This table reports depth within each thirty minute interval across specialist firms. The time-weighted bid and ask depth (in hundred-lots) is reported within each thirty minute interval. This is done on an overall basis as well as for each specialist firm. A parametric ANOVA test and a non-parametric Wilcoxon rank sums test are conducted to test for differences across specialist firms and across time intervals.

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Overall															
Ask Depth	40.5	15.2	28.7	35.2	39.7	42.6	44.8	46.5	47.0	47.8	48.3	48.3	48.1	47.6	24.5
Bid Depth	43.1	18.5	30.7	37.2	42.4	45.1	46.9	48.7	50.0	50.8	51.3	51.4	51.2	50.1	26.4
Specialist #															
20															
Ask Depth	50.5	21.9	35.4	43.4	46.5	50.1	54.3	53.7	56.4	56.8	59.3	56.8	55.5	53.5	58.7
Bid Depth	65.2	34.5	48.5	53.6	54.8	58.4	67.5	70.9	74.6	76.1	73.1	74.3	76.7	73.0	72.2
34															
Ask Depth	44.0	17.2	31.6	36.7	42.6	46.9	46.1	50.7	47.6	54.2	58.9	52.5	51.6	55.3	20.4
Bid Depth	50.8	19.4	34.7	44.3	51.5	52.4	53.4	60.8	59.4	61.8	67.5	63.8	57.8	61.4	18.9
104															
Ask Depth	40.7	14.0	23.5	32.4	36.0	41.8	45.9	47.5	49.1	50.4	49.5	53.8	49.9	51.5	20.6
Bid Depth	35.4	11.1	23.2	30.9	35.5	37.1	37.6	40.2	43.3	43.0	44.0	44.2	43.2	42.0	17.7
137															
Ask Depth	65.4	22.6	51.0	64.8	63.4	69.1	79.0	77.4	72.7	72.4	71.8	74.6	79.9	83.6	28.2
Bid Depth	66.7	26.2	51.4	62.6	63.3	70.0	76.4	73.9	73.9	77.7	81.3	81.9	83.2	81.8	25.6
202															
Ask Depth	40.4	13.6	28.8	35.8	40.0	42.2	45.3	47.8	46.6	44.0	46.0	46.7	47.9	46.6	31.6
Bid Depth	46.1	17.7	31.0	36.6	43.9	47.6	52.1	54.4	57.5	53.6	53.4	54.8	51.7	50.8	36.2
210															
Ask Depth	40.6	14.7	30.7	37.5	40.5	42.7	46.6	46.6	48.4	50.5	49.5	51.6	49.6	45.9	10.1
Bid Depth	50.1	26.5	39.2	45.8	48.2	52.2	56.7	58.4	58.6	59.0	59.7	62.8	60.4	58.3	13.1
215															
Ask Depth	31.2	14.5	24.6	27.8	30.6	32.6	33.4	34.1	35.4	38.4	37.6	36.8	38.8	36.4	14.3
Bid Depth	37.3	19.9	28.9	33.7	38.4	39.2	40.3	40.5	42.0	41.9	42.0	43.6	44.8	43.8	21.3

(table con'd)

(Table 50 continued)

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Specialist #															
240															
Ask Depth	33.6	14.0	26.0	28.1	32.2	34.8	34.9	37.6	40.9	42.4	43.8	42.7	42.4	40.6	8.2
Bid Depth	35.4	13.1	24.5	28.8	37.3	39.1	42.3	41.4	39.7	43.2	44.1	43.1	42.8	43.2	9.6
298															
Ask Depth	27.7	13.6	23.3	27.4	28.9	27.9	28.9	30.1	29.0	31.1	34.5	36.2	36.7	33.8	5.2
Bid Depth	33.0	18.2	26.0	29.2	33.4	33.8	33.9	37.0	35.5	38.2	41.4	42.3	43.6	41.1	7.3
364															
Ask Depth	53.7	20.7	39.4	47.8	62.2	59.3	59.2	63.4	58.1	62.3	60.4	61.7	59.7	60.3	33.4
Bid Depth	51.0	19.1	33.1	43.3	51.2	52.6	58.0	57.8	61.4	59.8	59.3	57.9	59.9	59.8	36.2
403															
Ask Depth	30.8	15.4	23.1	28.7	32.6	33.5	35.8	35.7	37.3	36.3	36.1	34.8	35.5	36.3	8.6
Bid Depth	36.4	22.9	31.0	35.8	38.6	40.6	41.4	41.2	42.8	40.8	41.1	40.5	41.3	39.6	10.3
501															
Ask Depth	35.8	12.7	23.7	26.8	32.2	37.3	38.2	39.8	41.9	41.9	42.4	43.0	41.6	42.5	33.6
Bid Depth	36.2	13.8	24.4	27.1	33.2	37.1	39.3	40.8	43.3	44.7	43.4	42.0	41.0	41.7	31.6
520															
Ask Depth	29.0	12.4	19.2	21.8	21.4	26.6	29.2	31.6	32.4	36.9	40.7	37.5	34.1	37.3	22.3
Bid Depth	31.8	14.7	18.9	20.8	27.3	29.2	32.5	37.9	37.1	35.9	39.7	38.4	39.2	37.6	34.0
551															
Ask Depth	32.1	13.8	22.0	25.6	30.5	35.4	35.6	39.2	38.9	40.1	39.1	41.1	40.1	37.7	7.8
Bid Depth	46.3	27.4	34.0	39.0	45.0	51.0	47.4	50.4	55.2	57.2	57.0	57.3	58.2	53.0	13.3
1010															
Ask Depth	29.6	12.3	19.6	25.1	29.6	27.7	28.4	28.4	36.2	35.8	40.3	40.0	43.7	40.7	4.5
Bid Depth	27.2	12.3	22.4	22.4	24.6	27.1	31.2	28.0	34.0	31.9	36.2	37.3	34.1	31.5	5.1
1027															
Ask Depth	77.5	27.3	74.3	79.8	95.1	92.1	90.1	95.6	82.4	78.4	79.1	73.2	74.1	74.6	62.6
Bid Depth	62.9	21.2	54.6	59.7	73.6	68.4	61.7	64.2	66.4	77.3	66.5	68.0	73.2	71.6	48.7

(table con'd)

(Table 50 continued)

Specialist #	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
1034															
Ask Depth	21.6	7.5	12.3	17.0	17.0	15.2	20.7	23.1	26.2	28.0	35.1	31.9	30.3	29.3	6.9
Bid Depth	15.6	8.0	11.0	13.5	16.0	17.7	17.6	18.7	16.8	17.2	17.9	18.5	19.6	18.5	6.5
1148															
Ask Depth	50.1	16.9	38.6	48.2	52.3	57.9	59.6	61.8	58.0	57.6	53.9	60.9	60.9	59.7	10.8
Bid Depth	47.0	16.0	30.7	43.8	51.0	56.4	55.9	55.8	54.8	55.1	55.0	55.2	55.3	57.6	11.4
1225															
Ask Depth	29.0	11.6	19.5	22.4	25.0	25.7	27.8	34.7	36.4	36.5	37.4	37.6	37.1	37.6	13.7
Bid Depth	33.3	22.0	27.2	30.3	33.0	32.3	30.7	34.3	36.4	37.4	41.6	40.7	41.2	41.1	16.2
1227															
Ask Depth	39.1	15.6	27.1	33.4	39.2	41.2	43.3	43.5	47.8	48.3	50.4	48.6	49.5	48.5	7.8
Bid Depth	44.5	18.9	31.5	40.5	44.5	46.3	47.1	48.9	52.8	53.2	55.8	57.5	57.7	57.3	8.3
1229															
Ask Depth	44.2	16.4	35.7	41.9	43.2	52.6	48.0	46.8	49.5	55.0	54.7	58.9	54.4	47.1	10.2
Bid Depth	52.7	21.7	36.8	45.3	52.1	70.0	60.8	63.6	64.6	68.0	65.1	63.1	58.9	54.1	9.8
1266															
Ask Depth	51.4	20.8	33.0	40.3	45.6	48.8	59.0	59.9	60.2	60.1	57.6	59.7	57.9	58.2	54.4
Bid Depth	51.5	18.9	29.3	43.9	52.2	50.6	55.6	53.8	54.2	59.2	61.4	64.9	63.7	62.5	46.0
1280															
Ask Depth	68.1	13.7	35.6	62.9	72.2	72.5	74.0	80.5	73.2	81.6	87.4	87.0	92.3	88.5	24.7
Bid Depth	58.7	16.9	33.8	54.7	64.4	65.6	65.8	70.4	67.2	73.0	72.4	68.7	70.5	72.7	19.3
1341															
Ask Depth	35.5	11.6	22.4	31.1	34.6	35.6	38.4	38.7	38.8	39.4	42.4	41.1	42.0	43.8	33.7
Bid Depth	37.8	16.6	25.7	31.3	34.8	33.2	39.2	41.4	42.6	45.2	44.7	44.4	45.5	45.5	36.5
1418															
Ask Depth	42.6	13.7	27.2	34.0	41.4	46.1	51.4	47.5	47.8	53.2	52.1	55.8	53.4	53.9	15.8
Bid Depth	44.5	16.2	31.7	38.8	45.3	48.4	50.9	49.2	52.9	55.1	53.4	52.3	56.8	52.5	16.7

(table con'd)

(Table 50 continued)

Specialist #	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
1679															
Ask Depth	45.4	15.0	28.8	35.4	40.6	45.7	48.6	52.9	51.6	52.7	58.2	54.3	50.1	55.6	41.1
Bid Depth	41.4	16.5	26.9	33.7	39.3	45.0	42.9	46.3	44.6	44.6	50.6	49.2	48.0	47.1	41.2
1687															
Ask Depth	42.7	16.2	29.9	40.4	43.5	50.7	44.2	46.8	50.9	50.7	48.1	46.6	46.1	45.1	35.6
Bid Depth	44.6	21.2	33.0	42.8	42.3	47.3	43.4	48.9	55.9	56.3	52.1	49.7	47.8	46.9	33.2
1726															
Ask Depth	38.7	13.8	28.3	35.1	42.1	44.0	44.7	48.6	45.1	43.1	45.1	45.1	43.3	42.0	18.0
Bid Depth	40.9	13.7	27.6	35.8	43.5	45.5	44.3	44.0	46.3	48.2	50.7	50.8	49.4	46.6	22.1
1746															
Ask Depth	45.4	15.0	30.5	38.6	46.7	52.2	55.9	59.2	52.6	54.1	55.7	54.8	56.7	48.9	10.2
Bid Depth	43.1	14.5	31.9	44.1	49.9	51.5	51.9	54.1	46.4	49.0	51.0	49.5	50.4	45.5	9.6
1903															
Ask Depth	36.9	14.4	26.9	33.0	38.9	37.5	39.0	40.6	41.7	41.1	40.3	38.4	40.3	41.4	39.5
Bid Depth	40.0	18.9	27.5	33.1	36.9	38.4	40.9	42.5	42.4	44.7	46.7	44.1	44.4	45.9	49.7
1910															
Ask Depth	54.1	21.1	40.4	49.4	53.6	56.0	56.0	59.0	61.2	58.0	56.8	64.7	62.9	61.1	52.3
Bid Depth	50.3	15.9	40.8	46.8	48.5	55.0	55.9	55.0	59.4	59.9	50.3	51.7	53.6	53.0	53.4
1941															
Ask Depth	56.9	19.4	39.8	52.1	57.6	59.8	63.4	65.0	66.8	68.1	67.7	63.3	65.0	64.9	38.8
Bid Depth	56.9	17.2	37.9	49.5	57.1	61.8	64.1	68.3	68.8	66.2	62.2	65.2	65.6	65.7	42.7
1966															
Ask Depth	32.5	15.0	26.3	30.0	33.9	34.9	39.5	42.0	40.7	36.6	36.6	39.2	36.3	35.6	6.0
Bid Depth	33.3	13.1	24.6	29.2	39.4	38.7	40.0	42.1	40.6	38.3	41.4	41.8	37.1	31.7	5.8
2022															
Ask Depth	47.1	15.5	36.5	44.0	46.1	46.9	46.9	53.1	59.1	59.0	55.1	55.9	56.9	54.8	25.3
Bid Depth	44.1	14.8	28.9	37.2	44.5	41.6	41.7	49.2	51.4	54.9	54.9	56.4	56.4	53.9	28.4
2090															
Ask Depth	72.2	19.3	45.9	68.3	77.4	76.8	85.3	85.5	84.5	85.0	84.2	80.0	76.4	71.8	63.0
Bid Depth	71.3	21.6	49.2	53.2	64.5	63.9	75.4	82.2	83.8	84.9	88.8	90.8	83.1	80.7	68.7

(table con'd)

(Table 50 continued)

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
Specialist #															
3011															
Ask Depth	31.4	9.6	18.3	24.4	24.6	29.3	33.4	34.4	36.9	35.4	31.7	33.8	36.4	32.1	56.4
Bid Depth	28.9	9.1	15.8	21.4	21.3	25.8	30.5	31.4	33.7	34.1	32.0	31.6	31.6	28.9	53.3
3174															
Ask Depth	34.6	12.4	20.3	22.5	29.8	35.9	38.1	41.1	40.6	41.8	44.0	41.3	40.8	43.8	28.8
Bid Depth	35.4	17.5	24.1	28.3	34.6	39.5	42.5	42.6	37.0	36.3	37.1	37.2	41.3	43.5	31.1

Tests of Difference

Ask Depth

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
ANOVA	79.8***	3.0***	6.4***	8.5***	8.1***	7.2***	7.6***	7.1***	5.8***	5.9***	5.7***	5.6***	5.9***	6.1***	24.9***
Wilcoxon	2792***	160.5***	205.2***	208.3***	194.4***	191.1***	201.6***	195.2***	191.1***	205.3***	200.9***	208.2***	202.0***	194.1***	2831.6***

Bid Depth

	overall	9:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30	11:30-12:00	12:00-12:30	12:30-1:00	1:00-1:30	1:30-2:00	2:00-2:30	2:30-3:00	3:00-3:30	3:30-4:00	4:00-4:30
ANOVA	63.8***	4.4***	5.0***	5.8***	4.9***	5.1***	5.5***	5.3***	5.3***	5.6***	5.2***	5.7***	5.4***	5.4***	23.7***
Wilcoxon	3268***	226.2***	262.5***	247.3***	222.2***	217.6***	225.5***	230.3***	221.6***	227.8***	241.5***	243.1***	238.3***	225.8***	2831.7***

* significant at $\alpha = 10\%$, ** significant at $\alpha = 5\%$, *** significant at $\alpha = 1\%$

depths across the half-hour intervals. One specialist firm has a statistically significant difference using a non-parametric Wilcoxon rank sums test but the parametric ANOVA test is not statistically significant.

The first half-hour mean depth is the smallest mean depth during the day for all 37 specialist firms. The decline in the depth levels from the 3:30-4:00 interval to the 4:00-4:30 interval is common to 35 of 37 specialist firms when the ask depth is examined and 36 of 37 specialist firms when the bid depth is considered.

The overall difference in mean depths across specialist firms within each half-hour interval is statistically significant both parametrically and non-parametrically at a level of 1% for both the bid depth and the ask depth.

These results indicate that hypothesis one (H1) is rejected both for the bid depth and the ask depth. The time-weighted depth in each period differs between the specialists when each half-hour interval is examined. The patterns throughout the day indicate that the depth increases following the opening, and the depth declines near the close. A larger mean depth is found for the bid depth in twice as many individual specialist firms. Whether the bid or the ask depth is larger, appears to be consistent across the day for most of the specialist firms. This suggests that the relative ask and bid depth sizes may be influenced by specialist firms' characteristics such as capitalization or risk aversion.

5.4.1.6. Summary

Hypothesis one (H1) is rejected for each of the price characteristics that are examined and there are clear differences across specialist firms. For volume, as measured by the percentage of day's volume that occurs in each half-hour trading interval, the percentage is found to differ among the specialist firms. This may indicate

that different specialist management strategies result in altering the timing of transactions. It may also indicate that certain types of traders are involved in specific stocks especially heavy near the close of trading. These two explanations are not mutually exclusive.

Volatility is measured in two ways, and both methods exhibit a reverse-J shape although the two methods have slightly different patterns in magnitude especially at the beginning and end of the trading day. The volatility measures are found to differ across the specialist firms.

The bid-ask spread has a pattern of decline during the trading day, with some specialist firms showing an increase near the close. This pattern is not consistent in magnitude, especially at the end of the day, and significant differences are found across the specialist firms.

The final transaction return and the final fifteen minute return have differences among the specialist firms. Significant difference are found parametrically, but non-parametric tests are at a lower level of significance. The significant positive means of the final return for some specialist firms and the insignificant means for the other specialist firms provides some support to the specialist explanations of the high end of day return. Since only some of the specialist firms exhibit this phenomenon it supports the suggestion that high returns are a technique for specialists to manage price or inventory.

The relative sizes of the mean ask and mean bid depths differ across specialist firms, with the number of specialist firms with a larger mean bid depth occurring twice as often as those specialist firms with a larger mean ask depth. The relative size is also consistent during the trading day. This may indicate that each specialist firm uses depth

in a certain way that may be related to the specialist firm's characteristics such as capitalization or risk aversion. The specialist, however, does not have complete control over depth. The quoted depth also includes public limit orders. The specialist only determines the minimum depth, therefore some of the differences across specialist firms may be attributable to the public limit orders for the specialist's stocks.

5.4.2. Differences Within Specialist Firms

Hypothesis two (H2) examines whether the pricing characteristics within a specialist firm are similar across individual specialists. For each specialist firm the number of individual specialists is reported. The pricing characteristics examined are volatility, the bid-ask spread, the end of day return and the ask and bid depths. The null of hypothesis two (H2) is that the pricing characteristic is the same for all individual specialists within an individual specialist firm. Each pricing characteristic is reported by taking the mean of the pricing characteristic for each individual specialist within each specialist firm. Then the mean of all individual specialists as well as the minimum and maximum values within each specialist firm are reported. A comparison across the individual specialists within each specialist firm is made and the parametric ANOVA test results and the non-parametric Wilcoxon rank sums[13] test results are reported.

5.4.2.1. Volatility

Volatility is examined using two separate measures and reported in Table 51. As explained in section 5.4.1.2., one measure of volatility is the high minus the low share price of transactions divided by the mean share price during each trading interval. A second measure is the standard deviation of successive midpoints of the bid-ask spread.

[13] The Wilcoxon rank scores test is used in the infrequent situation when only two individual specialists are compared.

Table 51 This table reports the volatility within specialist firms. Volatility is reported (in percent) using two measures. One measure calculates volatility as the difference between the high and the low share prices divided by the mean share price (H-L)/P for each half-hour. Volatility is also reported as the standard deviation of the change in successive midpoints of the bid-ask spread. Stocks are divided in groups based on the individual specialist location (post and panel). Mean, minimum and maximum volatility for individual specialists are reported for each specialist firm. The number of individual specialists within each specialist firm is reported. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences across individual specialists within each specialist firm.

	Mean	Min	Max	ANOVA	Wilcoxon
Specialist # (number of individual specialists)					
20 (10)					
(H-L)/P	0.235	0.102	0.437	72.0***	602.0***
standard dev.	0.215	0.136	0.305	56.1***	694.8***
34 (6)					
(H-L)/P	0.315	0.235	0.365	3.0**	120.6***
standard dev.	0.353	0.271	0.535	88.8***	144.5***
104 (9)					
(H-L)/P	0.249	0.139	0.361	16.2***	175.9***
standard dev.	0.305	0.199	0.439	28.4***	342.5***
137 (11)					
(H-L)/P	0.399	0.238	0.767	47.7***	392.5***
standard dev.	0.317	0.187	0.866	93.9***	256.0***
202 (16)					
(H-L)/P	0.279	0.082	0.554	50.5***	525.9***
standard dev.	0.241	0.178	0.426	59.3***	1209.4***
210 (16)					
(H-L)/P	0.334	0.143	0.531	39.0***	956.9***
standard dev.	0.283	0.154	0.685	135.6***	1762.3***
215 (15)					
(H-L)/P	0.314	0.193	0.523	35.8***	244.0***
standard dev.	0.286	0.161	0.709	31.2***	1175.2***
240 (6)					
(H-L)/P	0.331	0.179	0.913	27.9***	129.0***
standard dev.	0.739	0.147	3.116	114.9***	283.0***
298 (14)					
(H-L)/P	0.322	0.233	0.537	39.4***	245.4***
standard dev.	0.294	0.182	0.504	96.8***	1314.6***
364 (5)					
(H-L)/P	0.377	0.109	0.923	11.5***	45.7***
standard dev.	0.257	0.185	0.307	41.0***	129.0***
403 (18)					
(H-L)/P	0.315	0.070	0.536	63.1***	1352.7***
standard dev.	0.223	0.107	0.331	58.7***	1719.7***
501 (37)					
(H-L)/P	0.284	0.037	0.542	16.9***	968.2***
standard dev.	0.277	0.063	0.659	41.8***	3539.5***
520 (5)					
(H-L)/P	0.322	0.218	0.476	42.0***	182.3***
standard dev.	0.430	0.194	1.036	32.9***	276.4***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 51 continued)

Specialist # (number of specialist posts)

	Mean	Min	Max	ANOVA	Wilcoxon
551 (12)					
(H-L)/P	0.232	0.146	0.334	16.2^{***}	348.3^{***}
standard dev.	0.197	0.116	0.314	50.4^{***}	776.3^{***}
1010 (3)					
(H-L)/P	0.296	0.178	0.360	7.9^{***}	29.6^{***}
standard dev.	0.342	0.333	0.360	1.3	11.2^{***}
1027 (3)					
(H-L)/P	0.284	0.263	0.322	2.9^{***}	12.1^{***}
standard dev.	0.236	0.202	0.301	45.1^{***}	236.3^{***}
1034 (1)					
(H-L)/P	0.299	0.299	0.299	-	-
standard dev.	0.283	0.283	0.283	-	-
1148 (6)					
(H-L)/P	0.418	0.188	0.727	35.1^{***}	76.7^{***}
standard dev.	0.630	0.200	1.668	94.1^{***}	495.3^{***}
1225 (5)					
(H-L)/P	0.282	0.209	0.365	28.5^{***}	128.5^{***}
standard dev.	0.331	0.230	0.557	70.6^{***}	182.3^{***}
1227 (19)					
(H-L)/P	0.306	0.096	0.484	13.0^{***}	245.7^{***}
standard dev.	0.288	0.144	0.614	78.5^{***}	1332.1^{***}
1229 (4)					
(H-L)/P	0.324	0.234	0.363	3.9^{***}	39.4^{***}
standard dev.	0.322	0.262	0.391	24.0^{***}	112.7^{***}
1266 (7)					
(H-L)/P	0.344	0.135	0.491	17.0^{***}	338.2^{***}
standard dev.	0.317	0.172	0.566	57.4^{***}	275.2^{***}
1280 (2)					
(H-L)/P	0.339	0.283	0.395	32.0^{***}	23.7^{***}
standard dev.	0.313	0.232	0.395	109.8^{***}	32.0^{***}
1341 (6)					
(H-L)/P	0.438	0.321	0.597	27.4^{***}	141.7^{***}
standard dev.	0.298	0.207	0.329	17.7^{***}	309.4^{***}
1418 (13)					
(H-L)/P	0.355	0.224	0.574	17.9^{***}	306.8^{***}
standard dev.	0.321	0.120	0.654	59.6^{***}	1184.1^{***}
1679 (8)					
(H-L)/P	0.244	0.133	0.419	37.3^{***}	125.4^{***}
standard dev.	0.266	0.137	0.470	113.7^{***}	467.0^{***}
1687 (6)					
(H-L)/P	0.275	0.198	0.407	39.6^{***}	186.8^{***}
standard dev.	0.325	0.236	0.482	70.0^{***}	371.9^{***}
1726 (11)					
(H-L)/P	0.319	0.079	0.450	13.9^{***}	205.4^{***}
standard dev.	0.265	0.135	0.434	97.2^{***}	1093.3^{***}

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 51 continued)

<u>**Specialist #**</u> (number of specialist posts)

	Mean	Min	Max	ANOVA	Wilcoxon
1746 (3)					
(H-L)/P	0.337	0.293	0.388	10.6***	17.4***
standard dev.	0.383	0.269	0.551	97.2***	434.5***
1903 (15)					
(H-L)/P	0.283	0.125	0.595	41.8***	507.1***
standard dev.	0.295	0.147	0.642	49.1***	818.3***
1910 (4)					
(H-L)/P	0.208	0.184	0.219	1.0	7.2*
standard dev.	0.358	0.229	0.663	280.6***	582.7***
1941 (11)					
(H-L)/P	0.316	0.057	0.453	17.1***	151.2***
standard dev.	0.313	0.159	0.659	84.0***	802.2***
1966 (8)					
(H-L)/P	0.234	0.000	0.371	6.4***	114.5***
standard dev.	0.251	0.124	0.373	39.0***	818.9***
2022 (11)					
(H-L)/P	0.285	0.164	0.371	4.8***	30.6***
standard dev.	0.386	0.102	0.944	34.2***	532.7***
2090 (4)					
(H-L)/P	0.455	0.355	0.535	13.8***	64.7***
standard dev.	0.415	0.323	0.564	41.1***	77.8***
3011 (2)					
(H-L)/P	0.322	0.302	0.343	5.4**	60.6***
standard dev.	0.360	0.342	0.377	7.6***	118.9***
3174 (9)					
(H-L)/P	0.253	0.195	0.337	21.0***	83.2***
standard dev.	0.223	0.113	0.284	5.4***	403.6***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

For the 37 specialist firms examined, specialist number 1034 has only one individual specialist. Of the remaining 36 specialist firms the difference among the individual specialists within each of the specialist firms is statistically significant both parametrically and non-parametrically for both of the volatility measures at a level of significance of 1% with two exceptions. When using the volatility measure of the standard deviation of successive midpoints of the bid-ask spread, specialist number 1010 fails to reject the null hypothesis that the individual specialists all have the same volatility. When using the volatility measure of the high minus low price all divided by the mean price, specialist number 1910 fails to reject the null hypothesis that the individual specialists all have the same volatility using a parametric test. When using a non-parametric Wilcoxon rank sums test the null hypothesis was rejected but only at a level of significance of 10%.

These results indicate that there are differences between individual specialists in almost all specialist firms and therefore hypothesis two (H2) is rejected. For both volatility measures there are significant differences in 34 of the 36 specialist firms with more than one individual specialist.

5.4.2.2. Bid-Ask Spread

The percentage bid-ask spread is examined within specialist firms and the results are reported in Table 52. For the 36 specialist firms with more than one individual specialist, 34 specialist firms have parametric and non-parametric tests that indicate that there are statistically significant differences at significance levels of 1% among the individual specialists within each of the specialist firms. For the two specialist firms, numbers 1746 and 3011, that do not fall in this category, the statistical significance is 1%

Table 52 This table reports the bid-ask spread within specialist firms. The percentage bid-ask spreads (%BAS) are reported (in percent) for May 1995 by calculating the mean percentage bid-ask spread for each individual specialist within each specialist firm. Stocks are divided into groups based on the individual specialist location (post and panel). The mean, minimum and maximum bid-ask spreads for individual specialists are reported for each specialist firm. The number of individual specialists within each specialist unit is reported. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences across individual specialists within each specialist firm.

<u>Specialist #</u> (number of individual specialists)	% BAS	Minimum % BAS	Maximum % BAS	ANOVA	Wilcoxon
20 (10)	1.7499	0.7030	4.3319	346.0***	3405.6***
34 (6)	2.9438	2.0666	4.9732	395.6***	949.2***
104 (9)	2.8828	1.0833	4.5726	282.1***	3162.9***
137 (11)	2.5466	1.3182	4.6825	224.3***	1420.8***
202 (16)	2.1087	1.1264	5.2967	248.4***	2056.8***
210 (16)	1.9993	0.8326	3.6410	418.1***	7545.2***
215 (15)	2.5571	1.0156	6.7522	332.3***	4228.4***
240 (6)	2.6095	1.5124	4.4996	203.9***	1654.9***
298 (14)	2.4717	1.3729	4.8056	229.3***	3374.5***
364 (5)	2.4097	1.8666	3.1181	70.0***	963.2***
403 (18)	2.1968	0.8649	5.7891	251.8***	7475.7***
501 (37)	2.4284	0.2334	5.7257	248.0***	11052***
520 (5)	2.4436	1.6709	3.0742	128.4***	538.4***
551 (12)	1.7904	0.4777	3.4806	300.1***	1886.4***
1010 (3)	1.6768	1.3744	1.9190	138.7***	242.8***
1027 (3)	1.6274	1.5096	1.7982	24.7***	120.9***
1034 (1)	2.7931	2.7931	2.7931	-	-
1148 (6)	3.7295	1.1948	9.3155	721.3***	2077.1***
1225 (5)	2.0970	1.5283	3.7015	538.8***	1455.7***
1227 (19)	2.6196	0.7938	6.8061	199.9***	6053.7***
1229 (4)	2.3595	1.9906	3.1222	119.6***	194.2***
1266 (7)	2.5940	1.3498	4.5528	196.1***	795.7***
1280 (2)	2.4886	1.8196	3.1577	1369.4***	1558.7***
1341 (6)	2.3322	1.5864	4.1846	295.0***	702.4***
1418 (13)	2.2845	0.8249	6.0477	370.5***	6737.0***
1679 (8)	1.8453	0.6406	2.5374	124.1***	1166.7***
1687 (6)	2.0420	1.6309	2.4836	129.5***	762.8***
1726 (11)	2.3542	1.3698	4.9423	354.9***	1947.9***
1746 (3)	3.2117	2.1230	4.0502	161.5***	5.2*
1903 (15)	2.1380	0.8660	5.4760	259.0***	5028.2***
1910 (4)	2.4528	1.9083	3.0006	170.6***	262.1***
1941 (11)	2.9989	1.1393	5.6698	163.3***	1405.5***
1966 (8)	2.0329	0.8549	3.5220	277.6***	1976.1***
2022 (11)	2.4755	0.8179	6.4598	371.2***	2252.3***
2090 (4)	2.9721	2.4455	3.6695	104.7***	631.3***
3011 (2)	2.7505	2.3289	3.1721	383.1***	5.8**
3174 (9)	1.5760	5.9420	2.8960	313.9***	3119.3***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

for the parametric test for both of the specialist firms, while the non-parametric tests has significance levels of 10% and 5% for the two firms, respectively.

Hypothesis two (H2) is rejected when using the percentage bid-ask spread because in almost all cases, within almost all of the specialist firms, there are statistically significant differences across the individual specialists.

5.4.2.3. End of the Trading Day Returns

The final intraday transaction return is reported in Table 53 irrespective of the timing of the final two transactions. The final return is also reported in Table 54 by requiring that the final transaction occur after 3:45 pm and the prior price used to calculate the return is the last transaction that occurred before 3:45 pm.

Table 53 indicates that the final transaction return appears to be similar across the individual specialists within each specialist firm. Of the 36 specialist firms with at least one individual specialist, 27 have no statistically significant differences among the individual specialists within each individual specialist firm. Only three specialist firms have statistically significant differences using both parametric and non-parametric tests. Of the remaining six specialist firms, three have statistically significant differences according to parametric tests, while three have statistically significant differences according to non-parametric tests.

The final fifteen minute return in Table 54 appears to be robust across individual specialists within specialist firms, similar to the final transaction return in Table 53. Of the 36 specialist firms with at least one individual specialist, 27 have no statistically significant differences among the individual specialists within each individual specialist firm. Only three specialist firms have statistically significant differences using both

Table 53 This table reports the final intraday transaction return within specialist firms. Mean final intraday transaction returns (in percent) are reported for May 1995 by averaging the mean final transaction return for individual specialists within each specialist firm. Stocks are divided into groups based on the individual specialist location (post and panel). Mean, minimum and maximum returns of individual specialists are reported for each specialist firm. The number of individual specialists within each specialist firm is reported. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences across individual specialists within each specialist firm.

Specialist # (number of individual specialists)	Return	Minimum Return	Maximum Return	ANOVA	Wilcoxon
20 (10)	0.0407	-0.1000	0.1158	0.5	10.1
34 (5)	0.1162	-0.0730	0.2143	1.5	9.2*
104 (9)	-0.0290	-0.3960	0.1567	2.1**	20.6***
137 (11)	0.0784	-0.0850	0.2426	0.6	6.8
202 (16)	0.0466	-0.0460	0.1587	1.4	23.4*
210 (16)	0.0882	-0.0710	0.3132	1.2	33.8***
215 (15)	0.0871	0.0076	0.2576	0.9	16.3
240 (6)	0.0091	-0.1110	0.0923	0.4	6.3
298 (14)	0.0739	-0.0210	0.2145	1.4	15.4
364 (5)	0.1316	-0.1790	0.4673	0.7	0.3
403 (18)	0.0156	-0.3430	0.1563	1.6*	29.5**
501 (34)	0.0588	-0.3510	0.3608	0.7	35.4
520 (5)	-0.0180	-0.0760	0.0632	0.5	5.7
551 (11)	0.0281	-0.0750	0.0818	0.2	6.3
1010 (3)	0.0172	-0.0290	0.0868	0.2	0.7
1027 (3)	0.0268	0.0077	0.0418	0.1	0.1
1034 (1)	0.0898	0.0898	0.0898	-	-
1148 (5)	0.1001	0.0000	0.2631	0.9	3.3
1225 (5)	0.0422	-0.0720	0.1293	3.5***	14.8***
1227 (19)	0.1055	-0.1990	0.4209	1.7**	18.9
1229 (4)	0.1371	-0.0220	0.3270	1.2	9.2
1266 (5)	0.2079	0.0351	0.4266	1.2	3.8
1280 (2)	0.1516	0.0767	0.2264	2.5	0.8
1341 (5)	0.0321	-0.0420	0.0693	0.2	1.8
1418 (12)	0.0927	-0.0230	0.2230	0.6	17.9
1679 (8)	-0.0080	-0.6170	0.1344	0.4	2.6
1687 (6)	0.0369	-0.0590	0.1619	1.4	9.7
1726 (10)	0.0597	-0.4280	0.4780	3.0	20.1
1746 (3)	0.0471	0.0179	0.0902	0.2	0.1
1903 (15)	0.0509	-0.1050	0.2380	0.7	15.1
1910 (4)	0.0635	-0.3540	0.4507	2.8**	4.5
1941 (11)	0.1461	-0.0200	0.4200	1.5	5.9
1966 (8)	0.5879	-0.1010	3.8462	1.6	6.3
2022 (8)	0.0254	-0.7670	0.4576	1.9	7.1
2090 (4)	0.1236	-0.0530	0.2839	1.6	1.9
3011 (2)	0.1301	0.0938	0.1664	0.9	3.2*
3174 (8)	0.0701	-0.0060	0.1680	0.9	5.3

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

Table 54 This table reports the final fifteen minute return within specialist firms. Mean final fifteen minute returns (in percent) are reported for May 1995 by averaging the mean final transaction return for individual specialists within each specialist firm. Stocks are divided into groups based on the individual specialist location (post and panel) and the mean return is calculated for each specialist. Mean, minimum and maximum returns of individual specialists are reported for each specialist firm. The number of individual specialists within each specialist firm is reported. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences across individual specialists within each specialist firm.

<u>Specialist #</u> (number of individual specialists)	Return	Minimum Return	Maximum Return	ANOVA	Wilcoxon
20 (10)	0.0642	-0.0280	0.2890	0.5	8.7
34 (5)	0.1641	-0.0390	0.3065	1.4	6.9
104 (9)	0.0588	-0.2980	0.4243	0.7	6.0
137 (11)	0.0239	-0.1960	0.1525	0.6	9.0
202 (16)	0.0832	-0.0250	0.1992	0.3	8.1
210 (16)	0.1230	-0.0810	0.4715	1.6*	19.5
215 (15)	0.1129	0.0014	0.4992	0.8	23.1*
240 (6)	0.0049	-0.0770	0.2156	1.4	8.6
298 (14)	0.0757	-0.0280	0.2585	1.1	23.7**
364 (4)	0.1098	-0.0030	0.4420	12.5***	12.0***
403 (17)	0.0464	-0.3350	0.2741	1.1	19.2
501 (33)	0.0710	-0.1840	0.4871	0.9	27.2
520 (5)	0.0700	-0.0190	0.1763	1.1	7.2
551 (10)	0.0650	-0.1210	0.2316	1.2	6.6
1010 (3)	0.0798	0.0362	0.1637	0.1	0.5
1027 (3)	0.1149	-0.0290	0.2016*	2.0	4.7*
1034 (1)	0.3601	0.3601	0.3601	-	-
1148 (4)	0.1240	0.0501	0.1781	0.1	0.3
1225 (5)	0.0464	-0.1210	0.1662	3.7***	15.3***
1227 (18)	0.0840	-0.2210	0.3102	0.6	18.5
1229 (4)	0.0067	-0.2640	0.1804	0.3	1.8
1266 (5)	0.2531	0.0752	0.5770	1.4	3.2
1280 (2)	-0.0060	-0.0490	0.0367	0.4	0.1
1341 (5)	0.0473	-0.1500	0.1521	2.2*	7.3
1418 (11)	0.0664	-0.0390	0.1912	0.4	6.6
1679 (7)	0.0852	0.0415	0.2336	0.6	5.2
1687 (6)	0.0888	-0.0790	0.3188	3.0**	9.1
1726 (10)	0.1391	-0.0360	0.4692	2.9***	14.0*
1746 (3)	0.0767	-0.0980	0.2961	2.1	2.1
1903 (15)	0.0535	-0.1050	0.3112	0.7	10.9
1910 (4)	0.1134	-0.1310	0.3391	0.8	4.0
1941 (10)	0.0928	-0.2060	0.4163	1.2	2.9
1966 (5)	0.1154	0.0252	0.2110	1.0	4.7
2022 (6)	0.0325	-0.3430	0.2982	1.2	5.1
2090 (4)	0.1566	0.0596	0.2349	0.4	3.6
3011 (2)	0.0761	0.0589	0.0933	0.1	0.1
3174 (8)	0.0886	0.0287	0.1930	0.5	1.6

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

parametric and non-parametric tests, but only one of these three is the same specialist firm that has statistically significant differences in Table 53. Of the remaining six specialist firms, three have statistically significant differences according to parametric tests, while three have statistically significant differences according to non-parametric tests.

These results indicate that there are no statistically significant differences across individual specialists within a majority of the specialist firms. This therefore fails to reject hypothesis two (H2). This suggests that specialist firm characteristics may be driving the final transaction return since statistically significant differences across specialist firms are found and reported in Tables 48 and 49. Alternatively, low pwer of the test could result in no statistically significant differences. Furthermore, economic differences appear to be similar.

5.4.2.4. Depth

Mean, minimum and maximum depths of individual specialists are reported for each specialist firm in Table 55. The mean individual specialist ask depth is greater than the mean individual specialist bid depth for 13 of the 37 specialist firms. For all 36 specialist firms with more than one individual specialist, the parametric and non-parametric tests of difference between the individual specialists indicate the means are statistically significantly different at a level of 1%.

This result indicates that hypothesis two (H2) is rejected for both the bid and ask depths. The bid and ask depth levels are not the same across individual specialists within a specialist firm. The relative sizes of the bid and ask depths varies across the individual specialists.

Table 55 This table reports the depth within specialist firms. The time-weighted bid and ask depths (in hundred-lots) for May 1995 are calculated for each individual specialist within each specialist firm. Stocks are divided into groups based on the individual specialist location (post and panel). Mean, minimum and maximum depths of individual specialists are reported for each specialist unit. The number of individual specialists within each specialist unit is reported. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences across individual specialists within each specialist firm.

	Depth	Minimum Depth	Maximum Depth	ANOVA	Wilcoxon
<u>Specialist #</u> (number of individual specialists)					
20 (10)					
Ask Depth	51.1	25.2	99.5	41.8***	1144.3***
Bid Depth	66.3	19.7	117.9	36.7***	1224.6***
34 (6)					
Ask Depth	41.5	14.8	134.8	231.9***	943.5***
Bid Depth	47.8	16.9	111.0	72.1***	872.3***
104 (9)					
Ask Depth	36.9	10.7	77.7	51.4***	546.2***
Bid Depth	33.7	11.2	72.6	38.8***	526.8***
137 (11)					
Ask Depth	66.1	18.4	114.2	39.4***	454.6***
Bid Depth	68.9	12.8	148.1	45.7***	808.1***
202 (16)					
Ask Depth	41.9	10.0	72.7	39.1***	769.4***
Bid Depth	49.7	9.9	161.2	64.7***	1043.9***
210 (16)					
Ask Depth	34.4	9.0	111.0	93.7***	1411.1***
Bid Depth	44.1	8.9	130.8	86.7***	1636.2***
215 (15)					
Ask Depth	32.0	6.2	86.1	91.3***	1876.1***
Bid Depth	38.0	7.0	106.9	127.6***	2099.6***
240 (6)					
Ask Depth	35.5	14.0	73.8	97.3***	601.2***
Bid Depth	37.7	9.9	91.8	145.6***	612.0***
298 (14)					
Ask Depth	27.3	12.8	67.8	40.1***	494.5***
Bid Depth	31.4	13.1	79.9	53.2***	887.7***
364 (5)					
Ask Depth	50.9	13.4	86.1	46.4***	304.5***
Bid Depth	47.2	12.5	94.8	75.8***	261.6***
403 (18)					
Ask Depth	31.4	8.7	75.0	53.4***	1079.3***
Bid Depth	32.8	6.9	94.5	77.1***	1192.7***
501 (37)					
Ask Depth	34.4	3.7	157.8	98.4***	2829.5***
Bid Depth	35.2	3.7	113.8	64.2***	3074.4***
520 (5)					
Ask Depth	26.9	12.8	41.5	27.8***	120.8***
Bid Depth	27.9	15.2	57.5	46.3***	165.2***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 55 continued)

	Depth	Minimum Depth	Maximum Depth	ANOVA	Wilcoxon
Specialist # (number of individual specialists)					
551 (12)					
Ask Depth	38.1	7.3	123.9	64.2***	827.5***
Bid Depth	46.3	8.6	116.4	107.5***	1221.4***
1010 (3)					
Ask Depth	30.8	23.5	41.9	22.7***	61.6***
Bid Depth	27.4	21.5	37.4	22.9***	98.3***
1027 (3)					
Ask Depth	75.8	38.9	114.6	32.8***	189.0***
Bid Depth	61.9	35.7	91.4	26.8***	236.5***
1034 (1)					
Ask Depth	21.6	21.6	21.6	-	-
Bid Depth	15.6	15.6	15.6	-	-
1148 (6)					
Ask Depth	45.6	13.8	64.7	28.3***	246.1***
Bid Depth	41.3	10.9	62.9	37.9***	295.5***
1225 (5)					
Ask Depth	26.3	17.4	51.0	43.9***	149.1***
Bid Depth	34.3	16.8	65.3	43.4***	117.3***
1227 (19)					
Ask Depth	40.1	5.8	92.8	57.1***	1538.7***
Bid Depth	43.6	7.7	129.6	75.5***	1749.3***
1229 (4)					
Ask Depth	44.4	21.0	70.4	39.6***	104.1***
Bid Depth	53.2	26.8	100.5	64.4***	30.1***
1266 (7)					
Ask Depth	46.8	11.2	80.2	40.3***	310.0***
Bid Depth	49.4	10.8	91.7	32.0***	225.8***
1280 (2)					
Ask Depth	78.7	37.4	120.0	168.7***	8.2***
Bid Depth	66.2	36.8	95.5	114.6***	34.3***
1341 (6)					
Ask Depth	34.0	9.5	85.0	69.3***	528.7***
Bid Depth	35.9	8.5	94.3	82.3***	502.6***
1418 (13)					
Ask Depth	36.8	8.1	67.7	19.9***	242.7***
Bid Depth	37.0	6.1	93.6	42.6***	206.8***
1679 (8)					
Ask Depth	52.0	28.2	101.7	30.4***	193.6***
Bid Depth	44.8	28.1	71.0	13.9***	186.9***
1687 (6)					
Ask Depth	41.5	10.0	89.0	83.1***	533.8***
Bid Depth	43.4	7.9	79.9	77.8***	673.5***
1726 (11)					
Ask Depth	38.1	13.3	107.8	94.0***	1215.1***
Bid Depth	39.2	13.5	96.5	75.2***	1329.9***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 55 continued)

	Depth	Minimum Depth	Maximum Depth	ANOVA	Wilcoxon
Specialist # (number of individual specialists)					
1746 (3)					
Ask Depth	48.1	29.5	58.9	34.8***	47.3***
Bid Depth	45.8	28.6	57.2	40.5***	38.4***
1903 (15)					
Ask Depth	35.6	3.7	94.3	56.9***	1300.7***
Bid Depth	39.7	5.0	102.2	81.2***	1575.8***
1910 (4)					
Ask Depth	55.2	32.0	68.9	20.6***	132.2***
Bid Depth	51.3	34.6	66.0	17.6***	36.4***
1941 (11)					
Ask Depth	54.0	21.0	77.1	23.3***	510.1***
Bid Depth	53.4	16.1	120.4	48.6***	586.5***
1966 (8)					
Ask Depth	28.0	2.2	55.1	48.6***	821.7***
Bid Depth	29.5	1.5	71.8	59.3***	962.7***
2022 (11)					
Ask Depth	48.3	8.3	130.0	84.8***	474.9***
Bid Depth	43.8	8.1	111.1	57.6***	514.0***
2090 (4)					
Ask Depth	69.0	22.5	113.1	54.1***	103.5***
Bid Depth	67.5	19.0	102.7	75.5***	136.0***
3011 (2)					
Ask Depth	29.7	14.2	45.2	113.1***	273.7***
Bid Depth	27.9	19.4	36.4	41.5***	242.3***
3174 (9)					
Ask Depth	33.8	11.3	107.5	57.9***	194.4***
Bid Depth	35.1	11.7	96.4	51.5***	251.3***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

5.4.2.5. Summary

This section tests hypothesis two (H2) in order to determine if there are differences across individual specialists within a specialist firm. For most of the price characteristics examined there are statistically significant differences. For volatility, bid-ask spreads and depth there are statistically significant differences across individual specialists within a majority of the specialist firms. This suggests that these price formation characteristics may be a result of individual specialist differences and not necessarily attributable to the specialist firms. For the final transaction return of the day and the final fifteen minute return, the hypothesis is not rejected. Statistical differences are found for only a minority of the specialist firms. This suggests that characteristics of the specialist firm such as capitalization are related to the final returns during the trading day.

5.4.3. Level of Volume

The level of volume may be indicative of the level of profitability of stocks for specialists since it is through the actual capture of the bid-ask spread that a specialist firm earns revenue. Hypothesis three (H3) tests if the level of volume has an impact on the patterns observable in various price characteristics. The null hypothesis is that there is no difference between low and high volume stocks in various price formation characteristics. The price formation characteristics examined are the bid-ask spread, the final return, and the depths of bid and ask quotes. The volume groups are determined by ranking the volume of stocks within each individual specialist within each specialist firm, and then dividing the stocks into two groups at the median. The median is included in the sample and is not discarded.

5.4.3.1. Bid-Ask Spread

The percentage bid-ask spread over the final half-hour of trading is examined in Table 56. This corresponds to the 3:30-4:00 column in Table 47. The results indicate that for the percentage bid-ask spread there are statistically significant differences at a level of 1% between the two volume groups in 25 of the 37 specialist firms. Of these 25 specialist firms, the percentage bid-ask spread is larger for the lower volume group in 23 specialist firms.

Of the 12 specialist firms that did not have statistically significant differences at a level of 1%, only one firm has no statistically significant differences in both the parametric and non-parametric tests. Three specialist firms have no non-parametric test significance while three specialist firms have no parametric test significance. The remaining four specialist firms have statistical significance in both parametric and non-parametric tests, however, the level of significance is at 5% or 10%. Of the 12 specialist firms that did not have the highest level of statistically significant differences, 7 have a larger bid-ask spread for stocks with low volumes.

The third hypothesis (H3) is rejected for the percentage bid-ask spread measure. The majority of specialist firms have a statistically significant difference between the two volume groups. In most cases the lower volume stocks have a larger percentage bid-ask spread. Since the higher volume stocks have a smaller percentage bid-ask spread this suggests that the higher volume stocks may not be fully compensating for the lower stocks' lack of volume. They could still be higher than may occur without a specialist. Another possibility is that the lower volume stocks have a lower price and this may be driving the results.

Table 56 This table reports the bid-ask spread in the final half-hour of trading across specialist firms and volume. The time-weighted percentage bid-ask spreads are reported within the final half-hour of trading (from 3:30 pm - 4:00 pm) for May 1995. Stocks are divided into two groups within each specialist firm based on volume and the final half-hour percentage bid-ask spread is reported for each group. Parametric ANOVA test and non-parametric Wilcoxon rank scores tests are conducted to test for difference between the volume groups. Parametric ANOVA test and non-parametric Wilcoxon rank sums tests are conducted to test for difference between the specialist firms.

Specialist	% Bid-Ask Spread	low vol. stocks % Bid-Ask Spread	high vol. Stocks % Bid-Ask Spread	ANOVA	Wilcoxon
20	1.600	2.144	1.150	101.7***	103.4***
34	2.659	3.553	2.142	67.1***	15.9***
104	2.765	2.864	2.664	1.6	7.7***
137	2.528	3.675	1.551	157.0***	267.7***
202	2.187	3.100	1.427	140.1***	60.9***
210	1.979	2.084	1.890	6.4**	1.8
215	2.389	3.338	1.565	147.5***	273.7***
240	2.509	2.550	2.473	0.1	25.7***
298	2.288	3.201	1.467	168.7***	184.8***
364	2.343	2.198	2.508	2.3	11.2***
403	2.393	3.295	1.593	110.1***	203.5***
501	2.371	3.319	1.522	487.9***	723.5***
520	2.394	3.129	1.755	53.6***	24.4***
551	1.764	2.200	1.356	67.3***	107.0***
1010	1.485	1.395	1.562	3.7*	12.1***
1027	1.500	1.860	1.175	34.8***	32.1***
1034	2.906	4.058	1.919	95.0***	66.8***
1148	3.605	4.593	2.448	44.2***	49.2***
1225	1.995	2.409	1.604	43.6***	22.2***
1227	2.562	3.300	1.928	87.2***	165.8***
1229	2.183	1.922	2.429	9.5***	12.6***
1266	2.365	2.614	2.145	5.6**	39.0***
1280	2.125	2.256	1.994	4.3**	13.0
1341	2.318	2.786	1.918	26.2***	1.1
1418	2.705	3.161	2.262	22.9***	101.7***
1679	1.844	2.097	1.630	26.7***	4.0**
1687	1.917	2.029	1.819	7.9***	7.0***
1726	2.243	2.947	1.564	117.3***	161.7***
1746	2.878	4.187	1.755	51.9***	37.9***
1903	2.140	2.747	1.594	71.1***	42.6***
1910	2.323	2.018	2.640	17.3***	7.5***
1941	3.026	4.051	2.043	91.4***	171.2***
1966	1.989	2.096	1.902	2.8*	37.5***
2022	2.641	3.324	2.314	29.0***	86.2***
2090	2.754	2.753	2.755	0.0	0.0
3011	2.709	2.635	2.775	0.7	4.6**
3174	1.609	1.979	1.285	101.0***	60.9***
overall	2.335	2.929	1.813	1654.0***	2389.2***
ANOVA	22.0***	18.1***	32.0***		
Wilcoxon	1851.6***	972.9***	1810.5***		

*significant at α = 10%, **significant at α = 5%, ***significant at α = 1%

Although not shown, a lower mean price for stocks with higher volumes is confirmed. The higher price is, on average, only 18% higher which lessens the likely impact of price on the difference in the percentage bid-ask spread between the two groups. Of the 37 specialist firms, 32 specialist firms have a statistically significant difference between the price level of the stocks in the two volume groups. Of the 32 specialist firms, in 24 specialist firms the lower mean price is in the stocks with lower volume, while 8 specialist firms have a lower mean price in the higher volume stocks. This price effect may be a partial explanation, but it does not explain the entire difference since a lower price is not found in all the lower volume groups.

5.4.3.2. End of the Trading Day Returns

The final transaction return is examined across the two volume groups in Table 57. There are limited differences between the two volume groups. Only 8 of the 37 specialist firms have statistically significant differences in either the parametric and/or the non-parametric tests. Of these 8 firms, only two have any tests of difference that have a level of statistical significance that is 1%. While this fails to reject the hypothesis that the two groups are the same, it is interesting to note that the statistical significance of the difference across the specialist firms within each of the individual volume groups is not the same for the low and the high volume groups. The tests of difference for the low volume groups are not statistically significant, while the tests of difference for the high volume group are statistically significant at a level of 1% for the parametric test and 10% for the non-parametric test.

Differences across volume groups and the final fifteen minute return are examined in Table 58. The number of specialist firms with statistically significant

Table 57 This table reports the final intraday transaction return across specialist firms and volume. Mean final intraday transaction return (in percentages) is reported for May 1995. Stocks are divided into two groups within each specialist firm based on volume and the final intraday transaction return is reported for each group. Parametric ANOVA tests and non-parametric Wilcoxon rank scores tests are conducted to test for differences between the volume groups. Parametric ANOVA tests and non-parametric Wilcoxon rank sums tests are conducted to test for differences across specialist firms.

Specialist	Return	low volume stocks Return	high volume stocks Return	ANOVA	Wilcoxon rank scores
20	0.0608***	0.0728***	0.0558**	0.1	0.7
34	0.0908*	0.0495**	0.1064**	0.3	0.4
104	0.0296	0.0504	0.0224	0.2	0.2
137	0.0958**	0.2372**	0.0441**	5.2**	6.2**
202	0.0461***	0.0742***	0.0330***	1.5	0.5
210	0.0753***	0.0347***	0.0947***	2.3	2.3
215	0.0883***	0.1628***	0.0615**	5.6**	1.6
240	0.0180	0.0218	0.0162*	0.0	0.1
298	0.0730***	0.1018***	0.0614***	1.4	0.1
364	0.1701***	0.3366***	0.1153	3.8*	2.3
403	0.0272*	0.0305**	0.0256***	0.0	0.1
501	0.0833***	0.1500***	0.0592***	7.0***	0.5
520	-0.0166	0.0786	-0.0502**	3.5*	0.6
551	0.0463*	0.0327*	0.0498***	0.1	0.0
1010	-0.0109	-0.0692	0.0032	0.4	0.8
1027	0.0263	-0.0489	0.0647*	2.5	0.6
1034	0.0898	0.2042	0.0358	1.4	2.2
1148	0.1143**	0.1310*	0.1078**	0.0	0.0
1225	0.0489***	0.0823***	0.0366***	1.3	1.1
1227	0.0953***	0.1138***	0.0880***	0.2	0.1
1229	0.1523**	0.2840**	0.0932	2.0	1.5
1266	0.2520***	0.3326***	0.2155**	0.7	0.6
1280	0.1281***	0.1238**	0.1303	0.0	0.2
1341	0.0386*	0.2066**	-0.0409	7.2***	3.8*
1418	0.1011***	0.0687***	0.1176**	0.5	0.3
1679	0.0733***	0.1405**	0.0500***	3.0*	0.6
1687	0.0482*	0.0240***	0.0600*	0.4	0.1
1726	0.0941***	0.0961***	0.0932***	0.0	0.0
1746	0.0427	0.0692**	0.0317*	0.1	0.3
1903	0.0458	0.0427	0.0470***	0.0	1.5
1910	0.1648**	0.0403***	0.2009**	0.8	0.0
1941	0.1814***	0.1057***	0.2080**	1.1	3.6*
1966	0.0376	0.1038**	0.0201**	0.7	0.0
2022	0.1305***	0.2159***	0.0833	1.9	0.0
2090	0.1259**	0.1097**	0.1328***	0.0	0.0
3011	0.1328***	0.1181**	0.1399***	0.1	0.8
3174	0.0649***	0.0079***	0.0876***	3.8*	2.6
overall	0.0785***	0.0995***	0.0700***	7.0***	0.5
ANOVA	2.2***	1.1	2.3***		
Wilcoxon	53.8**	38.9	47.8*		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

Table 58 This table reports the final fifteen minute return across specialist firms and volume. Final fifteen minute return (in percent) is reported for May 1995. Stocks are divided into two groups within each specialist firm based on volume and the final fifteen minute return is reported for each group. Parametric ANOVA tests and non-parametric Wilcoxon rank scores tests are conducted to test for differences between the volume groups. Parametric ANOVA tests and non-parametric Wilcoxon rank sums tests are conducted to test for differences across specialist firms.

Specialist	Return	low volume stocks Return	high volume stocks Return	ANOVA	Wilcoxon rank scores
20	0.0589**	0.0940***	0.0510*	0.4	0.0
34	0.1495***	-0.0233**	0.1827**	1.9	2.3
104	0.0774**	0.0172	0.0884	0.5	0.2
137	0.0264	0.1515**	0.0048**	1.5	3.9**
202	0.0776***	0.0826***	0.0759***	0.0	0.4
210	0.1057***	0.0693***	0.1181***	1.1	0.2
215	0.0952***	0.1173***	0.0897**	0.2	0.3
240	0.0062	0.0058	0.0063*	0.0	0.3
298	0.0702***	0.1197***	0.0589***	1.8	0.0
364	0.1445**	0.3346***	0.1175	1.4	1.3
403	0.0527***	0.0758**	0.0457***	0.5	0.0
501	0.0748***	0.1431***	0.0620***	2.9*	0.9
520	0.0506	-0.0091	0.0645**	0.7	0.4
551	0.0775**	0.0695*	0.0788***	0.0	0.5
1010	0.0434	-0.0481	0.0611	0.6	1.0
1027	0.0483	-0.1959	0.1106*	5.9**	2.5
1034	0.3601***	0.6188	0.2027	2.8*	2.4
1148	0.1212*	0.1489*	0.1162**	0.0	1.3
1225	0.0591**	0.0692***	0.0569***	0.0	0.0
1227	0.0739**	0.0990***	0.0678***	0.2	0.1
1229	0.0561	0.2607**	-0.0047	1.2	1.6
1266	0.3274***	0.1929***	0.3640**	0.8	0.6
1280	-0.0224	-0.0442**	-0.0169	0.0	0.0
1341	0.0422*	0.0660**	0.0367	0.1	0.0
1418	0.0607	0.0579***	0.0617**	0.0	0.0
1679	0.0750***	0.1358**	0.0616***	1.1	0.6
1687	0.1130***	0.1154***	0.1123*	0.0	0.6
1726	0.1329***	0.1006***	0.1413***	0.3	0.2
1746	0.0662	0.0930**	0.0615*	0.0	0.2
1903	0.0606**	0.0571	0.0615***	0.0	0.3
1910	0.1610*	0.0587***	0.1786**	0.2	0.0
1941	0.1237***	0.1901***	0.1101**	0.7	7.7***
1966	0.1160***	0.0737**	0.1204**	0.2	0.2
2022	0.1624***	0.1556***	0.1641	0.0	1.0
2090	0.1670**	-0.0641**	0.2268***	3.1*	3.3*
3011	0.0723	0.0589**	0.0770***	0.0	0.0
3174	0.0858***	0.0151***	0.1023***	2.0	2.3
overall	0.0851***	0.0930***	0.0832***	0.4	2.3
ANOVA	1.9***	0.6	2.1***		
Wilcoxon	47.4*	29.9	51.0*		

*significant at α = 10%, **significant at α = 5%, ***significant at α = 1%

differences between the two volume groups are less numerous than in Table 57. Only 6 of the 37 specialist firms have any statistically significant differences between the two volume groups.

Hypothesis three (H3) fails to be rejected for the final transaction return and the final fifteen minute return. This indicates that the level of volume does not play a role in the return at the end of the day. Some literature suggests that the end of day price rise is related to the specialist, however, these results indicate that the final returns do not appear to be related to the level of volume of the stocks. This table does clarify the differences between the specialist firms that is examined in an overall basis in section 5.4.1.4. since statistically significant differences across the specialist firms are found only in those stocks that have a volume above the median.

5.4.3.3. Depth

The bid and ask depths are examined for stocks with high and low volume and the results are reported in Table 59. On an overall basis, the depth is larger for those stocks in the higher volume group. The difference is statistically significant at a level of 1% for both the parametric and non-parametric tests. Of the 37 specialist firms, 13 have statistically significant differences at a level of 1% between the two groups for both the bid and the ask depth. As may be expected, in each of these specialist firms the higher volume stocks have a greater depth than the lower volume stocks.

The other 24 specialist firms exhibit interesting patterns. In 10 of the specialist firms the higher volume stocks have larger bid and ask depths, however, the statistical significance of the tests are not at a level of 1% for all parametric and non-parametric tests. In four of the specialist firms there are no statistically significant differences in the

Table 59 This table reports the depth in the final half-hour of trading across specialist firms and volume. The time-weighted bid and ask depth (in hundred-lots) is reported within the final half-hour of trading (from 3:30 pm – 4:00 pm) for May 1995. Stocks are divided into two groups within each specialist firm based on volume and the final half-hour percentage bid-ask spreads are reported for each group. Parametric ANOVA tests and non-parametric Wilcoxon rank scores tests are conducted to test for differences between the volume groups. Parametric ANOVA tests and non-parametric Wilcoxon rank sums tests are conducted to test for differences across specialist firms.

Specialist	Depth	low volume stocks Depth	high volume stocks Depth	ANOVA	Wilcoxon
Overall					
Ask Depth	24.5	15.5	32.5	259.5***	504.0***
Bid Depth	26.4	19.1	32.8	145.3***	328.9***
Specialist #					
20					
Ask Depth	58.7	42.7	72.0	8.4***	28.3***
Bid Depth	72.2	43.4	96.1	17.1***	23.2***
34					
Ask Depth	20.4	8.8	27.2	5.8**	34.7***
Bid Depth	18.9	8.5	25.1	5.8**	26.3***
104					
Ask Depth	20.6	14.1	27.2	4.3**	5.9**
Bid Depth	17.7	10.3	25.3	7.8***	3.7*
137					
Ask Depth	28.2	11.5	42.6	15.5***	51.2***
Bid Depth	25.6	11.0	38.1	15.4***	38.6***
202					
Ask Depth	31.6	14.1	46.5	27.0***	67.2***
Bid Depth	36.2	22.6	47.8	11.9***	36.9***
210					
Ask Depth	10.1	5.2	14.3	24.5***	43.5***
Bid Depth	13.1	11.1	14.7	1.5	32.7***
215					
Ask Depth	14.3	17.9	11.1	6.3**	1.3
Bid Depth	21.3	27.1	16.2	5.8**	0.2
240					
Ask Depth	8.2	8.1	8.3	0.0	1.4
Bid Depth	9.6	13.6	6.1	6.2**	4.4**
298					
Ask Depth	5.2	4.3	6.1	6.1**	41.8***
Bid Depth	7.3	7.0	7.5	0.2	11.9***
364					
Ask Depth	33.4	24.5	43.5	3.2*	4.0**
Bid Depth	36.2	26.3	47.4	3.7*	0.2
403					
Ask Depth	8.6	5.3	11.6	16.4***	65.8***
Bid Depth	10.3	7.6	12.6	5.1**	62.1***
501					
Ask Depth	33.6	17.6	48.1	62.8***	114.5***
Bid Depth	31.6	17.9	44.1	56.9***	117.9***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$ (table con'd)

(Table 59 continued)

Specialist	Depth	low volume stocks Depth	high volume stocks Depth	ANOVA	Wilcoxon
Specialist #					
520					
Ask Depth	22.3	20.9	23.5	0.2	3.5*
Bid Depth	34.0	48.8	21.0	4.8**	0.5
551					
Ask Depth	7.8	6.6	8.9	3.3*	7.9***
Bid Depth	13.3	10.6	15.8	2.8*	3.3*
1010					
Ask Depth	4.5	4.7	4.4	0.0	0.1
Bid Depth	5.1	3.6	6.5	3.1*	2.5
1027					
Ask Depth	62.6	63.7	61.6	0.0	2.0
Bid Depth	48.7	56.5	41.8	0.5	4.2**
1034					
Ask Depth	6.9	4.8	8.7	1.6	0.1
Bid Depth	6.5	5.1	7.6	0.7	0.6
1148					
Ask Depth	10.8	7.1	15.0	5.2**	6.0**
Bid Depth	11.4	9.7	13.5	0.8	0.7
1225					
Ask Depth	13.7	8.7	18.6	4.1**	1.7
Bid Depth	16.2	19.2	13.3	1.1	0.6
1227					
Ask Depth	7.8	5.7	9.6	10.9***	20.4***
Bid Depth	8.3	6.4	9.9	11.8***	15.9***
1229					
Ask Depth	10.2	6.8	13.3	5.4**	14.7***
Bid Depth	9.8	7.0	12.4	4.5**	18.9***
1266					
Ask Depth	54.4	48.6	59.5	0.8	0.6
Bid Depth	46.0	44.6	47.2	0.1	0.6
1280					
Ask Depth	24.7	5.9	43.5	9.4***	13.9***
Bid Depth	19.3	5.7	32.8	14.7***	16.6***
1341					
Ask Depth	33.7	22.4	43.3	6.6**	1.4
Bid Depth	36.5	23.4	47.8	6.5**	0.9
1418					
Ask Depth	15.8	9.6	21.8	16.9***	42.7***
Bid Depth	16.7	8.3	25.0	19.0***	42.6***
1679					
Ask Depth	41.1	15.9	62.7	21.2***	54.5***
Bid Depth	41.2	18.8	60.4	21.8***	23.3***
1687					
Ask Depth	35.6	19.0	50.1	16.3***	30.3***
Bid Depth	33.2	21.0	44.0	8.6***	21.9***

*significant at α = 10%, **significant at α = 5%, ***significant at α = 1%

(table con'd)

(Table 59 continued)

Specialist	Depth	low volume stocks Depth	high volume stocks Depth	ANOVA	Wilcoxon
Specialist #					
1726					
Ask Depth	18.0	18.2	17.7	0.0	1.1
Bid Depth	22.1	22.5	21.6	0.0	1.8
1746					
Ask Depth	10.2	9.9	10.5	0.1	0.8
Bid Depth	9.6	11.5	8.0	3.0*	5.2**
1903					
Ask Depth	39.5	24.8	52.8	18.4***	15.8***
Bid Depth	49.7	34.8	63.1	11.2***	9.9***
1910					
Ask Depth	52.3	31.7	73.8	10.7***	39.3***
Bid Depth	53.4	35.1	72.6	7.8***	27.7***
1941					
Ask Depth	38.8	22.9	54.1	26.7***	74.4***
Bid Depth	42.7	30.1	54.8	9.6***	67.6***
1966					
Ask Depth	6.0	3.0	8.5	17.2***	40.1***
Bid Depth	5.8	4.2	7.1	6.6**	36.4***
2022					
Ask Depth	25.3	17.2	29.2	4.0**	11.6***
Bid Depth	28.4	22.7	31.1	1.4	2.8*
2090					
Ask Depth	63.0	40.7	81.9	5.7**	3.6*
Bid Depth	68.7	51.5	83.2	3.6*	0.7
3011					
Ask Depth	56.4	11.1	97.3	22.2***	4.9**
Bid Depth	53.3	17.5	85.8	16.1***	2.3
3174					
Ask Depth	28.8	22.8	34.0	1.9	2.6
Bid Depth	31.1	33.5	29.0	0.3	0.7

Tests of Difference

Ask Depth			
ANOVA	24.9***	16.9***	16.9***
Wilcoxon	2832***	1311***	1851***
Bid Depth			
ANOVA	23.7***	11.2***	17.6***
Wilcoxon	2832***	1287***	1843***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

depth levels of the two groups. In specialist firm number 215 the lower volume stocks have a greater depth, but only the parametric tests are statistically significant. In specialist firm 240 the ask depth of the two groups is not statistically significantly different, however, the bid depth is greater and this difference is statistically significant at a level of 5% for both the parametric and non-parametric tests. Specialist numbers 520, 1010 and 1746 have ask depths that are very similar, but the bid depth is much larger for the lower volume group of stocks and this difference is statistically significant.

Hypothesis three (H3) is rejected for 23 of the specialist firms and for these firms the larger volume group of stocks has a larger bid and ask depth. The pattern in the other 14 specialist firms suggest that there are differences in depth and the way depth is used by specialist firms. For some of the specialist firms the lower volume group of stocks have a greater depth level, especially bid depth. The hypothesis can be rejected since there are some differences between the two groups, however, the differences are not robust and this may indicate that specialist firms are using depth in different ways.

5.4.3.4. Summary

This hypothesis examines the effect of volume on various price characteristics. The results show that the bid-ask spread is larger for lower volume stocks and this indicates that the higher volume stocks are not subsidizing lower volume stocks. The higher price of lower volume stocks is only a partial explanation of the higher bid-ask spreads. The final returns do not differ across the volume groups. This indicates that the end of the day price rise explanations that involve the specialist are not related to the level of volume. For a majority of the specialist firms, the depth measures are found to differ between the two volume groups, however, a minority of specialist firms have

patterns that are significant and opposite to the majority. This is the most interesting finding in this section and suggests that specialist firms have a variety of ways to use depth.

5.4.4. Adjustment of Quotes Near the End of the Day Across Specialist Firms

The final transaction of the day generates a return that has been found to be large in many previous studies. Hypothesis four (H4) investigates whether the changes that occur immediately preceding the final quotes are the same across specialist firms. The effect on the bid-ask spread is the focus of this hypothesis, however, the bid and the ask prices are also examined separately to more fully explain how the bid-ask spread is altered. Table 60 reports the change in the percentage bid-ask spread at the end of the day between the final two quotes. On an overall basis, the percentage bid-ask spread increases by 0.4249% between the final two quotes of the trading day. This increase is consistent across specialist firms, however, the magnitude varies. Tests of difference are statistically significant at a level of 1% using both parametric and non-parametric tests.

The percentage change in bid price decreases on an overall basis by 0.1764%, while the ask price increases by 0.2475%. Of the 37 specialist firms, 35 have a statistically significant bid price decline and 36 have a statistically significant ask price increase. The difference across the specialist firms is statistically significant at a level of 1% using a non-parametric test, but is insignificantly different using a parametric test.

These results indicate that hypothesis four (H4) is rejected since the change in the percentage bid-ask spread does differ across the specialist firms. The consistent change in the bid and ask price indicates that the null of hypothesis four (H4) can not be rejected. Most of the specialist firms report a similar adjustment and parametric tests fail to find any statistically significant difference across the specialist firms.

Table 60 This table reports the final quote adjustment across specialist firms. This table reports the percent change in the % bid-ask spread and the percent change in the bid and ask price between the final two transactions of the trading day. A parametric ANOVA test and a non-parametric Wilcoxon rank sums test are conducted to test for differences across specialist firms.

Specialist	Change in Percentage Bid-Ask Spread	% Change in Bid Price	% Change in Ask Price
20	0.2303***	-0.1087***	0.1208***
34	0.3740***	-0.2137***	0.1590***
104	0.5769***	-0.2828***	0.2921***
137	0.3886***	-0.1682***	0.2082***
202	0.4772***	-0.2355***	0.2411***
210	0.2085***	-0.1014***	0.1061***
215	0.4293***	-0.1966***	0.2320***
240	0.8716***	-0.3710***	0.5315***
298	0.3869***	0.2193	0.5957
364	0.5914***	-0.2926***	0.2992***
403	0.3663***	-0.1863***	0.1798***
501	0.3195***	0.0219	0.3359***
520	0.5258***	-0.2852***	0.2398***
551	0.3089***	-0.1412***	0.1671***
1010	0.2434***	-0.1087**	0.1382*
1027	0.4104***	-0.1994***	0.2121***
1034	1.6750***	-0.8156***	0.8590***
1148	0.4583***	-0.2671***	0.2022**
1225	0.6373***	-0.2885***	0.3519***
1227	0.4160***	-0.2117***	0.2031***
1229	0.5365***	-0.2779***	0.2619***
1266	0.3668***	-0.1882***	0.1789***
1280	0.5455***	-0.2668***	0.2782***
1341	0.3611***	-0.1783***	0.1805***
1418	0.4217***	-0.2240***	0.1980***
1679	0.5673***	-0.2778***	0.2897***
1687	0.5161***	-0.2509***	0.2678***
1726	0.4084***	-0.2673***	0.1358**
1746	0.3752***	-0.1783***	0.1969***
1903	0.3335***	-0.1747***	0.1575***
1910	0.7851***	-0.4031***	0.3784***
1941	0.3618***	-0.1708***	0.1900***
1966	0.4393***	-0.2210***	0.2185***
2022	0.5636***	-0.2660***	0.2998***
2090	0.5203***	-0.2447***	0.2753***
3011	0.8170***	-0.4267***	0.3897***
3174	0.3167***	-0.1563***	0.1604***
overall	0.4249***	-0.1764***	0.2475***
ANOVA	5.8***	1.1	0.8
Wilcoxon	227.9***	211.6***	215.9***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

5.4.5. Effect of Inventory Accumulation

Accumulated inventory may play a role in the intraday price formation because of a specialist firm's ability to withstand a build-up or decline in inventory. Madhavan and Sofianos (1998) suggest specialists are more likely to buy when their inventory is low and sell when their inventory is high. They also suggest specialist involvement increases when the bid-ask spread widens. The effect of inventory accumulation on the bid-ask spread is uncertain. In this section, the short-term impact of inventory changes is examined. The null of hypothesis five (H5) is that accumulated inventory has no effect on price formation characteristics. The price formation characteristics that are examined are the bid-ask spread, the returns at the end of the trading day and volatility at the end of the day.

Inventory accumulation is done by assigning the direction of trade for each transaction based on Lee and Ready's (1991) procedure. The inventory changes are then accumulated during the trading day before 3:30 and then the resulting totals are ranked into five groups.

5.4.5.1. Bid-Ask Spread

The percentage bid-ask spread during the 3:30-4:00 time interval is reported across inventory accumulation quintiles in Table 61. On an overall basis, the percentage bid-ask spread exhibits an inverted U-shape. This may be explained as a result of low-volume low-priced stocks having little inventory changes and thus being concentrated in the middle quintiles.

The patterns across the inventory accumulation quintiles within each specialist firm are examined for the 32 of the 37 specialist firms that have statistically significant differences across the quintiles. Of these specialist firms, 6 have their peak in the second

Table 61 This table reports the bid-ask spread in the final half-hour of trading across inventory accumulation quintiles and specialist firms. The time-weighted percentage bid-ask spreads (% BAS) are reported in the final half-hour of trading (3:30 pm - 4:00 pm) for May 1995. The bid-ask spreads are reported in groups based on inventory accumulation quintiles. Inventory accumulation quintiles are formed by assigning the direction of trade for each transaction before 3:30 pm based on Lee and Ready's (1991) procedure and then accumulating inventory. The inventory changes for each day are then ranked into five groups. Parametric ANOVA tests and non-parametric Wilcoxon rank sums tests are conducted to test for difference across the inventory accumulation quintiles and across the specialist firms.

Specialist	Overall Bid-Ask Spread	Inventory Accumulation Group 1 low (negative)	2	3 medium	4	5 high (positive)	ANOVA	Wilcoxon
20	1.778	1.208	2.379	2.022	2.185	1.182	11.5^{***}	64.4^{***}
34	2.882	2.316	2.609	3.442	3.019	2.174	11.8^{***}	26.6^{***}
104	2.721	2.007	3.234	3.338	3.014	1.847	34.7^{***}	105.9^{***}
137	2.636	1.574	2.713	4.905	2.524	1.176	63.2^{***}	339.6^{***}
202	2.193	1.458	1.933	4.050	1.721	1.359	69.1^{***}	96.2^{***}
210	1.950	1.329	2.116	3.107	1.891	1.303	87.5^{***}	323.0^{***}
215	2.256	1.400	2.439	3.824	2.382	1.233	74.4^{***}	447.7^{***}
240	2.505	1.562	3.414	3.228	2.899	1.434	13.4^{***}	119.0^{***}
298	2.311	1.521	2.194	4.279	1.940	1.297	80.5^{***}	321.5^{***}
364	2.506	2.656		2.439		2.693	0.6	0.9
403	2.417	1.525	2.052	4.246	2.069	1.279	56.9^{***}	146.1^{***}
501	2.349	1.421	2.872	3.193	2.588	1.290	101.2^{***}	691.6^{***}
520	2.443	1.668	2.704	3.526	2.190	1.775	14.3^{***}	62.5^{***}
551	1.812	1.299	2.500	2.123	2.310	1.206	24.5^{***}	94.7^{***}
1010	1.616	1.761	1.532	1.532	1.478	1.764	1.8	8.4^{*}
1027	1.466	1.369	1.550	1.588	1.563	1.238	3.4^{**}	13.1^{**}
1034	2.255	2.043	2.331	2.201	2.499	2.210	0.9	4.9
1148	3.707	2.406	3.773	5.335	3.235	2.464	18.8^{***}	40.9^{***}
1225	2.072	1.617	2.336	2.744	2.127	1.532	21.8^{***}	91.7^{***}
1227	2.572	1.813	2.723	3.557	2.558	1.767	25.6^{***}	119.1^{***}
1229	2.305	2.318	2.631	2.121	3.263	2.041	5.4^{***}	24.2^{***}
1266	2.420	2.008	2.900	2.869	3.019	1.395	11.7^{***}	97.3^{***}
1280	2.386	1.732	2.665	2.847	2.879	1.807	18.0^{***}	81.0^{***}
1341	2.179	1.900	2.686	2.268	2.441	2.011	3.7^{***}	11.5^{**}
1418	2.470	1.741	3.602	2.754	3.187	1.452	29.8^{***}	169.9^{***}
1679	1.793	1.583	2.059	1.748	2.151	1.582	9.8^{***}	58.9^{***}
1687	1.886	1.689	2.001	2.116	2.059	1.567	11.6^{***}	73.5^{***}
1726	2.438	1.904	2.662	3.169	2.539	1.397	27.7^{***}	151.4^{***}
1746	3.134	1.861	3.021	5.790	3.025	1.739	21.8^{***}	84.3^{***}
1903	2.086	1.534	1.991	3.070	1.983	1.298	30.7^{***}	115.4^{***}
1910	2.377	1.990	2.503	2.621	2.387	2.162	2.7^{**}	12.4^{**}
1941	3.252	1.496	3.472	5.719	2.777	1.367	74.7^{***}	257.3^{***}

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(Table 61 continued)

Specialist	Overall Bid-Ask Spread	Inventory Accumulation Group 1 low (negative)	2	3 medium	4	5 high (positive)	ANOVA	Wilcoxon
1966	1.863	1.582	2.586	1.986	2.247	1.412	15.3***	56.6***
2022	2.637	3.026		2.594		2.463	1.7	3.9
2090	2.879	2.193	3.148	3.423	3.454	2.174	8.8***	67.5***
3011	2.532	2.250	2.847	3.367	2.201	1.926	13.1***	41.4***
3174	1.642	1.392	1.776	2.140	1.655	1.169	27.7***	79.5***
overall	2.353	1.677	2.520	3.214	2.367	1.526	692.8***	3268.2***
ANOVA	2.2***	20.6***	8.4***	21.4***	9.9***	25.6***		
Wilcoxon	53.8**	776.1***	361.7***	942.1***	498.4***	1003.0***		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

inventory accumulation quintile, 5 have their peak in the fourth inventory accumulation quintile and 21 have their peak in the middle inventory accumulation quintile. This indicates that a smaller bid-ask spread, rather than a shift in the bid-ask spread, may be used by specialists in order to manage inventory changes.

The difference in the percentage bid-ask spread between the two extreme quintiles may be of interest since the low-volume, low-price explanation for the inverted U-shaped pattern suggests price levels will be less important in the extreme quintiles. Although not shown, this explanation is tested by examining the average stock price in each inventory accumulation quintile. On an overall basis the average price exhibits a U-shape and the mean prices are statistically significantly different across the inventory accumulation quintiles. When the individual specialist firms are examined, 35 of the 37 specialist firms exhibit the same U-shape.

For the 32 specialist firms with statistically significant differences across the inventory accumulation quintiles a comparison of the relative sizes of the percentage bid-ask spread is made between the two extreme inventory accumulation quintiles. Of the 32 specialist firms, 27 (5) specialist firms have percentage bid-ask spreads that are larger in the extremely negative (positive) inventory accumulation quintile. A larger percentage bid-ask spread may indicate a reduced desire to be competitive and encourage trades. This is consistent with a decline in inventory since the specialist must maintain a positive level of inventory and therefore may wish to discourage trades that would reduce inventory further.

The patterns indicate that hypothesis five (H5) is rejected when the percentage bid-ask spread is examined across inventory accumulation quintiles. Inventory accumulation impacts on the bid-ask spread, possibly because of a high correlation between high-volume high-price stocks and inventory accumulation. The relative size of the percentage bid-ask spread between the two extreme inventory accumulation quintiles indicates that a larger bid-ask spread occurs when inventory is depleted.

5.4.5.2. End of the Trading Day Returns

The final intraday transaction return irrespective of the timing of the final two transactions is reported in Table 62 and the final fifteen minute return is reported in Table 63. The final intraday transaction return shows a statistically significant difference across the inventory accumulation quintiles, with the pattern roughly equivalent to an inverted U-shape. Quintiles 4 and 5, the two quintiles that represent the largest accumulation of inventory, have the lowest mean final transaction return. Quintile 1, the quintile with the largest inventory decline has the next largest final intraday transaction return, while the remaining two quintiles have a much larger final transaction return.

Of the 37 specialist firms, only eight specialist firms have differences across the inventory accumulation quintiles that are statistically significant both parametrically and non-parametrically. These eight specialist firms do not have patterns that match the overall pattern. The most noticeable difference is that for three of the specialist firms, the mean final transaction return for quintile 5 is negative. In only one of these three specialist firms is the return statistically significant.

Differences across specialist firms are also tested within each inventory accumulation quintile. Only the high inventory accumulation quintile (quintile 5) has differences across the specialist firms that are statistically significant both parametrically and non-parametrically. This suggests the high end of day return may be related to inventory management by the specialist.

When the final fifteen minute return is examined in Table 36, the overall pattern differs from the final intraday transaction return. On an overall basis, the pattern across the inventory accumulation quintiles is statistically significant at a level of 1% both parametrically and non-parametrically. However, the middle quintile has a mean final fifteen minute return that is not statistically different from zero. Furthermore, only two specialist firms out of 37 have differences across the inventory accumulation quintiles that are statistically significant both parametrically and non-parametrically. The statistically significant differences that were observed in Table 36 across specialist firms in quintile 5 are now only statistically significant using a non-parametric test. This suggests that the significance of the results in Table 36 are being driven by final transactions that occur near the close of trading.

Table 62 This table reports the final intraday transaction return across inventory accumulation quintiles and specialist firms. Mean final intraday transaction returns (in percent) are reported for May 1995. Each day's return is divided into groups based on inventory accumulation quintiles. Inventory accumulation quintiles are formed by assigning the direction of trade for each transaction before 3:30 pm based on Lee and Ready's (1991) procedure and then accumulating inventory. The inventory changes for each day are then ranked into five groups and the final intraday transaction return is reported for each group. Parametric ANOVA tests and non-parametric Wilcoxon rank sums test are conducted to test for difference across the inventory accumulation quintiles and across specialist firms.

		Inventory Accumulation Group						
Specialist	Overall Return	1 low (negative)	2	3 medium	4	5 high (positive)	ANOVA	Wilcoxon
20	0.0608***	0.0558***	0.1865***	-0.0015***	0.0549***	0.0206**	1.9	8.5*
34	0.0908*	0.1603*	0.2644**	0.0303**	-0.1522	0.1142	2.1*	5.3
104	0.0296	0.0154	0.2860	-0.0367	0.0222	-0.0460	4.5***	14.0***
137	0.0958**	0.0440	0.0952	0.2405**	0.1554**	0.0446**	0.8	3.5
202	0.0461***	0.0145***	0.0812	0.1046	-0.0091***	0.0733***	1.7	8.9*
210	0.0753***	0.0979***	0.0934***	0.1859***	0.0040	0.0506	1.9	9.5**
215	0.0883***	0.0729	0.1473	0.1741***	0.0713***	0.0443**	1.4	1.1
240	0.0180	0.0787	0.1169	-0.2466	-0.0526	0.0616*	2.0*	4.1
298	0.0730***	0.0547	0.1404	0.0910***	0.0462***	0.0656***	1.1	5.1
364	0.1701***	0.0949	0.4331	0.3767***	0.0738***	0.0734	2.4*	6.4
403	0.0272*	0.0791	0.1122	-0.0514*	-0.0430**	0.0015***	4.0***	11.7**
501	0.0833***	0.0324	0.1673	0.2467***	0.0513***	0.0521***	5.2***	6.6
520	-0.0166	0.0333	-0.0552	-0.0064	-0.0169	-0.0449**	0.3	2.7
551	0.0463*	0.0725	0.1699	0.0336*	-0.0828*	0.0292***	1.9	5.5
1010	-0.0109	0.0054	0.0257	-0.0593	0.0062	-0.0384	0.1	0.7
1027	0.0263	0.0620	0.0454	-0.0950	-0.0480	0.0831*	0.8	2.0
1034	0.0898	0.0076	0.4896	-0.0492	0.0434	0.0072	2.1*	9.0*
1148	0.1143**	0.1815	0.2412	0.1310**	0.0769*	-0.0091**	0.9	3.2
1225	0.0489***	0.0753	0.1008	0.1247***	0.0159***	-0.0186***	2.2*	10.7**
1227	0.0953***	0.1277	0.2223	0.1334***	0.0422***	0.0153***	2.4**	14.6***
1229	0.1523**	0.0206	0.3479	0.4064**	-0.0024**	0.1155	1.6	2.6
1266	0.2520***	0.1578	0.4969	1.1104***	-0.0461***	0.0527**	7.6***	9.7**
1280	0.1281***	0.1019	0.1967	0.3304***	-0.0307**	0.1400	1.2	3.3
1341	0.0386*	0.0245	0.0480	0.3844*	-0.0423**	-0.0563	2.4**	8.9*
1418	0.1011***	0.1067	0.1988	0.2679***	0.0109***	0.0302**	1.7	7.5
1679	0.0733***	0.0927	0.2002	0.0873***	-0.0545**	0.0333***	2.9**	7.9*
1687	0.0482*	0.0562	0.0638	-0.0087*	0.1670***	-0.0125*	1.4	3.2
1726	0.0941***	0.0709***	0.1719	0.1385	0.1015***	0.0402***	1.0	0.7
1746	0.0427	0.0486	-0.1182	0.3652	-0.0740**	0.0870*	1.8	6.7
1903	0.0458	0.0180	0.0751	0.0753	0.0601	0.0323***	0.1	0.4
1910	0.1648**	0.0896**	0.1723	0.5889	-0.0523***	0.0935**	1.8	13.2**
1941	0.1814***	0.0646	0.3292	0.6985**	0.0313***	0.1084**	5.6***	6.6
1966	0.0376	0.0166	0.1034	0.0872	-0.0681**	0.0674**	0.5	0.7
2022	0.1305***	0.1512***	0.2477	-0.0200	0.1641***	0.0891	0.7	1.7
2090	0.1259**	0.1340**	0.0623**	0.1286***	0.2381	0.0760	0.3	1.3
3011	0.1328***	0.1521	0.1543	0.1835***	0.1457**	0.0634***	0.3	1.3
3174	0.0649***	0.0714	0.1883	-0.0195***	0.0295***	0.0419***	2.7**	8.8*
overall	0.0785***	0.0700***	0.1566***	0.1578***	0.0294**	0.0405***	25.2***	83.3***
ANOVA	2.2***	1.2	1.2	1.6*	0.9	1.4**		
Wilcoxon	53.8**	32.0	43.4	37.8	24.8	55.5**		

*significant at α = 10%, **significant at α = 5%, ***significant at α = 1%

Table 63 This table reports the final fifteen minute return across inventory accumulation quintiles and specialist firms. Final fifteen minute returns (in percent) are reported for May 1995. Stocks are divided into five groups within each specialist firm based on inventory accumulation. Inventory accumulation quintiles are formed by assigning the direction of trade for each transaction before 3:30 pm based on Lee and Ready's (1991) procedure and then accumulating inventory. The inventory changes for each day are then ranked into five groups. Parametric ANOVA tests and non-parametric Wilcoxon rank sums test are conducted to test for difference across the inventory accumulation quintiles and across specialist firms.

		Inventory Accumulation Group						
Specialist	Overall Return	1 low (negative)	2	3 medium	4	5 high (positive)	ANOVA	Wilcoxon
20	0.0589**	0.0606***	0.1363***	-0.0761***	0.1415***	0.0087**	1.4	6.3
34	0.1495***	0.0913	0.4331	0.2229*	0.0132**	0.1284**	1.3	3.2
104	0.0774**	0.1043	0.2923	0.0385	-0.0722	0.0667	1.5	3.0
137	0.0264	-0.0062	-0.0365	-0.1673**	0.1542**	0.0521**	0.8	1.3
202	0.0776***	0.0153	0.1405***	0.1110***	0.0279***	0.1276	1.8	7.0
210	0.1057***	0.1230	0.1371	0.1041***	0.0828***	0.0880***	0.2	3.3
215	0.0952***	0.0974	0.1418	-0.0486***	0.0979***	0.0953**	0.6	3.1
240	0.0062	0.0126	-0.0241	-0.0411	-0.1115*	0.0651	0.5	2.5
298	0.0702***	0.0328	0.1117	0.1499***	0.0745***	0.0740***	0.8	1.1
364	0.1445**	0.1016	0.4115	0.0000	0.0457***	0.1080	1.0	3.6
403	0.0527***	0.0749	0.1585	0.0563*	-0.0354**	0.0404***	2.1*	5.8
501	0.0748***	0.0120	0.1774	0.0894***	0.0907***	0.0730***	1.9	2.1
520	0.0506	0.0734	0.0566	-0.1476	0.0227	0.0775**	0.6	1.9
551	0.0775**	0.0849	0.2138	-0.7150*	0.0337*	0.1080***	5.5***	4.4
1010	0.0434	0.0994	0.0155	-0.2360	0.0699	0.0349	0.5	3.3
1027	0.0483	0.1214	0.0537	-0.1693	-0.2040	0.1537*	1.8	5.0
1034	0.3601***	0.1366	1.0950	0.0421	0.0332	0.1131	4.0***	10.8**
1148	0.1212*	0.2592	0.0695	-0.6272**	0.1279*	0.1131**	1.6	3.8
1225	0.0591**	0.1025	0.1556	0.1223***	-0.0025***	-0.0051***	1.7	5.0
1227	0.0739**	0.1257	0.2471	-0.0535***	-0.0348***	0.0444***	2.2*	9.5**
1229	0.0561	0.0739	0.2178	0.3192**	-0.1148**	-0.0815	0.5	4.5
1266	0.3274***	0.2150	0.8789	1.2482***	0.2517***	0.1028**	4.4***	3.4
1280	-0.0224	-0.0427	-0.0628	-0.6112***	-0.2246**	0.2097	3.0**	7.3
1341	0.0422*	0.0661	0.0554	0.1597*	-0.0194**	0.0155	0.3	0.7
1418	0.0607	0.0992	-0.0565	0.0189***	0.1265***	0.0471**	0.6	2.1
1679	0.0750***	0.0892	0.1793	0.0751***	0.0026**	0.0449***	0.9	2.6
1687	0.1130***	0.0381	0.3131	0.1504*	0.0995***	0.1286*	1.2	4.0
1726	0.1329***	0.0757	0.2353	0.3802***	0.0606***	0.1309***	2.0*	7.4
1746	0.0662	-0.0122	-0.0317	0.5741	0.0375**	0.1338*	0.7	2.5
1903	0.0606**	0.0530	0.0580	-0.1477	0.1196	0.0704***	1.1	1.4
1910	0.1610*	0.1826	0.2778**	0.1665***	-0.0429**	0.1791	0.3	2.6
1941	0.1237***	0.0617	0.3035	0.3561***	-0.0086***	0.1561**	2.0*	6.5
1966	0.1160***	0.0388	0.1652	-0.0247	0.2209**	0.1349**	0.9	0.5
2022	0.1624***	0.1434	0.2738	0.0930***	-0.1032***	0.2728	1.5	6.8
2090	0.1670**	0.1924	0.3734	0.0158**	0.4142**	-0.0142***	1.5	5.5
3011	0.0723	0.0518	0.2304	0.3680***	0.0221**	-0.0335**	1.0	2.0
3174	0.0858***	0.0508	0.1129	0.1686***	0.0706***	0.0994***	3.8*	2.6
overall	0.0851***	0.0726***	0.1687***	0.0653	0.0555***	0.0800***	8.6***	24.6***
ANOVA	1.9***	1.2	1.5**	0.8	0.9	1.3		
Wilcoxon	47.4*	32.6	38.5	26.4	24.6	54.2**		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

The results indicate that inventory accumulation plays a role in the final transaction return since there are some significant differences across the inventory accumulation quintiles. The role is reduced when the final intraday transaction return is defined as the final fifteen minute return indicating that the significance is being driven by transactions near the close. Nevertheless, hypothesis five (H5) is rejected for the final intraday transaction return since there are significant differences across the specialist firms in the inventory accumulation quintile that represents the largest inventory accumulation. This indicates that specialist firms differ in the way that they handle inventory accumulation and how this impacts on the final transaction return.

5.4.5.3. Volatility

Volatility across inventory accumulation quintiles and specialist firms is reported in Table 64. As explained in section 5.4.1.2., one measure of volatility is the high minus the low share price all divided by the mean share price (HML). A second measure used to measure volatility is the standard deviation of changes in successive midpoints of the bid-ask spread (STD).

The overall patterns differ between the two volatility measures. The HML volatility measure exhibits a U-shape pattern, while the STD volatility measure exhibits an inverted U-shape pattern. For both patterns the differences across the inventory quintiles are statistically significant at a level of 1% both parametrically and non-parametrically.

The level of significance is repeated for all 37 specialist firms for the STD volatility measure and for 35 specialist firms using the HML volatility measure. The U-shaped pattern for the HML volatility measure is found in 33 of the 35 specialist firms

that have significant differences across the inventory accumulation quintiles. The inverted U-shape for the STD volatility measure is also robust across the specialist firms, however, the peak varies between the middle three quintiles, with the lowest volatility consistently in the two extreme quintiles.

Differences across the specialist firms within each of the inventory accumulation quintiles are shown to be statistically significant at a level of 1% both parametrically and non-parametrically for both measures of volatility. These patterns indicate that volatility may be affected by inventory accumulation during the day. The null of hypothesis five (H5) is therefore rejected.

5.4.5.4. Summary

The inventory accumulation during the day affects the bid-ask spread, final transaction return and volatility. The differing patterns across the inventory accumulation quintiles for the bid-ask spread suggests that the middle quintiles may contain some stocks that are more likely to have a higher bid-ask spread due to a lower price and this is confirmed by observing the average price. The final transaction return is shown to differ across specialist firms only in the inventory accumulation quintile with the largest accumulation. The significance is lost when the final fifteen minute return is examined, indicating that returns near the close of trading may be being used by specialist firms in their inventory management. Volatility patterns across the inventory accumulation quintiles are robust across specialist firms, however the magnitudes differ and volatility measures themselves are contradictory. The bid-ask bounce may be responsible for this discrepancy. Large percentage changes may be occurring in the quintiles with the largest inventory changes, but these quintiles may not have a large standard deviation of changes in successive midpoints of the bid-ask spread.

Table 64 This table reports the volatility in the final half-hour of trading across inventory accumulation quintiles and specialist firms. Volatility is reported (in percent) using two measures. One measure calculates volatility as the difference between the high and the low share prices divided by the mean share price (H-L)/P. Volatility is also reported as the standard deviation of the change in successive midpoints of the bid-ask spread. Stocks are divided into five groups within each specialist firm based on inventory accumulation. Inventory accumulation quintiles are calculated by assigning the direction of trade for each transaction before 3:30 pm based on Lee and Ready's (1991) procedure and then accumulating inventory. The inventory changes for each day are then ranked into five groups. Parametric ANOVA tests and non-parametric Wilcoxon rank sums test are conducted to test for difference across the inventory accumulation quintiles and across specialist firms.

		Inventory Accumulation Group						
Specialist	Overall Return	1 low (negative)	2	3 medium	4	5 high (positive)	ANOVA	Wilcoxon
20								
(H-L)/P	0.283	0.292	0.245	0.207	0.358	0.314	31.1***	660.0***
std dev.	0.227	0.194	0.261	0.231	0.234	0.218	15.6***	34.5***
34								
(H-L)/P	0.314	0.305	0.271	0.249	0.361	0.383	8.6***	183.0***
std dev.	0.341	0.333	0.421	0.314	0.406	0.335	20.6***	29.0***
104								
(H-L)/P	0.284	0.356	0.265	0.172	0.288	0.336	38.7***	559.8***
std dev.	0.311	0.288	0.387	0.299	0.377	0.246	28.9***	91.6***
137								
(H-L)/P	0.424	0.402	0.486	0.314	0.501	0.416	17.5***	903.9***
std dev.	0.331	0.216	0.460	0.452	0.347	0.182	77.1***	91.5***
202								
(H-L)/P	0.307	0.356	0.250	0.188	0.338	0.400	105.4***	947.3***
std dev.	0.243	0.219	0.261	0.266	0.231	0.236	13.1***	19.3***
210								
(H-L)/P	0.333	0.348	0.329	0.275	0.367	0.346	15.9***	1061.3***
std dev.	0.270	0.206	0.292	0.371	0.278	0.203	141.5***	328.8***
215								
(H-L)/P	0.313	0.336	0.311	0.248	0.315	0.353	20.6***	1148.7***
std dev.	0.291	0.201	0.313	0.480	0.287	0.177	59.7***	387.2***
240								
(H-L)/P	0.343	0.279	0.382	0.535	0.213	0.308	5.7***	289.9***
std dev.	0.721	0.182	1.098	1.693	0.445	0.190	43.4***	195.1***
298								
(H-L)/P	0.327	0.374	0.291	0.195	0.368	0.408	118.7***	1618.2***
std dev.	0.294	0.229	0.338	0.399	0.280	0.226	158.5***	292.8***
364								
(H-L)/P	0.319	0.314	0.375	0.242	0.314	0.347	4.0***	102.8***
std dev.	0.257	0.285	-	0.249	-	0.259	7.0***	27.2***
403								
(H-L)/P	0.326	0.403	0.300	0.222	0.308	0.397	109.2***	1602.0***
std dev.	0.228	0.211	0.271	0.237	0.247	0.181	53.0***	115.9***
501								
(H-L)/P	0.316	0.332	0.302	0.245	0.342	0.361	45.0***	2420.8***
std dev.	0.289	0.199	0.395	0.341	0.332	0.195	217.5***	895.6***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 64 continued)

Specialist	Overall Return	Inventory Accumulation Group 1 low (negative)	2	3 medium	4	5 high (positive)	ANOVA	Wilcoxon
520								
(H-L)/P	0.335	0.327	0.339	0.234	0.362	0.414	18.6***	346.6***
std dev.	0.495	0.223	0.347	1.353	0.326	0.228	51.5***	240.4***
551								
(H-L)/P	0.248	0.297	0.229	0.157	0.236	0.321	45.4***	776.9***
std dev.	0.206	0.146	0.284	0.228	0.288	0.144	139.9***	260.0***
1010								
(H-L)/P	0.346	0.427	0.295	0.183	0.227	0.600	61.3***	218.9***
std dev.	0.338	0.272	0.364	0.383	0.315	0.359	8.1***	43.7***
1027								
(H-L)/P	0.274	0.345	0.284	0.137	0.242	0.360	24.2***	152.2***
std dev.	0.230	0.189	0.251	0.243	0.217	0.244	6.2***	41.8***
1034								
(H-L)/P	0.299	0.405	0.308	0.170	0.271	0.340	6.6***	38.7***
std dev.	0.283	0.227	0.316	0.291	0.316	0.264	4.1***	6.8
1148								
(H-L)/P	0.458	0.532	0.409	0.370	0.438	0.540	4.8***	400.5***
std dev.	0.652	0.455	1.043	0.479	0.945	0.563	26.8***	78.1***
1225								
(H-L)/P	0.280	0.318	0.286	0.203	0.270	0.324	23.3***	367.4***
std dev.	0.324	0.223	0.329	0.548	0.314	0.207	92.6***	186.8***
1227								
(H-L)/P	0.327	0.320	0.314	0.271	0.349	0.379	16.1***	1044.6***
std dev.	0.288	0.254	0.374	0.277	0.342	0.225	83.2***	153.7***
1229								
(H-L)/P	0.339	0.388	0.260	0.210	0.295	0.543	25.5***	222.2***
std dev.	0.323	0.318	0.460	0.277	0.450	0.314	32.7***	50.9***
1266								
(H-L)/P	0.386	0.418	0.373	0.361	0.369	0.409	1.2	345.2***
std dev.	0.305	0.251	0.355	0.367	0.368	0.176	37.5***	125.5***
1280								
(H-L)/P	0.322	0.302	0.346	0.250	0.332	0.380	5.4***	209.7***
std dev.	0.282	0.189	0.306	0.360	0.352	0.204	25.3***	71.6***
1341								
(H-L)/P	0.414	0.428	0.369	0.293	0.362	0.620	38.9***	361.9***
std dev.	0.298	0.274	0.374	0.279	0.379	0.301	17.1***	162.5***
1418								
(H-L)/P	0.379	0.373	0.351	0.354	0.364	0.451	6.8***	893.9***
std dev.	0.351	0.293	0.498	0.338	0.450	0.244	56.3***	243.5***
1679								
(H-L)/P	0.264	0.290	0.270	0.170	0.232	0.359	39.4***	369.8***
std dev.	0.279	0.255	0.341	0.220	0.366	0.231	101.7***	304.3***
1687								
(H-L)/P	0.291	0.316	0.270	0.179	0.323	0.363	33.3***	555.0***
std dev.	0.328	0.303	0.345	0.350	0.372	0.267	18.0***	13.6***
1726								
(H-L)/P	0.341	0.363	0.351	0.261	0.330	0.403	21.0***	555.4***
std dev.	0.269	0.234	0.317	0.320	0.274	0.190	89.4***	141.5***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 64 continued)

Specialist	Overall Return	Inventory Accumulation Group 1 low (negative)	2	3 medium	4	5 high (positive)	ANOVA	Wilcoxon
1746								
(H-L)/P	0.330	0.309	0.299	0.291	0.328	0.422	7.9***	248.2***
std dev.	0.363	0.257	0.327	0.632	0.339	0.258	69.2***	127.8***
1903								
(H-L)/P	0.305	0.304	0.381	0.173	0.320	0.346	57.3***	1000.3***
std dev.	0.302	0.233	0.341	0.391	0.330	0.199	53.1***	413.9***
1910								
(H-L)/P	0.203	0.235	0.185	0.117	0.197	0.281	10.4***	124.1***
std dev.	0.325	0.263	0.277	0.394	0.302	0.264	30.6***	67.4***
1941								
(H-L)/P	0.341	0.356	0.331	0.261	0.366	0.392	18.7***	952.3***
std dev.	0.320	0.204	0.394	0.492	0.291	0.206	121.1***	16.1***
1966								
(H-L)/P	0.292	0.336	0.265	0.187	0.316	0.356	21.1***	451.3***
std dev.	0.276	0.281	0.370	0.219	0.379	0.260	36.9***	374.7***
2022								
(H-L)/P	0.316	0.283	0.347	0.280	0.342	0.329	1.5	266.6***
std dev.	0.414	0.497	0.000	0.395	2.479	0.325	75.7***	18.8***
2090								
(H-L)/P	0.466	0.545	0.450	0.352	0.526	0.457	8.2***	381.3***
std dev.	0.418	0.312	0.422	0.630	0.443	0.284	51.1***	57.2***
3011								
(H-L)/P	0.323	0.359	0.302	0.233	0.369	0.352	8.0***	155.6***
std dev.	0.358	0.330	0.375	0.451	0.376	0.259	24.4***	34.7***
3174								
(H-L)/P	0.261	0.299	0.246	0.158	0.291	0.313	48.7***	582.0***
std dev.	0.241	0.201	0.275	0.267	0.298	0.167	12.6***	348.4***
OVERALL								
(H-L)/P	0.325	0.348	0.314	0.242	0.338	0.381	479.6***	21881***
std dev.	0.227	0.243	0.374	0.366	0.335	0.227	573.9***	2249.0***

Tests of Difference

(H-L)/P

	Overall	1	2	3	4	5
ANOVA	49.1***	21.6***	14.6***	12.2***	18.2***	25.8***
Wilcoxon	2650***	889.4***	432.6***	328.5***	852.6***	1041.7***

standard dev.

	Overall	1	2	3	4	5
ANOVA	49.1***	54.0***	40.0***	99.7***	54.4***	85.2***
Wilcoxon	2650***	2266.5***	754.4***	2250.6***	1196.3***	2931.1***

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

5.5. Conclusion

Patterns are confirmed across volume, volatility, percentage bid-ask spreads, and end of day returns as well as bid and ask depths. This chapter finds that statistically significant differences exist across specialist firms. A reverse J-shape pattern is found for volume and differences across specialist firms are found at the beginning and end of the trading day. Volatility exhibits a U-shaped pattern during the trading day. The percentage bid-ask spread is found to be largest immediately following the open and declines throughout the trading day with a late afternoon peak that is smaller than that at the open. There is much variation between specialist firms in the timing of the late afternoon peak. For some specialists, final returns are found to be positive and statistically significant, while for others the final return is not statistically significant. This gives support to specialist explanations involving the high end of day transaction price rise, and indicates that the phenomenon may be related to specialist firm characteristics. The relative size of the ask and bid depths differs between specialist firms, with twice the number of specialist firms with a larger mean bid depth. This relative size is consistent during the trading day and may indicate that each specialist firm uses depth in a certain way that may be related to the specialist firm's characteristics such as capitalization or risk aversion.

This chapter also contributes to the literature by examining some of the same price formation characteristics across individual specialists within each specialist firm. Differences are found across individual specialists for most specialist firms when volatility, percentage bid-ask spreads and depths are examined. No differences are found within specialist firms when the final transaction return is examined. This suggests that price formation characteristics that vary within specialist firms may be attributable to

individual specialists, and price formation characteristics that are robust across individual specialists within a specialist firm are attributable to specialist firm characteristics such as risk aversion and capitalization.

The level of volume has been suggested as a possible source of differences since higher volume stocks may garner more attention from the specialist because of the increased activity and the increased opportunity to profit by capturing the bid-ask spread. No difference across volume groups are found for the end of day return suggesting specialist explanations involving the end of day prices rise are not related to the volume of a stock. The percentage bid-ask spread is found to be larger for lower volume stocks indicating that specialists are capturing bid-ask spreads from these stocks possibly because of the reduced volume. This could indicate that cross-subsidization is not necessarily decreasing the percentage bid-ask spread for these low volume stocks. Competing explanations involving stock price effects on the percentage bid-ask spread are shown to provide only a partial explanation. Depths are also compared across volume groups and very different patterns in separate specialist firms indicate that there are myriad ways that depth may be being used by specialist firms.

The method of adjusting bid-ask quotes in advance of the final trade is examined across specialist firms to test for differences between specialist firms that may indicate some expertise at the specialist firm level in assessing inelastic demand. The only difference in the adjustment of quotes near the end of the trading day is shown to be in the magnitude of the bid-ask spread. Most specialist firms decrease the bid price and increase the ask price between the final two quotes of the day.

The effect of inventory accumulation on the percentage bid-ask spread is difficult to determine since the impact of price confounds the impact of inventory accumulation

quintiles. The limited inventory change middle three quintiles are shown to have the higher prices and thus higher percentage bid-ask spreads. A comparison of the two extreme quintiles shows that the most negative accumulation quintile has a larger percentage bid-ask spread than the quintile with the largest positive inventory accumulation. This indicates that the specialist may be less competitive in attracting orders once inventory is depleted since a positive inventory level must be maintained. Examining inventory accumulation and the final transaction returns shows that only those stocks in the inventory quintile with those stocks with the largest inventory accumulation by the specialist have differences across specialist firms. This indicates that the price rise at the end of the day may be effected by the specialist to increase the value of the accumulated inventory or may be a method to induce more buy orders the following day. Examining volatility over accumulated inventory quintiles results in conflicting findings based on the volatility measure used. The extreme quintiles with the largest inventory changes have the largest volatility when using the transaction prices, yet when using the midpoint of the bid-ask spread the lowest volatility occurs in the extreme quintiles. This may indicate that the bid-ask spread bounce may be responsible for some of the observed patterns in volatility.

CHAPTER 6

ESSAY FOUR:

MARKET ON CLOSE ORDER RULE CHANGE AND INTRADAY PRICE FORMATION ACROSS SPECIALIST FIRMS

6.1. Introduction

Volatility differences between trading and non-trading periods (identified by French and Roll (1986)), and the high end of trading day transaction return (identified by Harris (1989)) suggest that the closing price deserves specific examination. Harris (1989) indicates that closing prices may not consistently represent "true" stock values. This is particularly disturbing given the high degree of importance placed on closing prices, not only for valuation, but also for information dissemination and use in academic studies.

NYSE rule 116.40 sets forth procedures to facilitate the handling of market-on-close (MOC) orders. This rule was changed on June 5, 1995. Before this date, MOC orders were constrained only on expiration days[14]. On expiration days (usually the third Friday of the month), MOC orders in any stock related to a strategy involving derivative index products were required to be entered by 3:40 pm and no cancellation or reduction of any MOC order in any of these stocks was permitted after 3:40 pm. After the cut-off time any order imbalances of 50,000 or more shares in a group of pilot stocks[15] would be published and additional MOC orders were allowed to offset this published imbalance. If no imbalance was published (e.g. less than a 50,000 share imbalance) then no additional

[14] The term "expiration" days refers to the last trading day before the one day a month that standardized contracts in derivative products (such as stock index futures, stock index options and options on stock index futures) expire, and the last trading day of each calendar quarter when quarterly index expiration ("QIX") options expire.

[15] Pilot stocks consist of the 50 most highly capitalized Standard & Poors ("S&P") 500 stocks, any component stocks of the Major Market Index not included therein, and the 10 highest weighted S&P MidCap 400 stocks.

MOC orders were allowed after 3:40 pm. This policy has not changed for expiration days; however, after June 5 traders in all stocks were required to input MOC orders by 3:50 pm on non-expiration days. The same group of pilot stocks is used for non-expiration days as expiration days. For those pilot stocks with order imbalances of 50,000 shares or more, the order imbalance is published as soon as practicable after 3:50 pm in order to facilitate additional orders to offset the imbalance. The details regarding the restrictions on market on close orders are detailed in Appendix B.

If the pilot stocks have order imbalances of at least 50,000 shares then the imbalance will be published after the MOC entry deadline and compensating MOC entries will be allowed. Pilot stocks are chosen based on the market values of all stocks fifteen days in advance of that month's expiration day. The list varies only minimally from month to month. On the day of the rule change, June 5, 1995, the pilot stocks in effect for the previous expiration Friday (May 19, 1995) became the pilot stocks for non-expiration days as well. The June expiration Friday fell on June 16 and the pilot stocks were unchanged from the previous month with the exception of one stock. Franklin Resources Inc. replaced Cabletron Systems Inc. on the MidCap pilot stocks list. For the purposes of this study both of these stocks will be excluded from the pilot and non-pilot stock groups. Appendix C lists the pilot stocks.

If the MOC orders are balanced at the close then the final transaction occurs at the price of the last sale just prior to the close of trading in that stock. If there is an imbalance, then the imbalance is executed against the bid or ask, depending on the direction of the imbalance. An imbalance of buy (sell) orders is executed against the ask (bid). The price of the remaining orders is the same price as that of the imbalance

portion. The specialist pairs off the remaining orders, absorbs the imbalance and these transactions are identified as stopped stock.

The stated reason for the rule change is to minimize excess market volatility that may be associated with large-size MOC orders that are entered very near the close. The rule change is expected to minimize volatility by preventing a last-minute influx or disappearance of MOC orders which could potentially add to volatility at the close. The earlier cut-off time for MOC orders also allows sufficient time to attempt to offset large imbalances that may be published if they are both large enough (at least 50,000 shares) and in a pilot stock. This rule change does not prevent last minute orders from being entered, but the orders may or may not be executed at the closing price.

The focus of this essay is the effect of the change in NYSE closing procedure on both the day-end price rise and volatility. Additionally, the group of individual pilot stocks are separately examined to determine if the requirement to publish large imbalances in these stocks alters the effect of the rule change on the end of day pricing or volatility.

6.2. Hypotheses

The hypotheses involve examining the day end price rise and volatility both before and after the implementation of the NYSE MOC rule change. Even though this was not the intended purpose of the rule change, the objective of reducing volatility may have an impact on the end of day price rise documented by Harris (1989). The first hypothesis is as follows:

> $H1_O$: The end of the day price rise is the same both before and after the MOC rule change.
>
> $H1_A$:. The end of the day price rise is reduced after the MOC rule change.

The stated objective of the rule change, to reduce the volatility at the close, is tested by examining the immediate effectiveness of the rule change as evidenced by volatility. The second hypothesis is as follows:

$H2_O$: Volatility is the same before and after the MOC rule change.

$H2_A$:. Volatility is reduced after the MOC rule change.

The group of pilot stocks with order imbalances greater than 50,000 shares have the imbalances published and additional offsetting MOC orders are allowed to be entered. The effectiveness of publishing order imbalances is examined by comparing the pilot stocks with the non-pilot stocks. The third hypothesis is as follows:

> $H3_O$: The end of the day price rise and volatility for the entire period and changes in the end of day price rise and volatility following the NYSE MOC rule change are the same for pilot stocks and non-pilot stocks.
>
> $H3_A$: The end of the day price rise and volatility for the entire period and changes in the end of day price rise and volatility following the NYSE MOC rule change are lower for pilot stocks than for non-pilot stocks.

6.3. Data and Method of Analysis

Data is from May and June 1995 and includes all transactions and quotes on the NYSE provided by the TAQ (trades and quotes) database. The analysis excludes those stock issues for which an identifiable specialist firm is not available from the *NYSE Specialist Directory*. It also excludes those security issues that are not classified as either a common stock issue or a preferred stock issue. Transactions that are identified as corrections, or have a condition code or g127 code[16] are also excluded. Of the 2,849,367 transactions in May and 2,816,842 transactions in June, after filters are applied there remain 1,819,387 transactions in May and 1,875,681 transactions in June.

[16] These codes represent abnormal trades such as cash sales, bunched trades, or rule 127 trades that are executed as a block position.

In order to test the first hypothesis, final intraday transaction returns are calculated for all eligible NYSE stocks. The returns are reported for the final transactions of the trading day similar to Harris (1989). In addition to the final intraday transaction, the returns are examined over the final fifteen minutes of trading. The return is calculated from the price of the last transaction that occurred at least fifteen minutes before the close of trading. Both the final intraday transaction return and the final fifteen minute return require that a transaction occur during the final fifteen minutes of trading. This ensures that the final transaction is captured near the close of trading and reduces the impact of infrequently traded stocks that may have a final transaction that occurs earlier in the trading day.

The effect on volatility is assessed first by examining the standard deviation of returns calculated using the change in successive midpoints of the bid and ask quotes for each quote change during the last half-hour of trading each day. Volatility is also examined in the last half-hour of trading by calculating the difference between the high and low transaction share prices divided by the mean share price during that trading interval. In order to compare the pre- and post-rule change periods, the return and volatility characteristics for each stock are tested for similarity using an ANOVA test. Additionally, non-parametric Wilcoxon rank sums or rank scores tests are performed to alleviate any concerns about distributional assumptions that may affect the ANOVA test.

The group of pilot stocks contains the 50 highest capitalized stocks on the S&P 500 as well as the top ten capitalized firms on the MidCap 400. Additionally, a reduced sample of pilot stocks are selected and compared with non-pilot stocks which are matched to minimize differences in liquidity and capitalization between the samples.

This ensures the comparison made between pilot and non-pilot stocks is appropriate and captures only the effect of the publication of order imbalances. This reduced sample is created by using the lowest ten capitalization pilot stocks matched to similarly capitalized non-pilot stocks.

6.4. Results

The differences between the pre- and post-rule change periods are first reported in section 6.4.1. by examining the price rise at the end of the trading day. Final intraday transaction returns and final fifteen minute returns are examined using the entire sample. Volatility at the end of the trading day, using the two measures described in section 6.3., is examined in section 6.4.2., also using the entire sample Stocks are divided into pilot and non-pilot stocks and the end of day price rise and volatility are examined and the results of this testing are reported in section 6.4.3. The reduced sample of pilot stocks is also used to better control for capitalization and liquidity differences and the results of this testing are reported in section 6.4.4. A summary of the results is provided in section 6.4.5.

6.4.1. Price Rise at the End of the Trading Day

The final intraday transaction return is used to determine if there is a difference before and after the NYSE MOC rule change on June 5, 1995. Table 65 reports that, on an overall basis, the final intraday transaction return for the entire period is 0.0981%, with 0.0960% before June 5 and 0.1009% after June 5. There is no statistically significant difference between the return in the two periods using either the parametric ANOVA test or the non-parametric Wilcoxon rank scores test.

Table 65 This table reports the final intraday transaction returns across specialist firms. Mean final intraday transaction returns (in percentages) are reported for the entire May-June 1995 period for NYSE stocks. The returns are also divided into the period before and after the NYSE rule change on June 5, 1995. A parametric ANOVA test and a non-parametric Wilcoxon rank scores test are conducted to test for differences between the two periods. A parametric ANOVA test and a non-parametric Wilcoxon rank sums test are conducted to test for differences across specialist firms.

Specialist	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
20	0.0653***	0.0637***	0.0674*	0.01	0.30
34	0.1225***	0.1171**	0.1294**	0.02	0.34
104	0.0333	0.0103	0.0573	1.12	0.88
137	0.0950***	0.0988**	0.0899**	0.02	0.07
202	0.0717***	0.0593***	0.0876***	1.30	0.16
210	0.0881**	0.0933***	0.0818***	0.19	0.03
215	0.0622***	0.0692***	0.0526**	0.32	2.16
240	0.1596*	0.0995	0.2423*	0.70	0.31
298	0.0638***	0.0672***	0.0592***	0.11	0.85
364	0.1048**	0.1839***	0.0219	2.69	4.99**
403	0.0554***	0.0351**	0.0819***	3.35**	6.75***
501	0.0912***	0.0876***	0.0957***	0.14	0.18
520	0.0431	0.0014	0.0938**	3.00*	1.89
551	0.0748***	0.0453	0.1080***	2.47	0.06
1010	0.0396	0.0258	0.0604	0.14	0.01
1027	0.0839**	0.0579	0.1161*	0.64	0.04
1034	0.1647**	0.1806	0.1432	0.05	0.06
1148	0.1299***	0.1170*	0.1482**	0.12	0.12
1225	0.0823***	0.0590***	0.1099***	2.12	0.48
1227	0.1539***	0.1547***	0.1529***	0.00	0.02
1229	0.1791***	0.2110**	0.1372	0.29	0.19
1266	0.2678***	0.2779***	0.2550**	0.03	0.53
1280	0.1178***	0.1484**	0.0747	0.73	0.72
1341	0.0594*	0.0933**	0.0186	1.36	0.35
1418	0.1137***	0.1303***	0.0917**	0.58	0.03
1679	0.1070***	0.0675**	0.1525***	3.62*	2.53
1687	0.0901***	0.1017***	0.0740*	0.31	0.71
1726	0.1113***	0.1301***	0.0859***	1.24	1.18
1746	0.0059	0.0752**	-0.0870*	8.51***	6.88***
1903	0.0719***	0.0528	0.0936***	0.60	1.16
1910	0.3061***	0.3286***	0.2761**	0.10	0.15
1941	0.1405***	0.1783***	0.0888**	1.70	2.90*
1966	0.0979***	0.0964**	0.0999**	0.00	0.02
2022	0.1216***	0.1793***	0.0460	3.09*	2.30
2090	0.1935***	0.1537**	0.2458***	0.63	0.84
3011	0.2230***	0.1101**	0.3602***	6.30**	0.48
3174	0.1194***	0.1111***	0.1295***	0.34	0.19
overall	0.0981***	0.0960***	0.1009***	0.30	0.14
ANOVA	3.35***	2.23***	2.44***		
Wilcoxon	63.54***	54.01**	51.91**		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

Hypothesis one (H1) is also examined for each specialist firm. Differences across specialist firms have been found when examining stock volatility (Barnea (1974), inventory holding costs (Coughenour and Deli (1996)), execution costs (Cao, Choe and Hatheway (1997)) and trading costs (Corwin (1997)). Table 65 divides the final intraday return by specialist firm and reports the overall return and the return in each sub-period. The significance of a t-test comparing the return with zero is also provided. For the 37 specialist firms active during the two-month period, only two have returns in the period before and after the rule change that have statistically significant differences at a level of 1% using a parametric ANOVA test and a non-parametric Wilcoxon rank scores test. Six other specialist firms have significant differences between the two periods using either the parametric or the non-parametric test. Of these eight specialist firms, three have a higher mean return in the period following the rule change.

Differences in the final intraday return across the specialist firms are tested on an overall basis and both before and after the rule change. In all cases the parametric ANOVA and the non-parametric Wilcoxon rank sums tests indicate that there are significant differences across the specialist firms.

The final fifteen minute return is also used to determine if there is a difference in the mean between the period before and after the NYSE rule change on June 5, 1995. Table 66 reports that the mean final fifteen minute return is 0.0906% over the entire period. The mean final fifteen minute return is 0.0869% before the rule change and increases to 0.0941% after the rule change. The difference, however, between these two means is not statistically significant.

For four specialist firms there is a statistical difference between the means of the final fifteen minute returns before and after the rule change using both a parametric

Table 66 This table reports the final fifteen minute returns across specialist firms. Mean final fifteen minute returns (in percentages) are reported for the entire May-June 1995 period for NYSE stocks. The returns are also divided into the period before and after the NYSE rule change on June 5, 1995. A parametric ANOVA test and a non-parametric Wilcoxon rank scores test are conducted to test for differences between the two periods. A parametric ANOVA test and a non-parametric Wilcoxon rank sums test are conducted to test for differences across specialist firms.

Specialist	Overall Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
20	0.0461**	0.0601**	0.0264	0.62	0.53
34	0.1549***	0.1419***	0.1719***	0.16	0.28
104	0.0561**	0.0774**	0.0340	0.81	1.89
137	0.0258	0.0274	0.0239	0.00	0.99
202	0.0787***	0.0751***	0.0833***	0.08	0.00
210	0.0870***	0.1000***	0.0709***	0.97	0.56
215	0.0989***	0.0966***	0.1001***	0.03	2.51
240	0.1609*	0.1159	0.2232	0.39	0.63
298	0.0924***	0.0690***	0.1222***	4.13***	2.20
364	0.0819**	0.1407**	0.0186	2.43	1.86
403	0.0744***	0.0590***	0.0966***	1.63	2.52
501	0.0922***	0.0790***	0.1092***	1.72	2.01
520	0.1019***	0.0545	0.1502***	3.42*	4.79**
551	0.0854***	0.0767***	0.0957***	0.24	0.28
1010	0.0563	0.0411	0.0747	0.17	0.38
1027	0.0798**	0.0562	0.1174*	0.57	0.06
1034	0.2307***	0.3499***	0.0827	2.51	1.73
1148	0.0854*	0.1021	0.0648	0.15	0.25
1225	0.0591***	0.0503**	0.0702***	0.31	0.51
1227	0.1003***	0.0737***	0.1326***	2.10	0.62
1229	0.1353**	0.0879	0.1827***	0.65	1.89
1266	0.2016***	0.3046***	0.0583	5.30**	3.42*
1280	0.0217	-0.0131	0.0663	0.74	1.36
1341	0.0455	0.0428	0.0490	0.01	0.17
1418	0.1095***	0.0664*	0.1618***	3.68*	1.16
1679	0.0641***	0.0841***	0.0400	1.15	1.19
1687	0.0970***	0.1203***	0.0695*	0.93	0.02
1726	0.1040***	0.1353***	0.0647*	2.54	4.83**
1746	0.0514	0.0629	0.0387	0.07	0.19
1903	0.0932***	0.0668***	0.1250***	1.72	0.61
1910	0.1467***	0.1383*	0.1567**	0.03	0.15
1941	0.1255***	0.1206***	0.1304***	0.03	0.12
1966	0.0896***	0.1293***	0.0351	3.08*	5.40**
2022	0.0833*	0.1516***	-0.0029	3.02*	2.97*
2090	0.1373***	0.1774***	0.0902	0.82	1.38
3011	0.1263***	0.0716	0.1947***	1.81	0.06
3174	0.0933***	0.0875***	0.1000***	0.14	0.03
overall	0.0906***	0.0869***	0.0941***	0.63	0.01
ANOVA	1.48**	1.64***	1.32*		
Wilcoxon	37.63	48.65*	44.52		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

ANOVA test and a non-parametric Wilcoxon rank scores tests. Three other specialist firms have statistically significant differences using either the parametric or the non-parametric test. In four of the seven firms there is an increase in the final fifteen minute return following the rule change.

When all the specialist firms are compared, the differences are limited. Using the final fifteen minute return for the entire period, the differences across the firms are statistically significant using the parametric ANOVA test. When the period before and after the rule change are individually examined, only the period before the rule change has significant differences across the specialist firms and only using the parametric ANOVA test.

The rule change on June 5, 1995 has little, if any, effect on the price rise at the end of the day. Tables 65 and 66 indicate that the final intraday transaction return and the final fifteen minute return exhibit no differences on an overall basis and limited differences when specialist firms are individually examined. This fails to reject hypothesis one (H1) that the end of day price rise is the same in the period before and after the rule change.

6.4.2. Volatility at the End of the Trading Day

Volatility, as reported in Table 67, measures volatility as the standard deviation of changes in successive midpoints of the bid and ask quotes during the final half-hour of trading. On an overall basis, volatility is 0.716%, with volatility slightly larger in the period before the NYSE MOC rule change (0.721% versus 0.709%). A parametric ANOVA test finds no statistical difference between the two periods. However, a non-parametric Wilcoxon rank scores test finds that the difference is statistically significant at a level of 1%.

Table 67 This table reports the volatility (standard deviation) across specialist firms. Volatility over the final half-hour of trading as measured by the standard deviation (in percent) of changes in successive midpoints of the bid-ask spread across specialist firms is reported for the entire May-June 1995 period and the period before and after the NYSE rule change on June 5, 1995. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences between the groups.

Specialist	Entire Period Volatility	Pre-06/05/95 Volatility	Post-06/05/95 Volatility	ANOVA	Wilcoxon
20	0.493	0.503	0.482	0.62	0.01
34	0.682	0.680	0.684	0.01	2.18
104	0.712	0.667	0.767	0.92	0.09
137	0.753	0.767	0.735	0.21	0.27
202	0.531	0.573	0.479	1.21	0.50
210	0.544	0.556	0.529	0.97	0.25
215	0.646	0.651	0.640	0.11	0.64
240	1.156	1.291	0.992	1.61	2.09
298	2.545	1.796	3.469	4.87**	0.10
364	0.534	0.560	0.503	2.78*	1.98
403	0.487	0.495	0.477	0.87	2.52
501	0.600	0.612	0.587	1.25	0.01
520	0.870	0.987	0.726	2.11	0.04
551	0.448	0.441	0.458	0.13	3.80*
1010	0.598	0.664	0.519	10.08***	5.97**
1027	0.441	0.444	0.437	0.05	2.89*
1034	0.579	0.581	0.576	0.01	0.51
1148	1.026	1.164	0.856	3.31*	0.43
1225	0.701	0.719	0.680	0.35	2.65
1227	0.557	0.563	0.549	0.56	0.10
1229	0.674	0.688	0.656	0.59	0.00
1266	0.764	0.825	0.691	1.04	1.20
1280	0.636	0.668	0.596	3.34*	3.82*
1341	0.578	0.599	0.553	2.47	0.56
1418	0.660	0.672	0.645	0.42	1.83
1679	0.532	0.533	0.530	0.02	0.13
1687	0.618	0.632	0.600	1.35	2.78*
1726	0.532	0.544	0.518	1.52	3.12*
1746	0.717	0.785	0.633	4.98**	8.66***
1903	1.023	1.381	0.586	1.57	1.65
1910	0.612	0.631	0.587	1.35	0.00
1941	0.726	0.746	0.702	0.94	1.40
1966	0.568	0.566	0.570	0.02	0.08
2022	0.640	0.627	0.657	0.64	4.82**
2090	0.812	0.850	0.766	2.47	0.04
3011	0.685	0.686	0.684	0.00	0.00
3174	0.532	0.541	0.520	0.49	0.10
overall	0.716	0.721	0.709	0.08	9.54***
ANOVA	10.69***	3.01***	11.9***		
Wilcoxon	1276.7***	727.0***	596.1***		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

Of the thirty-seven individual specialist firms, three firms have statistically significant differences at a level of one percent using both the parametric ANOVA test and the non-parametric Wilcoxon rank scores test. For eight other specialist firms, either the parametric or the non-parametric test is significant. Of these eleven specialist firms with significant differences between the two periods, eight firms experience a decline in volatility following the rule change.

Examining the differences across the thirty-seven specialist firms indicates that there are differences across the specialist firms when the entire period is examined and within the period before and after the rule change. Parametric ANOVA tests and non-parametric Wilcoxon rank sums tests indicate that the differences across specialist firms are statistically significant at a level of 1%. This indicates that the specialist firms do not all exhibit a similar volatility, and consequently, the effect of the rule change is better examined on an individual specialist firm basis for this period. Differences may also be a result of stock characteristics and the time period.

Another measure of volatility is also used in this analysis. Table 68 measures volatility as the difference between the high and low share price during the final half-hour of trading, divided by the mean share price during that period. The mean volatility during the entire period is 0.483%. There is an increase in volatility after the rule change from 0.472% to 0.497%. This difference is statistically significant at a level of 1% using both a parametric and non-parametric test.

Examining the thirty-seven individual specialist firms indicates that four have statistically significant differences between the period before and after the rule change

Table 68 This table reports the volatility (difference) across specialist firms. Volatility during the final half-hour of trading, as measured by the difference between the high and low share price divided by the mean share price, is reported (in percent) across specialist firms for the entire May-June 1995 period and the period before and after the NYSE rule change on June 5, 1995. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences between the groups.

Specialist	Entire Period Volatility	Pre-06/05/95 Volatility	Post-06/05/95 Volatility	ANOVA	Wilcoxon
20	0.411	0.394	0.437	2.05	4.36^{***}
34	0.525	0.542	0.504	0.57	0.00
104	0.423	0.413	0.434	0.55	1.12
137	0.629	0.624	0.635	0.05	2.19
202	0.438	0.434	0.444	0.23	0.79
210	0.479	0.313	0.474	0.15	0.24
215	0.493	0.480	0.511	1.50	3.95^{**}
240	0.493	0.427	0.580	1.81	0.57
298	0.461	0.437	0.495	8.75^{***}	10.29^{***}
364	0.486	0.507	0.464	0.57	0.58
403	0.480	0.467	0.499	2.26	0.25
501	0.462	0.463	0.462	0.00	2.35
520	0.492	0.447	0.544	3.00^{*}	2.35
551	0.370	0.365	0.377	0.19	1.61
1010	0.542	0.499	0.609	3.70^{*}	3.58^{*}
1027	0.388	0.388	0.387	0.00	1.09
1034	0.485	0.483	0.487	0.00	0.11
1148	0.642	0.682	0.593	2.14	0.51
1225	0.422	0.412	0.434	0.80	0.06
1227	0.505	0.492	0.523	1.48	1.93
1229	0.473	0.443	0.508	1.04	2.29
1266	0.630	0.643	0.613	0.15	0.01
1280	0.535	0.527	0.545	0.12	0.01
1341	0.520	0.533	0.504	0.41	0.79
1418	0.570	0.547	0.599	1.63	3.71^{*}
1679	0.393	0.386	0.402	0.35	0.03
1687	0.429	0.423	0.437	0.21	0.81
1726	0.494	0.511	0.473	1.64	4.76^{**}
1746	0.485	0.483	0.486	0.00	0.20
1903	0.445	0.419	0.478	5.00^{**}	1.52
1910	0.378	0.358	0.406	0.96	2.46
1941	0.524	0.508	0.546	0.91	0.14
1966	0.461	0.469	0.449	0.22	0.00
2022	0.585	0.532	0.654	3.38^{*}	0.33
2090	0.699	0.654	0.752	2.23	2.67
3011	0.443	0.402	0.499	4.28^{**}	7.40^{***}
3174	0.398	0.380	0.421	3.77^{*}	5.38^{**}
overall	0.483	0.472	0.497	16.50^{***}	25.76^{***}
ANOVA	13.18^{***}	8.88^{***}	5.66^{***}		
Wilcoxon	425.02^{***}	277.59^{***}	195.11^{***}		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

using both a parametric and non-parametric test of differences. A further seven specialist firms have statistically significant differences using either a parametric or a non-parametric test. Ten of these eleven specialist firms with statistically significant differences exhibit an increase in volatility following the rule change.

This measure of volatility also exhibits differences across the specialist firms in the entire period and the period before and after the rule change. Both parametric ANOVA and non-parametric Wilcoxon rank sums tests are statistically significant at levels of 1% in tests of difference across the specialist firms. This indicates that specialist firms do not have a similar volatility.

The two measures of volatility contradict each other. For the standard deviation of changes in the midpoint of the bid-ask spread, eight of the eleven specialist firms with statistically significant differences between the two periods experience a decline in volatility. Using the difference between the high and low share price divided by the mean share price, ten of the eleven specialist firms with statistical significance experience an increase in volatility between the two periods. Of all the specialist firms with statistically significant differences in Tables 67 and 68, four firms are statistically significant in both tables. Of these four, three specialist firms are in agreement regarding the direction of change between the period before and after the rule change. For specialist firms 298 and 2022, there is an increase in the volatility measure between the two periods. For firm 1726 there is a decrease following the rule change. For firm 1010, the standard deviation measure of volatility shows a decrease, while the other volatility measure indicates volatility increases following the rule change.

Given these limited differences between the two periods the hypothesis that there is a reduction in volatility following the rule change is concluded for nine of the thirty-seven specialist firms. For the remaining twenty-eight specialist firms, hypothesis two (H2) fails to be rejected and it is concluded that the volatility is similar in the period before and after the rule change.

6.4.3. Pilot Stocks

Pilot stocks versus non-pilot stocks are examined for each of the two measures of the final return and each of the two measures of volatility.

6.4.3.1. Price Rise at the End of the Trading Day

Table 69 examines the final intraday transaction return divided into pilot and non-pilot stocks. As shown in Panel A, the overall mean for non-pilot stocks is 0.0996%, while the mean for the pilot stocks is 0.0404%. This difference is statistically significant at a level of 1% using a parametric ANOVA test. Of the thirty-seven specialist firms, only twelve firms have pilot stocks with a sufficient number of final transaction observations. For eleven of these twelve specialist firms, the final return is lower for the pilot stocks. However, of these twelve specialist firms, only two have statistically significant differences between pilot and non-pilot stocks. The mean return for pilot stocks is larger for specialist firm 298 and this difference is statistically significant using a non-parametric test. For firm 3174, the mean final transaction return for pilot stocks is smaller and this difference is statistically significant using both a parametric and a non-parametric test.

Panel B examines only the pilot stocks and shows the mean final intraday transaction return for the period before and after the NYSE MOC rule change. On an overall basis the mean return after the rule change is slightly larger (0.0417% versus

Table 69 This table reports the final intraday transaction returns across specialist firms and pilot stocks. Mean final intraday transaction returns (in percentages) are reported for the entire May-June 1995 period and the period before and after the NYSE rule change on June 5, 1995. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences between the groups.

PANEL A - PILOT VERSUS NON-PILOT STOCKS

Specialist	Entire Period Return	Non-Pilot Stocks Return	Pilot Stocks Return	ANOVA	Wilcoxon
20	0.0653***	0.0653***	-	-	-
34	0.1225***	0.1225***	-	-	-
104	0.0333	0.0333	-	-	-
137	0.0950***	0.0966***	0.0697***	0.05	1.77
202	0.0717***	0.0717***	-	-	-
210	0.0881***	0.0908***	0.0414**	0.73	0.02
215	0.0622***	0.0622***	-	-	-
240	0.1596*	0.1596*	-	-	-
298	0.0638***	0.0619***	0.1123***	0.67	4.26**
364	0.1048**	0.1048**	-	-	-
403	0.0554***	0.0573***	0.0233**	0.39	0.19
501	0.0912***	0.0928***	0.0371**	0.74	0.41
520	0.0431	0.0442	0.0237	0.03	0.15
551	0.0748***	0.0748***	-	-	-
1010	0.0396	0.0396	-	-	-
1027	0.0839**	0.0839**	-	-	-
1034	0.1647**	0.1647**	-	-	-
1148	0.1299***	0.1299***	-	-	-
1225	0.0823***	0.0823***	-	-	-
1227	0.1539***	0.1580***	0.0436*	1.15	0.49
1229	0.1791***	0.1791***	-	-	-
1266	0.2678***	0.2678***	-	-	-
1280	0.1178***	0.1178***	-	-	-
1341	0.0594**	0.0594**	-	-	-
1418	0.1137***	0.1197***	0.0159	0.94	0.86
1679	0.1070***	0.1070***	-	-	-
1687	0.0901***	0.0901***	-	-	-
1726	0.1113***	0.1131***	0.0529*	0.27	0.04
1746	0.0059	0.0059	-	-	-
1903	0.0719**	0.0735***	0.0185	0.13	0.58
1910	0.3061***	0.3061***	-	-	-
1941	0.1405***	0.1405***	-	-	-
1966	0.0979***	0.1012***	0.0422	0.18	0.07
2022	0.1216***	0.1216***	-	-	-
2090	0.1935***	0.1935***	-	-	-
3011	0.2230***	0.2230***	-	-	-
3174	0.1194***	0.1310***	0.0184	4.67**	7.63***
overall	0.0981***	0.0996***	0.0404***	4.57***	0.24
ANOVA	3.35***	3.29***	1.93**		
Wilcoxon	63.54***	66.94***	23.08**		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 69 continued)

PANEL B - PILOT STOCKS - Pre and Post June 5, 1995

Specialist	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
20	-	-	-	-	-
34	-	-	-	-	-
104	-	-	-	-	-
137	0.0697***	0.0709**	0.0684**	0.00	0.41
202	-	-	-	-	-
210	0.0414**	0.0605***	0.0184	1.71	3.01*
215	-	-	-	-	-
240	-	-	-	-	-
298	0.1123***	0.1362***	0.0845**	1.27	1.07
364	-	-	-	-	-
403	0.0233**	0.0077	0.0414***	2.72	2.41
501	0.0371**	0.0456**	0.0270	0.36	0.61
520	0.0237	0.0224	0.0251	0.00	0.05
551	-	-	-	-	-
1010	-	-	-	-	-
1027	-	-	-	-	-
1034	-	-	-	-	-
1148	-	-	-	-	-
1225	-	-	-	-	-
1227	0.0436*	0.0261	0.0666	0.62	0.19
1229	-	-	-	-	-
1266	-	-	-	-	-
1280	-	-	-	-	-
1341	-	-	-	-	-
1418	0.0159	-0.0017	0.0362	0.55	0.21
1679	-	-	-	-	-
1687	-	-	-	-	-
1726	0.0529*	0.0340	0.0706**	0.38	0.88
1746	-	-	-	-	-
1903	0.0185	0.0250	0.0107	0.13	0.31
1910	-	-	-	-	-
1941	-	-	-	-	-
1966	0.0422	0.0260	0.0617	0.46	0.20
2022	-	-	-	-	-
2090	-	-	-	-	-
3011	-	-	-	-	-
3174	0.0184	0.0136	0.0243	0.13	0.00
overall	0.0404***	0.0394***	0.0417***	0.04	0.53
ANOVA	1.93**	1.90**	0.67		
Wilcoxon	23.08**	21.58**	10.07		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 69 continued)

PANEL C - NON-PILOT STOCKS - Pre and Post June 5, 1995

Specialist	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
20	0.0653***	0.0637***	0.0674*	0.01	0.30
34	0.1225***	0.1171**	0.1294**	0.02	0.34
104	0.0333	0.0103	0.0573*	1.12	0.88
137	0.0966***	0.1004**	0.0914**	0.02	0.08
202	0.0717***	0.0593***	0.0876***	1.30	0.16
210	0.0908***	0.0952***	0.0854***	0.12	0.02
215	0.0622***	0.0692***	0.0526**	0.32	2.16
240	0.1596*	0.0995	0.2423*	0.70	0.31
298	0.0619***	0.0647***	0.0582***	0.07	0.60
364	0.1048**	0.1839***	0.0219	2.69	4.99**
403	0.0573***	0.0367**	0.0845***	3.12*	5.69**
501	0.0928***	0.0888***	0.0978***	0.16	0.10
520	0.0442	0.0002	0.0981**	3.00*	2.03
551	0.0748***	0.0453	0.1080***	2.47	0.06
1010	0.0396	0.0258	0.0604	0.14	0.01
1027	0.0839**	0.0579	0.1161*	0.64	0.04
1034	0.1647**	0.1806	0.1432	0.05	0.06
1148	0.1299***	0.1170*	0.1482**	0.12	0.12
1225	0.0823***	0.0590***	0.1099***	2.12	0.48
1227	0.1580***	0.1596***	0.1560***	0.01	0.01
1229	0.1791***	0.2110**	0.1372	0.29	0.19
1266	0.2678***	0.2779***	0.2550**	0.03	0.53
1280	0.1178***	0.1484**	0.0747	0.73	0.72
1341	0.0594**	0.0933**	0.0186	1.36	0.35
1418	0.1197***	0.1378***	0.0954**	0.63	0.01
1679	0.1070***	0.0675***	0.1525***	3.62*	2.53
1687	0.0901***	0.1017***	0.0740*	0.31	0.71
1726	0.1131***	0.1325***	0.0864***	1.27	1.49
1746	0.0059	0.0752**	-0.0870*	8.51***	6.88***
1903	0.0735***	0.0537	0.0961***	0.61	1.33
1910	0.3061***	0.3286***	0.2761**	0.10	0.15
1941	0.1405***	0.1783***	0.0888**	1.70	2.90*
1966	0.1012***	0.1003**	0.1022**	0.00	0.04
2022	0.1216***	0.1793***	0.0461	3.09*	2.30
2090	0.1935***	0.1537**	0.2458***	0.63	0.84
3011	0.2230***	0.1101**	0.3602***	6.30**	0.48
3174	0.1310***	0.1222***	0.1418***	0.31	0.23
overall	0.0996***	0.0974***	0.1025***	0.33	0.06
ANOVA	3.29***	2.20***	2.39***		
Wilcoxon	66.94***	54.42**	54.10**		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

0.0394%), however the difference is not statistically significant. For individual specialist firms, only one of the twelve specialist firms has a statistically significant difference between the two periods. Firm 210 shows a decline following the rule change, but the difference is only statistically significant at a level of 10% using a non-parametric Wilcoxon rank scores test.

The difference across the specialist firms is apparent on an overall basis and in the period before the rule change. Using a parametric ANOVA test and a non-parametric Wilcoxon rank sums test indicates that the differences across the specialist firms are significant at a level of 5% in the entire period and in the period before the rule change. For the period following the rule change, the difference is not statistically significant. This suggests that the rule change may influence the final return for the pilot stocks. Since the pilot stocks must publicize order imbalances, this may be influencing the final intraday return and resulting in a similarity across specialist firms.

For non-pilot stocks, as shown in Panel C, the overall final transaction return increases slightly from 0.0974% to 0.1025% following the rule change. This difference is not statistically significant. Of the thirty-seven specialist firms, eight firms have statistically significant differences between the period before and after the rule change. The individual specialist firms that are significant are the same firms that are significant in Table 65. Four of the eight firms show a decrease in the mean return.

The differences among the specialist firms are also examined in Panel C of Table 69. The differences across the specialist firms remain statistically significant as in Table 65, however, the non-parametric measure is slightly reduced in significance from 1% to 5% in the individual periods before and after the rule change.

The final fifteen minute return is examined across pilot and non-pilot stocks in Table 70. On an overall basis, as shown in Panel A, the mean final fifteen minute return is lower for pilot stocks, however, this difference is not statistically significant. Of the thirty-seven specialist firms, twelve firms have pilot stocks that have a sufficient number of observations to be included in the analysis. Only two of these firms have statistically significant differences between pilot and non-pilot firms. Firm 137 has a much larger final fifteen minute return for pilot stocks and the difference is statistically significant at a level of 10% using a non-parametric test. Firm 3174 has a much lower final fifteen minute return for pilot stocks and the difference is statistically significant at a level of 5% using a non-parametric test.

The mean final fifteen minute return is examined across specialist firms and differences are statistically significant for non-pilot stocks. Using a parametric test, the level of significance is 5%, but there is no statistically significant difference using a non-parametric test. Also, there is no statistically significant differences across specialist firms for pilot stocks using either parametric or non-parametric tests.

Pilot stocks are examined separately in Panel B. The final fifteen minute return declines following the rule change from 0.0659% to 0.0598%, but the difference is not statistically significant. When the twelve individual specialist firms are examined, only one firm shows statistically significant differences in the mean final fifteen minute return between the two periods. Firm 298 shows a decline in the mean final fifteen minute return and this difference is statistically significant at a level of 5% using a parametric test and at a level of 10% using a non-parametric test. There are no differences noted across the specialist firms when they are compared during the entire period, or in the period before or after the rule change.

Table 70 This table reports the final fifteen minute returns across specialist firms and pilot stocks. Mean final fifteen minute returns (in percentages) are reported for the entire May-June 1995 period and the period before and after the NYSE rule change on June 5, 1995. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences between the groups.

PANEL A - PILOT VERSUS NON-PILOT STOCKS

Specialist	Overall Return	Non-Pilot Stocks Return	Pilot Stocks Return	ANOVA	Wilcoxon
20	0.0461**	0.0461**	-	-	-
34	0.1549***	0.1549***	-	-	-
104	0.0561**	0.0561**	-	-	-
137	0.0258	0.0188	0.1413**	0.99	3.81*
202	0.0787***	0.0787***	-	-	-
210	0.0870***	0.0876***	0.0751***	0.04	0.15
215	0.0989***	0.0989***	-	-	-
240	0.1609*	0.1609*	-	-	-
298	0.0924***	0.0917***	0.1128***	0.08	0.50
364	0.0819**	0.0819**	-	-	-
403	0.0744***	0.0770***	0.0279	0.55	0.21
501	0.0922***	0.0923***	0.0895***	0.00	1.20
520	0.1019***	0.1019***	0.1023**	0.00	1.00
551	0.0854***	0.0854***	-	-	-
1010	0.0563	0.0563	-	-	-
1027	0.0798**	0.0798**	-	-	-
1034	0.2307***	0.2307***	-	-	-
1148	0.0854*	0.0854*	-	-	-
1225	0.0591***	0.0591***	-	-	-
1227	0.1003***	0.1035***	0.0250	0.58	0.05
1229	0.1353**	0.1353**	-	-	-
1266	0.2016***	0.2016***	-	-	-
1280	0.0217	0.0217	-	-	-
1341	0.0455	0.0455	-	-	-
1418	0.1095***	0.1167***	-0.0025	1.31	1.93
1679	0.0641***	0.0641***	-	-	-
1687	0.0970***	0.0970***	-	-	-
1726	0.1040***	0.1034***	0.1252*	0.03	0.42
1746	0.0514	0.0514	-	-	-
1903	0.0932***	0.0947***	0.0372	0.18	0.00
1910	0.1467***	0.1467***	-	-	-
1941	0.1255***	0.1255***	-	-	-
1966	0.0896***	0.0894***	0.0934	0.00	0.23
2022	0.0833*	0.0833*	-	-	-
2090	0.1373***	0.1373***	-	-	-
3011	0.1263***	0.1263***	-	-	-
3174	0.0933***	0.1026***	0.0136	2.59	4.54**
overall	0.0906***	0.0913***	0.0630***	1.04	0.15
ANOVA	1.48**	1.50**	1.52		
Wilcoxon	37.63	41.21	13.45		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 70 continued)

PANEL B - PILOT STOCKS - Pre and Post June 5, 1995

Specialist	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
20	-	-	-	-	-
34	-	-	-	-	-
104	-	-	-	-	-
137	0.1413**	0.1258*	0.1592	0.08	0.16
202	-	-	-	-	-
210	0.0751***	0.0793**	0.0700	0.03	0.11
215	-	-	-	-	-
240	-	-	-	-	-
298	0.1128***	0.1879***	0.0335	4.76**	3.71*
364	-	-	-	-	-
403	0.0279*	0.0176	0.0394	0.19	0.79
501	0.0895***	0.0902**	0.0885**	0.00	0.02
520	0.1023**	0.0973	0.1083**	0.02	0.09
551	-	-	-	-	-
1010	-	-	-	-	-
1027	-	-	-	-	-
1034	-	-	-	-	-
1148	-	-	-	-	-
1225	-	-	-	-	-
1227	0.0250	0.0173	0.0394	0.12	0.03
1229	-	-	-	-	-
1266	-	-	-	-	-
1280	-	-	-	-	-
1341	-	-	-	-	-
1418	-0.0025	0.0019	-0.0076	0.01	0.00
1679	-	-	-	-	-
1687	-	-	-	-	-
1726	0.1252*	0.0893	0.1571	0.25	0.07
1746	-	-	-	-	-
1903	0.0372	0.0714	-0.0022	0.83	1.24
1910	-	-	-	-	-
1941	-	-	-	-	-
1966	0.0934	0.0945	0.0921	0.00	0.35
2022	-	-	-	-	-
2090	-	-	-	-	-
3011	-	-	-	-	-
3174	0.0136	0.0150	0.0120	0.00	0.24
overall	0.0630***	0.0659***	0.0598***	0.08	0.74
ANOVA	1.52	1.08	0.85		
Wilcoxon	13.45	13.25	7.39		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 70 continued)

PANEL C - NON-PILOT STOCKS - Pre and Post June 5, 1995

Specialist	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
20	0.0461^{**}	0.0601^{**}	0.0264	0.62	0.53
34	0.1549^{***}	0.1419^{***}	0.1719^{***}	0.16	0.28
104	0.0561^{**}	0.0774^{**}	0.0336	0.81	1.89
137	0.0188	0.0216	0.0154	0.01	0.94
202	0.0787^{***}	0.0751^{***}	0.0833^{***}	0.08	0.00
210	0.0876^{***}	0.1011^{***}	0.0710^{***}	0.94	0.45
215	0.0989^{***}	0.0960^{***}	0.1027^{***}	0.03	2.51
240	0.1609^{*}	0.1159	0.2232	0.39	0.63
298	0.0917^{***}	0.0653^{***}	0.1256^{***}	4.99^{**}	3.40^{*}
364	0.0819^{**}	0.1407^{**}	0.0186	2.43	1.86
403	0.0770^{***}	0.0601^{***}	0.0999^{***}	1.58	2.14
501	0.0923^{***}	0.0784^{***}	0.1098^{***}	1.74	2.05
520	0.1019^{***}	0.0518	0.1524^{***}	3.40^{*}	4.67^{**}
551	0.0854^{***}	0.0767^{***}	0.0957^{***}	0.24	0.28
1010	0.0563	0.0411	0.0747	0.17	0.38
1027	0.0798^{**}	0.0562	0.1174^{*}	0.57	0.06
1034	0.2307^{***}	0.3499^{***}	0.0827	2.51	1.73
1148	0.0854^{*}	0.1021	0.0648	0.15	0.25
1225	0.0591^{***}	0.0503^{**}	0.0702^{***}	0.31	0.51
1227	0.1035^{***}	0.0762^{***}	0.1364^{***}	2.03	0.68
1229	0.1353^{**}	0.0879	0.1859^{***}	0.65	1.89
1266	0.2016^{***}	0.3054^{***}	0.0667	5.30^{**}	3.42^{*}
1280	0.0217	-0.0131	0.0663	0.74	1.36
1341	0.0455	0.0428	0.0490	0.01	0.17
1418	0.1167^{***}	0.0704^{*}	0.1730^{***}	3.83^{*}	1.31
1679	0.0641^{***}	0.0841^{***}	0.0400	1.15	1.19
1687	0.0970^{***}	0.1203^{***}	0.0695^{*}	0.93	0.02
1726	0.1034^{***}	0.1365^{***}	0.0614^{*}	2.73^{*}	5.13^{**}
1746	0.0514	0.0629	0.0387	0.07	0.19
1903	0.0947^{***}	0.0665^{***}	0.1287^{***}	1.85	0.85
1910	0.1467^{***}	0.1383^{*}	0.1567^{**}	0.03	0.15
1941	0.1255^{***}	0.1219^{***}	0.1304^{***}	0.03	0.12
1966	0.0894^{***}	0.1315^{***}	0.0309	3.13^{*}	5.53^{*}
2022	0.0833^{*}	0.1512^{***}	-0.0020	3.02^{*}	2.97^{*}
2090	0.1373^{***}	0.1774^{***}	0.0902	0.82	1.38
3011	0.1263^{***}	0.0716	0.1947^{***}	1.81	0.06
3174	0.1026^{***}	0.0960^{***}	0.1103^{***}	0.15	0.12
overall	0.0913^{***}	0.0877^{***}	0.0958^{***}	0.83	0.00
ANOVA	1.50^{**}	1.60^{**}	1.37^{*}		
Wilcoxon	41.21	46.20	48.05^{*}		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

The non-pilot stocks, as shown in Panel C, have a mean final fifteen minute return that increases following the rule change from 0.0877% to 0.0958%, but this difference is not statistically significant. Of the thirty-seven specialist firms, seven firms show a statistically significant difference between the periods before and after the rule change. These results are similar to Table 66. Four of the seven firms show an increase in the final fifteen minute return following the rule change.

The differences across the specialist firms for non-pilot stocks in Panel C are statistically significant in the entire period, as well as when the period before and after the rule change are separately examined. The parametric test is statistically significant in all periods at a level of 5 to 10%, while the non-parametric test is only statistically significant at a level of 10% in the period following the rule change.

These results indicate that pilot stocks have an overall end of day price rise that is smaller than non-pilot stocks when the final intraday return is examined. When the final fifteen minute return is examined there are only limited differences between the pilot and non-pilot stocks. When the period after the rule change is examined, there are no statistically significant differences in the final intraday transaction return across the specialist firms. This indicates that the publication of order imbalances for pilot stocks may be reducing the differences in the final intraday transaction return across the specialist firms. In comparisons between the period before and after the rule change, neither pilot nor non-pilot stocks show statistically significant differences between the periods. This indicates that, in aggregate, the impact on the end of day price rise following the rule change is not affected by whether the stock is a pilot stock. This

rejects hypothesis three (H3) for the end of day price rise since differences are found between pilot and non-pilot stocks, however, this does not reject the second part of the hypothesis that there are differences in the effect of the rule change on pilot versus non-pilot stocks.

6.4.3.2. Volatility at the End of the Trading Day

Two measures of volatility are used to compare pilot and non-pilot stocks. In Table 71 volatility is measured as the standard deviation of changes in successive midpoints of the bid-ask spread. As shown in Panel A, the volatility for non-pilot stocks is much larger than the volatility for pilot stocks (0.728% versus 0.244%). This difference is statistically significant at a level of 1% using parametric and non-parametric tests of difference. Twenty-three of the thirty-seven specialist firms have pilot stocks that have a sufficient number of observations to be included. This is a larger number of firms than for the returns at the end of the trading day since the volatility measure uses an entire half-hour of transactions. There is therefore a lower likelihood of not having any observations in a half-hour compared to the fifteen minute period used by the return measures. Of these twenty-three firms, all show a statistically significant difference between the non-pilot and pilot stocks using either parametric and/or non-parametric tests.

There are differences across the specialist firms in the entire period when all the stocks are examined and when the pilot and non-pilot stocks are examined separately. Parametric and non-parametric tests indicate that the differences are statistically significant at a level of 1%.

Table 71 This table reports the volatility (standard deviation) across specialist firms and pilot versus non-pilot stocks. Volatility over the final half-hour of trading as measured by the standard deviation (in percent) of changes in successive midpoints of the bid-ask spread across specialist firms is reported for May-June 1995 and the period before and after the NYSE rule change on June 5, 1995. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences between the groups.

PANEL A - PILOT VERSUS NON-PILOT STOCKS

Specialist	Overall Return	Non-Pilot Stocks Return	Pilot Stocks Return	ANOVA	Wilcoxon
20	0.493	0.502	0.237	13.76***	26.57***
34	0.682	0.682	-	-	-
104	0.712	0.727	0.171	3.12*	96.86***
137	0.753	0.769	0.246	6.76***	64.48***
202	0.531	0.531	-	-	-
210	0.544	0.559	0.170	29.02***	150.54***
215	0.646	0.654	0.227	14.44***	40.30***
240	1.156	1.156	-	-	-
298	2.545	2.602	0.204	0.94	79.89***
364	0.534	0.544	0.122	14.34***	53.72***
403	0.487	0.500	0.170	45.78***	221.98***
501	0.600	0.611	0.260	30.44***	277.78***
520	0.870	0.888	0.155	1.62	48.80***
551	0.448	0.454	0.169	2.62	44.41***
1010	0.598	0.598	-	-	-
1027	0.441	0.441	-	-	-
1034	0.579	0.579	-	-	-
1148	1.026	1.026	-	-	-
1225	0.701	0.701	-	-	-
1227	0.557	0.571	0.157	68.46***	187.63***
1229	0.674	0.690	0.144	21.04***	68.09***
1266	0.764	0.712	2.881	25.99***	0.80
1280	0.636	0.636	-	-	-
1341	0.578	0.578	-	-	-
1418	0.660	0.675	0.270	14.37	55.01***
1679	0.532	0.548	0.127	40.72***	121.77***
1687	0.618	0.625	0.245	14.23***	28.98***
1726	0.532	0.545	0.122	48.51***	128.39***
1746	0.717	0.717	-	-	-
1903	1.023	1.061	0.158	0.32	200.74***
1910	0.612	0.612	-	-	-
1941	0.726	0.733	0.216	6.53**	36.32***
1966	0.568	0.590	0.252	21.08***	43.54***
2022	0.640	0.664	0.208	29.56***	117.17***
2090	0.812	0.812	-	-	-
3011	0.685	0.685	-	-	-
3174	0.532	0.550	0.157	31.10***	133.52***
overall	0.716	0.728	0.244	14.80***	2159.3***
ANOVA	10.69***	10.66***	3.04***		
Wilcoxon	1276.7***	1176.7***	427.73***		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 71 continued)

PANEL B - PILOT STOCKS - Pre and Post June 5, 1995

Specialist	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
20	0.237	0.259	0.209	4.08**	4.07**
34	-	-	-	-	-
104	0.171	0.166	0.177	0.33	1.18
137	0.246	0.160	0.353	3.08*	7.72***
202	-	-	-	-	-
210	0.170	0.175	0.163	0.62	0.15
215	0.227	0.238	0.212	1.79	1.65
240	-	-	-	-	-
298	0.204	0.239	0.162	5.13**	5.38**
364	0.122	0.133	0.109	1.28	0.61
403	0.170	0.134	0.214	1.21	0.59
501	0.260	0.305	0.204	0.47	0.71
520	0.155	0.151	0.162	0.72	0.36
551	0.169	0.217	0.111	0.66	0.04
1010	-	-	-	-	-
1027	-	-	-	-	-
1034	-	-	-	-	-
1148	-	-	-	-	-
1225	-	-	-	-	-
1227	0.157	0.166	0.145	1.12	1.34
1229	0.144	0.149	0.138	0.96	0.56
1266	2.881	4.867	0.427	0.82	0.65
1280	-	-	-	-	-
1341	-	-	-	-	-
1418	0.270	0.289	0.246	1.71	1.29
1679	0.127	0.122	0.134	0.65	1.49
1687	0.245	0.251	0.238	0.10	0.01
1726	0.122	0.125	0.119	0.20	0.24
1746	-	-	-	-	-
1903	0.158	0.166	0.149	1.73	1.63
1910	-	-	-	-	-
1941	0.216	0.279	0.137	1.17	2.47
1966	0.252	0.258	0.245	0.34	0.18
2022	0.208	0.187	0.233	0.55	4.87**
2090	-	-	-	-	-
3011	-	-	-	-	-
3174	0.157	0.148	0.167	1.21	3.74*
overall	0.244	0.284	0.194	1.05	2.30
ANOVA	3.04***	2.86***	1.20		
Wilcoxon	427.73***	261.89***	190.43***		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 71 continued)

PANEL C - NON-PILOT STOCKS - Pre and Post June 5, 1995

Specialist	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
20	0.502	0.511	0.492	0.52	0.01
34	0.682	0.680	0.684	0.01	2.18
104	0.727	0.681	0.784	0.92	0.06
137	0.769	0.786	0.747	0.30	0.06
202	0.531	0.573	0.479	1.21	0.50
210	0.559	0.571	0.543	0.94	0.19
215	0.654	0.659	0.649	0.09	0.55
240	1.156	1.291	0.992	1.61	2.09
298	2.602	1.834	3.550	4.88**	0.26
364	0.544	0.570	0.512	2.75*	1.97
403	0.500	0.510	0.488	1.24	2.77*
501	0.611	0.622	0.599	1.01	0.05
520	0.888	1.008	0.740	2.11	0.05
551	0.454	0.445	0.464	0.16	3.70*
1010	0.598	0.664	0.519	10.08***	5.97**
1027	0.441	0.444	0.437	0.05	2.89*
1034	0.579	0.581	0.576	0.01	0.51
1148	1.026	1.164	0.856	3.31*	0.43
1225	0.701	0.719	0.680	0.35	2.65
1227	0.571	0.577	0.563	0.51	0.06
1229	0.690	0.705	0.673	0.59	0.00
1266	0.712	0.724	0.697	0.19	1.06
1280	0.636	0.668	0.596	3.34*	3.82*
1341	0.578	0.599	0.553	2.47	0.56
1418	0.675	0.687	0.661	0.37	1.53
1679	0.548	0.550	0.546	0.03	0.22
1687	0.625	0.639	0.607	1.33	2.76*
1726	0.545	0.556	0.530	1.54	3.20*
1746	0.717	0.784	0.633	4.98**	8.66***
1903	1.061	1.433	0.605	1.56	1.97
1910	0.612	0.631	0.587	1.35	0.00
1941	0.733	0.752	0.709	0.86	1.25
1966	0.590	0.587	0.593	0.03	0.03
2022	0.664	0.651	0.680	0.54	4.87**
2090	0.812	0.850	0.766	2.47	0.04
3011	0.685	0.686	0.684	0.00	0.00
3174	0.550	0.560	0.537	0.53	0.02
overall	0.728	0.732	0.723	0.05	9.02***
ANOVA	10.66***	3.00***	11.89***		
Wilcoxon	1176.7***	658.18***	565.61***		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

Panel B separately examines pilot stocks in the period before and after the NYSE MOC rule change. The overall volatility declines slightly after the rule change from 0.284% to 0.194%, but the difference is not statistically significant. For five of the twenty-three specialist firms there are differences noted between the period before and after the rule change for pilot stocks. For three of these five firms, the volatility increases following the rule change.

When the differences across specialist firms are examined, there is no statistically significant difference in the period after the rule change using a parametric test. In the period before the rule change, the parametric test is significant at a level of 1%. This indicates that, following the rule change, pilot stocks have a similar volatility using a parametric test of difference. The non-parametric test is significant at a level of 1% in the period before and after the rule change. This may be because the publication of order imbalances for the pilot stocks reduces the differences in volatility.

Panel C examines non-pilot stocks and shows that there is a marginal decline in volatility for non-pilot stocks from 0.732% to 0.723% following the rule change. The difference is statistically significant at a level of 1% using a non-parametric Wilcoxon rank scores test, however, the magnitude is not economically meaningful. The solely significant non-parametric test is similar to Table 67. The number of individual specialist firms with significant differences between the period before and after the rule change is slightly larger in Table 71 Panel C compared to Table 67 (twelve versus ten). Eight of the twelve specialist firms show a decline in volatility.

When the mean volatility of the specialist firms are all compared, the differences are statistically significant using parametric and non-parametric tests. For the entire period, and for the period before and after the rule change, the differences are statistically

significant at a level of 1% using the parametric ANOVA test and the non-parametric Wilcoxon rank sums test.

Table 72 presents an analysis based on the second measure of volatility. Quite different from the first measure of volatility, in this table, volatility is measured as the difference between the high and low share price divided by the mean share price during the final half-hour of the trading day. There are fewer number of observations in this table than when using the other measure of volatility since this measure requires at least two different transactions in the half-hour period. The other measure of volatility only requires a change in the midpoint of the bid and ask quotes from those outstanding at the beginning of the period.

A comparison between pilot and non-pilot stocks, as shown in Panel A, indicates that the volatility is marginally lower for pilot stocks (0.479% versus 0.483%). This difference is statistically significant at a level of 1% using a non-parametric test. There are thirteen specialist firms with pilot stocks that have an observed value for volatility for pilot stocks. Of these thirteen firms, ten show statistically significant differences between the pilot and non-pilot stocks. In all ten firms differences are significant using non-parametric tests and in two of these firms the differences are corroborated by significant parametric tests.

When the mean volatility measures are compared across the specialist firms, there are statistically significant differences noted using parametric and non-parametric tests. Examined separately, pilot and non-pilot stocks both show differences between specialist firms at a level of 1% using parametric and non-parametric tests.

Table 72 This table reports the volatility (difference) across specialist firms and pilot versus non-pilot stocks. Volatility during the final half-hour of trading as measured by the difference between the high and low share price divided by the mean share price is reported (in percent) across specialist firms for May-June 1995 and the period before and after the NYSE rule change on June 5, 1995. Parametric ANOVA and non-parametric Wilcoxon rank sums tests are conducted to test for differences between the groups.

PANEL A - PILOT VERSUS NON-PILOT STOCKS

Specialist	Overall Return	Non-Pilot stocks Return	Pilot Stocks Return	ANOVA	Wilcoxon
20	0.411	0.411	-	-	-
34	0.525	0.525	-	-	-
104	0.423	0.423	-	-	-
137	0.629	0.625	0.735	0.75	24.74***
202	0.438	0.438	-	-	-
210	0.479	0.479	0.464	0.06	13.67***
215	0.493	0.493	0.454	0.07	1.19
240	0.493	0.493	-	-	-
298	0.461	0.462	0.423	0.39	0.93
364	0.486	0.486	-	-	-
403	0.480	0.481	0.457	0.16	10.72***
501	0.462	0.464	0.395	1.45	9.00***
520	0.492	0.496	0.373	0.60	2.40
551	0.370	0.370	-	-	-
1010	0.542	0.542	-	-	-
1027	0.388	0.388	-	-	-
1034	0.485	0.485	-	-	-
1148	0.642	0.642	-	-	-
1225	0.422	0.422	-	-	-
1227	0.505	0.509	0.354	3.22*	3.93**
1229	0.473	0.473	-	-	-
1266	0.630	0.630	-	-	-
1280	0.535	0.535	-	-	-
1341	0.520	0.520	-	-	-
1418	0.570	0.565	0.707	1.68	28.80***
1679	0.393	0.393	-	-	-
1687	0.429	0.429	-	-	-
1726	0.494	0.489	0.743	5.41**	21.31***
1746	0.485	0.485	-	-	-
1903	0.445	0.445	0.421	0.05	8.14***
1910	0.378	0.378	-	-	-
1941	0.524	0.524	-	-	-
1966	0.461	0.457	0.552	0.62	17.13***
2022	0.585	0.585	-	-	-
2090	0.699	0.699	-	-	-
3011	0.443	0.443	-	-	-
3174	0.398	0.397	0.404	0.03	11.84***
overall	0.483	0.483	0.479	0.03	154.66***
ANOVA	13.18***	12.69***	12.61***		
Wilcoxon	425.02***	391.35***	122.00***		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 72 continued)

PANEL B - PILOT STOCKS - Pre and Post June 5, 1995

Specialist	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
20	-	-	-	-	-
34	-	-	-	-	-
104	-	-	-	-	-
137	0.735	0.682	0.796	0.81	0.01
202	-	-	-	-	-
210	0.464	0.457	0.472	0.09	1.44
215	0.454	0.464	0.444	0.03	2.29
240	-	-	-	-	-
298	0.423	0.460	0.380	1.57	1.55
364	-	-	-	-	-
403	0.457	0.492	0.416	2.78*	1.51
501	0.395	0.420	0.369	1.42	4.06**
520	0.373	0.421	0.314	1.81	1.18
551	-	-	-	-	-
1010	-	-	-	-	-
1027	-	-	-	-	-
1034	-	-	-	-	-
1148	-	-	-	-	-
1225	-	-	-	-	-
1227	0.354	0.413	0.284	3.68*	7.38***
1229	-	-	-	-	-
1266	-	-	-	-	-
1280	-	-	-	-	-
1341	-	-	-	-	-
1418	0.707	0.696	0.719	0.05	0.35
1679	-	-	-	-	-
1687	-	-	-	-	-
1726	0.743	0.787	0.696	0.54	0.58
1746	-	-	-	-	-
1903	0.421	0.448	0.389	0.57	3.74*
1910	-	-	-	-	-
1941	-	-	-	-	-
1966	0.552	0.586	0.510	0.98	3.98**
2022	-	-	-	-	-
2090	-	-	-	-	-
3011	-	-	-	-	-
3174	0.404	0.409	0.399	0.04	0.03
overall	0.479	0.495	0.461	2.63	3.48*
ANOVA	12.61***	4.73***	9.14***		
Wilcoxon	122.00***	48.83***	85.95***		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

(table con'd)

(Table 72 continued)

PANEL C - NON-PILOT STOCKS - Pre and Post June 5, 1995

Specialist	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
20	0.411	0.394	0.437	2.05	4.36**
34	0.525	0.542	0.504	0.57	0.00
104	0.423	0.413	0.434	0.55	1.12
137	0.625	0.622	0.629	0.02	2.03
202	0.438	0.434	0.444	0.23	0.79
210	0.479	0.484	0.474	0.17	0.17
215	0.493	0.480	0.512	1.52	3.99**
240	0.493	0.427	0.580	1.81	0.57
298	0.462	0.437	0.498	9.50***	11.04***
364	0.486	0.507	0.464	0.57	0.58
403	0.481	0.466	0.502	2.66	0.37
501	0.464	0.464	0.464	0.00	2.65
520	0.496	0.448	0.551	3.20*	2.75*
551	0.370	0.365	0.377	0.19	1.61
1010	0.542	0.499	0.609	3.70*	3.58*
1027	0.388	0.388	0.387	0.00	1.09
1034	0.485	0.483	0.487	0.00	0.11
1148	0.642	0.682	0.593	2.14	0.51
1225	0.422	0.412	0.434	0.80	0.06
1227	0.509	0.493	0.528	1.79	2.24
1229	0.473	0.443	0.508	1.04	2.29
1266	0.630	0.643	0.613	0.15	0.01
1280	0.535	0.527	0.545	0.12	0.01
1341	0.520	0.533	0.504	0.41	0.79
1418	0.565	0.542	0.594	1.57	3.28*
1679	0.393	0.386	0.402	0.35	0.03
1687	0.429	0.423	0.437	0.21	0.81
1726	0.489	0.506	0.468	1.57	4.85**
1746	0.485	0.483	0.486	0.00	0.20
1903	0.445	0.419	0.479	5.16**	1.62
1910	0.378	0.358	0.406	0.96	2.46
1941	0.524	0.508	0.546	0.91	0.14
1966	0.457	0.465	0.447	0.18	0.00
2022	0.585	0.532	0.654	3.38*	0.33
2090	0.699	0.654	0.752	2.23	2.67
3011	0.443	0.402	0.499	4.28**	7.40***
3174	0.397	0.378	0.423	3.96**	5.42**
overall	0.483	0.472	0.498	17.28***	26.29***
ANOVA	12.69***	8.62***	5.43***		
Wilcoxon	391.35***	259.90***	179.88***		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

Panel B reports the mean volatility for pilot stocks on an overall basis and in the period before and after the rule change. The overall mean volatility declines from 0.495% to 0.461% following the rule change. The difference is statistically significant at a level of 10% using a non-parametric test. Of the thirteen specialist firms with pilot stocks, five show a statistically significant difference between the period before and after the rule change. All five of these firms exhibit a decrease in volatility.

The mean volatility is compared across specialist firms and differences across the specialist firms are found in both the period before and after the rule change. Parametric and non-parametric tests indicate that there are statistically significant differences at a level of 1% across the specialist firms.

Non-pilot stocks are examined in Panel C. The results are similar to Table 68. A slight increase is found in the overall volatility measure after the rule change (0.498% versus 0.472%). This is found to be statistically significant using parametric and non-parametric tests. The same eleven individual specialist firms as in Table 68 are found to exhibit statistically significant differences between the period before and after the rule change. Only one of the eleven specialist firms shows a decline in the volatility following the rule change.

When the mean volatility is compared across specialist firms the difference is found to be significant in the period before and the period after the rule change. In both periods the parametric ANOVA test and the non-parametric Wilcoxon rank sums test are statistically significant at a level of 1%. Using this difference measure of volatility, a similar level of volatility is not observed across the specialist firms.

The results show that both measures of volatility are not the same across pilot and non-pilot stocks. The standard deviation measure shows a volatility level that is much

lower for pilot stocks, and the difference is statistically significant. The difference measure of volatility is only slightly lower for pilot stocks but the difference between pilot and non-pilot stocks is statistically significant. The volatility for pilot stocks declines following the rule change, but this decline has only mild statistical significance. For non-pilot stocks there are conflicting findings. Using the difference measure of volatility shows a statistically significant increase following the rule change. Using the standard deviation measure of volatility shows a slight decline that is only statistically significant with a non-parametric test. These results reject hypothesis three (H3) since the volatility of pilot stocks is lower than that of non-pilot stocks and there is a significant decline following the rule change.

6.4.4. Reduced Sample of Pilot Stocks

A reduced sample of pilot stocks is used to examine both measures of returns at the end of the day and both measures of volatility at the end of the day. The reduced sample is formed by using the ten lowest capitalization pilot stocks and matching with the nearest capitalization non-pilot stocks. A minimum number of transactions is required near the end of the day to be included in the reduced sample.

6.4.4.1. Price Rise at the End of the Trading Day

Table 73 reports the final intraday transaction for the reduced sample of pilot and non-pilot stocks. The overall final intraday return is 0.0531%. This is approximately half the size of the overall final intraday return when all the stocks are examined. The pilot stocks have a final intraday return that is slightly smaller than the final intraday return for non-pilot stocks, however the difference is not statistically significant. There is no statistically significant difference between the pilot and non-pilot stocks in either the period before or the period after the NYSE MOC rule change.

Table 73 This table reports the final intraday transaction returns using a matched sample. Mean final intraday transaction returns (in percentages) are reported in the May-June 1995 period for a matched sample of the ten lowest capitalization pilot stocks and the closest capitalization non-pilot stocks. The return is reported for each of the groups of pilot and non-pilot stocks for the overall period and for the period before and after the NYSE rule change on June 5, 1995. A parametric ANOVA test and a non-parametric Wilcoxon rank scores test are conducted to test for differences between the two periods and between pilot and non-pilot stocks.

	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
All Stocks	0.0531***	0.0507***	0.0559***	0.10	0.67
Non-Pilot Stocks	0.0582***	0.0672***	0.0479**	0.57	4.21**
Pilot Stocks	0.0484***	0.0306**	0.0633***	1.56	0.60
ANOVA	0.35	2.12	0.35		
Wilcoxon	0.15	2.36	1.58		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

For the entire reduced sample of stocks, the mean final intraday transaction return increases after the rule change, however, the difference is not statistically significant. The non-pilot stocks show a decline following the rule change from 0.0672% to 0.0479% and this difference is statistically significant at a level of 5% using a non-parametric Wilcoxon rank scores test. The pilot stocks show an increase in the final intraday transaction return, however the difference is not statistically significant.

Table 74 uses a reduced sample to calculate the final fifteen minute return for pilot and non-pilot stocks. The overall return is 0.0691%. This is lower than the overall final fifteen minute return using all stocks (0.0906%) reported in Table 66. In the reduced sample, the return for the entire period is higher for pilot stocks (0.0767% versus

Table 74 This tale reports the final fifteen minute returns using a matched sample. Mean final fifteen minute returns (in percentages) are reported in the May-June 1995 period for a matched sample of the ten lowest capitalization pilot stocks and the closest capitalization non-pilot stocks. The return is reported for each of the groups of pilot and non-pilot stocks for the overall period and for the periods before and after the NYSE rule change on June 5, 1995. A parametric ANOVA test and a non-parametric Wilcoxon rank scores test are conducted to test for differences between the two periods and between pilot and non-pilot stocks.

	Entire Period Return	Pre-06/05/95 Return	Post-06/05/95 Return	ANOVA	Wilcoxon
All Stocks	0.0691***	0.0642***	0.0749***	0.14	0.09
Non-Pilot Stocks	0.0609***	0.0718***	0.0479	0.31	1.81
Pilot Stocks	0.0767***	0.0571**	0.0991***	1.12	0.75
ANOVA	0.30	0.16	1.27		
Wilcoxon	0.11	0.74	2.10		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

0.0609%), although the difference is not statistically significant. The final fifteen minute return for pilot stocks in the period before the rule change is smaller than that for non-pilot stocks, but the difference also is not significant. In the period after the rule change, pilot stocks have a larger final fifteen minute return, but the difference is also not statistically significant. For all the reduced sample stocks, there is no statistical difference between the period before and after the rule change. This is also true separately for pilot and non-pilot stocks.

The results indicate that the price rise at the end of the day is similar across pilot and non-pilot stocks. A statistically significant decline in the price rise following the rule change is significant using a non-parametric test when the final intraday transaction

return measure is used. However, no decline is observed for the reduced sample of pilot stocks. These results for the reduced sample fail to reject hypothesis three (H3) that there is similar behavior for pilot and non-pilot stocks following the rule change.

6.4.4.2. Volatility at the End of the Trading Day

Volatility as measured by the standard deviation of successive midpoints of the bid-ask spread in the final half-hour of trading is reported for the reduced sample in Table 75. The overall volatility is 0.236%. This is smaller than the overall volatility (0.716%) reported for all stocks in Table 67. No statistical difference is found between the pilot and non-pilot stocks in the entire period, nor separately in either of the periods before or after the NYSE MOC rule change. When the volatility is compared before and after the rule change, no difference is found between these two periods for the entire reduced stock sample, nor for the pilot nor the non-pilot stocks.

Table 75 This table reports the volatility (standard deviation) using a matched sample. Volatility over the final half-hour of trading as measured by the standard deviation (in percent) of changes in successive midpoints of the bid and ask quotes is reported in the May-June 1995 period for a matched sample of the ten lowest capitalization pilot stocks and the closest capitalization non-pilot stocks. The volatility is reported for the entire period and for the periods before and after the NYSE rule change on June 5, 1995. A parametric ANOVA test and a non-parametric Wilcoxon rank scores test are conducted to test for differences between the two periods and between pilot and non-pilot stocks.

	Entire Period Volatility	Pre-06/05/95 Volatility	Post-06/05/95 Volatility	ANOVA	Wilcoxon
All Stocks	0.236	0.224	0.251	1.21	0.63
Non-Pilot Stocks	0.249	0.234	0.267	0.63	0.40
Pilot Stocks	0.224	0.215	0.236	0.66	0.25
ANOVA	1.01	1.26	0.38		
Wilcoxon	0.71	0.32	0.49		

*significant at α = 10%, **significant at α = 5%, ***significant at α = 1%

Volatility is also measured as the difference between the high and low price divided by the mean price in the final half-hour of trading. This measure is reported for the reduced sample of stocks in Table 76. The volatility for the entire reduced sample is calculated to be 0.488%. This is slightly larger than the volatility for all stocks calculated to be 0.483% as shown in Table 68. The pilot stocks in the reduced sample have a larger volatility on an overall basis (0.548% versus 0.428%). This is also true in the period before the rule change (0.546% versus 0.416%) and the period after the rule change (0.549% versus 0.441%). The difference between pilot and non-pilot stocks is statistically significant using parametric and non-parametric tests. The level of significance for both tests is 1% over the entire period and in the period before the rule change. The level of significance falls to 5% for both tests in the period after the rule change.

Table 76 This table reports the volatility (difference) using a matched sample. Volatility during the final half-hour of trading as measured by the difference between the high and low share price divided by the mean share price is reported (in percent) in the May-June 1995 period for a matched sample of the ten lowest capitalization pilot stocks and the closest capitalization non-pilot stocks. The volatility is reported for the entire period and for the period before and after the NYSE rule change on June 5, 1995. A parametric ANOVA test and a non-parametric Wilcoxon rank scores test are conducted to test for differences between the two periods and between pilot and non-pilot stocks.

	Entire Period Volatility	Pre-06/05/95 Volatility	Post-06/05/95 Volatility	ANOVA	Wilcoxon
All Stocks	0.488	0.482	0.496	0.24	0.06
Non-Pilot Stocks	0.428	0.416	0.441	0.57	0.05
Pilot Stocks	0.548	0.546	0.549	0.00	0.06
ANOVA	19.56***	14.14***	6.36**		
Wilcoxon	13.01***	6.63***	6.58**		

*significant at $\alpha = 10\%$, **significant at $\alpha = 5\%$, ***significant at $\alpha = 1\%$

These results indicate that the measure of volatility impacts on the observed differences. For the reduced sample of stocks, when the standard deviation measure of volatility is used, no differences are found between pilot and non-pilot stocks and between the period before and after the rule change. When the difference measure of volatility is used, the pilot stocks show a significantly larger volatility during the entire period as well as before and after the rule change. Using the difference measure fails to find any differences between the period before and after the rule change for either pilot or non-pilot stocks. These results for the reduced sample fail to reject hypothesis three (H3) since pilot stocks are shown to have a larger volatility using only the difference measure of volatility. Also, the rule change is shown to have no effect on either pilot or non-pilot stocks.

6.4.5. Conclusion

This chapter examines the effect of the NYSE MOC rule change on June 5, 1995. The intended effect of the rule change is to reduce volatility at the end of the day and this may also have an impact on the well-documented price rise at the end of the trading day. In this chapter, it is shown that there is no effect on the price rise when all the stocks are examined in aggregate. This chapter shows that for the group of pilot stocks that publicize order imbalances, the overall end of day price rise is lower. This may be a function of the capitalization and liquidity of the stocks in this category, and a reduced sample of stocks that match on capitalization shows that the characteristics may be driving the comparison. No decline in the price rise following the rule change is found on an aggregate basis.

Two measures of volatility are used in this chapter. One measure is the standard deviation of changes in successive midpoints of the bid-ask spread during the final half-hour of trading. A second measure is the difference between the high and low share price during the last half-hour of trading all divided by the mean share price during this period. In aggregate, the two measures come to different conclusions. When individual specialist firms are examined then it is clear that the differences are driven by significant differences in separate specialist firms. The relative size of volatility in the period before and after the rule change agrees for most of the specialist firms that have significant differences using both volatility measures. The volatility is shown to decline in nine of the thirty-seven specialist firms. Additionally, pilot stocks are shown to have a much lower volatility than non-pilot stocks. A mildly significant volatility decline is also observed in pilot stocks when examined in aggregate. When a reduced sample is examined that controls for differences in capitalization and liquidity, the two measures of volatility have conflicting results. The standard deviation measure exhibits no difference, but the other volatility measure indicates that the pilot stocks in this sample have a larger volatility than non-pilot stocks. For the reduced sample, no differences are noted between the period before and after the rule change.

The rule change is found to affect some specialists more than others. This suggests that some specialists may be more likely to be affected by the factors that the rule is trying to correct. One possible example is the additional influx of orders near the close. Some specialists may be able to quickly fill the orders, while other specialists may be slower to respond and, thus, any orders near the close would have to be made as market on close orders. For these slower specialists, the additional market on close orders could cause an imbalance and impact the closing price for stocks by that specialist.

This may explain why some specialists are disproportionately impacted by the NYSE MOC rule change.

CHAPTER 7

CONCLUSION

7.1. Synopsis of Major Findings

This dissertation investigates different trading mechanisms, focusing on comparing specialist versus multiple dealer markets. The purpose of the dissertation is to better understand the impact of these trading mechanisms on intraday price formation and the components of the bid-ask spread. Price formation patterns are of interest because previous findings of empirical regularities appear to contradict efficient markets. The components of the bid-ask spread are of interest since they provide an indication of costs facing traders of stocks on the different market structures.

This dissertation uses data from the Paris Bourse to provide insight into the effect of different market structures. The simultaneous trading in two market structures on the Paris Bourse isolates the effect of the specialist by removing institutional differences that plague comparisons across exchanges. In Chapter 3, price formation patterns on the Paris Bourse are found to be similar to known patterns on other exchanges. Comparing stocks on the Paris Bourse that are traded with and without an assigned market maker demonstrates the impact of the assigned market maker, or specialist, on the various price patterns. Assigned market makers are shown to exacerbate the end of day price rise on the Paris Bourse. The larger price rise for stocks with an assigned market maker implies that the explanations for the end of day price rise that center on the specialist have some validity. The specialists do not fully explain this phenomenon since the effect is also present when there is no assigned market maker. The finding that one third of the end of day return is subsequently reversed overnight demonstrates the temporary nature of a

portion of the end of day price rise. This is consistent with Hatheway's (1994) explanation that the end of day price rise is done by the specialist in order to extract information at the open the following morning.

Stock volatility and bid-ask spreads are found to be larger for those shares traded on the Paris Bourse with an assigned market maker. This is contradictory to research using data from North American markets that show a decline in the bid-ask spread when the trading location of shares move from Nasdaq, a multiple dealer market, to the NYSE and ASE, two exchanges with specialists. Moves between these exchanges do not, however, provide clean comparisons since there are institutional differences across these exchanges. For example, the strict NYSE monitoring and enforcement procedures may curtail the activities of the specialists on this exchange.

Chapter 3 also shows that trades that occur off the exchange have some peculiarities in the patterns observed. There may be some attempt to utilize cross-trades to influence the closing price since a larger proportion of cross-trades occurs at the end of the trading day. Additionally, when the last transaction is a cross trade, the percentage of the final transaction return that is reversed overnight is 55%. The procedures surrounding transactions that occur off the exchange vary for exchanges around the world, with the Paris Bourse allowing prices to marginally differ outside prevailing quotes. This practice appears to exacerbate the end of day price rise.

In Chapter 4 the trade execution costs are estimated for the two market structures on the Paris Bourse. Prior empirical work is contradictory as to the impact of the specialist on the adverse selection component of the bid-ask spread. Two separate methods of estimating the adverse selection component using data from the Paris Bourse were both unable to resolve the conflicting findings.

A larger inventory holding cost component is found for those stocks with an assigned market maker on the Paris Bourse. This confirms that specialists face an identifiable cost of maintaining inventory and, in turn, that cost is passed on in the form of a larger inventory holding cost component of the bid-ask spread.

Higher trading costs are found for those stocks that trade with an assigned market maker. The quoted, effective and realized bid-ask spreads are all approximately twice as large for stocks with an assigned market maker. Again, this is contradictory to findings on North American markets. This suggests that the comparisons in earlier empirical research are limited to conclusions about the specific exchanges and not the market structure, since the Paris Bourse findings are based on a much cleaner comparison.

This dissertation also examines the effect of long-term inventory changes on the inventory holding cost component. Inventory changes are calculated and ranked over two months and then the effect on the trading costs in the subsequent two months is examined. Large changes in inventory are found to have twice as large an impact on the inventory holding cost component of those stocks that have an assigned market maker. Additionally, depletion of inventory is found to have a larger impact on the inventory holding cost component than when there is a large build up of inventory.

In Chapter 5, the market structure issue is also examined by looking at individual specialist firms on the NYSE and noting differences across these firms. Consistent intraday patterns are found for volume and volatility. The pattern in the bid-ask spread is consistently large immediately after the open for all specialist firms, however, there is some variation noted in the late afternoon peak. Likewise, the end of day returns are not

consistently large for all specialists, suggesting that the final intraday transaction price rise may be related to the individual specialist. The bid and ask depths also show considerable variation across specialist firms, with twice as many firms having a consistently larger bid depth.

Differences within specialist firms across individual specialists are observed when examining volatility, percentage bid-ask spreads and depths. No differences are noted within a specialist firm when the final intraday transaction return is examined. This suggests that there is some consistency within a specialist firm in the use of the final intraday transaction return in managing end of day prices.

Cross-subsidization of stocks within a specialist firm is examined by dividing stocks into groups based on the level of volume in the stock. No differences are noted in the end of day price rise between these two groups, indicating that the end of day price rise is not systematically occurring for stocks with a certain volume. The percentage bid-ask spread is found to be larger for lower volume stocks suggesting that specialists are capturing larger bid-ask spreads from these stocks. This implies that cross-subsidization from high to low volume stocks is not sufficient to keep the percentage bid-ask spreads low for these low volume stocks. As an alternative explanation, these stocks may have lower prices and the price effect may be influencing the percentage bid-ask spread. This is tested, but the prices only provide a partial explanation for the higher bid-ask spreads.

Inventory accumulation is also examined using the NYSE stocks, but this is done on a short term basis in contrast to the long term effects observed on the Paris Bourse. Using NYSE data, inventory is accumulated from the open until 3:30 pm and then the percentage bid-ask spread is examined in the final half-hour. Higher bid-ask spreads are

found in the middle three quintiles, indicating that the specialist may be less competitive in attracting orders for the stocks with minimal inventory changes. In comparing the two extreme quintiles, the inventory depletion quintile has a larger percentage bid-ask spread then the quintile with the large inventory build up. This indicates the specialist may be less competitive in attracting orders when inventory is depleted, possibly because a positive inventory must be maintained. Differences in final transaction returns across specialist firms are only noted for those stocks with the largest inventory accumulation. This suggests that the price rise at the end of the day may be effected by the specialist in order to increase the value of inventory or may be a method to induce more orders the following day.

The effect on end of day prices and volatility of the change in the market on close rule on the NYSE is examined in Chapter 6. Minimal differences are found for the end of day price rise. Volatility, however, is shown to decline in nine of the thirty-seven specialist firms. The reduction in volatility in only some specialist firms following the rule change may indicate that specialists' ability to deal with a large influx of orders may not be consistent. This rule change institutes specific procedures and, thus, has the effect of eliminating any differences across specialist firms in the ability to dispose of large orders.

The handling of the NYSE MOC orders appears to be indicative of the arrangement on the NYSE that may help to explain the differences observed across exchanges that are not necessarily attributable to the market structure. As shown by the data from the Paris Bourse, using a specialist results in many patterns that could indicate that the specialist is acting like a monopolist. The findings from the Paris Bourse data

provide a clean comparison that suggests other factors may be impacting market structure comparisons across North American exchanges.

7.2. Future Work

This dissertation has provided a detailed investigation of the specialist and multiple dealer market structures and their impacts on both intraday price formation and the components of the bid-ask spread. Further follow up work can continue with an extended data set that examines the impact of the change in closing procedures on the Paris Bourse. Also, an expanded data set would enable testing of the robustness of the findings across specialist firms, since conclusions about differences across specialist firms may be specific to the time period under study.

REFERENCES

Admati, Anat R., and Paul C. Pfleiderer, 1988, A theory of intraday patterns: Volume and price variability, *Review of Financial Studies 1*, 3-40.

Admati, Anat R., and Paul C. Pfleiderer, 1989, Divide and conquer: A theory of intraday and day-of-the-week mean effects, *Review of Financial Studies 2*, 189-223.

Affleck-Graves, John, Shantaram P. Hedge, and Robert E. Miller, 1994, Trading mechanisms and the components of the bid-ask spread, *Journal of Finance 49*, 1471-1488.

Barnea, Amir, 1974, Performance evaluation of New York Stock Exchange specialists, *Journal of Financial and Quantitative Analysis 9*, 511-534.

Berry, Thomas D. and Keith M. Howe, 1994, Public information arrival, *Journal of Finance 49*, 1331-1346.

Benveniste, L., A. Marcus and W. Wilhelm, 1992, What's special about the specialist?, *Journal of Financial Economics 32*, 61-86.

Bessembinder, Hendrik and Herbert M. Kaufman, 1997, A comparison of trade execution costs for NYSE and NASDAQ-listed stocks, *Journal of Financial and Quantitative Analysis 32*, 287-310.

Biais, Bruno, Pierre Hillion and Chester Spatt, 1995, An empirical analysis of the limit order book and the order flow in the Paris Bourse, *Journal of Finance 50*, 1655-1689.

Blume, Marshall E. and Michael A. Goldstein, 1997, Quotes, order flow, and price discovery, *Journal of Finance 52*, 221-244.

Brock, W.A., and Kleidon, Allan W., 1992, Periodic market closure and trading volume: A model of intraday bids and asks, *Journal of Economic Dynamics and Control 16*, 451-489.

Cao, Charles, Hyuk Choe and Frank Hatheway, 1997, Does the specialist matter? Differential execution costs and inter-security subsidization on the NYSE, *Journal of Finance 52*, 1615-1640.

Chan, K.C., William G. Christie and Paul H. Schultz, 1995, Market structure and the intraday pattern of bid-ask spreads for Nasdaq securities, *Journal of Business 68*, 35-60.

Chang, Eric C., Prem C. Jain, and Peter R. Locke, 1995, Standard and Poor's 500 index futures volatility and price changes around the New York Stock Exchange close, *Journal of Business 68*, 61-84.

Cheung, Yan-Leung, 1995, Intraday returns and the day-end effect: Evidence from the Hong Kong equity market, *Journal of Business, Finance and Accounting 22*, 1023-1034.

Christie, William G., Jeffrey Harris and Paul Schultz, 1994, Why did Nasdaq market makers stop avoiding odd-eighth quotes?, *Journal of Finance 49*, 1841-1860.

Christie, William G. and Paul Schultz, 1994, Why do Nasdaq market makers avoid odd-eighth quotes?, *Journal of Finance 49*, 1813-1840.

Christie, William G. and Roger D. Huang, 1994, Market structures and liquidity: A transactions data study of exchange listings, *Journal of Financial Intermediation 3*, 300-326.

Copeland, Thomas D., and Dan Galai, 1983, Information effects on the bid-ask spread, *Journal of Finance 38*, 1457-1469.

Corwin, Shane A., 1996, Differences in trading behavior across NYSE specialist firms, *Ohio State University Dissertation.*

Coughenour, Jay and Daniel Deli, 1996, On the organizational form of NYSE specialist firms, working paper, *University of Massachusetts-Boston.*

De Jong, Frank , Theo Nijman and Ailsa Röell, 1996, Price effects of trading and components of the bid-ask spread on the Paris Bourse, *Journal of Empirical Finance 3*, 193-213.

De Jong, Frank , Theo Nijman and Ailsa Röell, 1995, A Comparison of the cost of trading French shares on the Paris Bourse and on SEAQ International, *European Economic Review 39*, 1277-1301.

Easley, David, Nicholas M. Kiefer, Maureen O'Hara, and Joseph B. Paperman, 1996, Liquidity, information, and infrequently traded stocks, *Journal of Finance 60*, 1405-1436.

Foster, F. Douglas and Srinivasan Viswanathan, 1990, A theory of the intraday variations in volume, variance, and trading costs in securities markets, *Review of Financial Studies 3*, 593-624.

Foster, F. Douglas and Srinivasan Viswanathan, 1993, Variation in trading volume, return volatility, and trading costs: Evidence on recent price formation models, *Journal of Finance 48*, 187-211.

French, Kenneth R. and Richard Roll, 1986, Stock return variances: The arrival of information and the reaction of traders, *Journal of Financial Economics 17*, 5-26.

George, Tom H., Gautam Kaul and M. Nimalendran, 1991, Estimation of the bid-ask spread and its components; A new approach, *Review of Financial Studies 4*, 623-656.

Gerety, Mason S. and J. Harold Mulherin, 1994, Price formation on stock exchanges: The evolution of trading within the day, *Review of Financial Studies* 7, 609-629.

Glosten, Lawrence R., 1989, Insider trading, liquidity, and the role of the monopolist specialist, *Journal of Business 62*, 211-236.

Glosten, Lawrence R., 1994, Is the electronic open limit order book inevitable?, *Journal of Finance 49*, 1127-1161.

Glosten, Lawrence R. and Lawrence Harris, 1988, Estimating the components of the bid-ask spread, *Journal of Financial Economics 21*, 123-142.

Glosten, Lawrence R. and Paul R. Milgrom, 1985, Bid, ask, and transaction prices in specialist market with heterogenously informed traders, *Journal of Financial Economics 14*, 71-100.

Godek, Paul, 1996, Why Nasdaq market-makers avoid odd-eighth quotes, *Journal of Financial Economics 41*, 465-474.

Gosnell, Thomas F., 1987, An empirical investigation of high end-of-day transaction returns between 1978-1985, *Unpublished Ph.D. dissertation*, Virginia Polytechnic Institute and State University.

Gosnell, Thomas F., 1995, End-of-day security price movement and the concentration of trading at the close, *Research in Finance 12*, 97-113.

Grossman, Sanford J., and Merton H. Miller, 1988, Liquidity and market structure, *Journal of Finance 43*, 617-633.

Harris, Lawrence, 1986, A transactions data study of weekly and intradaily patterns in stock returns, *Journal of Financial Economics 16*, 99-117.

Harris, Lawrence, 1989, A day-end transaction price anomaly, *Journal of Financial and Quantitative Analysis 24*, 29-45.

Harris, Lawrence, and Joel Hasbrouck, 1996, Market versus limit orders: The SUPERDOT evidence on order submission, *Journal of Financial and Quantitative Analysis 31*, 213-231.

Hasbrouck, Joel, and George Sofianos, 1993, The trades of market makers: An analysis of NYSE specialists, *Journal of Finance 48*, 1565-1593.

Hatheway, Frank M., 1994, Explorations in the empirical microstructure of equity and futures markets (empirical market microstructure, equity markets), *Unpublished Ph.D. Dissertation*, Princeton University.

Ho, Thomas S.Y. and Hans R. Stoll, 1981, Optimal dealer pricing under transaction and return uncertainty, *Journal of Financial Economics 10*, 47-74.

Ho, Thomas S.Y. and Hans R. Stoll, 1983, The dynamics of dealer markets under competition, *Journal of Finance 38*, 1053-1074.

Ho, Yan-ki, and Yan-Leung Cheung, 1991, Behaviour of intra-daily stock return on an Asian emerging market - Hong Kong, *Applied Economics 23*, 957-966.

Huang, Roger D. and Hans R. Stoll, 1996, Dealer versus auction markets: A paired comparison of execution costs on Nasdaq and the NYSE, *Journal of Financial Economics 41*, 313-357.

Huang, Roger D. and Hans R. Stoll, 1997, The components of the bid-ask spread: A general approach, *Review of Financial Studies 10*, 995-1034.

Jones, Charles M. and Marc L. Lipson, 1997, Price adjustments and trading costs on the Nasdaq and NYSE/AMEX, *working paper*, University of Georgia, January.

Keim, Donald B., 1989, Trading patterns, bid-ask spreads, and estimated security returns: The case of common stocks at calendar turning points, *Journal of Financial Economics 25*, 75-98.

Keim, Donald B. and Robert F. Stambaugh, 1984, A further investigation of the weekend effect in stock returns, *Journal of Finance 39*, 819-840.

Kim, Sok Tae, Ji-Chai Lin and Myron B. Slovin, 1997, Market structure, informed trading, and analysts' recommendations, *Journal of Financial and Quantitative Analysis 32*, 507-524.

Krinsky, Itzhak and Jason Lee, 1996, Earnings announcements and the components of the bid-ask spread, *Journal of Finance 60*, 1523-1535.

Lakonishok, H. Josef and Edwin Maberly, 1990, The weekend effect: Trading patterns of individual and institutional investors, *Journal of Finance 45*, 231-243.

Laux, Paul A., 1995, Dealer market structure, outside competition, and the bid-ask spread, *Journal of Economic Dynamics and Control 19*, 683-710.

Leach, J. Chris and Ananth N. Madhavan, 1993, Price experimentation and security market structure, *Review of Financial Studies 6*, 375-404.

Lee, Charles, 1993, Market integration and price execution for NYSE-listed securities, *Journal of Finance 48*, 1009-1038.

Lee, Charles and Mark Ready, 1991, Inferring trade direction from intraday data, *Journal of Finance 46*, 733-746.

Lee, Charles, Belinda Mucklow and Mark Ready, 1993, Spreads, depth, and the impact of earnings information: An intraday analysis, *Review of Financial Studies 6*, 345-374.

Lin, Ji-Chai, Gary C. Sanger and G. Geoffrey Booth, 1995a, Trade size and components of the bid-ask spread, *Review of Financial Studies 8*, 1153-1183.

Lin, Ji-Chai, Gary C. Sanger and G. Geoffrey Booth, 1995b, External information costs and the adverse selection problem: A comparison of Nasdaq and NYSE stocks, *working paper*, Louisiana State University, June 7.

Madhavan, Ananth N., 1992, Trading mechanisms in securities markets, *Journal of Finance 47*, 607-642.

Madhavan, Ananth N. and George Sofianos, 1998, Auction and dealer markets: An empirical analysis of NYSE specialist trading, *Journal of Financial Economics*, forthcoming.

Madhavan, Ananth N. and S. Smidt, 1993, An analysis of changes in specialist inventories and quotations, *Journal of Finance 48*, 1595-1628.

Masulis, Ronald W. and L. Shivakumar, 1997, Intraday market response to equity offering announcements: A NYSE/AMEX-NASDAQ comparison, working paper, Financial Markets Research Center, Vanderbilt University, June 27.

McInish, Thomas H., and Robert A. Wood, 1990, An analysis of transactions data for the Toronto Stock Exchange: Return patterns and end-of-the-day effect, *Journal of Banking and Finance 14*, 441-458.

McInish, Thomas H., and Robert A. Wood, 1992, An analysis of intraday patterns in bid/ask spreads for NYSE stocks, *Journal of Finance 47*, 753-764.

Miller, Edward M., 1989, Explaining intra-daily and overnight price behavior, *Journal of Portfolio Management 4*, 10-16.

Mok, M.K., 1988, Opening and quarter-hour intradaily seasonalities in Hong Kong's stock market: pre- and post-market crash, *working paper series*, Chinese University of Hong Kong.

Pagano, Marco and Ailsa Röell, 1990, Shifting gears: An economic evaluation of the reform of the Paris Bourse, London School of Economics Working Paper.

Pagano, Marco and Ailsa Röell, 1996, Transparency and liquidity: A comparison of auction and dealer markets with informed trading, *Journal of Finance* 51, 579-612.

Petersen, Mitchell and David Fialkowski, 1994, Posted versus effective spreads: Good prices or bad quotes?, *Journal of Financial Economics 35*, 269-292.

Porter, David C., 1992, The probability of a trade at the ask: An examination of interday and intraday behavior, *Journal of Financial and Quantitative Analysis 27*, 209-227.

Porter, David C., and Daniel G. Weaver, 1995, Late reporting, spread widths, and Nasdaq's selective enforcement of the 90 second rule, *working paper*.

Rogalski, R., 1984, New findings regarding the day of the week returns over trading and non-trading periods, *Journal of Finance 39*, 1603-1614.

Roll, Richard, 1984, A simple implicit measure of the bid-ask spread in an efficient market, *Journal of Finance 39*, 1127-1139.

Seppi, Duane J., 1997, Liquidity provision with limit orders and a strategic specialist, *Review of Financial Studies 10*, 103-150.

Solnik, Bruno, 1990, The distribution of daily stock returns and settlement procedures: The Paris Bourse, *Journal of Finance 45*, 1601-1609.

Solnik, Bruno and Laurence Bousquet, 1990, Day-of-the-week effect on the Paris Bourse, *Journal of Banking and Finance 14*, 461-468.

Stoll, Hans R., 1978, The supply of dealer services in securities markets, *Journal of Finance 33*, 1133-1151.

Stoll, Hans R., 1989, Inferring the components of the bid-ask spread: Theory and empirical tests, *Journal of Finance 44*, 115-134.

Stoll, Hans R. and R. Whaley, 1990, Stock market structure and volatility, *Review of Financial Studies 3*, 37-71.

Tinic, S., 1972, The economics of liquidity services, *Quarterly Journal of Economics 86*, 79-93.

Wood, Robert A., Tom H. McInish and J.K. Ord, 1985, An investigation of transactions data for NYSE stocks, *Journal of Finance 40*, 723-729.

APPENDIX A: PARIS BOURSE TRADING GROUP INDICATOR

Trading Group #	Name / Description
11	**Multiple Dealer A Règlement Mensuel** High liquidity stocks traded on the Règlement Mensuel on a continuous basis
15	**Multiple Dealer A Règlement Mensuel** High liquidity stocks traded on the Règlement Mensuel on a continuous basis (index component stocks)
21	**Multiple Dealer A Règlement Mensuel - foreign stocks** High liquidity foreign stocks traded on the RM on a continuous basis
16	**Multiple Dealer A cash market** High liquidity stocks traded on the cash market on a continuous basis
22	**Multiple Dealer A cash market - foreign stocks** High liquidity foreign stocks traded on the cash market on a continuous basis
31	**Multiple Dealer A cash market secondary issues** High liquidity secondary issues traded on the cash market on a continuous basis
32	**Multiple Dealer A RM secondary issues** High liquidity secondary issues traded on the RM on a continuous basis
12	**Single Market Maker B cash market** Medium liquidity stocks traded on the cash market on a continuous basis
17	**Single Market Maker B cash market foreign** Medium liquidity stocks traded on the cash market on a continuous basis
13	**Fixing A French stocks** Medium liquidity French stocks traded on a call market (2 fixings a day)
23	**Fixing A Foreign stocks** Medium liquidity foreign stocks traded on a call market (2 fixings a day)
33	**Fixing A secondary issues** medium liquidity secondary issues traded on a call market (2 fixings a day)

APPENDIX B: NYSE MARKET ON CLOSE ORDER RULE DESCRIPTIONS

Type of stock	Before June 5, 1995	After June 5, 1995
Non-derivative related	No restriction	10 minutes before close all days (<3:49:59)
Derivative related	20 minutes before close on expiration days (<3:39:59)	20 minutes before close on expiration days (<3:39:59)
	No limit on other days	10 minutes before close on other days
Pilot stocks (derivative related)	20 minutes before close on expiration days (<3:39:59)	20 minutes before close on expiration days (<3:39:59)
	Publish imbalances over 50,000 shares	10 minutes early on non-expiration days (<3:49:59)
		Publish imbalances over 50,000 shares

APPENDIX C: LISTING OF JUNE 1995 PILOT STOCKS

Panel A: 50 most highly capitalized S&P 500 stocks including Major Market Index Stocks

ABT	Abbott Laboratories
AXP	American Express Company
AHP	American Home Products Corporation
AIG	American International Group Inc.
T	American Telephone and Telegraph
AIT	Ameritech Corp.
AN	Amoco Corporation
ARC	Atlantic Richfield Company
BAC	Bankamerica Corporation
BEL	Bell Atlantic Corporation
BLS	Bellsouth Corporation
BA	Boeing Company
BMY	Bristol Myers Squibb Company
CHV	Chevron Corporation
CCI	Citicorp
KO	Coca-Cola Company
COL	Columbia Healthcare Corp.
DOW	Dow Chemical Company
DD	Du Pont Company
EK	Eastman Kodak Company
LLY	Eli Lilly and Company
XON	Exxon Corporation
FNM	Federal National Mortgage Association
F	Ford Motor Company
GE	General Electric Company
GM	General Motors Corporation
G	Gillette Company
GTE	GTE Corporation
HWP	Hewlett-Packard Company
HD	Home Depot Inc.
IBM	International Business Machines Corp.
IP	International Paper Company
JNJ	Johnson and Johnson
MCD	McDonalds Corporation
MRK	Merck and Company Inc.
MMM	Minnesota Mining and Manufacturing
MOB	Mobil Corporation
MOT	Motorola Inc.
NYN	Nynex Corporation
PEP	Pepsico Inc.
PFE	Pfizer Inc.
MO	Philip Morris Cos. Inc.
PG	Procter and Gamble Company
RD	Royal Dutch Petroleum Company
S	Sears Roebuck Company
SBC	Southwestern Bell Corporation
TX	Texaco Inc.
UN	Unilever N.V. Ord Shares
USW	U.S. West Inc.
WMT	Wal-Mart Stores Inc.
DIS	Walt Disney Company

(appendix con'd)

(Appendix C continued)

Panel B: 10 highest weighted S&P MidCap 400 stocks

AFL	AFLAC Inc.
AOC	AON Corp.
CMA	Comerica Inc.
EMC	EMC Corp.
FBS	First Bank System Inc.
FFM	First Financial Management Corp.
LSI	LSI Logic Corp.
MS	Morgan Stanley Group Inc.
ODP	Office Depot Inc.

Panel C: Stocks that were added or deleted during June 1995

CS	Cabletron Systems Inc.
BEN	Franklin Resources Inc.

VITA

David Michael Michayluk is a Canadian citizen and attended primary and secondary schools in Saskatoon, Saskatchewan, Canada. He received a Bachelor of Commerce (Honours) degree from Queen's University at Kingston in 1989, majoring in Accounting and Finance. He worked in public accounting in Toronto as an auditor with Deloitte, Haskins and Sells. After successfully passing the Uniform Final Exam and obtaining a Chartered Accounting designation, David worked as a tax specialist with Price Waterhouse. He returned to Saskatoon in 1992 and accepted a position as lecturer at the University of Saskatchewan in the Department of Finance. During this time he operated a consulting firm specializing both in taxes for individuals and small businesses and in accounting computer applications. In August, 1993, he entered the doctoral program in Business Administration (Finance) at Louisiana State University. He graduated in the summer of 1998. David will be joining the faculty at the University of New South Wales in Sydney, Australia.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: David Michael Michayluk

Major Field: Business Administration (Finance)

Title of Dissertation: The Impact of Specialist and Multiple Dealer Market Structures on Intraday Price Formation and Bid-Ask Spread Components

Approved:

Major Professor and Chairman

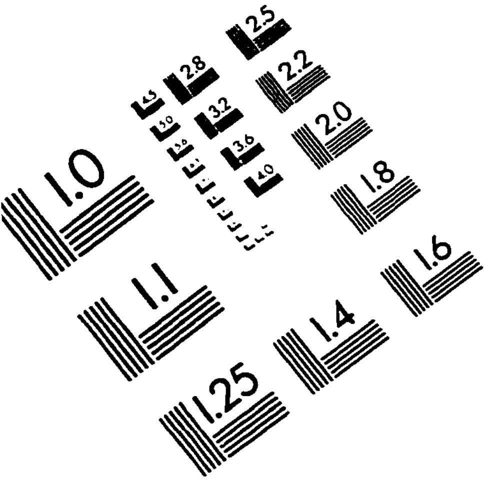
Dean of the Graduate School

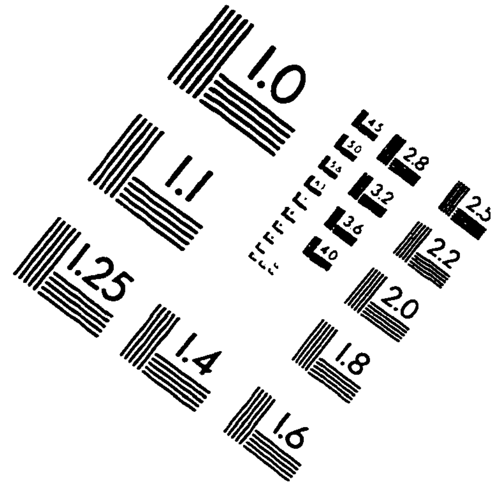
EXAMINING COMMITTEE:

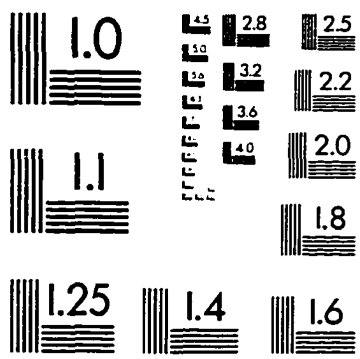
Date of Examination:

March 19, 1998

IMAGE EVALUATION TEST TARGET (QA-3)

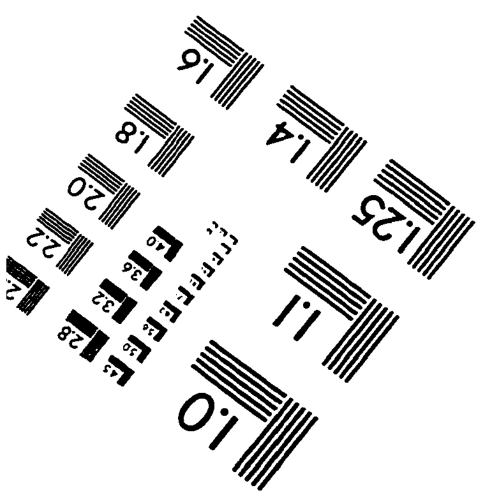






150mm

6″



APPLIED IMAGE . Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989