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FINANCIAL MARKET CONSOLIDATION VERSUS FRAGMENTATION: A COMPARATIVE ANALYSIS

by

Albert J Murphy

A dissertation submitted to the graduate Faculty in Business in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

2002

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PART I

ISSUES, CONCEPTS, and LITERATURE SYNTHESIS

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Chapter ONE: Introduction

1.1 Motivation

With the 1975 amendments to the Securities Exchange Act of 1934, Congress mandated that the Securities and Exchange Commission (SEC) initiate steps to improve the efficiency and competitiveness of U.S. securities markets. The SEC would oversee the development of a National Market System (NMS) that would link financial markets in the U.S. by consolidating trade and quote information, and facilitate the efficient routing of orders among trading venues in that national market. Proponents of the system hoped that its implementation would reduce trade execution costs, as the resulting consolidation of order flow would increase the interaction of public orders, and improve the efficiency of the system's pricing mechanisms. However that linking, or consolidation, of markets could alternatively result in the development of monopolistic inefficiencies that would limit options available to the system's participants and reduce the incentive for the system to improve its efficiency and effectiveness. Thus, the SEC also sought to promote competition among the market centers within the system. For example the New York Stock Exchange (NYSE) was required to modify its Rule 394, which prohibited members from engaging in the market making and trading of securities off the exchange floor, to become Rule 390, which allowed agency transactions away from the exchange floor.[1]

Hamilton (1979) identifies groups of traders who seek better market services off

[1] In 1980 the S.E.C. instituted its own rule, Rule 19c-3, that allowed NYSE members to not only engage in off-board transactions but to make off-board markets for stocks that were listed on the exchange after April 26, 1979, in direct competition with the NYSE specialists.

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the primary exchanges, resulting in the fragmentation or dispersal of orders in a particular stock across distinct market centers. Hamilton suggests two resulting, conflicting effects of market fragmentation on the trade execution costs, the net effect of which could harm or benefit traders: 1) the increased competition faced by the primary exchanges would force them to improve services and reduce transaction costs, but 2) the reduction in trading volume on the primary exchanges as a result of the flight of order flow would reduce liquidity and increase transaction costs at all venues. Proponents of the NMS felt that competition among the various market centers trading a given stock would be preserved, while the harmful effects of promoting competition among market centers by splitting order flow among those centers and having separate, independent transaction protocols prevail in each market would be eliminated.

To date, the market consolidation envisioned by its early advocates is not complete. For example, one major system that links financial markets in the U.S. is the Intermarket Trading System (ITS).[2] This system facilitates the routing of orders by exchange members and Nasdaq dealers to other markets for execution at the quote of the destination market, with the requirement that a public order submitted to the market be traded at a price no worse that the best price displayed on the Consolidated Quotation System (CQS).[3] This requirement does not preclude the possibility that the transaction

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[2] Other major systems linking U.S. Markets are the Consolidated Tape Association (CTA), which reports trading activity in NYSE – listed stocks and stocks listed on regional exchanges and Nasdaq, and the Consolidated Quotation System (CQS) which makes current quotations on NYSE-listed stocks widely available throughout the system.

[3] In the case of the NYSE, if a regional market is displaying a quote for one round lot, the NYSE can ignore it and trade at an inferior price.

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may be executed at a better price than the best-quoted price. Further, the preservation of price priority (i.e. the highest priced buy order and the lowest price sell order should get trading priority), a primary and desirable characteristic of a high quality financial market, is not guaranteed by the electronic linking of exchanges. For example, it often happens that a broker on a primary exchange such as the NYSE may attempt to route an order to a regional exchange where the best price is being posted. However, the specialist on the regional exchange may refuse the order, and explain the refusal by saying that he/ she is updating his / her quotes. As a result the broker may have to execute the trade elsewhere (probably on the primary exchange) at an inferior price. Additionally, a consistent secondary priority rule (for example, time priority (often considered a desirable property of a high quality market by investors who want immediacy): if two or more orders tie at the same best price then the order that was submitted first should get trading priority) is not guaranteed by such a system. Market quality could decline if those possibilities exist.

Another illustration of the possible problems associated with attempts to promote competition is a special case of fragmentation, called internalization, where member firms execute orders in-house before they reach the exchange floor.[4] This practice effectively isolates orders from full interaction with other orders in the wider market. For example, a trader may enter a limit order to sell a stock at a price lower than the current bid quote, thus setting a new best price in the market system. Market centers holding buy orders are not obliged to route such orders to fill this price setting sell order. Instead they

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may trade as principal with their buy orders at the price set by the trader with the sell order. To the extent that the trader's order remains isolated, that order's participation in price competition is diminished (and execution costs increase) as the order's execution is delayed. Moreover, the issue of whether a member firm's role as the client's agent (one who acts in the best interests of his /her client) directly conflicts with its role as the client's principal (one who takes the other side of a client's order) assumes prominence. Thus the circumstances under which a consolidated market may be more or less beneficial to particular investor clienteles are still being debated.

[4] Although NYSE's Rule 390 precludes that possibility, the SEC's rule 19c-3 relaxes those restrictions to some degree. See fn. 1.

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1.2 Dissertation Outline

This dissertation attempts to contribute to this debate. The concepts of security market consolidation and market fragmentation are surveyed. Tests are then developed to assess the impact on market quality of an attempt to consolidate order-flow on the Toronto Stock Exchange (TSE). In particular, on October 26, 1998 the TSE enacted rules requiring all trades of 5,000 shares or less either to receive price improvement or to be routed to the limit-order book for execution. The implications are discussed in the context of the current proliferation of new trading systems throughout the world.

In the first section of my dissertation (which consists of chapters1 and 2) I explore the issues and concepts relevant to the market consolidation versus fragmentation debate, and review and synthesize the appropriate literature. Section II (which consists of chapter 3) discusses the nature of the TSE, and describes three important factors that influenced the TSE's decision to prioritize a speedy remedy to the problem of internal market fragmentation by introducing new trading rules. This section also discusses theories that attempt to explain the phenomenon. Section III (which consists of chapters 4 and 5) discusses the empirical tests used to determine the nature of the influence of the introduction of the Price Improvement Rule on the quality of the TSE market. The rule's introduction was designed to stem the negative impact of internal market fragmentation on market quality. Findings are described and interpreted, and the resulting implications and conclusions are discussed.

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Chapter TWO: Literature Review and Synthesis

2.1 Market Consolidation

According to Mendelson (1987), a market mechanism for a specific security tends to consolidate if all the information the market agents need to transform orders into prices and quantities of that security is available when the transformation takes place. Harris (1993) argues that this occurs when traders seek and find accurate and timely information about other traders who will take the other side of their orders. Therefore one definition of consolidation can be: 'market consolidation occurs when orders flow to a single location for execution, and all buying and selling interest is shown.'[5]

If many traders are available and willing to take the other side of a trader's order in a market, and the trader is aware of all the trading interest in his/ her order, the cost of transacting will be relatively low and the market will be relatively attractive to the trader. The liquidity of the market, which refers to the ease and stability with which a security is traded, improves as a result. As such, traders tend to process their orders through a single market mechanism, resulting in natural consolidation of the market. Stated differently, order flow attracts order flow. However this conclusion rests on a very important assumption: traders are essentially identical in their trading needs. If traders have heterogeneous trading needs (for example the existence of large/small, informed /uninformed traders) then a market mechanism that represents an optimal trading environment for one type of trader may be suboptimal for another type [see Harris,

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[5] Toronto Stock Exchange's Special Committee Report, Market Fragmentation (1997). It must be noted that consolidation of orders in a financial market can refer to the centralization of trading interest display

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(1993)]. If a critical mass of traders of a particular type feels sufficiently disenfranchised in a consolidated market, then they may be willing to give up the benefits of consolidated market for one that caters to their specific needs. Bloch and Schwartz (1979) use a theoretical model to demonstrate that market fragmentation can naturally occur as limit order traders employ strategies in an attempt to get ahead of each other in a trading queue. This kind of gaming ultimately results in increased trade execution time uncertainty. Market order traders will experience increased search costs, greater spreads, and more volatile prices. Additionally, the maintenance of a 'fair and orderly' market system would be challenging, since it would be difficult to effectively incorporate a specialist in a multimarket system. In other words, a consolidated market may not occur naturally. If policy makers deem such markets desirable, then the costs and benefits of consolidation must be weighed against those of fragmentation.

The complete consolidation of order information in a market system allows maximum order exposure and increased competition among investors. A system-wide price priority protocol will not be violated: traders match their incoming buy (sell) orders against orders offering the best sell (buy) orders across all market centers within the system.[6] Additionally, a market system typically seeks to preserve a 'time' secondary precedence rule. That is, of all incoming orders offering the same price, the first order to arrive is executed first. This secondary priority rule is desirable from an investor's

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and execution in one physical location, or across a network of market centers where priority rules are uniformly enforced across market centers.

[6] This consolidated multi-market system can be distinguished from a segmented market (described in the next section), where arbitrageurs specialize in transferring liquidity across constituent centers and in so doing eliminate price differentials (down to transaction costs). Consolidated multi-market systems are

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perspective because it tends to reduce the time an order waits before execution. A market system with a uniform price-time priority applied across its constituent center experiences increased buying and selling interest. Limit order traders, attracted by the reduced time to execution of their orders, increase the supply of orders [See Cohen, Conroy, and Maier (1985)]. The price discovery process, or the process by which prices converge to their true values, becomes more efficient [See Harris (1993) and Hasbrouck (1995)] in a competitive environment. Consolidation also allows market surveillance and regulation to be more effectively applied, and the costs of such surveillance to be more equitably borne by market participants [See Harris (1993) and Schwartz (1993)]. This improves the integrity of the market (the confidence that investors have in the market).

However, a consolidated monopoly market system has some potentially damaging effects such as the limited range of services offered to a diverse investor clientele, little incentive on the part of the market system to improve and innovate in the provision of services. As a result, regulatory authorities may need to invest considerable resources in the system to ensure that the welfare of retail investors is not compromised.

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subject to uniform primary and secondary protocols, and as such price and liquidity differential opportunities do not arise for arbitrageurs.

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2.2 Market Fragmentation / Segmentation

At the other end of the spectrum, a fragmented market exists when the market mechanism consists of mutually exclusive, disjoint sub-mechanisms where orders are matched separately within each mechanism. In a fragmented market system, orders for a particular stock are dispersed across distinct constituent market centers or liquidity pools. Thus, a completely fragmented market is characterized by the absence of information and liquidity transmission across sub-mechanisms. This can occur when

- Orders are dispersed among different organized market centers
- Orders are dispersed among separate order matching systems (for example, a stock is traded on various private trading systems or securities dealers' internal order matching services as well as on one or more organized market centers)
- Significant timing differences in the decisions of different investors to participate in the market for any given stock exist.

With respect to the first two examples, the degree of fragmentation is reflected in the extent to which information flows are constricted across market centers (or private matching systems within a market center), and differences across the resulting liquidity pools are significant. Order priority protocols may not be uniform across market segments; order books in the various centers may not be completely linked, and may in fact be entirely disconnected.[7] Thus investors' trades of a particular stock may execute at different prices across liquidity pools at the same time, or may face different waiting periods before execution at the same price. The price discovery process will be impaired as a result. With respect to the third example of market fragmentation, temporal

[7]Harris, 1993

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fragmentation is the result of the nature of a continuous market.[8] To avoid significant price impacts, large orders are broken up into smaller orders and introduced into the market in a piecemeal fashion. Also, large orders may be broken up and processed in a market center over a trading day so that a stock's volume-weighted average price (VWAP) can be calculated. Such practices distort true order flow or trading interest at any given point in time, and lead to greater price volatility. Ultimately the price discovery process is impaired as price, timing of trades, and liquidity differences among the system's constituent market centers corrupt the integrity and accuracy of the information received by investors. Cohen, Conroy, and Maier (1985) develop a theoretical model that analyzes the effect of market fragmentation on (limit) order flow and market quality. They find that market fragmentation results in

(a) a smaller average number of limit orders within the market maker's quotes,

(b) a lower probability that a limit order placed within the market maker's quotes will execute, and

(c) a greater average length of time to execute for any limit order placed within the market maker's quotes, assuming it executes rather than expires.

Those conclusions hold even when price priority is fully maintained between markets. They also find that as long as there is a significant positive correlation between the probability that a limit order will soon expire and the length of time it has already been on the book (a likely empirical reality), market quality deteriorates when time priority is not uniformly maintained across constituent market centers.

[8] Schwartz, 2000

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There can be benefits to traders in a fragmented system. Market fragmentation can foster the development of strong intermarket competition for the provision of market making services, where constituent market centers cater to the specific needs of investor clienteles. Traders may then be attracted to the unique, innovative, or cheaper services provided by particular market centers, resulting in greater trading interest (liquidity) in the entire market system. This can mitigate the potentially damaging effects of a consolidated, monopoly market system, and can ultimately result in lower trading costs relative to those in a consolidated system. Additionally, if trading in a particular security trading in a specific market center is exposed to the sales persons of broker-dealer member firms in other market centers, then trading interest in that security may increase.

A typical market system lies somewhere between the two extremes of consolidation and fragmentation, with some markets accommodating very little information flow across their submarkets and with others allowing substantial information flow. A fully consolidated multi-market system is characterized by a central electronic limit order display of all trading interest in the system, where the entire system is strictly subject to uniform primary and secondary priority protocols, and where all traders are considered identical (in terms of their trading needs).

Such a system can be contrasted with another type of multi-market system that accommodates significant information flow across constituent market segments, but is not characterized by a uniform primary and secondary priority protocol regime across those segments. This latter arrangement is called a segmented market [Harris, (1993)]. It

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consists of an amalgam of submarkets or segments trading a stock, with each market catering to a particular trader type, and where information flows freely across market segments. Thus a segmented market simultaneously accommodates a heterogeneous trading community while avoiding information flow problems associated with a fragmented market. A segmented market system can also exist within a market center, where the segments consist of separate order matching systems operating within that center. The successful coalescing of a segmented market system depends on, among other things, the ability of a group of market participants called arbitrageurs who specialize in the transfer of liquidity among market segments. Arbitrageurs simultaneously buy and sell the asset in different market segments until price differentials across segments are eliminated down to the costs of arbitrage. The quality of the system depends in part on the transaction costs incurred in the arbitrage process and the degree of competition among arbitrageurs.[9]

However, such a system frequently does not have a uniform priority protocol regime applied uniformly across market segments. The smooth functioning of the system requires significant intervention by regulatory authorities who can then establish an enforceable regime of trading priorities across the system. This is a major challenge to regulatory authorities, who generally cannot force market segments to adhere to a single precedence rule regime. Additionally, market segments may not voluntarily cooperate because their secondary precedence rules may frequently be in conflict. The Intermarket

[9] Transaction costs include costs of building, maintaining and operating systems to identify price differentials among market segments. Arbitrageurs in relatively competitive markets are less able to extract abnormal profits from investors.

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Trading System (ITS) in the U.S. is an example of a segmented market. This study investigates an instance where regulation is introduced to reverse the harmful effects of internal market fragmentation on the Toronto Stock Exchange. My findings indicate that the effort was largely successful. However, as we will see, one must proceed with caution when one attempts to draw conclusions about the attempts by a market system to address the problems posed by *external* market fragmentation through similar reforms.

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2.3 Market Consolidation versus Fragmentation

Consolidated markets provide depth and liquidity, allowing traders cheap and immediate execution. A fragmented market system caters to different investor types, protects investors from the high economic rents that can be extracted by a consolidated monopoly system, and fosters competition in the provision of trade execution services. Such competition may result in reduced execution costs for traders. Tinic (1972), Tinic and West (1972), Branch and Freed (1977), Hamilton (1979), Cohen and Conroy (1990), Stoll (1994) and McInish and Wood (1994) all conclude that the benefits of fragmentation (competition) outweigh the costs (primarily loss of liquidity) and result in a reduction in quoted bid-ask spreads in equity markets. Those studies compared quoted and effective bid-ask spreads across securities and market centers. However these studies may have dealt inadequately with firm- and market-specific characteristics. Christie and Huang (1994) suggest that the cost differences found by these studies may be due to fundamental asset value differences. Battalio, Green and Jennings (1997) find that, after correcting for such differences, trading costs (as measured by posted or effective bid-ask spreads) decrease for about 66% of their sample when order flow is attracted from the NYSE by the Boston and Cincinnati stock exchanges when they introduced rule changes that facilitated the internalization and preferencing of trades. Also, they find no evidence that trading costs rise. Battalio and Holden (2000) develop, as part of a model of payment for order flow, internalization and trading costs, a measure of trading costs called total trading costs (TTC). TTC is equal to the effective half-spread (EHS) plus the broker's dollar amount per share commission. They also define the TTC – Equalizing Passthrough Percentage as the percentage of payment for order flow that the broker must pass through

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to the trader in order to equalize the TTC's of primary and third-market venues. They re-examine some of the empirical literature on trading costs by trading venue that suggests that the NYSE provide the lowest-cost (as measured by the EHS). Their findings that in 9 of the 11 cases investigated the passthrough percentages are less than 100%, suggesting that with sufficient competition within the brokerage industry, the costs of trading would actually be lower on the third market than on the NYSE. Battalio, Hatch and Jennings (2000) compare market order execution quality between the NYSE, and the Nasdaq third market measuring, in addition to effective spreads, the net price improvement rate, the liquidity premium, and liquidity enhancement. They also suggest a measure of overall execution quality, the realized liquidity premium (the distance between the trade price and the quoted bid-ask spread's mid point five minutes after the trade), which is used as a proxy for the liquidity provider's gross trading revenue.[10] They find that while the NYSE provides better execution prices, the third market provides faster execution and more liquidity enhancement than the NYSE, suggesting that no one trading venue is best for all retail market orders. Fong, Madhavan and Swan (2000) study off-market trading using detailed panel data from the Australian Stock Exchange. They find that off-market trading can co-exist with trading on the primary market center without systematically undermining trading on the primary center. Specifically, gains from network externalities do not extend beyond a certain level of trading activity: off-market trading occurs in the most liquid, active stocks. A significant portion of such trading occurs with larger effective spreads than those on the primary exchange. However, this represents an

[10] The liquidity premium is defined as the average amount by which a buy (sell) order's trade price exceeds (falls below) the mid-point of the contemporaneous bid-ask spread. Liquidity enhancement is defined as the frequency with which orders for more shares than the quoted NBBO size receive the quoted price or better.

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arrangement that accommodates investors' strong demand for immediacy, as well as provides off-market competition for the trading of highly liquid securities that has spurred the emergence of innovative practices by the primary market.[11] Battalio, Green, Hatch and Jennings (2000) examine across-exchange fill rates, execution waits, and economic performance metrics identical limit orders submitted simultaneously to NYSE and regional exchanges. They also compare limit order execution quality before and after a broker redirects order flow from the regionals to the NYSE. They find that the limit order execution quality on the regional exchanges is comparable with that on the NYSE. Battalio, Jennings and Selway (2000) use data from Knight Securities, a major Nasdaq dealer and purchaser of order flow, to investigate, among other things, whether traders using brokers accepting order-flow payments are unambiguously worse off than traders using brokers who do not accept such payments. They find that several brokers selling order flow offer traders lower trading costs when compared with a broker who did not accept payment for order flow. They conclude that those brokers who received payment for order flow shared the resulting revenues with traders through lower commissions.

Other studies suggest that a high degree of market fragmentation leads to high trading costs. Lee (1993), Christie and Huang (1994), and Huang and Stoll (1996) find that the costs of trading are lower on the NYSE than those on Nasdaq, a relatively fragmented market. Bessembinder and Kaufman (1996), Chordia and Subrahmanyam (1995), and Easley, Kiefer and O'Hara (1996) argue that, because most of the NYSE-listed order flow directed to other trading venues contains very little information, the

[11] For example, Fong et al (2000) find that off-market trading declines with the introduction of a closing call market on the primary exchange.

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NYSE specialists face a relatively larger proportion of informed traders. The specialists widen their spreads to recover increased losses to informed traders, which in turn leads to higher trading costs for stocks throughout the market system. This occurs because the NYSE matches or determines the best bid or ask quote most of the time [Blume and Goldstein, (1997)]. Battalio, Greene and Jennings (1998) obtain results that appear to corroborate this conjecture. They investigate Merrill Lynch's decision, consummated at the close of trading on October 31, 1995, to stop the routine routing of small retail orders in securities listed on the NYSE and AMEX to affiliated regional exchanges. They hypothesize that since Merrill Lynch is a very large brokerage firm, this move would significantly increase the order flow of small retail orders on the NYSE, and reduce per share order processing and inventory costs. This additional order flow would be uninformed, causing the NYSE specialists' adverse selection costs to decline, resulting in tighter spreads in the market system. While they do not find a significant decline in the overall NYSE-quoted spread, they do find that relative to a matched sample of stocks, spreads decline in the stocks most affected by Merrill's rerouting. Further, a subsample of the stocks believed to be most affected by the rerouting (specifically, stocks with a large adverse selection spread component) experienced significant declines in their quoted spreads.

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2.4 Payment for Order Flow, Internalization, Preferencing, and Other Emergent Issues in a Segmented Market System.

As described above, a market system operates in the best interests of investors if it fosters fair competition for order flow among its member market centers. Specifically, within a market system such as the US's National Market System, market centers attempt to attract order flow from brokers (in other market centers) seeking execution of their customers' orders by offering fast and reliable executions, low transaction fees, and innovative trading services. Market centers may also offer inducements to brokers to have them agree to route all or part of their order flow to the market centers in return. Brokers are primarily motivated by the opportunity to share in profits generated by such practices. Thus, brokers may have to deal with the question of whether their participation in those arrangements conflicts with their fiduciary responsibility to act in the best interest of their clients. Two important types of economic inducement are

(1) Payment for order flow, the cash payments by market makers to brokers in an effort to attract orders, and

(2) Internalization of trades, the in-house execution of a customer's order- - that is, the execution of a customer's order against a firm's inventory, or the in-house matching of customer orders. Internalization is often facilitated by preferencing arrangements, which involve the pre-arranged routing of orders by brokers (on a primary exchange, for example) to competing specialists on regional exchanges, or dealers on OTC markets.[12]

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Opponents of such practices believe that the consequent outcome of greater market fragmentation dramatically increases the likelihood of trade execution occurring at prices no better than the NBBO (National Best Bid and Offer) and a corresponding reduction in execution quality.[13] For example, since a larger fraction of the trades clear inside the posted quote on the NYSE than on any other trading venue, the diversion of order flow from the NYSE to other trading venues reduces the opportunities for traders to enjoy price improvement. Price improvement occurs when market orders execute against other market or limit orders that lie within the quoted spread [See Lee (1993), and Peterson and Fialkowski (1994)].[14] Further, the price discovery (or formation) process for the security is impaired because the diverted orders are usually cleared at the quoted prices, and do not contribute to the discovery of the new (improved) price, if there is one. Preferencing and internalization could result in the violation of price priority: new orders may not be exposed to the best counter orders. This is because the third market or regional exchange dealer has no incentive to set the best quote for a preferenced or internalized order because he/ she receives the order in any event. The result is impaired price discovery, thinner markets, more volatile prices, and ultimately, wider bid-ask. Thus the issue of whether a broker acts in the best interest of a client when he/ she preferences or internalizes a trade must be addressed: the broker's role as an agent may

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[12] Order flow due to 'payment for order flow' practices cannot be preferenced.

[13] In 1992 Forbes Magazine documented that Bernard L. Madoff Investment Securities, a third market dealer, executed over 10% of all orders in NYSE-listed securities. Battalio, Greene, and Jennings (1997) estimate that approximately 7% of all orders in a group of actively traded, NYSE-listed securities were internalized on the Cincinnati Stock Exchange during September 1994.

[14] However, such price improvement may be realized at the expense of public (limit order) traders. That is, a market order that is delayed for price improvement may have initially cleared against a limit order. All else constant, this could result in the reduction in the number of traders willing to submit limit orders, and lead to a reduction in market liquidity.

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conflict his/her role as principal to the other side of the client's trade. The ability and /or willingness of the broker to provide the 'best' execution for the client are compromised. Godek (1996) and Dutta and Madhavan (1997) focus on the effects of preferencing on trade execution quality on Nasdaq. Brokers and market makers are only required to match the best price in order to receive preferenced order flow – they do not have to improve on that price. Thus a market maker may receive preferenced order flow because that dealer or specialist has an established business relationship with the order flow routing broker, the broker may have received some form of per share payment for order flow to the market maker, or a broker –dealer firm may decide to take the other side of a trade by directing the order from its brokerage services division to its market-making desk (that is, the firm may internalize the trade), in effect preferencing the trade to itself. Battalio, Greene and Jennings (1998) investigate the effects on trading costs on the NYSE of a decision (made in 1997) by Merrill Lynch, a major brokerage firm, to terminate its preferencing arrangements with some regional exchanges and direct its orders to the market center offering the best price (most frequently, the NYSE). They find a decline in quoted bid-ask spreads for stocks most likely to be affected by the decision.

Earlier research (see Christie and Shultz, 1994, and Chordia and Subrahmanyan, 1995) suggests that trade execution costs are higher on Nasdaq than on the NYSE because market makers on Nasdaq tacitly agreed to avoid odd-eighth quotes, thus keeping effective spreads higher than the marginal cost of market-making. Christie and Schultz also suggested that some of Nasdaq's institutional features, such as the non-exposure of its limit orders, facilitated collusion among its market makers. In 1997, the

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Securities and Exchange Commission (SEC) instituted new rules designed to increase competition on Nasdaq. The rules require that customer limit orders and electronic communication networks (ECN) market maker quotes be displayed as Nasdaq quotes. Additionally, the minimum price variation (tick size) on both the Nasdaq and NYSE was reduced from $1/8 to $1/16. Several researchers have investigated the effects of those rule changes on Nasdaq's trade execution costs. Barclay, Christie, Harris, Kandel and Schultz (1999) report a decline in trade execution costs for the first set of Nasdaq stocks subject to the new trading rules. However, Schultz (1997) finds that trading costs had begun to decline even before the implementation of the new rules, a phenomenon he attributes to 'regulatory and legal pressures'. Kandel and Marx (1999) develop a model that predicts a shift in brokerage volume away from preferencing market makers and internalizing broker –dealers to Nasdaq's Small Order Execution System (SOES) market makers, in response to an exogenous decline in the tick size. They provide empirical evidence they claim is consistent with their model's predictions. Simaan, Weaver and Whitcomb (1998) find that Nasdaq market makers continue to avoid odd (sixteenth) ticks. They find empirical evidence in support of the tacit collusion hypothesis and explain the spread reductions found by Barclay et al as due to the quote competition provided by the ECNs. Bessembinder (1999) also finds that quotations continue to cluster significantly on fractions, and more on Nasdaq than on the NYSE. However, he is unable to find significant relationship between the (positive) difference in execution costs on Nasdaq and the NYSE on the one hand, and the extent of quotation rounding on the other hand. He concludes that the continued and widespread use of preferencing arrangements among Nasdaq's market makers and brokers is the primary explanatory factor.

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However, the evidence is not conclusive on the deleterious effects of preferencing, internalization, and payment for order flow. Proponents welcome such practices as innovative, competitive responses to an increasingly complex and diverse financial marketplace where the benefits of market fragmentation outweigh the costs. In their analysis of preferencing using experimental markets, Bloomfield and O' Hara (1996) find that where all, or all but one, dealers receive preferred orders, preferencing widens spreads, increases dealer profits and reduces market efficiency. When two or more dealers do not receive preferenced orders, none of these negative effects occur. The authors conclude that if preferencing is not prevalent, markets are not adversely affected.

Battalio (1997) finds that when third market broker-dealer, Madoff Investment Securities, selectively purchases and executes order flow in NYSE-listed securities, quoted spreads decline and effective half-spreads do not increase. This result suggests competition reduced execution costs.[15] The finding is in sharp contrast to the 'cream skimming' effect predicted by some researchers, where purchasers of order flow selectively purchase order flow from relatively uninformed investors and effectively divert most of the order flow from informed investors to the exchanges, where market makers (the specialists) increase the spreads they charge to cover the increased adverse selection costs they face. Battalio, Jennings, and Greene (1997) find that there was little short run effect on quoted or effective bid-ask spreads when the Cincinnati Stock Exchange's Preferencing Dealer program was implemented in 1991, and when the Boston Stock Exchange's Competing Specialist Initiative was implemented in 1994.

[15] A reduction in quoted spreads could also mean that specialist may have set quotes in a monopolistic setting, and the purchase of order flow by Madoff led to a reduction in quoted spreads (without Madoff providing cost-competitive services).

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Battalio, Jennings and Selway (2000) investigate the relationship between payment-for-order flow routing arrangement and the sharing of market making revenue among broker, dealer, and trader. In particular, they study the interaction of Knight Securities, a major Nasdaq dealer, with market orders in actively traded stocks during the fourth quarter of 1996. If brokers use order flow payments to reduce brokerage commissions, then those payments emphasize broker competition on commissions rather than dealer competition on trade prices. They find, using a measure of trading costs that includes commissions as well as trade prices, that execution costs for investors who trade with some brokers who receive payment for order flow were lower that costs for the one brokerage who was identified as not receiving payment for order flow. Some researchers suggest that profits associated with payment for order flow arise because observed spreads are merely rounded-up values of true spreads. [16] Thus, discreteness allows for excess rents to those paying for order flow. Battalio and Holden (2000) develop a model that shows that profitable payment for order flow and internalization are possible even when prices are not discrete and primary dealers are competitive. They show that traders can be selected for profitable internalization and preferencing according to characteristics that a third party can easily verify (for example an informed, professional trader, versus an uninformed, nonprofessional trader). Battalio and Holden use a measure of trading costs called the Total Trading Cost (TTC), defined as the effective half-spread (EHS) plus the broker's per share commission. They then show that over time their model can generate (1) a drop in the TTC, implying that some of the payment for order flow is being passed on to the uninformed trader as the competition for the purchase of order flow by third

[16] See, for example, Chordia and Subrahmanyam (1995). The predictions of their model are directly contradicted by evidence from Porter and Weaver (1997), and Ricker (1997), who find no reduction in

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market dealers increases through a lowering of commissions, and (2) separating equilibria with a lower probability of informed trading in the third market than in the primary market.[17] The latter result is consistent with the finding of Easley, Kiefer, and O'Hara (1996) that purchased order flow has little information content. However, Battalio's (1997) finding that the EHS does not increase with Madoff's purchase of order flow, coupled with the fact the many on-line brokers who accept payment for order flow from uninformed investors have begun offering deep-discount commissions, suggests that brokers pass on some of the profits from purchased order flow to their clients through lower commissions. So, while the EHS does not fall, the TTC does, suggesting that payment for order flow is not 'cream skimming'.

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internalization following tick size reduction on the Toronto Stock Exchange.

[17] Commissionless trading by third markets such as Charles Schwab and Olde lend support to the notion.

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2.5 Price Discovery

Research efforts have tended to focus on the bid-ask spread as a measure of market quality. But spreads measure one aspect of market quality—the quality of the broker-dealers services provided in the market. Schreiber and Schwartz (1985) identify three major regulatory objectives that a public securities market should attempt to achieve. The market should (1) ensure that all market participants are fairly treated, (2) make the competitive provision of dealer services, (3) enhance the efficiency of the price discovery process. The third (and perhaps most important) regulatory objective represents an oft-ignored dimension of market quality assessment.

Fair equilibrium stock prices are determined purely according to the demand and supply functions of market participants, and reflect investors' aggregate desire to hold shares of the stock. In the presence of market frictions, however, transaction prices often differ from the fair equilibrium price. Ho, Schwartz and Whitcomb (1985) show in a theoretical model that two conditions must hold so that the aggregation of orders result in a transaction price that is equal to the fair equilibrium price: (1) there must be symmetry in the distribution of buy / sell orders, and (2) investor expectations concerning the market clearing price must be unbiased. If traders expect a transaction price that is different from the fair equilibrium price, then transaction price instability will ensue (as a series of price changes is generated, and traders process the resulting information at each price change) as the market searches for new equilibrium price following a change in demand to hold shares of the asset. This complex price discovery process is influenced by the particular market realities faced by traders, such as the nature of the information

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systems used by the market, the role of the market maker in the market, and the market's basic structure.

Relatively few researchers have explored the question of how market fragmentation affects the price discovery process. Biais (1993) models centralized (consolidated) markets as relatively transparent and fragmented markets as relatively opaque. One of his conclusions is that while the expected bid-ask spread is invariant to the type of market structure present, the volatility of the spread is greater in the centralized market. Blume and Golstein (1997) find that prices in the NYSE quote match the best-displayed quote of NYSE-listed stocks most of the time. However, when a non-NYSE market does post the best bid or ask price, it attracts additional order flow. The implication is that non-NYSE markets contribute to price discovery when they improve on the quoted price. They also found that non-NYSE markets attract significant order flow when both sides of their quotes were inferior to the best-displayed quotes. While this important tendency has been linked to the phenomenon of internalization and payment for order the flow in terms of their effect of market spreads, its effect on the price discovery process was not investigated. Flood, Huisman, Koedijk and Mahieu (1999) consider the effect of pretrade transparency (public quote disclosure) on transaction prices, trading volume and the price discovery process. They develop an experimental model where seven dealers set quotes and trade with other dealers and customers that represent both informed and liquidity motivated traders. The amount of publicly available quote information (pretrade transparency) is varied over multiple rounds of trading. Flood et al find that high pre-trade transparency significantly reduces

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trader search costs such that interdealer-trading volume substantially increases and spreads decline, resulting in high market liquidity. However, low search costs also enable speculating dealers to shade quotes so as to avoid being picked off in a trade on the 'wrong' side of the market. Thus price adjustments tend to be less aggressive in relatively transparent markets. On the other hand, relatively high search costs in opaque markets tend to favor aggressive quoting and price adjustments and to discourage quote shading. Thus they find that the price discovery process is more efficient in the less transparent market.

Hasbrouck (1995) conducts an econometric analysis of a single security trading in multiple markets. By invoking the law of one price, he identifies the common factor of the efficient price of the security, which is defined statistically as the random-walk component of the prices from the diverse markets. The innovation variance of this random walk is a measure of the 'information intensity' of the efficient price process. The information share of a market (i.e. its contribution to the discovery of the efficient price) is defined as the proportion of the innovation variance attributable to this market. Hasbrouck finds that the median information share (for the 30 DJIA stocks analyzed) on the NYSE was 93%. For twenty-eight of those stocks, this percentage is larger than each stock's market share. Handa, Schwartz and Tiwari (1999), in noting the complex nature of the price discovery process on the AMEX, focus on the important role played by floor brokers. Floor brokers, by making a timely, comprehensive assessment of current market conditions (including order flow), are able to improve on price appropriately and thus facilitate the discovery of the efficient price. They surmise that when order flow for a

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single security is dispersed among several market centers, the ability of the floor brokers to comprehensively observe order flow is impaired, and the price discovery process is hindered. The resulting erosion of the primary market center's integrity could eventually lead to the breakdown of the entire multi-market system.

Traders having timely, accurate information that facilitates the formation of more accurate expectations about the end-of-trading, equilibrium value of a security facilitate the price discovery process. This equilibrium value reflects investors' collective desire to hold shares of the security. As a result, investors will incur lower trading costs if the market takes less time to find this equilibrium price, and the transaction price convergence to that equilibrium price is less volatile. The price discovery process, which can be described as the process of revising expectations of the security's equilibrium value and the convergence of the market-clearing price of the security to this equilibrium value, is more efficient if investors have timely access to comprehensive information about the trading interest in the security. A consolidated market is one where traders can universally expose their orders, and where traders can act upon exposed orders in a timely fashion. This structure forms just the kind comprehensive information base that facilitates the formation of more accurate expectations of the end-of-trading equilibrium value of the security, and as such contributes to efficient price formation. A fragmented market undermines the comprehensiveness of information available to a trader by limiting the trader's timely access to information to his/ her particular market fragment. The efficiency of the price discovery process declines as a result.

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2.6 Summary and Implications

To summarize, a fully consolidated market for a security provides investors with timely, comprehensive information that allows them to make efficient trading decisions in a fair trading environment. However such a system may stifle innovation in the provision of trading services and may be unable to efficiently cater to a diverse investor clientele. Fragmented market systems have emerged in part as attempts to address those deficiencies. However, fragmented markets carry their own problems. Information flows across market fragments may be constricted, and trading precedence rules may differ across market fragments. Thus, trading efficiency and fairness are compromised, where some market participants profit at the expense of others. Eventually trading may become more costly for all market participants as some participants flee. A compromise market system, a segmented market, can successfully address the problem of poor information floe by allowing arbitrageurs to transfer liquidity across market segments, and eliminate price differentials in the process. Therefore such a system can naturally maintain price priority. However, it may suffer from diverse secondary precedence rules among its segments. Thus government regulation is needed to ensure that the interests of all participants in the system are considered.

The US's system of financial markets, the National Market System (NMS), is an example of a segmented market. Some practices have emerged within the system that concern market regulators: preferencing, internalization, and payment for order flow allow brokers to direct incoming orders to specific market makers. Brokers and market makers then get the opportunity to share in profit from such arrangements—at the

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expense of clients. Additionally, if such practices become pervasive, limit order traders can be dissuaded from supplying limit orders, which are the foundation of an auction market. This happens because limit orders often get sidelined in the midst of such arrangements, while the price- setting information they provide is used by the parties involved to engage in abnormally profitable trading. However such practices can also represent competitive, innovative responses to demands by a diverse investor clientele. Extant empirical evidence suggests that there are certain circumstances under which such practices are harmful and other circumstances where they offer superior trading services at lower costs. However the literature has not cohesively identified nor explained those circumstances, and has not comprehensively investigated possible relationships among those circumstances. Part of the problem may lie in the fact that some conceptual and methodological issues (for example empirical measurement of market quality) are outstanding, and continue to evolve.

The issue of financial market fragmentation versus consolidation is currently an important one for US regulators. While the SEC has sought to remove unnecessary barriers to vigorous price competition among market centers, it has also begun an analysis of the possible negative consequences of the resulting market fragmentation. The SEC is in favor of centralizing order flow in a security, and applying a uniform price / time priority protocol across all market centers in the system. [18] However the current system of US markets approximates the structure of a segmented market at best, and often exhibits the symptoms of a fragmented system. Further, the question of whether a

[18] See Department of Justice (2000), for example.

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strict price/time priority protocol results in the maximum possible welfare enhancement of all participants has not been satisfactorily answered.

The segmented market system in the US maintains price priority by obtaining the commitment of markets to match the best-quoted price when executing incoming orders. Such a scenario does not guarantee the maintenance of price priority at all times. For example, a large order in one market center may trade through prices in another market center. Additionally, some new ECNs do not commit to matching the best price across the market system. Further, as is typical of a segmented market, time priority is frequently violated.

Even though market centers could organize perfect physical links among their upstairs markets, the practices of preferencing and internalization could continue unabated because the brokers engaged in such practices are only required to *match* the best quoted price, not post the best quote. It has been empirically demonstrated that such practices introduce innovation and reduce trading costs in a market system by facilitating the introduction of cost-reducing technology and the efficient execution of trades among market participants who have long term, whole sale business relations. However, excessive preferencing and internalization dissuades the posting of best prices, and undermines the price discovery process. Thus, the successful linking of markets depends primarily on the nature of rules governing the routing of orders. Stoll (2001) advocates the introduction of a 'best –quoted price' rule to eliminate the price matching that is typical in preferencing and internalization. He suggests two advantages of this new rule:

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(i) a best-posted price then has a better chance of attracting order flow because order flow would not be lost to those who simply matched best prices. (ii) the cost of preferencing or internalization would increase because, to receive order flow, a market center would have to post the best prices and accept all orders. Thus, such practices would be tempered.

The question of whether a strict price/ time priority protocol is always optimal should also be examined. While a market order may be indifferent to a time priority rule, success in limit order trading depends on its existence. Limit orders that execute under a strict secondary time priority rule can attract market orders in a new market center, even if that center is small, illiquid and does not attract market orders naturally. Limit orders remain isolated in the absence of the rule. Thus we have an example of the existence of a time priority rule that leads to more, not less harmful fragmentation in a multicenter market. By contrast, the existence of this same rule *within* a market center conveys significant benefits (such as greater liquidity) to the center. This dissertation empirically investigates such a case. However, based on this analysis, it is ill advised to use those results to predict outcomes in an *externally* fragmented market.

The implementation of strict price/ time priority rules could create incentives to charge fees and commissions and could alter how transaction costs are split between the bid-ask spread and commissions. For example, a market center that previously received preferenced order flow may be required, with the introduction of a 'best quoted price' rule, to post the best quote in order to receive order flow. That market could then be faced with more costly trading, but could recoup the costs by charging, say, an order handling

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fee that would be discounted for preferenced order flow. However, commissions represent the explicit costs of transacting in the market and better reflect the results of cost competition than the implicit cost of trading, the bid-ask spread. Additionally, the central advantage of implementing the 'best quoted price ' rule still remains: it forces greater interaction of orders.

The above analysis suggests possible avenues for future research:

1) The fact that the practices of preferencing, payment for order flow and internalization not only exist, but appear to thrive in some instances may reflect the belief by regulators that the institution of sweeping reforms may cause more harm than good, and that those practices actually convey some benefits to the market. Much of the financial market dynamics that concern regulators and other market participants may ultimately stem from the rules governing the behavior of market participants. The behavior of brokers, large traders, small traders, dealers, upstairs traders, downstairs traders, etc., is governed by a plethora of rules. Often, there are significant differences in the restrictions placed on, and the freedoms granted to various market participants. For example, on the NYSE there are limits placed on the trades and orders than can be submitted to the market by upstairs customers and traders, relative to those in the downstairs market. Some of those rules have not kept pace with the dramatic, technology-driven transformations in financial markets. The increased access, and greater transparency brought about by such transformations has blurred the distinction among many kinds of market participants. For example, institutional traders market making ability has

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increased over time. Thus it would be useful to explore the relevance of, or need for rules and regulations that govern the behavior of the various market participants in the current context. Such an investigation could help clarify the causes and consequences of the phenomena we observe in segmented markets.

2) It would be instructive to investigate the differential impact of the presence or absence of a time priority secondary rule under the three kinds of market fragmentation: internal, external, and temporal. The role of limit orders in assessing market quality could be assessed more thoroughly in this context, and non- price measures of limit order execution quality (such as fill rates, execution wait times, etc.) should be included in the assessment [See Battalio, Green, Hatch, and Jennings (2000)].
3) Using either a natural experiment (that is, a rule change by an exchange or market system) or a theoretical model, the impact of requiring market makers to post the best quote in order to attract order flow could be investigated.
4) More comprehensive tests of market of the impact of market fragmentation on market quality should be undertaken. For example in addition to the usual measures of market quality such as quoted and effective spreads, market depth and volatility, other measures such as trade execution speed and liquidity enhancement (or quantity improvement – the ability to trade more than the quoted number of shares at the quoted price) should also be used. In particular, it would be interesting to see how a measure of trading costs that describes both the explicit and implicit costs of trading, is influenced by attempts to improve market

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quality. For example, Battalio (2001) uses the following measure total trading costs = per share commission+ realized half-spread.

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PART II

THE TORONTO STOCK EXCHANGE AND INTERNAL MARKET FRAGMENTATION

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Chapter THREE: Internal Market Fragmentation: The Case of the Toronto Stock Exchange

In this chapter I discuss, in some detail, a recent attempt by the Toronto Stock Exchange (TSE) to consolidate its order flow. I begin, as an attempt to demonstrate the universality of concerns about off-market trading, by referring to efforts made by several other exchanges around the world to centralize trading. The nature of the TSE, and the evolution of its regulatory framework regarding off-market trading are then described. Next, I describe the TSE's motivation for implementing new trading rules. I highlight three important reasons that served as a catalyst for the TSE's decision: 1) the evolution of its trading rules, 2) members' development of Order Management Systems (OMSs), and the impact on their tendency to internalize 'on the book', and 3) the growth of institutional trading. Some theories, which have been used to explain the internal market fragmentation experienced by the TSE, are introduced. Thus this chapter provides the basis for the empirical tests that are developed and conducted in 4. Those tests assess the effectiveness of the TSE's attempt to consolidate its order flow through trading rule changes.

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3.1 Market Consolidation Efforts by Other Exchanges.

In recent years many exchanges around the world have undergone major technological transformations, and now have centralized trading where off-market trading is either not allowed, allowed only for block transactions, or is not an issue. However some exchanges have recently introduced trading rule amendments designed to redirect off-market trading to the central exchange.

The Italian Stock Exchange displays trading interest in shares of stock in its consolidated limit order book. Its structure is that of a continuous auction. Although it allows trading outside the central auction market, it has instituted rules aimed at concentrating the display of trading interest in the auction market. Specifically, a broker who wants to execute a customer's order off-market must obtain written permission from the customer and improve the execution price relative to the best price offered in the central market.

The Danish Stock Exchange has expressed interest in addressing off-market trading. Tanggaard (2000) reports that the introduction of a new trading system on the exchange has apparently increased opportunities for off-market trading. He finds that, over the period July 1999 to October 2000, effective spreads are smaller for trades executed on the exchange versus off-exchange trades. The market share of the central market has increased significantly, and the increase is due mostly to an increase in crossed trades. Market depth has increased. Market impact, measured by the deviation between the transaction price and the true, equilibrium stock price, is higher for exchange

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trades than for off-exchange trades.

The National Stock Exchange in Lithuania did implement a rule (in 1998) designed to consolidate order flow. The relevant clause states: "Where securities registered with the Securities Commission intended for public trading are included into the Official or Current Trading Lists of the Stock Exchange, the sale-purchase transactions of the secondary trading shall be executed only at the Stock Exchange." As result, off-market trading is no longer an issue.

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3.2 The Structure of the Toronto Stock Exchange (TSE)

Recent rule changes on the Toronto Stock Exchange (TSE) allow for the examination of efforts to consolidate order flow in a formerly fragmented system. Before I discuss the rule changes, it is useful to examine the basic structure of the TSE in the context of the structure of capital markets in Canada. The TSE is the largest stock market in Canada. Before 1999, there were four other stock markets in Canada: Alberta, Montreal, Vancouver, and Winnipeg. There were no formal direct trading links among the exchanges that allowed the transmission of orders from one market to another for execution, nor was there a mechanism for determining a BBO. Each province's Securities and Exchange Commission was responsible for regulating its stock market. The automated systems that most of the exchanges use are not compatible. However, the exchanges did cooperate to an extent so that where an investor in one province (with the assistance of a dealer registered in the province) could trade in the securities of an exchange located in another province through facilities provided by that exchange. Also, exchanges such as Montreal and Toronto were allowed to have terminals placed in other provinces to facilitate the trading of listed securities by investors in those provinces.

On March 15, 1999 the Montreal, Vancouver and Alberta exchanges entered into an agreement to restructure the existing exchanges according to their trading of a particular security type. Specifically, the TSE now specializes in trading large cap, mature equities, and the Montreal Exchange specializes in trading derivative products. The equities of smaller, emerging businesses are now traded on the Canadian Venture

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Exchange, which was created through the merger of the Alberta, Vancouver and Winnipeg Stock exchanges.

The Toronto Stock Exchange operates essentially as a limit order driven market. Trades are created by the interaction of market orders and limit orders stored in a central limit order book. The limit orders are listed in the central limit order book as a bid price (the price at which the limit order trader wishes to sell the asset) or an ask price (the price at which the limit order trader is willing to buy the asset). Because wild price fluctuations may result as the market attempts to equate aggregate demand for the stock with aggregate supply at a given point in time, professional market makers (called Registered Traders) step in to provide price stability and market continuity by relieving market surpluses or shortages.

On July 29, 1996, the introduction of the CATS (Computer Assisted Trading System) II trading rules changed the character of CATS trading system on the Toronto Stock Exchange. The post-opening allocation of stocks is now based on secondary priority rule principles of equal-by-member and pro rata distribution (described below), followed by time priority. Previously, stock allocation on CATS (i.e. the CATS I system) was made according to strict price/ time priority, while those on the exchange floor were made according to equal-by-member and pro rata distribution protocols. Thus the new allocation rules on CATS are identical to the old floor rules, effectively subjecting trading on the exchange to a single set of trading rules.

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Tradable orders are allocated among offsetting bid and ask prices according to the following priority. Consistent with price priority, client crosses (where a market buy order is executed against a market sell order at a price within quotes) are executed first, followed by non-client crosses. Client trades are prioritized to enhance the protection that clients get from the informed trading of professional (i.e. non-client) traders. Then if, at the same price, a member has priority volume on an order, that order is prioritized, and orders of equal volume are subject to a price-time priority regime. Once a member has exhausted its priority volume, then equal-by-member distribution takes effect, and guarantees each member an equal allocation of up to 2,000 shares. Allocation beyond equal-by-member distribution is done on a pro rata basis: each member receives a portion of the remaining tradeable volume proportional to the total size of its order. If a member has several competing orders queued up, allocation is prioritized as follows: client orders in time priority sequence, then non-client orders in time priority sequence.

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3.3 Meeting Investor Needs: The Evolution of the Toronto Stock Exchange's Trading Rules

The TSE has attempted to meet the needs of an increasingly diverse investor clientele (in a competitive financial market environment) through an ongoing revision and updating of its regulatory framework. In that process, it has identified 6 key attributes against which the success of the TSE in meeting investor needs are to be measured. They are (i) high market liquidity, or the ease with which trades can be consummated with minimum price impact; (ii) immediacy, or the speed with which investors' trading demands are met; (iii) pre-trade market visibility or transparency, or the extent to which traders have access to current stock prices and available quantities before trading; (iv) efficient price discovery, or the process by which a stock price converges to its fundamental value (that is, its full-information, 'present value of future cash flows' value); (v) low transaction costs ; and (vi) fairness to all market participants, and the maintenance of the integrity of the credit ring (the certainty with which participants can expect their trades to be settled) and the market place (the general level of confidence that investors and the general public have in the marketplace).[19] [20]

Before 1970 TSE members found it almost impossible to internalize trades. Members were subject to a cross interference rule that required them to offer 15% of matching orders to offsetting orders declared on the floor at the same price. Customer-principal trades were not permitted on the TSE floor. They were allowed to take place in

[19] With the exception of the last attribute, the other attributes are described and explained at various points in this dissertation.

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the upstairs market at a minimum value of $500,000. In 1970 the cross interference rule was suspended by the TSE in response to a similar decision by the Montreal Exchange. In 1975 the TSE changed its rules to allow customer-principal trading to take place on the floor, and the minimum trade value was reduced to $400,000, with a further reduction to $100,000 in 1977 because of concern that such trades (that is, customer-principal trades of minimum value $100,000) could be consummated on the American Stock Exchange. The fact that such trades took place on the TSE's floor was thought to be enough protection (for clients) from any improprieties by TSE members.

In 1984, the $100,000 minimum trade value requirement was removed. This rule change allowed members to do principal-client trades with retail orders, with the requirement that the member executing a principal trade had to give the client a better price than was available from any client order on the TSE, and at least a price equal to any available from any non-client order (see overview on Table 1). This change was made in an effort to increase small order liquidity on the TSE. In 1985, client priority was removed. Professional and client orders now competed on an equal basis, subject to the requirement that a member could not buy or sell as principal if it held any client orders on the same side of the market at that price. The new rule also required that a member trade as principal at a price at least as good as that otherwise available from any other order. This was a direct response to increased competition from U.S. dealers in TSE-listed securities, who were treated as clients on the TSE. It was felt that these two rule changes

[20] With respect to the third attribute, while small (or retail) investors prefer to transact in transparent markets, large, informed traders prefer pre-trade anonymity in their transactions. The successful resolution

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would encourage orders to be entered and matched in the TSE's auction market, thereby increasing overall liquidity at the TSE. Instead, it was observed that an increasing number of small order trades were intercepted, matched internally by members and then reported to the TSE as crosses.

In 1987 the rule was again amended. Members who wished to do a principal-client trade were required to

- execute the trade at a price equal or superior to the best posted bid or ask price on the TSE
- take reasonable steps to ensure that the price obtained for the customer is the best available price at that time, taking into account the relevant market factors
- ensure that the price is justified by the condition of the market

The CATS system, which was inaugurated in 1977, displays the aggregate size and total number of orders at each of 5 price levels of all orders in its order book. Until 1989 this was not the case for orders declared on the Floor, where only the registered traders knew the true order size, an important indicator of market liquidity. In 1989 the floor trading rules were amended, and required that all orders, including those declared on the floor, be entered and displayed in an electronic order book in order to be eligible to trade. The TSE reasoned that the (resulting) increase in order exposure would attract traders who had previously diverted their trading away from the TSE (i.e. liquidity would attract liquidity). While trading volume appeared to have increased as a result of the rule change, most of the new volume was taking place outside of the auction market's order book. The

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of these two conflicting demands represents an important challenge to the TSE.

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new rules proved inadequate in effectively addressing the diversion of order flow away from the TSE's auction market.

The regulatory framework was adjusted over time in an attempt to lure potential and actual dissident investor clienteles back to the TSE exchange, but such adjustments also gave member firms unprecedented leeway in internalizing trades at the expense of investors. Additional developments, described below, increased the tendency of member firms to internalize orders in the upstairs market and to avoid seeking the best prices for their clients.

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3.4 The Development of Order Management Systems and Institutional Trading

The development of automated Order Management Systems (OMS) dramatically increased the ability of member firms to filter orders according to characteristics such as risk and trade size, and route them to a trader who can trade against them as principal or match them in the upstairs market, and then enter them in the order book. Orders from branch offices can be classified or filtered by symbol, volume, price, duration and terms, and then routed to the exchange's order book or to the firm's trading desk. The benefits of such an arrangement to the member include the increased ability to make on-the-spot routing decisions, a reduction in the manual handling of trades (which is relatively more error-prone and demands more staff), and ultimately faster and more efficient trade confirmation and execution. Additionally, in 1991 the TSE developed an order management (OM) application. This was a response to the growing retail business of its larger members, and requests by those members for additional order management capability. The application allows individual traders to define and use detailed filter criteria to select certain orders for management by the trader, rather than allow the orders to be routed directly to the order book. Thus, orders that would normally be managed and processed by registered traders on the floor can now be entered directly into the electronic book or handled by upstairs traders before entry into the book. This is possible as long as upstairs traders observe in-house client priority and match the best price on the TSE auction market. For example, orders of a certain size can now be are routed to internal professional traders for and assessment of the risk of filling the order from inventory. If the risk is judged to be favorable the order is usually filled at the bid or ask price, and does not receive price improvement. This occurs despite the TSE's 1987 rule

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that requires members to offer a price that is justified by market conditions. Thus, the member firms can use proprietary order management systems to select the orders they wish to process, increasing the probability that their clients' best interests are not prioritized in such transactions. Similarly, the development of Proprietary Electronic Trading Systems (PETS) has automated large portions of the trading process. This has reduced the manual handling of trades, and the tendency of broker-dealers to 'work' the orders (i.e. make some effort beyond trading at the best-quoted prices) in an attempt to obtain the best execution for their clients.

Another development that has generated concern is the increased presence of institutional trading, and the demand by clients involved in those trades for immediacy, or immediate execution. Order driven markets are generally unable to conduct large block trades effectively, because of the considerable inventory risk borne by the market maker, and the information conveyed to market participants if the order were exposed in the limit order book[21] Consequently, block trades are negotiated off the order book, in what is called the *upstairs market* by TSE members. In this case member firms may act as the agent in the block transactions by facilitating the trade between clients (primarily institutions), or they may take the other side of the trade with a client (i.e., act as principal in the trade)(See Keim and Madhavan, 1996). This has resulted in members having to take large positions that they would like to get rid of, or 'unwind' as quietly as possible. This is done by trading against retail orders in the upstairs market away from the central auction market, thereby avoiding any exposure of the dealer's trades, and then reporting

[21] See O'Hara (1995).

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the trades in the book as crosses. Again the information is provided after the transaction has been consummated.

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3.5 Internalizing On The Book.

The TSE sought to address concerns about the detrimental effects of crossing by implementing the order exposure rule on August 31, 1998 and the price improvement rule (the rule whose effects are investigated in depth in this study) on October 26, 1998. The TSE required that member firms follow extensive compliance procedures to ensure that the rules were as effective as possible. In response to requests by some members for assistance in implementing the compliance procedures, the TSE issued Regulatory Notice 98-003 on October 26, 1998 that included guidelines for handling orders of 5,000 shares or less (see Appendix B). According to the guidelines, the compliance procedures must address the particular systems used by the member for processing orders. The two main systems used are order management systems OMSs and trader-managed orders. As described above, the OMSs can filter incoming trades according to various characteristics and automatically execute the selected trades. Such trades tend to be small trades (trades of 1,200 shares and below). Larger trades tend not to be automatically processed through an OMS, but to be managed by a trader.

The price improvement rule provides that members can cross an incoming order against their own inventory if they offer the client a better price than the client could obtain on any Canadian stock exchange, unless the spread for the stock is the minimum tick size. Initially, the rule applies to what is referred to as 'intentional' crossing --- crossing of orders against a member's inventory without exposing the order in the book (a practice I term 'internalizing off the book'), or trades where the client's order is 'held up' or withheld solely to give the member's inventory trader an opportunity to enter an

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offsetting order to cross with it in the book (a practice I term 'internalizing on the book'). The latter practice (internalization on the book without improving on price) is facilitated through the use of OMSs. Since many members had not fully established compliance procedures at the time the Price Improvement Rule had been implemented --October 26, 1998--it is unclear whether that practice was fully curtailed by the end of the few months immediately following that date.

One possibility of this uncertainty is that members could shift from internalizing small orders off the book, where they must improve on price, to internalizing on the book, where, although the price improvement rule requires price improvement, members' OMSs have not yet been configured to fully reflect the requirements of the compliance procedures. As a result we could see more crossing on the book, at the spread.

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3.6 The TSE's Rules to Consolidate Order Flow

In late 1995 the Toronto Stock Exchange established the Special Committee (SC). Its primary mission was to identify and provide recommendations on the changes in the TSE's market structure, and the appropriate trading rule changes necessary to respond to the impact of market fragmentation.

The SC documented that in the early 1990s trading volume (measured by total number shares traded per year) and value (measured by the value of traded shares in Canadian dollars) increased at a much faster rate than increases in displayed size. From 1990 to 1995 the Toronto 35 Index average number of Board Lots Bid and Offered showed fluctuating annual percentage point volume (or value) increases ranging from 35% to 83%, with a percentage increase of 35% in 1990, 65% in 1992, 83% in 1993, and 60% in 1995 (See Table 2).[22] On the other hand, over the same period, the Index showed annual percentage point increases in total annual TSE share volume and dollar value from -9% and −17% respectively in 1990, -2% and −12% respectively in 1992, -60% and 49% respectively in 1993, and 101% and 133% respectively in 1995. Similar results were observed for the TSE 300 Index, and for all stocks on the TSE. Some TSE members believed that the disparity between displayed trade size (that is, orders in the book) on one hand and realized trading volume and value on the other was due to increased internalization and crossing of order flow, while others believed it was due to increased institutional trading in the upstairs.[23] The SC also noted that from 1990 to 1995 total annual crossed trade volume as a percentage of total trading volume on the TSE

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[22] Toronto Stock Exchange Special Committee Report on Market Fragmentation

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increased steadily from 37.05% to 51.9%, while total annual crossed trade value as a percentage of total annual trade value on the TSE increased from 40.64% to 52.60%.

The SC concluded that a significant portion of the TSE's retail order flow was being diverted away from its central limit order book (whose volume display is reflected in the number of board lots offered), in effect 'internally fragmenting' the TSE's retail order flow. Thus, the TSE's ability to provide a liquid market, give the investor the best price possible, and provide efficient price discovery was impaired. The TSE's Special Committee recommended that the 'Order Exposure Rule' be adopted. This rule requires members to immediately enter a customer order of 1,200 shares or less in the book unless they were prepared to give the customer a better price than any price the customer could receive in any market, or unless the unimproved price was justified by market conditions. This rule was implemented on August 31, 1998

While it was believed that the adoption of The Order Exposure Rule would force the exposure of more of the TSE's retail order flow, there remained the lingering question of whether the practice of executing some small and medium sized orders outside of the TSE's central market with a member taking the opposite side of the trade did not directly conflict with the member's fiduciary obligation to do what is in the best interest of the client. It was felt that the primary motive for a member's interest in internalizing order flow was not to improve the price for the client, but to profit from the transaction. Members frequently executed the trades at the best-posted quotes without making a reasonable effort to seek a better price. To address this issue the TSE implemented 'Price

[23] Toronto Stock Exchange Special Committee Report on Market Fragmentation

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Improvement Rule' or, as it is also known, the 'Customer-Principal Trading Rule' on Monday, October 26, 1998:

> Any member wishing to do a principal–client trade of 5,000 shares or less is required to give the client a better price than the client could receive on any Canadian exchange unless the spread between the highest bid and the lowest ask prices on any Canadian exchange is the minimum price variation (5 cent tick for securities trading over $5, 1 cent tick for prices less than $5).

The hypotheses that follow are designed to assess the impact of this rule change on the TSE's order flow and market quality.

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3.7 Some Theories of Internalization

Several theories have been developed to explain the phenomena of preferencing and internalization. Bessembinder (1999), Dutta and Madhavan (1997) and Godek (1995) suggest that market makers are not able to compete on price in an effort to attract order flow away from those who receive preferenced or internalized trades. They describe how institutional arrangements restrict access to order flow, and thereby reduce the market makers' incentive to compete on price. Examples of such institutional arrangements are the ability of integrated firms to internalize order flow, or where order flow is directed to specific members regardless of the competitiveness of their quotes. The implication of those theories is that spreads widen, market maker profits increase, and general execution quality deteriorates. Therefore if the ability of members to profit abnormally and unfairly from crossing is curtailed, as intended by the TSE order execution rule, we would expect spreads to decline, market maker profits to decrease, and general execution quality to improve.

Copeland and Galai (1983), and Harris (1993) suggest that internalization is inconsistent with a price-time priority protocol. In general, extant order–driven markets use a priority protocol where orders are exposed to market participants and executed at the best prevailing price.[24] Internal matching of orders effectively allows brokers to execute trades ahead of limit orders and quotes in the limit order book (i.e. brokers 'step in front of the book'), while utilizing the information provided by the limit orders—a

[24] The NYSE actually follows what is called 'priority, parity and precedence' where size priority is sometimes used in place of time priority. This is an attempt to minimize the number of separate transactions required to consummate a large trade while adhering to time priority as closely as possible. At the time of the rule changes, the TSE used a price/ sharing / time protocol. The implications of theory are

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process referred as front running. This process works to the disadvantage of limit order traders, who have options (that they have effectively written by pre-committing to buy or sell the stock at a particular price) exercised against them. In the case of the TSE, limit order traders, who supply liquidity to an auction market such as the TSE's, are thus dissuaded from submitting limit orders. The increasingly important role played by members' order management systems coupled with the relatively liberal evolution of trading rules (described in chapter 3) form just the kind of institutional arrangement that facilitates internalization. Also, since the upstairs traders have the ability to select trades according to risk, riskier trades would be diverted to the downstairs market, further raising the costs of execution at the TSE. This occurs because a higher percentage of informed trades execute on the floor, raising the adverse selection component of the spread there [see Easley, Kiefer and O'Hara, (1996)]. The TSE's introduction of its price improvement rule would remove the incentive for members to profit at the expense of (especially small, retail) investors through the practice of internalizing trades, and would ultimately result in a significant decline in execution costs.

However, Battalio (1997), and Battalio and Holden (2000) suggest that the practices of preferencing, payment for order flow, and internalization do not result in an increase in (and in some cases result in a decline in) trading costs if the initiators of such practices introduce a cost advantage (due to, for example, technological innovation or a particular trading venue's cost efficiency) to the trading process.[25] Thus, the introduction

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not materially affected by these considerations because fragmentation (due to internalization) is not significantly affected.

[25]Those studies measure trading costs using the time-weighted bid-ask spread, the liquidity premium (or effective half spread), and Battalio and Holden (2000) use an additional measure, total trading costs (TTC),

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of current technology order management systems may enable market makers to execute trades more quickly and efficiently to the extent that resulting cost savings could be passed on to investors as lower execution costs. So the issue of how internalization of trades on the TSE affects investors is an empirical one.

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defined as the effective half-spread plus average per share commission.

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PART III

EMPRICAL EVIDENCE, CONCLUSIONS AND IMPLICATIONS

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Chapter FOUR: Hypotheses, Tests, Findings and Analysis

In this chapter I describe the methodology and sample used the empirical investigation. I then develop some hypotheses and tests around various aspects of market quality change assessment after the introduction of the Price Improvement Rule. The tests differ in their degree of sophistication and focus because market quality and market quality changes are best measured using a multi-dimensional approach. I report and analyze findings.

4.1 Methodological Overview, Data and Descriptive Statistics

4.1.1 Methodological Overview

The hypotheses that follow are tested using time-stamped intraday trade and quote data obtained from the Toronto Stock Exchange. Except where otherwise specified, a hypothesis is tested using the value of an appropriate measure defined in a pre-event period and compared with the measure's value in a post-event period to determine whether a statistically significant change occurred. Since testing for a change market quality involves the careful assessment of change along several dimensions, several kinds of statistical tests (described in subsequent sections) of varying sophistication are conducted. This is done on a stock-by-stock basis. The pre-event period is defined as the period from 35 trading days to 11 trading days prior to the event date (October 26, 1998), and the post-event period is from 11 trading days to 35 trading days afterward. The measurement period consists of the pre- and post-event periods. Following Madhavan, Weaver and Porter (1999), 10 trading days immediately before and after the

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event date are excluded from the measurement period to avoid any bias in the results due to the proximity of the measurement period to the event date. Such biases may arise because in the days just before the rule changes, traders may have begun routing some additional orders to the floor as a way of preparing their order management systems. Also in the first few days after the rule change, some traders may not have adjusted to the new rules fully. For a given set of trade type comparisons, included firms (stocks) must have traded all types. For example, in comparing the effects of internalized and non-internalized trades, included firms would have handled both types of trades.

Cross-sectional tests are conducted to determine whether any significant differences in results exist among stocks. It is most likely, for example, the TSE rule change would affect stocks that differ by average crossing rate or trading volume differently. In light of this possibility, the effects of the rule change on stocks are compared according to volume quartiles. Some comparisons are made according to trade size ranges of less than and more than 5,000 shares to capture differential effects in accordance with trade size limits specified in the price improvement rule. It is also likely that the rule change would affect particular trade types (for example upstairs trades versus downstairs trades, internalized trades versus non-internalized trades, trades occurring at the spread versus trades occurring outside the spread, etc.) differently.

4.1.2 Data

The TSE Equity Trading History CD-ROM products are the primary data source used in this study. They provide historical trade and quote data for the months of

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September through December 1998. Available trade information includes the stock symbol, trade date, trade time (stamped to the nearest second), number of shares traded, and buyer and seller identification. Available quote information includes the stock symbol, quote date, quote time, and bid and ask prices and corresponding trade sizes displayed in the TSE's limit order book.

Specifically the sample consists of all qualifying equity trade and (accompanying) inside quote information covering two 25-trading day periods before and after the introduction of the Price Improvement Rule on October 26, 1998. The pre-event period consists of the 25 trading days from September 3rd to October 8th 1998, 11 days prior to the introduction of the Price Improvement Rule. The post-event period consists of the 25 trading days from November 10th, 11 days after the introduction of the Price Improvement Rule, to December 14th, 1998.

Since open trades occur under a different protocol than those made during the rest of the day, they are eliminated from the sample. Canceled trades, and trades with no buyer or seller identification are eliminated. Trades with negative prices (due to data errors), quotes or bid-ask spreads are eliminated. To avoid measurement error due to changing tick sizes, trades with prices with prices below C$5.00 are excluded from the sample. Trades occurring before or after the TSE's normal trading hours of 9:30 a.m. to 4:00 p.m. are excluded.

Stocks with fewer than 50 quotes in either the pre- or post-event period are excluded from the sample. Unit stocks, international receipts, warrants and debentures

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are also excluded. Firms without at least one trade in each of the 50 trading days in the sample are excluded.

4.1.3 Descriptive Statistics

Table 3 gives some descriptive statistics by stock trading volume quartile in the pre-event period. The percentage of internalized trades does not appear to be related to trading activity. However, the percentages of trades with quoted spreads of more than one tick and of trades executed downstairs do appear to be related to trading activity. The proportion of trades with quoted spreads of more than one tick appears to decline with trading activity, suggesting that more price competition (brought about by more trading) leads to lower spreads. The proportion of trades executed downstairs increases with trading activity.[26] This finding is consistent with that of Smith, Turnbull, and White (2001), that less liquid stocks are more heavily traded in the upstairs market. It is noted that the percentage of internalized trades is greater than that of upstairs trades. One reason for this difference may be that the definition for crosses may include intentional as well as unintentional internalization. The data do not allow a separation of the two types of crosses. However, the intention of this study is to capture changes in the crossing rate as a result of the introduction of the Price Improvement Rule, and there is no *a priori* reason why the unintentional internalization rate would be affected by the rule change. Therefore we can successfully investigate the effect of the rule change on intentional crosses. Another important reason for the difference may be that intentional crosses may include trades that are processed through the TSE's limit order book. The TSE reports (see Sections 3.4 and 3.5) that members with sophisticated order management systems

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may actually send an order to the book and, using those systems, send a previously 'held up' client order timed to trade against the principal order displayed in the book.[27] This kind of crossing is intentional, and members may profit from such transactions through the reduction in execution costs they are able to realize because of the efficiency of their order management systems, as well as through the possibility that they may be able to avoid having to improve on prices.

[26] A chi-squared test confirms strongly significant (at the 0.01 level) differences among the proportions.
[27] Toronto Stock Exchange Special Committee Report on Market Fragmentation

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4.2 Internalization

4.2.1 Hypothesis

The continued expansion and development of the TSE members' order management systems have substantially increased their ability to internalize order flow by matching client orders within the firm (or crossing a client's order against a member's inventory) and then report the transactions as crosses in the auction market. Suppose internalization practices are motivated purely by abnormal profits without an accompanying improvement in trade execution efficiency. Then the introduction of the Price Improvement Rule should result in a reduction in internalization rates, as members are forced to improve on the best-quoted prices and earn lower profits when they internalize trades. On the other hand if internalization results in the more efficient execution of trades, then internalization rates may not decline as members attempt to capture (albeit lower) profits from internalization rather than give other market participants the opportunity to earn the spread when the order is routed to the book. Additionally, since members' order management systems were rapidly evolving when the Price Improvement Rule was introduced, members may have been motivated to improve the efficiency of those systems (to the extent possible in the short run) to stem the resulting decline in profits. Also, members' order management systems actually allow them to internalize *on the book*, where a tradable order is 'held up' and a matching order is entered in the book.[28] The tradable order is then released in the book, and subsequently crosses with the member's order. The rule change could make such a practice more

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[28] See the TSE's Special Committee Report on Market Fragmentation (1997). Also, see Sections 3.4 and 3.5.

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attractive than crossing orders *off* the book, where price improvement would be required. As described in Section 3.5, the Price Improvement Rule requires price improvement for orders intentionally crossed on the book. Yet, as late as October 26 1998, the date the Rule was implemented, member firms OMSs had not yet adjusted to the new rule requirements and the price improvement requirement may not have been in effect (see Appendix B). Such practices could result in an increase in crossing rates. Thus the issue of the direction in which crossing rates move after the rule change is an empirical one. The relevant null hypothesis is:

H1: *The rule change had no effect on internalization rates.*

This effect can be tested by comparing the percentage of trades that had the same firm on both sides before and after the introduction of the rules.

4.2.2 Results from Test for Internalization

Table 4 describes the effect on the rule change on crossing rates for various trade types. Overall, trades of 5,000 shares or less (Panels A and D), high trading volume stock (Panel B), and trades occurring at the spread and outside the spread (Panel D) all show strong increases in crossing rates. A much higher percentage (66.30% in the pre-event period, 64.55% in the post-event period) of the trades of size greater than 5,000 shares than the percentage (10.44% in the pre-event period, 11.11 % in the post-event period) of the medium-to-low-sized trades in the post-event period were internalized (Panel A).

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An assessment of internalization by spread location is made by analyzing two specific stock samples. In keeping with the general approach to analyzing the effects of the Price Improvement Rule Table 4, Panel D presents internalization results for firms that processed trades of all types (for example, trades less than 5,000 shares, occurring at the spread; trades less than 5,000 shares, occurring inside the spread, and so on). This selection criterion results in a sample of 21 firms, a relatively small number of firms compared with the raw sample size of 258 firms. Presumably, those 21 stocks are active and highly liquid. By contrast Table 4, Panel E presents results of internalization by spread location where included firms may not necessarily have handled every trade type over the sample period. This criterion generally results in a much larger samples of firms (stocks) which may include more of the less liquid stocks. Sample sizes vary form 24 to 258.

For the small sample of 21 stocks, strong increases in internalization at the spread and outside the spread occur for trades of size 1,200 shares or less, and a significant increase in internalization at the spread occurs for trades greater than 5,000 shares. In the case where the sample is not restricted to firms that processed trades of all types in all categories (Table 4, Panel E) a strong increase in internalization also occurs for trades of size 1,200 shares or less. However an insignificant decline in internalization outside the spread occurs, and a significant decline in internalization at the spread is recorded for the small-to-medium trades (between 1,200 and 5,000 shares).

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The increase in internalization rates for small trades suggests that members attempt to profit by improving the efficiency of trading where possible. Additionally members can internalize on the book (through their order management systems, which process small trades) or off the book. They are required to improve on the best-quoted prices if the trade is crossed off the book. Thus members would tend to internalize trades in an attempt to gain profits from the transaction (rather than have other participants garner those profits), and would tend to prefer internalization on the book, where they may still be able to intentionally internalize at the spread (see discussion in the following paragraph). The finding that the crossing rate for small trades occurring at the spread increased significantly bolsters this conjecture. Where market conditions dictate, members would offer competitive prices on retail trades and eke out possible profits by crossing off the book and improving on price. Profits are possible in this case because of members' use of relatively efficient order management systems. Absent the rule change members can pocket the entire savings from the off- market trades. The rule change allows exposure of the order on the book and forces members to pass on savings from execution of the trade off the book to the retail investor.

Those results suggest that in re-fashioning their (already rapidly evolving) order management systems to meet the compliance procedure requirements for the newly implemented rules, members may have found ways to internalize on the book, at the spread, and such loopholes have not yet been closed by the TSE (See Appendix B). As described in Section 3.5, members had requested assistance from the TSE in developing proper compliance procedures as late as the day the price improvement rule had been implemented (and possibly beyond that date). It is therefore unlikely that by the end of

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the post-event period members had fully organized their OMSs to comply with the price improvement rule requirements.

A significant increase in internalization occurs outside the spread for small trades in the sample of 21 presumably highly active, liquid stocks (Table 4, Panel D), while an insignificant decline in internalization rates occurs for the same type of trades in the larger samples (Table 4, Panel E). This finding could represent a response by members to the high demand for immediacy in highly liquid stocks, as queuing delays may result from a redirection of order flow to the book, even for market orders. Thus clients are prepared to pay a premium for immediacy in those stocks compared with less liquid stocks, and members are able to justify a spread that reflects the 'condition of the market' [see Fong, Mahavan, and Swan (2000)].

On the other hand, and in general, internalized rates declined (though the decline was statistically insignificant) for trades of size greater than 5,000 shares. Such trades, which tend to be initiated by relatively knowledgeable and sophisticated market participants, are already crossed at much higher rates than retail trades, and are unlikely candidates for selection by the members' order management systems because of their risk and size. Consequently, the small marginal decline in internalization rates can be explained by the decline in the marginal opportunities available to members to profit unfairly through internalization, as the market as a whole has become more efficient. However, high volume, liquid stocks of size 5,000 shares or more show a significant increase in crossing, reflecting members attempts to meet immediacy needs of their

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clients through the use of their order management systems (See Table 4, Panels B and D). This result is consistent with the finding of Fong, Madhavan and Swan (2000), that off-market trading (at relatively high effective spreads) is most pronounced for very liquid stocks.

To summarize, the practice of crossing does not appear to be harmful to investors if it is tempered with regulation that requires members to pass on any savings they generate to their clients. This way members can profit from transactions and simultaneously contribute to the enhancement of market quality, instead of unfairly profiting from the information provided by other market participants. Booth, Kallunki, Lin and Martikainen (2000) find in their study of the Finnish Stock Exchange that brokers are not allowed to internalize trades using a price that is not the 'best' for the customer. Such a price (which could be one that improves upon the best-quoted price) is possible because, according to Grossman (1992) internalizing brokers and dealers are 'repositories of information' about their customers' unexpressed demands, and face relatively low trading risk when they internalize trades. Additionally, although they do not provide an explanation, Hansch, Naik and Viswanathan (1999), in their study of internalization and preferencing on the London Stock Exchange in August 1994 (which was at that time a quote-driven market), find that while execution costs increase with preferencing, they decline with internalization, and dealers' abnormal profits are not significantly different from zero.

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4.3 Price Improvement

4.3.1 Hypothesis

Although the incentive to internalize would tend to decline after the rule change, the effect of the new rules would be to increase the percentage of internalized trades where trades occurred within quotes if members find the practice profitable. So, while members would experience reduced excess rents, they would internalize as long as it was possible profitable to do so. Additionally, if the introduction of new rules result in an improvement in the efficiency of trade execution, members could pass on the costs to investors in the form of improved prices (See Section 3.5 and Appendix B). However if quoted spreads decline following the rule change, then opportunities for price improvement could decline and price improvement rates could decline in general. Again, the issue of how the rule change affects price improvement rates is an empirical one. The relevant null hypothesis is:

> **H2:** *The rule change did not affect the number of shares (as a proportion of the total number of shares traded) that received price improvement.*

The effect can be tested by analyzing the proportion of trades where execution occurs within quotes. A t-test is used to test for paired differences among stocks with respect to the degree of change in internalization and price improvement following the rule changes. The Wilcoxon Sign Test for paired observations is also conducted.

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4.3.2 Results from a Test for Price Improvement

For two-tick spreads, significant increases in price improvement rates occurred for trades of 5,000 shares or less, non-internalized trades, and downstairs trades (Table 5, Panel A). For 3-or-more-tick trades significant declines in upstairs trades and trades of more than 5,000 shares occurred (Table 5, Panel B). The higher price improvement rates for two-tick trades may reflect that tendency for more price improvement after the introduction of the price improvement rule, given that members cannot internalize (cross) unless they improve on price. The result may also reflect the possibility that many trades that would have been 3-tick trades (before the rule change) are now two-tick trades, and may still be eligible for price improvement. The remaining three-tick trades cannot benefit from the rule change as much because of particular characteristics (risk, size, etc.) that justify high spreads.

Handa, Schwartz and Tiwari (1999), in their study of price discovery on the American Stock Exchange, suggest that price discovery occurs primarily through quote revision and price improvement, and that higher price improvement rates imply better price discovery. However, an insignificant (or even a significant negative) change in price improvement rates does not necessarily imply a decline in the quality of the price discovery process (See Section 4.8 for a detailed description of price discovery). Market quality can improve alongside insignificant changes or declines in price improvement rates if the *role* that price improvement plays in the price discovery process becomes less important. The implication is that the role played by quote revision has become more

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relevant and the quote revision process has become more efficient, and opportunities for price improvement decline.

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4.4 Trade Execution Costs: Spreads

4.4.1 Spreads: Hypothesis

An important measure of an equity market's quality is its liquidity. This refers to the ability of traders to trade an asset without undue price impact. Liquidity can be characterized by the market's depth. Market depth refers to the number of shares offered or sought at the current market by limit order traders (See Section 4.5). In a continuous auction setting, deeper markets increase the frequency with which limit orders execute against market orders, increase the frequency with which market orders execute against posted quotes, and decrease the time between limit order execution. The resulting increase in order price competition reduces the quoted price at which investors are able to buy the stock and increases the price at which investors can sell the security. Thus bid-ask spreads are lower.

Traders who desire to transact immediately will pay whoever supplies the necessary liquidity. This can be the registered trader (the TSE's equivalent of the NYSE's Specialist), limit order trader or floor broker. Such traders will pay a relatively high price, the ask price, to suppliers of liquidity to obtain shares of stock immediately and will accept a relatively low price, the bid price, to sell shares immediately. This arrangement effectively compensates the suppliers of liquidity for satisfying traders' immediacy needs.

Investors wish to execute their trades as cheaply as possible at prices that are accurate and stable. Liquid markets satisfy those needs. Investors are attracted to more

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liquid markets, causing already liquid markets to become even more liquid. In illiquid markets trade execution is costly, and investors hold suboptimal portfolios when they cannot rebalance portfolios as frequently as they would prefer. This situation creates 'backed-up' demand for execution. When investors do trade in such markets, they are more likely to demand immediacy by submitting market orders rather than to supply liquidity by submitting limit orders, resulting in a further reduction in the market's liquidity (See Schwartz, 1993). A fully consolidated market system would tend to enhance the system's liquidity, as such a system is characterized by the simultaneous universal exposure of limit orders (possibly in a central limit order book) requiring that an incoming market order be executed at the best price across the system, and, where limit orders are exposed at the same price, requiring that the earliest arriving limit order be executed first.[29]

Internalization creates a new priority rule because when a member takes the other side of its client's order and bypasses the limit order book, the member stands to gain at the expense of limit order traders (who are the primary suppliers of liquidity in an auction market such as the TSE's) as market prices change. The limit order trader has committed to buying or selling the stock at a prespecified price, effectively writing an option at that price. Internalization affords members the opportunity to exercise those free options at the expense of limit order traders by trading with clients (based on quote information provided by limit orders) ahead of the limit orders. The limit order is effectively isolated from full interaction with the rest of the market, and takes more time to execute.

[29] Although the TSE has a price/ sharing priority rule, the first order to set a new price gets priority. All other orders arriving at that price are subject to the sharing rule.

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Additionally, when the limit order is eventually executed, the market has moved against it. Limit order traders are then dissuaded from submitting limit orders, and may decide to submit market orders instead. The isolation of orders from full interaction with the wider market reduces the extent to which those orders can price-compete, and may result in investors having to pay artificially high prices to have their orders executed. These negative effects of internalization could lead to a decline in market liquidity and an increase in execution costs.

The introduction of the rules requiring members who execute trades away from the arena where orders are fully and fairly exposed would force members to direct more of their order flow to the auction market. In terms of the direction of order flow, limit orders trade on the opposite side of the market direction. If the market is rising, limit sell orders are triggered. If the market is falling, limit buy orders are triggered. Consequently limit orders provide liquidity to the market by supplying offsetting orders in an otherwise one-sided market. Consider the TSE's introduction of its Price Improvement Rule. Limit order traders, attracted by the prospect of reduced time to execution brought about by an increase of market orders directed to the book, and by the reduced possibility that they will pay abnormally high execution costs, converge on the auction market. The result is a more consolidated market. Quoted bid-ask spreads should fall as more limit orders compete on price. Those members who do not route trades to the order book must improve on price. Thus effective bid-ask spreads (defined below) may decline. I test whether execution costs changed after the Price Improvement Rule was introduced on October 26, 1998. The relevant null hypothesis is:

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H3: *There are no statistically significant changes in execution costs following the implementation of the Price Improvement rule.*

Following the specification of Stoll (1989), one measure of the cost of executing a trade is the quoted, or dollar, spread:

$$Dollar\ Spread_{it} = Ask_{it} - Bid_{it}, \qquad (1)$$

where Ask_{it} *and* Bid_{it} are the time-weighted average ask and bid prices for stock i in measurement period t. The time-weighted average spread in the pre-event period is compared with that in the post-period using a paired t-test.

A related execution cost measure is the relative, or percentage spread, which measures transaction costs per dollar of investment:

$$Percentage\ Spread_{it} = \frac{(Ask_{it} - Bid_{it})}{(Ask_{it} + Bid_{it})/2} \qquad (2)$$

Trades frequently take place at prices between the spread as market makers update their information set after posting quotes, raising the possibility that the quoted spread measures may not accurately measure execution costs to the investor. Thus, test for changes in the following measures of actual (or effective) execution costs are conducted [see Peterson and Fialkowski, (1994)]:

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$$Effective\ Dollar\ Spread_{it} = \left| Price_{it} - \left(\frac{Ask_{it} + Bid_{it}}{2} \right) \right| \qquad (3)$$

$$Effective\ Percentage\ Spread_{it} = \frac{\left| Price_{it} - (Ask_{it} + Bid_{it})/2 \right|}{(Ask_{it} + Bid_{it})/2} \qquad (4)$$

where the spread measures are share-weighted [See Battalio (1997)], and $Price_t$ is the average transaction price of stock i in measurement period t.[30]

The introduction of these rules may be one of several factors that affect spreads. Several other factors are thought to influence the execution costs faced by traders [Hamilton (1979), Stoll (1989)]:

(1) The greater the trading volume in the stock, the smaller the waiting time between trades, and the market maker faces a less risky inventory position as a result. As the trading volume in a stock increases, the resulting increase in liquidity should result in a decline in execution costs as more orders (per period of time) compete on price.

(2) As the return variability of the stock increases, a specialist's chances of experiencing a capital gain or loss on his or her transactions increase. A risk-averse specialist will demand compensation for executing riskier transactions.

(3) A dealer trading in a relatively high-priced stock will require more capital for an inventory of a given share of stock, increasing the registered trader's cost of capital per share, again increasing execution costs.

[30] The effective sprerad is also known as the liquidity premium, and provides a per share estimate of the execution costs of a market order (that is, the cost of liquidity).

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I would expect, controlling for the influence of the above-mentioned factors on spreads, a decline in trade execution costs following the rule change. I estimate this effect by running the following regression model:

$$L_{it} = \beta_0 + \beta_1 \ln V_{it} + \beta_2 \sigma_{it}^2 + \beta_3 P_{it} + \beta_4 D\_RULECH_{it} + \varepsilon_{it} \quad (5)$$

where: L_{it} = average time-weighted daily spread measure for firm i in (pre- or post-event) measurement period t. The spread measures are dollar spread, percentage spread, effective dollar spread and effective percentage spread.

lnV_{it} = the log of daily average trading volume (in number of shares) for firm i in measurement period t.

σ_{it}^2 = the return variance of return for firm i in measurement period t (returns are calculated from daily closing prices).

P_{it} = average of daily closing prices for stock i in measurement period t.

D_RULECH_{it} = dummy variable with a value of 1 if the observation is in the post-event measurement period, and 0 otherwise.

ε_{it} = error term, assumed to have distribution N $(0, \sigma_\varepsilon^2)$

Thus the null hypothesis specifies that $\beta_4 = 0$ in equation (5).

The fact that the TSE has experienced increased retail order flow away from its auction market, along with the increasing presence of the order management systems, could indicate that retail traders are enjoying lower trading costs. The benefits of preferencing and internalizing order flow through the vertical integration and automation of trade services may be significant. Harris (1993) states: "Competition among markets for order flow represents, in part, a competition to determine what set of... trading systems best serves the different needs of the trading community." Traders generally

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benefit from this competition as exchanges and proprietary trading systems introduce service-enhancing and cost-reducing innovations. Battalio, Green and Jennings (1997) find that costs do not increase when the Boston and Cincinnati stock exchanges allow members to take the other side of their customers' orders through affiliated market makers. Battalio (1997) finds that bid-ask spreads declined when Madoff Investment Securities (a third market broker-dealer) entered the market and diverts order flow from the NYSE. If the diversion of order flow from the TSE to the upstairs market occurred because of cheaper execution in the upstairs market, then we could see a decline in spreads accompanied by increased internalization (see Section 4.2).

4.4.2 Results from Tests for a change in Spreads

Tables 6 (Panels A and B) gives results of univariate tests of the effect of the rule change on quoted spreads. As expected, quoted dollar and percentage spreads decline with trading volume. With the exception of dollar quoted spreads for low-volume stocks, strong declines in quoted spreads occur following the introduction of the Price Improvement Rule. Limit order traders, attracted by the resulting market conditions which protect them from exploitation by front-runners, are encouraged to submit limit orders, and in so doing contribute to greater price competition. Quoted prices improve as a result, and the quoted bid-ask spreads fall.

Table 7 gives regression results of the influence of the rule change on quoted spreads, after controlling for the influence of other factors known to significantly affect spreads (see equation (5)). While stock price, trading volume, and return volatility all

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appear to significantly impact quoted spreads, the rule change also had a significant impact, as reflected in the significant, negative dummy variable coefficient value. This result provides stronger evidence that the rule change reduced quoted spreads.

Panels A and B of Table 8 show the results of univariate tests of whether a significant change in effective spreads occurred for various trading volume categories and trade types after the introduction of the Price Improvement Rule. In general, effective spreads show strong declines. Market participants who execute trades outside the exchange's central limit order book (CLOB) are forced to improve on the best-quoted price. This fact, coupled with the fact crossing rates increase, suggests that brokers are able to execute trades, improve on price, and realize a profit. This may be possible if the brokers previously earned abnormal profits and / or realized cost savings through the use of more efficient trade execution systems (for example, their order management systems) after the rule change. However insignificant declines in dollar effective spreads were recorded for low volume stocks, trades of size greater than 5,000 shares, and upstairs trades. The finding on upstairs trades, coupled with the significant decline in the price improvement rate for upstairs trades, is consistent with that of Smith, Turnbull, and White (2001), who, in a study of the Toronto Stock Exchange's upstairs market, find that the upstairs market provides liquidity when liquidity is low in the downstairs market.

A comparison of quoted and effective spreads reveals that in general dollar and percentage price improvement amounts (the difference between quoted and effective spreads in for any given category) decline after the introduction of the Price Improvement

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Rule. Overall, in the average dollar price improvement declined from 17¢ in the pre-event period to 14.5 ¢ in the post-event period; while the average percentage price improvement declined from 0.93 percentage points in the pre-event period to 0.70 percentage points in the post-event period. Despite this result, price improvement rates increased for small trades, suggesting that small traders incur lower costs associated with the ill effects of an unfair market.

Table 9 shows the results of regression analyses, which attempt to determine the influence of the rule change on effective dollar and percentage spreads after accounting for the influence of the stock price, trading volume, and return volatility. Over, a weak but significant decline in dollar effective spreads is recorded (Panel A). However, percentage spread declines are much stronger (Panel B). Additionally, when specific categories are compared, where the sample more liquid stocks, strong declines in dollar and percentage spreads occur (Panels A and B). Thus the rule change has achieved the desirable result of lowering effective costs of trading by reducing opportunities for the exploitation of retail investors by more sophisticated and better-informed market participants.

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4.5 Trade Execution Costs: Adverse Selection Component of the Spread

4.5.1 Hypothesis

As described earlier, the increasing sophistication and dominance of the TSE members' order management systems allow members to select orders for internalization according to several criteria, including risk. For example, TSE members can select uninformed order flow for internalization, and allow the relatively informed order flow to fair exposure in the order book. This results in a widening of the inside quote, as the adverse selection component of the spread, the part of the spread charged by the market makers to protect against losses to informed traders, increases. With the implementation of the Price Improvement Rule, I would expect the adverse selection component to decline. This occurs because when members are required to improve on prices when they internalize or expose the order in the book (where that order then vigorously price-competes with other orders) the opportunities for market participants to profit at the expense of other participants (whose quote information they have picked off) diminish. Specifically, the opportunities for market participants to receive priority simply by matching the best quotes (instead of improving on price) established by other participants, or to isolate orders from wider interaction with other orders, are reduced. The proportion of informed trades routed to the book declines, the proportion of uninformed trades routed away from the book declines, the value of information asymmetry declines, and the result is a decline in the adverse selection component of the spread. Following the methodology used in Booth, Lin and Sanger (1995) the adverse selection component of the spread is estimated using the fundamental relation

$E_t(P_{t+1}) - P_t$ = dealer's gross profit for a sell order at time t

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$$= [\delta B_{t-1} - (1-\delta) A_{t-1}] - P_t \qquad (6)$$

$$= -(1-\lambda-\theta)z_t \text{, where}$$

$E_t(P_{t-1})$ = the expected equilibrium price at time $t-1$,

$B_{t-1} = B_t + \lambda z_t$ is the bid price at time $t-1$,

$A_{t-1} = A_t + \lambda z_t$ is the ask price at time $t-1$, bid price at time t,

λ = the percentage adverse selection component of the bid-ask spread,

$z_t = P_t - Q_t$ = effective spread at time t,

Q_t = quote midpoint at time t,

δ = the probability of order persistence (that is, a buy order following a buy order or a sell order following a sell order), and

$\theta = 1 - 2\delta$.

A similar expression holds for the dealer's expected profit conditioned on a sell order. The dealer's gross profit as a fraction of the effective spread is given by

$$\gamma = 1-\lambda-\theta,$$

and reflects the dealer's costs of processing orders. The percentage adverse selection component of the effective spread, λ, is estimated by the following OLS regression:

$$\Delta QL_t = \lambda z_{t-1} - e_t, \qquad (7)$$

where $\Delta QL_t = QL_t - QL_{t-1}$,

QL_t = the log mid quote at time t,

$z_t = PL_t - QL_t$, and

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PL_t = log transaction price at time t. The appropriate null hypothesis is

H4: *The rule changes have no effect on the percentage adverse selection component of the effective spread.*

A paired t-test is used to test for a change in each component of the bid-ask spread around the event.

4.5.2 Results from Test for Change in Adverse Selection Component of Spread

Table 10 describes the results of a test to determine whether the adverse selection component of the effective bid-ask spread declines after the introduction of the price improvement rule. As described earlier, the introduction of the price improvement rule would reduce the opportunities for members to unfairly profit form information provided by other market participants (for example, limit order traders, retail investors). The incentive for members to select uninformed trades for crossing and to direct informed trades to the TSE's CLOB would diminish. Except for the low-volume, illiquid stocks, strong declines in that component occurred, suggesting a decline in information asymmetry among market participants. Small, retail investors and limit order traders are thus encouraged to submit orders, thereby increasing market activity, market liquidity, and, ultimately, market quality.

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4.6 Market Depth

4.6.1 Hypothesis

Market depth or the volume of orders at the inside quote is an important measure of market quality. Investors seek a liquid market that provides the maximum number of offsetting orders at the best prices. Such competitive conditions provide the investor with cheap, timely execution. In an auction market, market depth is provided by the entry, consolidation, and display of limit order bid and ask prices along with their trade sizes in a central order book. Lee, Mucklow and Ready (1993), and Harris (1994) note that market depth assessments, in addition to bid-ask spread estimates, provide a more complete description of market quality. For example, if a market maker (or limit order trader) believes that there is an increase in trading interest initiated by informed traders, he/ she could respond by increasing the spread or, alternatively, by offering to trade fewer shares at the best-quoted price (or by using a combination of both strategies). Market quality is thus compromised along a dimension other than price. The introduction of the price improvement rule should attract limit order traders (as described above) to the auction market, as such traders would have greater confidence that their orders would not be front-run, increasing market depth as a result. Market makers would reduce the adverse selection component of their spreads and offer more shares at the best prices for similar reasons. The relevant null hypothesis is:

H5: *There was no change in mean quoted depth following the rule changes.*

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The effect of the rule introduction on market depth can be determined by comparing the time-weighted average quoted depth, measured by the arithmetic average of the number of shares offered at the bid price, and the number of shares offered at the ask price, before and after the rules introduction using a t-test.

Lee Mucklow and Ready (1993) show that a combination of wider (narrower) spreads and lower (higher) depths is sufficient to infer a decrease (increase) in liquidity, rather than a decline in spreads only. This finding is consistent with institutional constraints that force market participants to use both depth and spreads to convey their intention to supply liquidity.[31] They also find that quoted depth falls following periods of abnormally high trading volume, and attribute the result to an attempts by market participants to protect themselves from large informed traders. However Harris (1994), Chordia, Roll, and Subramanyam (2000), and Heflin and Shaw (2001), while they find a negative relationship between quoted depth and spreads, all find that market depth increases with trading volume. Additionally, one would expect market participants to offer more shares (at best-quoted prices) when return volatility is low (see Heflin and Shaw (2001)). As such, a more accurate determination of the effect of the price improvement rule on market depth can be made by controlling for the influence of spreads, trading volume and return volatility on market depth. The following regression is estimated:

$$Depth_{it} = \beta_0 + \beta_1 L_{it} + \beta_2 \ln V_{it} + \beta_3 \sigma^2 + \beta_4 D\_RULECH_{it} + \in_{it} \qquad (8)$$

where $Depth_{it}$ = the time-weighted average of the sum of the number of shares offered at the bid price and the number of shares offered at the ask price for firm i in measurement period t.

[31] For example, because NYSE specialists are pressured to keep spreads low, they may use depth quotation adjustments to manage inventory instead of spread adjustments.

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L_{it} = time-weighted daily average quoted spread for firm i in period t.

lnV_{it} = the log of daily average share volume (in number of shares) for firm i in period t.

σ_{it}^2 = the average return variance of return for firm i in period t.

D_RULECH_{it} = dummy variable with a value of 1 if the observation is in the post-event period, and 0 otherwise.

ε_{it} = error term, assumed to have distribution N $(0, \sigma_\varepsilon^2)$

4.6.2 Results from Tests for a Change in Market Depth

Table 11 A shows the results of a univariate test of whether a significant change in quoted depth occurred for various trading volume categories, after the introduction of the price improvement rule. *Market Depth*$_{it}$ is defined as the time-weighted sum of the arithmetic average of the number of shares offered at the bid price and the number of shares offered at the ask price for firm i in (pre- or post-event) period t. Strong (significant) increases in market depth are recorded across all categories, with the strongest increase occurring for the most active stocks. This result is consistent with the hypothesis that limit order traders are encouraged to offer more shares at the best-quoted prices because the probability of their being exploited by other participants with superior information has diminished significantly with the rule changes.

Table 12 gives the results of tests for a change in market depth following the rule change after controlling for the influence of other well-known factors. It is expected that if market quality improves due to the introduction of the new rule, then one unambiguous

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manifestation of the resulting higher market liquidity would be lower quoted spreads accompanied by higher market dept. Market depth is also expected to increase with trading volume and decline with higher return volatility. The regression coefficients estimates assume the expected signs. However, there is a weak, negative association between quoted spreads and depth, a strong, positive association between depth and trading volume, and a marginally significant, negative relation between market depth and return volatility. Most important, a positive but insignificant direct association between market dept and the rule change appears to exist. The influence of the rule change on market depth appears to be an indirect one, primarily through the rule change's effect on return volatility and trading volume.

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4.7 Market Volatility

4.7.1 Hypothesis

As order flow is directed away from the TSE's auction market and limit order traders decide to submit their orders elsewhere, price determination becomes less precise as temporary order imbalances become more frequent and severe. The reduction in limit orders decreases market depth, which in turn decreases the ability of the market to accommodate order flow without significantly affecting prices. As a result order imbalances attract orders relatively slowly. Market resiliency declines. Therefore short term price instability and volatility increase. The introduction of the Price Improvement Rule would reverse that trend as the increased order flow and return of limit order traders to the auction market would increase market depth, resulting in shorter-lived order imbalances and less price instability. Short-term price volatility would decline as a result. The introduction of the price improvement and order consolidation rules would reverse that trend as the increased order flow and return of limit order traders to the auction market would increase market depth, resulting in short-lived order imbalances and less price instability. Short-term price volatility would decline as a result. The relevant null hypothesis is:

H6: *The TSE rule changes did not affect short-term stock price volatility.*

An assessment of the rule change on market volatility is tested by using the F-test: for stock *i*,

$$F_i = \frac{\sigma_A^2}{\sigma_B^2}$$

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where σ_A^2 = the post–event volatility defined as

for the post-event period and P_t, σ_B^2 is an identical measure except that the prices and P_t,

$$\sigma_A^2 = \frac{\sum_{t=1}^{T}(\ln(P_t) - \ln(P_{t-1}))^2}{T-1}$$

t and T observations are for the pre-event period.

Then, a univariate assessment of the effect of the rule change on market-wide volatility is made by using the Wilcoxon one-tailed sign-ranks test. This test involves the determination of whether the median of the calculated F-values significantly less than one; thus verifying whether market volatility has fallen overall.

There is an established (positive, information-induced) relationship between market volatility, and trading activity in a stock [see Easley and O'Hara (1987); Harris and Raviv (1993); and Jones, Kaul and Lipson (1994)]. To control for this influence on the stock volatility, the following linear regression is estimated:

$$\sigma^2_{it} = \beta_0 + \beta_1 N\_Trades_{it} + \beta_2 D\_RULECH_{it} + \varepsilon_{it} \qquad (9)$$

where σ^2_{it} is the variance of price for firm i on day period t during the measurement period, N_$Trades_{it}$ is the number of transactions for firm i during the measurement period t, and D_RULECH_{it} is a dummy variable assigned the value of 1 if the observation is from the post-event period, 0 otherwise. ε_{it} is an error term with properties as described in equation (5).

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From equation (9), and equivalent description of the null hypothesis is $\beta_2 = 0$.

4.7.2 Results from Tests for a Change in Short Term Stock Return Volatility

Table 13 gives the results of univariate tests for the effect of the rule change on market volatility after controlling for the influence of the stock's trading activity. Strong declines in market volatility are recorded. A much higher proportion of stocks had F-values significantly less than one (32 %) than greater than one (2%). More concretely, the Wilcoxon one-tailed signed-ranks test for an overall decline in market volatility after the introduction if the price improvement rule results in p-values below 0.001 for the entire sample of 258 stocks and all volume quartiles.

Table 14 gives the result of the effect of the new rule on market volatility after accounting for the influence of trading activity, which is known to significantly affect market volatility. Overall, and for all volume quartiles, strong declines in market volatility occurred, as evidenced by negative and statistically significant dummy variable coefficient values. Thus the introduction of the new rule has directly reduced market uncertainty by gaining the confidence of the more vulnerable investors in the market place, and encouraging them to offer more liquidity.

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4.8 Price Discovery, Pricing Error, and Market Quality

4.8.1 Hypothesis

Typically, trading systems are assumed to pursue the goals of cheap and fair trade executions, and efficient price determination. The mechanism by which a market determines a fair and accurate security price, or a price that reflects traders' aggregate desire to hold shares of a security is called its price discovery mechanism. In a perfectly efficient market any new public information about the value of a security is immediately and costlessly impounded in its fair (or equilibrium, or efficient) price.[32] This equilibrium price changes only in response to new value-related information that, by definition, cannot be anticipated, and causes investors to revalue the security. Under such circumstances the efficient price is equal to the transaction price and follows a random walk.

In reality if the price discovery process is not instantaneous, traders cannot predict the market-clearing price with certainty, as this price is created as traders reveal their supply and demand intentions. This occurs because traders have heterogeneous expectations and information is costly and of varying quality. As a result the market-clearing price may be different from the efficient price at any given point in transaction time. If traders expect a market-clearing price that is greater (less) than the efficient price, the actual transaction price can be less (greater) than the efficient price. Consequently, prices fluctuate as the market attempts to determine a new equilibrium price following a change in the demand to hold shares of the security. Further, inaccurate price

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determination may result from traders who do not immediately convey their orders to the market, or from extant limit orders that are not regularly revised, leading to a lagged adjustment of prices to information.

Other market imperfections may result in the deviation of a security's transaction price from its equilibrium (efficient) price. A trader seeking to consummate a large trade or trade against scarce counter-orders may have to pay a premium over the quoted price to ensure the timely completion of transaction. A market maker may adjust his/ her bid-ask spread in an effort to maintain optimal inventory balances. In many financial markets transaction prices are rounded to the nearest minimum price variation (or 'tick') and, as a result, may differ from the efficient price.

The deviation of the transaction price from the efficient price is closely related to the notion of market impact. Price discovery errors impose costs on traders because buyers may end up paying more than the equilibrium price for a security, while sellers may end up receiving less the equilibrium price. Such costs can be considered to result form a market impact effect caused by trades collectively. Market impact also describes the losses limit order traders incur when informed traders hit their orders. Limit orders may be triggered over time by changes in the expected value of the security. To the extent that limit orders represent precommitments to trade at a particular price, they are effectively free options to other traders. As a result, limit order traders incur a cost when they have submitted limit orders based on past economic environments and 'stale'

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[32] Hasbrouck (1993) defines the efficient price as the 'final, end-of-trading, value of the security conditional on all public information at time t, including whatever private information may be inferred

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information in the face of rapidly changing security values. Market impact may also reflect costs incurred by a large trader. A large buy order may drive the price of a security up while a large sell order may drive it down, because the probability of a large order executing complete against a limit order at any given price is relatively small. As a result a limit order would have to hit against several limit orders at over several price levels in order to execute, resulting in an evaporation of liquidity and higher execution costs.

It is convenient to partition the discrepancy between the transaction price and the equilibrium price, heretofore known as the *pricing error*, into two components: pricing errors due to the inefficient and lagged translation of information into prices (that is, information- related market impact) and other errors.

Following Hasbrouck (1993), transaction price decomposition can be modeled using a general framework that allows serial correlation in returns and other explanatory variables. Specifically the logarithm of the observed transaction price of a security is expressed as the sum of two components:

$$p_t = m_t + s_t \tag{10}$$

where m_t is the efficient price, defined as the expectation of the end-of-trading value of the security conditional on all public information available at transaction time t, including whatever private information may be inferred from the published terms of the transaction,

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from the published terms of the transaction'.

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and s_t = the deviation of the transaction price from the efficient price. The efficient price is assumed to evolve as follows:

$$m_t = m_{t-1} + \gamma x_t + u_t \tag{11}$$

where x_t the signed log of the square root of the trade size, where the sign is negative if the transaction price falls below the misquote, positive if the transaction price falls above the misquote, γx_t represents information that the market infers from the trade direction and size respectively, and u_t is an innovation in that is uncorrelated with x_t and the result of nontrade information. Note that $E[u_t] = 0$, $E[u^2_t] = \sigma^2_u$, and $E[u_t u_\tau] = 0$, for $t \neq \tau$. Similarly, the pricing error is expressed as a function of information related errors and non-information related errors:

$$s_t = \alpha x_t + \beta u_t + \eta_t \tag{12}$$

In equation (12) αx capture market impact effects due to price discovery errors and other lagged price adjustment effects, while the βu term captures pricing errors due transient market impact effects (due to large trades, for example), inventory control mechanisms, and price discreteness. It is assumed that s_t is a zero-mean, covariance-stationary process. To facilitate estimation, the return is calculated as

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$$r_t = p_t - p_{t-1} \qquad (13)$$

$$= (\gamma_1 + \alpha)\, x_t - \alpha_1\, x_{t-1} + (1-\beta)\, u_t - \beta u_t + \eta_t + \eta_{t-1},$$

a moving average representation. To facilitate identification and estimation the following restriction (due to Beveridge and Nelson (BN)(1981)) is used: $\eta_t = \eta_{t-1} = 0$. More generally, a representative Vector AuotregRessive (VAR) model involving returns, trade size and trade direction is given by

$$r_t = a_1 r_{t-1} + a_2 r_{t-2} + \cdots + b_1 x_{t-1} + b_2 x_{t-2} + \cdots + v_{1,t}, \qquad (14)$$

$$x_t = c_1 r_{t-1} + c_2 r_{t-2} + \cdots + d_1 x_{t-1} + d_2 x_{t-2} + \cdots + v_{2,t},$$

where the $v_{\cdot,t}$'s are zero-mean, serially uncorrelated errors, Var($v_{1,t}$) = σ^2, and var($v_{1,t}$) = Ω. This VAR system can be transformed into a vector moving average (VMA) system:

$$r_t = a_0^{*} v_{1,t} + a_1^{*} v_{1,t-1} + a_2^{*} v_{1,t-2} + \cdots + b_0^{*} v_{2,t} + b_1^{*} v_{2,t-1} + b_2^{*} v_{2,t-2} + \cdots, \qquad (15)$$

$$x_{1,t} = c_0^{*} v_{1,t} + c_1^{*} v_{1,t-1} + c_2^{*} v_{1,t-2} + \cdots + d_0^{*} v_{2,t} + d_1^{*} v_{2,t-1} + d_2^{*} v_{2,t-2} + \cdots,$$

and s_t, the pricing error can be expressed as

$$s_t = \alpha_0 v_{1,t} + \alpha_0 v_{t-1} - \ldots + \beta_0 v_{2,t} + \beta_1 v_{2,t-1} + \ldots + \eta_t + \delta\eta_{t-1}, \qquad (16)$$

where η_t is a disturbance uncorrelated with all components of v_t, and

$\alpha_j = -\sum_{k=j+1}^{\infty} a_k^{*}$, $\beta_j = -\sum_{k=j+1}^{\infty} b_k^{*}$. The variance of the pricing error is given by

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$$\sigma^2 = \sum_{j=0}^{\infty} [\alpha_j{}^2 + \beta_j \Omega \beta_j'] \qquad (17)$$

Again, the BN restriction $\eta_t = \eta_{t-1} = \cdots = \delta = 0$ is used to facilitate estimation and identification.

Market quality can be assessed by focusing on s_t and its constituent and derivative measures. The α, β, and γ parameters measure the permanent price effects, or price impacts in the market due to lagged adjustment of prices to information (see De Jong, Nijman, and Roel, (1996)). In particular, the standard deviation of the pricing error, σ_s, can be construed as a summary measure of market quality, and describes how closely the transaction price tracks the efficient price. A lower (higher) value of σ_s implies (lower) higher market quality. I would expect that the introduction of the price improvement rule to result in greater, timelier exposure of orders in the order book, as broker-dealers become less motivated to profit at the expense of clients traders by isolating their trades. Price discovery errors should decline, as traders use more accurate information in forming expectations. Also, transitory price impacts related to large trades would decline and market depth should increase, as more orders are exposed in the order book. In general, market quality should improve after the introduction of the price improvement rule.

The relevant null hypothesis:

H7: *There was no change in market quality (as measured by the standard deviation of the pricing error) after the introduction of the price improvement*

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rule.

This hypothesis can be tested by comparing the standard deviation of the pricing error in the pre-event period with the corresponding value in the post-event period. Specifically, univariate assessment of the effect of the rule change on market-wide volatility is made using the Wilcoxon one-tailed sign-ranks test. This test involves calculating, on a stock-by-stock basis, the ratio of the variance of the pricing error in the post-event period to the variance in the pre-event period. Then, following Kumar, Sarin, and Shastri (1998), the signed-ranks test is used to the determine of whether the median of the calculated variance ratios are on average significantly less than one; thus verifying whether market quality has improved (variance of the pricing error has fallen) overall.

4.8.2 Results from a Test for a Change in The Variance of The Pricing Error

Table 15 describes the result of a test of the effect of the price improvement rule introduction on overall market quality, which is measured by the standard deviation of the pricing error. The pricing error at a point in time is defined as the difference between stock's efficient (true) stock price and its transaction price. The variation of this pricing error over time can be construed as a measure of how closely the transaction price tracks the efficient price, and, consequently, of how efficient the price discovery process is. A much higher proportion of stocks had F-values significantly less than one (69.38 %) than greater than one (8.91%). More concretely, the Wilcoxon one-tailed signed-ranks test for an overall decline in market volatility after the introduction if the price improvement rule show a strong decline in the variance of the pricing error overall, and results in p-values below 0.001 for the two highest volume quartiles. For the second highest volume quartile

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the p-value is 0.005. However, for low volume stocks the improvement was marginal, with the test generating a p-value of 0.075. The results of the Wilcoxon signed-ranks test a result are generally indicative of a more efficient price discovery process and a better quality market in the post event period.

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Chapter FIVE: Summary and Conclusions

In Chapter 5 I summarize the contents of my dissertation, the important issues I addressed, and the main conclusions I drew after reviewing the literature on market consolidation and fragmentation and conducting an empirical investigation. I then discuss the implications of my analysis and possible avenues for future research.

5.1 Background

This study assesses the outcome of attempts to consolidate a financial market. If a financial market wants to attract investors, one of its important goals is to ensure that they are given the opportunity to execute orders on a timely basis in markets that are fair, stable and inexpensive. In recent times several key financial market around the world have signaled their recognition of this goal by investing in state-of–the-art technology and modifying trading rules in highly dynamic economic environments. Additionally, financial market system regulators have worked in tandem with member financial markets to ensure that this goal is achieved within the context of member markets' unique and common needs and characteristics. They are guided by the twin sub-goals of achieving the optimal level of *transparency* in each member market, and mutually beneficial *competition* among member markets within a market system. Transparency refers to the comprehensive and timely display of trading interest and other information needed by investors to make sensible trading decisions. In a multi-market system where shares of a security can be traded on more than one member market, transparency is believed to be facilitated best when relevant information on the security is *consolidated*

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across member markets. Consolidated trading information allows investors to interpret signals about the value of the security more accurately, and hence to make more efficient trading decisions. Market consolidation facilitates the maximum interaction of orders, and hence, the flourishing of the most efficient kind of pricing mechanism that is based on the aggregate demand and aggregate supply for a security. Investors who offer the best prices first are able to consummate their trades the fastest, through their timely access to counterorders wherever those orders are located within the market system. Thus, the proponents of consolidated market systems maintain that investors' trade execution costs are lowest when the system is fully consolidated. As more and more investors converge on market system because of its attractive features, that very process (convergence) enriches the information base and attracts still more investors. Thus market consolidation occurs naturally. However, this view of market consolidation and its beneficial effects relies on one key assumption: that all investors want exactly the same thing from financial markets. The reality is that investors may differ in several respects. Some investors want to trade large numbers of shares while others want to trade small numbers. Some investors wish to consummate trades immediately, while others are able to wait. Some like highly transparent markets, while others prefer opaque markets. Some investors are risk loving, others are risk-averse. Investor trading preferences change over time as their economic, social and psychological characteristics change. If some investors become sufficiently dissatisfied with the services provided by the fully consolidated market system, they might decide to seek the services of a new, separate market. The market system is now *fragmented.* This new, separate market fragment typically differs from the main market system in liquidity and trading priority protocol

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characteristics. A trader seeking to trade shares of a security in the market fragment would tend to face higher liquidity costs, as he/she would not have timely access to information on the entire trading interest in that security. Also, traders in the market fragment may offer the best prices in the market system, but may not be able to consummate their trades as quickly as in the main market. The first problem can be resolved through the actions of an arbitrageur, who specializes in the transfer of liquidity among market fragments, and whose actions serve to reduce liquidity differentials across market fragments (down to the costs of arbitrage). The main market plus its fragment then coalesce to form a *segmented* market, where a trader may trade in any segment. However the segmented market still suffers from the different trading priority protocols that could exist among the member market segments: a primary order precedence rule such as price priority would tend to be self-enforcing, for example, but not a secondary order precedence rule.

Thus market regulators are charged with the responsibility of ensuring that the benefits of such a system outweigh the costs, and that the costs are as low as possible. The benefits are that market segments have opportunities to innovate in, and provide unique, competitive services to particular investor clienteles. The costs are that investors may face less liquid markets, and may be discouraged from trading because other market participants (from any market segment) may be able to trade ahead of them based on information about their trading intentions. In a segmented market system such as that in the US, which consists of the NYSE, regional exchanges and OTC market segments, several practices have emerged that are of concern to market regulators. As member

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market centers compete by offering fast reliable order executions, low transaction fees, and innovative trading services, they may also compete in nontraditional, nonprice ways. For example, certain market centers may offer economic inducements to brokers in other market centers, so that those brokers may route all or part of their order flow to that market center. Economic inducements take two major forms. One form is called *payment for order flow*, an example of which is where a third market dealer pays a broker from a primary market center (the NYSE, for example) an agreed-upon amount per share. The other is called *internalization*, or alternatively, *crossing*, which is the routing of an order by a broker to the market-making desk of that broker's firm or affiliate. The primary motivation for the broker to enter into such arrangements is the opportunity to share in the profits earned by the market maker, who can earn significant abnormal profits because the orders are not exposed to vigorous price competition in the wider market. Consequently investors are dissuaded form supplying liquidity to the market if execution costs rise as a result of those practices, resulting in a general decline in market quality. However, some schools of thought maintain that such practices may actually be innovative competitive responses to the challenge of providing cutting-edge trading services to an increasingly diverse investor clientele. If such practices are the result of the practioners' use of innovative technology and / or greater efficiency in providing trading services, and are sufficiently competitive, then their introduction into a marketplace could result in lower, not higher execution costs, and could ultimately increase market quality.

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5.2 Focus of This Study

This study examines the effects of internalization on the market quality of stocks traded on the Toronto Stock Exchange (TSE). In a 1997 report on the purported negative impact of market fragmentation, the Exchange studied why an increasing number of orders that were executed off the TSE's central market, and were not exposed in its central limit order book. They found three factors:

(1) the evolution of a regulatory framework resulted in relatively liberal set of trading rules. This evolution was in part due to the increased competition from Canadian and foreign markets for the listing and trading of Canadian firms' stock.

(2) The rising sophistication of members' order managements systems (OMSs) dramatically increased their ability to capture and cross small orders without exposing the orders in the wider central market. A kind of crossing that is considered particularly suspect (the kind this study refers to as 'crossing on the book') is where a client's order is 'held up' while a counter principal order was entered in the book. The client's order is then released into the book (with the appropriate timing) so that it crossed with the principal order.

(3) The increased institutionalization of the market, where large, institutional traders put pressure on market makers to provide immediate execution of trades. The pressure forced market makers to hold large positions that they wished to sell quietly, through breaking up and crossing large positions against captive retail order flow.

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In noting the possible negative impact of crossing on the TSE's market quality, the report recommended the introduction of two rules, whose joint effect was expected to lower crossing rates and improve market quality. The first rule was the 'Order Exposure Rule'. It requires members to immediately enter orders of 1,200 shares or less in the TSE's central market unless (i) the client requests that the order be crossed, (ii) market conditions justify the crossing of the order, or (iii) the member improves on the best price offered on any Canadian exchange. The focus of this study is on the analysis of the effects of the second rule, 'Customer-Principal Rule', (also called the 'Price Improvement Rule') where members who execute a customer-principal trade (that is, cross a client's order against their own inventory) of 5,000 shares or less are required to give the customer a better price than the best price offered on any Canadian Exchange, unless the quoted spread is between the highest bid and the lowest ask price offered is equal to the minimum tick size.

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5.3 Tests and Findings

Statistical tests are conducted to determine the effect of implementation of the Price Improvement Rule on the TSE's market quality. Comprehensive tests for changes in market quality are conducted along several dimensions. On stock-by-stock basis, tests for statistically significant changes in the TSE's crossing (internalization) rates, price improvement rates, quoted and effective bid-ask spreads, quoted depth, and return volatility are conducted. Additionally, a test for a change in overall market quality, measured by the variance of the pricing error (the difference between the transaction price and a hypothesized efficient, or true price), is conducted. Trades of 5,000 shares or less, trades occurring at the spread, and high trading volume stocks all show strong increases in crossing rates after the rule was implemented. Also, further investigation reveals the source of the increase in crossing rates appears to be trades of size 1,200 shares or less occurring at the quoted spread for relatively large stock samples which contain firms that did not necessarily trade shares in all categories, and at the quoted spread and outside the quoted spread for a much smaller sample (21 stocks) of presumably more liquid stocks. These results, coupled with the fact that spreads fall over the period, suggest that members have adjusted their OMSs in such a way as to provide more cost –efficient trading services, and as a result are still able to provide price improvement and realize a (normal) profit. Additionally, because members have not yet fully adjusted their OMSs to meet the requirement that that they price-improve all intentional crosses (including those on the book), many trades are internalized on the book at a spread, and traders do not enjoy price improvement. An examination of changes in price improvement rates after the event reveals a strong increase in rates for small

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trades of 5,000 shares or less, non-internalized trades, and downstairs trades for two-tick spread trades. For 3-tick spread trades however, only a strong decline in price improvement rates is recorded. It must be noted that a fall in dollar and percentage point price improvement occurred after the rule introduction. This result, coupled with the recorded increase in price improvement rates for small trades, suggests that small traders are operating in a fairer, more efficient market. It should be borne in mind though, that a decline in price improvement rates does not necessary imply a reduction in market quality if the quote revision process simultaneously becomes more efficient.

A dramatic fall in quoted and effective spreads occur after the event. With the exception of low-volume stocks, univariate tests show that quoted spreads fall in all categorizes. Significant declines in quoted spreads occur even after controlling for the influence of factors -- stock price, trading volume, and return volatility-- known to significantly influence spreads. Similar results are obtained for effective spreads. The declined in quoted spreads is most likely the result of market participants' greater willingness to supply liquidity, while the fall in effective spreads, which appears to be most significant for trades of size 5,000 shares or less, is due to the greater efficiency with which trades are executed after the rule change. The finding that the adverse selection component of the spread also registered significant declines (with the exception of low volume stocks) reinforces the conclusion that relatively uninformed market participants are encouraged to supply liquidity to the market because adverse information asymmetry influences have declined. A comparison of quoted and effective spreads

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indicates a fall in dollar and percentage point price improvement, reinforcing the notion that opportunities for price improvement have declined.

Other tests for a change in market quality also demonstrate improvements. Univariate tests for a change in market depth show strong increases overall and for all volume quartiles. However, a regression test, which measures the influence of the rule change on market depth after accounting for the influence of other factors thought to impact significantly on market depth -- the quoted spread, trading volume, and return volatility -- find a positive but insignificant direct impact on market depth. The influence appears to be indirect, operating mainly through the rule change's influence on return volatility and trading volume. F-tests and a signed-ranks test for a change in return volatility reveal strong declines across all volume quartiles. Regression tests for changes in return volatility after controlling for the influence of trading activity also show strong declines in market volatility overall and for all except the second volume quartile, which shows a marginal decline. Those above findings are strongly corroborated by the results of a specific test for a change in overall market quality (measured by the variance of the pricing error, defined as the difference between the transaction price and a hypothesized efficient, or true price). A signed-ranks test reveals a decline in the pricing error variance, and (hence) a significant improvement in market quality.

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5.4 Discussion

The results of an empirical investigation into the effects of an attempt by the Toronto Stock Exchange to centralize trading indicate a generally successful effort. Spreads fell, volatility declined, and market quality improved. Overall, the implementation of the Price Improvement Rule reduced opportunities for profitable front running, restored time priority, and increased price competition and order interaction among market and limit orders. The fact that higher internalization (crossing) accompany such changes for example, does not reflect conflicting indications of a change in market quality. Such a change can be compatible with an improvement in market quality. It reflects the nature of the change, and underscores the need to assess market quality changes along as many dimensions as possible. In this case, the increase in internalization rates reflects members' attempts maximize profits while introducing cost-efficient trading on the TSE. An insignificant change or significant reduction in price improvement rates could reflect the improved efficiency of the quote revision process, and the reduced importance of price improvement in the price discovery process.

One may ask to what extent financial centers around the world have taken steps through rule changes to consolidate order flow. In 1998 Italy's national financial market regulatory authority, CONSOB, decreed that brokers are still required by CONSOB regulation (not by Borsa Italiana rules) to concentrate all trades in the official market, Borsa Italiana. Specifically, if a broker wants to execute a customer order off the central market it needs: (i) written approval from its customer and (ii) a price improvement (best

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execution) in comparison with the price available at the time of the operation on the market.

At the initiative of the National Stock Exchange of Lithuania the Law on Public Trading of Securities of the Republic of Lithuania was supplemented in 1998. A new clause was introduced: "Where securities registered with the Securities Commission intended for public trading are included into the Official or Current Trading Lists of the Stock Exchange, the sale-purchase transactions of the secondary trading shall be executed only at the Stock Exchange." (Article 8.2). Hence trading in listed shares is concentrated on the Central Market of the Stock Exchange. All other transactions with listed securities (i.e., donation, inheritance, etc.) executed off-exchange must be reported to the Stock Exchange.

Tanggaard (2000) studies market quality on the Copenhagen Stock Exchange from July 1999 to October 2000. He finds that the fraction of trades executed on Saxcess, the Exchange's consolidated limit order book, increases over the period for 32 % to 47%, and attributes most of that increase to the number of crossed trades on the book. He describes a process for crossing trades on the book that is very similar to that used by the TSE to cross small trades: a member enters an order at the best price simultaneously with the placement of a customer's order with a matching price. The process is automated, and is analogous to the TSE's use of OMSs. He views that kind of crossing as much less of a problem than off-market (or OTC) crossing, and recommends that more of the

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former and less of latter kind of trading. Thus the TSE's Price Improvement Rule and Italy's CONSOB rule would be of interest to the Copenhagen Stock Exchange.

Preliminary information from the German financial market system, Deutsche Börse AG, suggests that market fragmentation is an important issue. Besides the system's comprehensive electronic trading system, there exist eight more floor markets, with the Frankfurt Stock Exchange being by far the largest one.

On October 27th, 1999, Arthur Levitt, then chairman of the Securities and Exchange Commission spoke before Congress on some important market fragmentation issues. He communicated the SEC's position that market center rules such as NYSE's Rule 390, which, subject to certain restrictions, forbade market-making in an NYSE-listed security outside the NYSE's central market, exacerbated the vices of a consolidated monopoly market: little innovation and diversity coupled with high costs. Subsequently, the NYSE proposed that rule 390 be rescinded. But the rescission of this rule could lead to extensive off-board trading, order flow fragmentation, and its attendant problems. The SEC thus decided to organize public discussion forums to investigate the extent of possible fragmentation in the wake of the rescission of Rule 390, and to assess whether market fragmentation was a significant issue faced by the US's National Market System in general. In its statement of purpose on the rescission of Rule 390, the NYSE proposed that the possible effects of internal market fragmentation could be successfully addressed if the SEC adopted a system-wide rule. The rule is as follows: broker –dealers can trade as principal with their own customer market or marketable limit orders only at the BBO

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or at a price that is between the BBO. The proposed rule is similar in spirit to the TSE's price improvement rule. and results of a study of the TSE rule's effects should be of interest to the NYSE and the SEC. In recent years many other financial markets have undergone major technological transformations. Some have identified market consolidation as a primary goal, and now have highly automated, centralized trading where off -market trading is either not allowed, allowed only for block transactions, or is not an issue.

The importance of resolving the issue of market fragmentation or consolidation problem depends on many factors: the degree of technological innovation in, and its effect on, the market center or market system; the public goods produced by the system; the existing regulatory framework; and the diversity of the market centers' financial products and investor needs within a system. The issue at hand is to resolve the difficult public policy problem that arises in an internally segmented market such as the TSE's because a secondary precedence rule like time precedence is not uniformly applied across market segments, while recognizing the advantages to automatic, efficient execution of trades brought about by the use of order management systems for internalizing trades. At the same time it must be borne in mind that optimal price discovery is a function of the interaction of all orders (for a particular security) in all market segments. The results of this study illustrate that the implementation of new technology does not, by itself, enhance market quality. The value judgements, which are a necessary aspect of the decision –making process where trade-offs are involved, are the key inputs which this final outcome (improvement in market quality) reflects, and must be effected through

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market self-regulation and / or government regulation. Hence the rule changes. The implementation of the price improvement rule on the TSE represents a culmination of an extensive, thoughtful effort to accommodate a diverse investor clientele (and thus permit off-market, fragmented trading), while ensuring that orders are exposed to as much price competition as possible. The goal is to meet the needs of as many investor clienteles as possible without unfairly jeopardizing the interests of any. It is fair to say, based on the empirical evidence, that this goal has been achieved.

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5.5 Implications

In Section 4.6 I extensively discuss some of the outstanding issues associated with the market fragmentation versus consolidation debate. This empirical investigation analyzed the effects of reducing *internal* market fragmentation. However, as discussed in Section 2.6, the institution of a strict price/ time priority rule in a single market center that experiences internalization, for example, would lead to greater liquidity as more limit and market orders flow to the central market. However the same rule implementation in a multi-centered market could encourage the creation of more market centers, and hence, more (and possibly harmful) fragmentation. Therefore any generalizations about the applicability of similar policy to markets experiencing different kinds of market fragmentation should be avoided.

Several issues that have arisen from this empirical investigation.. They point to some research possibilities:

1) One of the main hypotheses of this dissertation is that the implementation of the price improvement rule would encourage submission of limit orders in the central market of the TSE, as front-running declined following the rule change. Since a reduction in tick size could with the existence of front running would should result in the opposite effect—the dissuasion of limit order submission—the hypothesis that a market with significant front –running experiences a fall in market quality could be tested.
2) The order exposure rule was implemented on August 31, 1998. The Price Improvement Rule, whose effects I investigate, was implemented on October

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26, 1998. However I find significant effects for the critical trade size range targeted by the order exposure rule: trades of 1,200 shares or less. I also find what appears to be a significant lag between is an apparent (and significant lag) between the implementation of the price improvement and order exposure rules and the market's adjustment to the rules. It would be interesting to investigate possible changes in market quality around August 31, 1998. This investigation could provide some insight into attempts to address the effects of external market fragmentation.

3) I find what appear to be significant differences in some effects following the introduction of the Price Improvement Rule between a sample of presumably liquid active, stocks and other larger sample that also include significant numbers of less active stocks. The differential effect of the new rule on the market quality of different stocks. Firm characteristics such as size, industry, etc. should be incorporated in to the analysis.

4) A strong increase in internalization outside the spread for highly liquid stocks is found. Fong, Madhavan, and Swan obtain similar result in their investigation of market fragmentation on the Australian Stock Exchange. Are there limits to positive network externalities? Could some off-market trading successfully co-exist with trading in a central market if that central market's trading volume has moved beyond an optimal level?

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Table 1

Key Events in the Evolution of the Toronto Stock Exchange's Trading Rules

Affecting Principal-Client Trades

Year	Event
1984	TSE allows members to do principal-client trades with retail orders, with the requirement that the member executing a principal trade had to give the client a better price than was available from any client order on the TSE, and at least a price equal to any available from any non-client order.
1985	Client priority is removed. Professional and client orders now compete on an equal footing, subject to the in-house requirement that a member could not buy or sell as principal if it held any client orders on the same side of the market at that price.
1987	Members who wish to do a principal-client trade are required to execute the trade at a price equal or superior to the best posted bid or ask price on the TSE; take reasonable steps to ensure that the price obtained for the customer is the best available price at that time, taking into account the relevant markets factors; and ensure that the price is justified by the condition of the market.
1989	Amendments to the floor trading rules require that all orders, including those declared on the floor, be entered and displayed in an electronic order book.
1998	The Order Exposure and Price Improvement rules are introduced in an effort to stem the increasing fragmentation of the market for TSE-listed stocks, and to consolidate more of TSE's order flow in the central limit order book. The Order Exposure Rule was implemented on 8/31/98. The Price Improvement Rule was implemented on10/26/98

Source: The Toronto Stock Exchange's Special Report on Market Fragmentation (1997)

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Table 2

Recent Trends in Trading Volume: Annual Percentage Changes

	1990	1991	1992	1993	1994	1995
Toronto 35 Index						
Board Lots	35%	64%	65%	83%	43%	60%
Total Volume	-9	-7	-2	60	88	101
Total Value	-17	-17	-12	49	98	133
TSE 300 Index						
Board Lots	33	27	55	73	55	76
Total Volume	-12	-10	6	88	111	126
Total Value	-25	-22	-11	68	111	143
All Stocks						
Board Lots	11	24	13	46	48	72
Total Volume	-13	-11	12	128	137	142
Total Value	-23	17	-9	76	118	149

* One Board Lot = 100 shares with quotes in the order book.

Total Volume = total number of shares traded in the year

Total Value = total Canadian dollar value of shares traded in the year

Source: The Toronto Stock Exchange's Special Report on Market Fragmentation (1997)

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Table 3
Descriptive Statistics

Table 3 provides a breakdown of a sample of equity trades on the Toronto Stock Exchange that occurred prior to the introduction of the Price Improvement Rule on October 26, 1998. The pre-event period consists of 25 trading days of trades from September 3rd to October 8th 1998, 11 days prior to the introduction of the Price Improvement Rule. Internalized trades occur where the same brokerage firm is on both sides of the trade. Downstairs trades occur where orders are displayed, matched, and executed on the TSE's consolidated limit order book. All other trades are upstairs trades. Prices are expressed in Canadian Dollars (C$). Trades eligible for price improvement have a (quoted) tick size greater than the minimum tick size (equal C$0.05 when the stock price is greater than C $5.00). Share volume is average daily trading volume (in hundreds of shares).

		VOLUME QUARTILES			
	ALL FIRMS	1 (LOWEST)	2	3	4 (HIGHEST)
Number of Stocks	258	64	65	65	64
Mean Price	C$22.34	C$27.03	C$18.70	C$20.75	C$22.96
Mean Share Volume	2,259	124	461	1,335	7,159
Minimum Volume	0	0	1	1	23
Maximum Volume	98,139	2,307	11,156	35,510	98,139
Percentage of Trades Internalized	11.18%	11.59	12.53	11.81	10.94
Percentage of Trades with Spreads of More Than One Tick	61.70%	92.58	84.25	81.70	55.26
Percentage of Trades Executed Downstairs	99.11%	97.46	98.26	98.57	99.34
Number of Trades:					
Total	890,404	27,896	57,103	114,965	690,440
≤ 1,200 shares	706,915	25,673	49,715	96,078	535,449
> 1,200 shares, ≤ 5,000 shares	156,566	1,961	6,233	15,320	133,052
> 5,000 shares	26,923	262	1,155	3,567	21,939

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Table 4
Internalization Rates Around The Introduction of The Price Improvement Rule

This table shows the results of a test of whether a significant change in the crossing internalization rate occurred for various types of trades after the introduction of the Price Improvement Rule using the sample described in Table 3. An internalized trade is one where the same buying and selling brokerage firm is on both sides of the trade. The internalization rate for a particular type of trade is defined as the ratio of internalized trades of that type to all trades of that type, and is done on a stock-by-stock basis. A paired t-test is used to test for significant changes in crossing rates after the rule change. A nonparametric paired observations test, the Wilcoxon Sign Test, is also conducted. Unless otherwise specified, and where applicable, for a given set of trade types, included firms trade all types.

Panel A: Overall Internalization Rates						
	Sample Size	Pre	Post	Change	t- statistic	P-Value for Sign Test
≥ 5,000 Shares	221	10.44%	11.11%	0.67	2.75***	<0.01
> 5,000 Shares	221	66.30	64.55	-1.75	-1.37	= 0.24

Panel B: Internalization Rates by Volume Quartiles							
	Trading Volume Quartile	Sample Size	Pre	Post	Change	t- statistic	P-Value for Sign Test
≤ 5,000 Shares	1	64	11.50%	11.80%	0.30	0.49	= 0.15
	2	65	10.72	11.96	1.24	2.60***	< 0.01***
	3	65	9.94	10.60	0.66	1.79*	= 0.03*
	4	64	10.32	11.01	0.69	2.70***	< 0.01***
> 5,000 Shares	1	56	79.05	68.17	-10.88	-1.93*	= 0.04*
	2	65	72.76	70.89	-1.87	-0.72	= 0.25
	3	65	69.48	67.47	-2.01	-0.98	= 0.20
	4	64	50.77	53.70	2.93	2.20**	< 0.01***

Panel C: Internalization Rates by Spread Width							
	Width	Sample size	Pre	Post	Change	t- statistic	P-Value for Sign Test
Overall	1 Tick	130	11.06%	11.68%	0.62	1.93*	<0.01**
	2 Tick	130	12.42	13.15	0.73	1.98**	<0.01
	≥ 3 Tick	130	12.79	13.17	0.38	1.13	=0.03*
≤ 5,000 Shares	1 Tick	130	9.32	10.00	0.68	2.32**	<0.01***
	2 Tick	130	10.19	11.08	0.89	2.94***	<0.01***
	≥ 3 Tick	130	10.43	10.89	0.46	1.42	<0.01**
> 5,000 Shares	1 Tick	130	55.85	55.23	-0.61	-0.28	=0.22
	2 Tick	130	61.02	60.08	-0.94	-0.43	=0.49
	≥ 3 Tick	130	60.19	61.06	0.87	0.52	=0.19

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

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Table 4 (Continued)

Panel D: Internalization Rates by Spread Location : Included Firms Trade All Types							
	Spread Location	**Sample size**	**Pre**	**Post**	**Change**	**t- statistic**	**P-Value for Sign Test**
≤ 5,000 Shares	**At Spread**	21	10.90	12.13	1.23	2.70***	<0.01***
	Inside Spread	21	8.93	9.49	0.56	0.82	=0.12
	Outside Spread	21	10.76	14.88	4.12	3.27***	<0.01**
> 5,000 Shares	**At Spread**	21	48.16	52.02	3.86	2.50**	<0.01**
	Inside Spread	21	48.03	51.41	3.38	1.05	=0.14
	Outside Spread	21	52.52	51.91	-0.61	-0.10	=0.41
≤ 1,200 Shares	**At Spread**	21	10.44	12.22	1.76	3.44***	<0.01***
	Inside Spread	21	8.95	9.47	0.52	0.69	=0.08
	Outside Spread	21	10.61	15.00	4.39	3.17***	<0.01***
> 1,200 Shares, < 5,000 shares	**At Spread**	21	12.24	11.40	-0.84	-1.50	=0.07
	Inside Spread	21	8.27	10.05	1.78	2.46**	<0.01**
	Outside Spread	21	12.70	15.88	3.18	1.21	=0.02

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

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Table 4 (Continued)

Panel E: Internalization Rates by Spread Location: Included Firms do not Necessarily Trade All Types							
	Spread Location	**Sample size**	**Pre**	**Post**	**Change**	**t- statistic**	**P-Value for Sign Test**
≤ 5,000 Shares	**At Spread**	258	10.75	11.61	0.86	3.56***	<0.01***
	Inside Spread	257	10.41	10.59	0.18	0.56	=0.20
	Outside Spread	110	13.50	12.69	-0.81	-0.67	= 0.19
> 5,000 Shares	**At Spread**	208	66.06	64.07	-1.99	-1.32	=0.20
	Inside Spread	195	64.11	64.51	3.38	0.23	=0.44
	Outside Spread	24	53.59	54.38	0.79	0.14	=0.49
≤ 1,200 Shares	**At Spread**	258	10.00	11.31	1.31	5.66***	<0.01***
	Inside Spread	253	9.85	10.04	0.19	0.57	=0.19
	Outside Spread	103	14.11	12.31	-1.80	-1.23	= 0.31
> 1,200 Shares, < 5,000 shares	**At Spread**	233	16.86	14.58	-2.28	-3.08***	<0.01***
	Inside Spread	208	15.52	14.90	-0.62	-0.84	=0.45
	Outside Spread	30	18.73	19.85	1.12	0..30	=010

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

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Table 5
Percentage of Trades Receiving Price Improvement

This table shows the results of a test of whether a significant change in the price improvement rate occurred for various types of trades after the introduction of the Price Improvement rule using sample described in Table 3. A price-improved trade is where the trade price is within the inside quotes. The price improvement rate for a particular type of trade is defined as the ratio of price-improved trades of that type to all trades of that type, and is done on a stock-by-stock basis. A paired t-test is used to test for significant changes in price improvement rates after the rule change. A nonparametric paired observations test, the Wilcoxon Sign Test, is also conducted. Where applicable, for a given set of categories, included stocks trade shares in all categories.

Panel A. 2 -Tick Spreads						
	Sample Size	Pre	Post	Change	t- statistic	P-Value for Sign Test
<=5,000 Shares	101	15.36%	17.30%	1.94	3.84***	<0.01***
>5,000 Shares	101	29.04	31.11	2.07	1.06	=0.10
Internalized	149	15.72	15.75	0.03	0.03	=0.37
Non-Internalized	149	13.49	16.01	2.52	5.58***	<0.01***
Upstairs Trades	79	60.03	56.41	-3.62	-1.07	=0.19
Downstairs Trades	79	16.34	18.24	1.90	3.29***	<0.01***
Panel B. 3 or More -Tick Spreads						
	Sample Size	Pre	Post	Change	t- statistic	P-Value for Sign Test
<=5,000 Shares	218	30.84%	31.19%	0.35	0.69	=0.22
>5,000 Shares	218	48.88	46.35	-2.53	-1.85*	=0.08
Internalized	257	31.30	31.20	-0.10	-0.15	=0.28
Non-Internalized	257	31.29	32.05	0.76	1.53	=0.04
Upstairs Trades	219	74.90	66.83	-8.07	-5.18***	<0.01***
Downstairs Trades	219	30.53	30.88	0.35	0.73	=0.15

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

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Table 6
Time-Weighted Quoted Spreads: Univariate Results

This table shows the results of a test of whether a significant change in quoted spreads occurred for various trading volume categories after the introduction of the Price Improvement Rule. The dollar spread is defined as: Dollar Spread$_{it}$= Ask_{it}–Bid_{it}, where Ask_{it} *and* Bid_{it} are the time-weighted average ask and bid prices for stock *i* on measurement period *t* respectively. The percentage spread measures transaction costs per dollar of investment: *Percent Spread*$_{it}$ = (Ask$_{it}$ -Bid$_{it}$) / ((Ask_{it}+Bid_{it})/2). A nonparametric paired observations test, the Wilcoxon Sign Test, is also conducted. Where applicable, for a given set of categories, included stocks trade shares in all categories.

Panel A. Quoted Dollar Spreads						
	Sample Size	**Pre**	**Post**	**Change**	**t- statistic**	**P-Value for Sign Test**
Overall	258	C$0.2850	C$0.2471	-C$0.0379	-6.09***	<0.01***
Volume Quartile 1 (lowest)	64	C$0.4889	C$0.4532	-C$0.0357	-1.69*	<0.001***
Volume Quartile 2	65	C$0.3018	C$0.2459	-C$0.0559	-5.29***	<0.01***
Volume Quartile 3	65	C$0.2206	C$0.1783	-C$0.0423	-5.71***	<0.01***
Volume Quartile 4 (highest)	64	C$0.1297	C$0.1121	-C$0.0176	-5.12***	<0.01***
Panel B. Effective Percentage Spreads						
	Sample Size	**Pre**	**Post**	**Change**	**t- statistic**	**P-Value for Sign Test**
Overall	258	1.56%	1.19%	-0.37	-12.10***	<0.01***
Volume Quartile 1 (lowest)	64	2.23	1.72	-0.51	-6.75***	<0.01***
Volume Quartile 2	65	1.90	1.43	-0.47	-5.30***	<0.01***
Volume Quartile 3	65	1.35	1.01	-0.34	-7.50***	<0.01***
Volume Quartile 4 (highest)	64	0.74	0.60	-0.14	-7.96***	<0.01***

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

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Table 7
Time-weighted Quoted Spreads: Regression Results

This table shows the results of a test of whether a significant change in quoted spreads occurred for various types of trades after the introduction of the Price Improvement Rule. The effect of the rule change on spreads is determined after controlling for the effects of other factors. Specifically, the model is given by $L_{it} = \beta_0 + \beta_1 lnV_{it} + \beta_2 \sigma_{it}^2 + \beta_3 P_{it} + \beta_4 D\_RULECH_{it} + \varepsilon_{it}$, where L_{it} = quoted spread measure for firm i in (pre- or post-event) period t, lnV_{it} = the log of average daily trading volume (number of shares) for firm i in period t, σ_{it}^2 = the return variance for firm i in period t, P_{it} = daily average price for firm i in period t. D_RULECH_{it} = dummy variable with a value of 1 in the pre-event period, 0 otherwise and ε_{it} = error term, assumed to have distribution $N(0,\sigma_\varepsilon)$

Spread	Sample Size	Intercept	Price	Volume	Volatility	Dummy	F-Statistic { adjusted R^2 }
Quoted Spread ($)	516	0.8438	0.2410	-0.09372	3.2218	-0.0553	113.11
		(6.07***)	(10.63***)	(-10.45***)	(12.32***)	(-2.05**)	{0.4655}
Quoted Spread (%)	516	0.0835	-0.0067	-0.0034	0.0211	-0.0028	166.02
		(29.22***)	(-14.42***)	(-18.57***)	(3.92***)	(-5.03***)	{0.5617}

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

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Table 8
Share-Weighted Effective Spreads: Univariate Results

This table shows the results of a test of whether a significant change in effective spreads occurred for various trading volume categories after the introduction of the Price Improvement Rule. Effective spreads are measured in addition to quoted spreads because trades frequently occur at prices within quotes. The specific effective spread measures are: *Effective Dollar Spread*$_{it}$ = | *Price*$_{it}$ - (*Ask*$_{it}$-*Bid*$_{it}$)/2 |, and *Effective Percentage Spread*$_{it}$ = | *Price*$_{it}$ - (*Ask*$_{it}$-*Bid*$_{it}$)/2 | /((*Ask*$_{it}$+*Bid*$_{it}$)/2), where the measures are share (trade size)-weighted averages for firm i in period *t*. Paired t-tests are conducted. A nonparametric paired observations test, the Wilcoxon Sign Test, is also conducted. Where applicable, for a given set of categories, included stocks trade shares in all categories.

Panel A. Effective Dollar Spreads

	Smpl. Size	Pre-Event Period		Post-Event Period		Change in Spread	t- stat.	P-Value for Sign Test
		Dollar Spread	Ave. No. of Trades	Dollar Spread	Ave. No. of Trades			
Overall	258	C$0.1152	3,452	C$0.1020	3,208	-C$0.0132	-3.98***	<0.01***
Vol. Qrtle. 1 (lowest)	64	C$0.1966	435	C$0.1870	542	-C$0.0096	-0.80	<0.01***
Vol. Qrtle. 2	65	C$0.1212	877	C$0.1006	1,120	-C$0.0206	-4.75***	<0.01***
Vol. Qrtle. 3	65	C$0.0910	1,768	C$0.0745	2,088	-C$0.0165	-4.33***	<0.01***
Vol. Qrtle. 4 (highest)	64	C$0.0524	10,792	C$0.0030	9,131	-C$0.0494	-3.93***	<0.01***
≤5,000 Shrs	228	C$0.1117	3,681	C$0.0971	3,415	-C$0.0146	-4.08***	<0.01***
> 5,000 Shrs	228	C$0.1086	117	C$0.0907	107	-C$0.0179	-0.93	=0.01**
≤ 1,200 Shrs	174	C$0.0937	3,604	C$0.0789	3,341	-C$0.0148	-6.60***	<0.01***
> 1,200 Shrs, ≤ 5,000 Shrs	174	C$0.0886	801	C$0.0741	567	C$0.0119	-6.27**	<0.01***
> 5,000 Shrs, < 10,000 Shrs	174	C$0.0908	62	C$0.0742	46	-C$0.0166	-2.36**	<0.01***
≥ 10,000 Shrs	174	C$0.1138	79	C$0.0691	79	-C$0.0447	-1.04	=0.05*
Internalized Trades	258	C$0.1158	386	C$0.0987	402	-C$0.0171	-6.64***	<0.01***
Non-Internalized Trades	258	C$0.1165	3,066	C$0.1032	2,806	-C$0.0133	-3.63***	<0.01***
Upstairs Trades	242	C$0.1025	32	C$0.0924	32	-C$0.0101	-0.68	<0.01***
Downstairs Trades	242	C$0.1153	3,587	C$0.1022	3,310	-C$0.0131	-3.94***	<0.01***

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Table 8 (Continued)
Share-Weighted Effective Spreads: Univariate Results

Panel B. Effective Percentage Spreads								
	Sample Size	Pre-Event Period		Post-Event Period		Change in Spread	t- statistic	P-Value for Sign Test
		%Spread	Ave. No. of Trades	% Spread	Ave. No. of Trades			
Overall	258	0.63%	3,452	0.49%	3,208	-0.14	-11.09***	<0.01***
Volume Quartile 1 (lowest)	64	0.90	435	0.71	542	-0.19	-5.84***	<0.01***
Volume Quartile 2	65	0.77	877	0.59	1,120	-0.18	-6.09***	<0.01***
Volume Quartile 3	65	0.55	1,768	0.42	2,088	-0.13	-6.73***	<0.01***
Volume Quartile 4 (highest)	64	0.30	10,792	0.25	9,131	-0.05	-6.21***	<0.01***
≤ 5,000 Shrs	228	0.61%	3,618	0.47%	3,415	-0.14	11.79***	<0.01***
> 5,000 Shrs	228	0.58	117	0.49	107	-0.09	-1.77	<0.01***
≤ 1,200 Shrs	174	0.55%	3,604	0.42%	3,341	-0.13	10.43***	<0.01***
> 1,200 Shrs, ≤ 5,000 Shrs	174	0.53	801	0.40	567	-0.13	-9.83***	<0.01***
> 5,000 Shrs, < 10,000	174	0.53	62	0.40	46	-0.13	-3.62***	<0.01***
≥ 10,000 Shrs	174	0.56	79	0.39	79	-0.17	-3.97***	<0.01***
Internalized Trades	258	0.64%	386	0.49%	402	-0.15	-9.28***	<0.01***
Non-Internalized Trades	258	0.64	3,066	0.50	2,806	-0.14	-11.67***	<0.01***
Upstairs Trades	242	0.54%	32	0.42%	32	-0.12	-3.36***	<0.01***
Downstairs Trades	242	0.63	3,587	0.50	3,310	-0.13	-10.67***	<0.01***

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

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Table 9
Share-Weighted Effective Spreads: Regression Results

This table shows the results of a test of whether a significant change in effective spreads occurred for various types of trades after the introduction of the Price Improvement rule using sample information described in Table 3. The effect of the rule change on spreads is determined after controlling for the effects of other factors. Specifically, the model is given by $L_{it} = \beta_0 + \beta_1 lnV_{it} + \beta_2 \sigma_{it}^2 + \beta_3 P_{it} + \beta_4 D\_RULECH_{it} + \varepsilon_{it}$. where L_{it} = share-weighted dollar or percentage effective spread measure for firm i in (pre- or post-event) period t, lnV_{it} = the log of average daily trading volume (number of shares) for firm i in period t, σ_{it}^2 = the return variance for firm i in period t, P_{it} = daily average price for firm i in period t, D_RULECH_{it} = dummy variable with a value of 1 in the pre-event period, 0 otherwise. Where applicable, for a given set of categories, included stocks trade shares in all categories.

Panel A. Effective Dollar Spreads							
	Sample Size	**Intercept**	**Price**	**Volume**	**Volatility**	**Dummy**	**F–Statistic {Adjusted R^2}**
Overall	516	0.3428	0.0957	-0.0377	1.3007	-0.0201	109.73
		(6.05***)	(10.39***)	(-10.32***)	(12.20***)	(-1.82*)	{0.4621}
≤ 5,000 Shares	452	0.4062	0.1010	-0.0461	1.3282	-0.0211	102.05
		(6.63***)	(9.96***)	(-10.31***)	(12.10***)	(-1.81*)	{0.47}
>5,000 Shares	452	1.31E-4	0.034	-0.0032	0.5333	-0.0114	562.73
		(0.00)	(5.01***)	(-1.17)	(41.69***)	(-1.44)	{0.83}
≤ 1,200 Shares	374	0.3499	0.0449	-0.0300	0.0938	-0.0161	172.94
		(23.13***)	(17.37***)	(-24.03***)	(3.26***)	(-5.73***)	0.65
> 1,200 Shares, ≤5,000 shares	374	0.3182	0.0361	-0.0252	0.0922	-0.0186	138.37
		(20.70***)	(13.77***)	(-21.28***)	(3.40***)	(-6.35***)	(0.60}
> 5,000 Shares, < 10,000 Shares	374	0.2200	0.0311	-0.0192	0.03126	-0.0153	50.70
		(10.20***)	(8.35***)	(-11.04***)	(2.24***)	(-3.57***)	{0.35}
≥ 10,00 Shares	374	0.2215	0.0216	-0.0141	0.0120	-0.0135	26.07
		(8.26***)	(5.92***)	(-7.93***)	(0.83)	(-3.15***)	{0.21}

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

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Table 9, Panel A (Continued)

	Sample Size	Intercept	Price	Volume	Volatility	Dummy	F–Statistic {Adjusted R^2}
Internalized Trades	516	0.0210	-0.0000	-0.0011	0.7707	-0.0008	81.61
		(18.77***)	(-5.47***)	(-14.05***)	(7.48***)	(-2.95***)	{0.39}
Non-Internalized Trades	516	0.0286	-0.0000	-0.0017	0.6979	-0.0011	142.46
		(25.85***)	(-5.46***)	(-20.90***)	(7.91***)	(-3.23***)	{0.30}
Upstairs Trades	486	-0.0392	0.1294	-0.0265	0.1078	-0.0252	46.32
		(-0.85)	(12.48***)	(-6.25***)	(2.87***)	(-1.97***)	{0.27}
Downstairs Trades	486	0.39024	-0.0983	-0.0414	1.3478	-0.0210	114.80
		(6.45***)	(10.15***)	(-10.67***)	(12.05***)	(-1.81***)	{0.48}

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Table 9 (Continued)
Share-Weighted Effective Spreads: Regression Results

Panel B. Effective Percentage Spreads							
	Sample Size	**Intercept**	**Price**	**Volume**	**Volatility**	**Dummy**	**F–Statistic {Adjusted R^2}**
Overall	516	0.0338	-0.0028	-0.0014	-0.0093	-0.0010	158.01
		(28.47***)	(-14.53***)	(-17.85***)	(4.15***)	(-4.47***)	{0.55}
≤ 5,000 Shares	452	0.0342	-0.0025	-0.0016	0.0093	-0.00100	180.11
		(29.82***)	(13.04***)	(-18.69***)	(4.52***)	(-4.59***)	{0.61}
>5,000 Shares	452	0.02986	-0.0041	-9.2137E-4	0.0042	-0.0002	142.46
		(13.16***)	(-10.60***)	(-5.99***)	(5.86***)	-0.43	{0.30}
≤ 1,200 Shares	374	0.0315	-0.0021	-0.0016	0.0064	-8.9E-4	186.97
		(29.64***)	(-11.32***)	(-17.76***)	(3.17***)	(-4.50***)	(0.67}
> 1,200 Shares, ≤5,000 shares	374	0.0287	-0.0022	-0.0013	0.0057	-9.907E-4	157.73
		(26.92***)	(-12.24***)	(-15.66***)	(3.03***)	(-4.55***)	0.63
> 5,000 Shares, < 10,000 Shares	374	0.0240	-0.0026	-9.734E-4	0.0026	-6.765E-4	58.85
		(14.72***)	(-9.40***)	(-7.43***)	(2.48**)	(-2.09**)	0.38
≥ 10,00 Shares	374	0.0236	-0.00301	-0.0007	0.0018	-0.0135	62.16
		(13.00***)	(-12.21***)	(-5.82***)	(1.83)	(-2.53***)	0.40

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

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Table 9, Panel B (Continued)

	Sample Size	Intercept	Price	Volume	Volatility	Dummy	F–Statistic { Adjusted R^2 }
Internalized Trades	516	0.0210	-0.0000	-0.0011	0.7707	-0.0008	81.61
		(18.77***)	(-5.47***)	(-14.05***)	(7.48***)	(-2.95***)	{0.39}
Non-Internalized Trades	516	0.0286	-0.0000	-0.0017	0.6979	-0.0011	142.46
		(25.85***)	(-5.46***)	(-20.90***)	(7.91***)	(-3.23***)	{0.30}
Upstairs Trades	486	0.0185	-0.0012	-0.0010	-1.1186	-0.0012	41.37
		(15.86***)	(-4.75***)	(-9.70***)	(-0.12)	(-3.85***)	{0.25}
Downstairs Trades	486	0.3902	-0.0000	-0.0015	0.627	-0.0008	114.80
		(22.80***)	(-5.76***)	(-18.37***)	(6.78***)	(-3.09***)	{0.48}

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

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Table 10
Adverse Selection Component of Spread

This table shows the results of a test of whether a significant change in the percentage adverse selection component occurred for various trading volume groups and intraday time intervals after the introduction of the Price Improvement Rule, using 152 stocks from the original sample (described in Table 3). Each included stock had at least a total of 50 trades in the first and last half–hours of trading. The percentage adverse selection component of the effective spread, λ, is estimated by the following regression: $\Delta Q_t = \lambda z_{t-1} + e_t$, where $\Delta Q_t = Q_t - Q_{t-1}$, Q_t is the log mid quote at time t, $z_t = P_t - Q_t$, and P_t is the log transaction price at time t.

	Pre	Post	Change	t- statistic
Overall	20.58	15.95	-4.63	-4.35***
Volume Quartile 1 (lowest)	32.11	28.56	-3.55	-0.41
Volume Quartile 2	23.33	15.22	-8.11	-3.12***
Volume Quartile 3	21.44	16.86	-4.92	-2.10**
Volume Quartile 4 (highest)	16.82	13.88	-2.94	-3.62***

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

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Table 11

Time-Weighted Depth

Univariate Results

This table shows the results of a test of whether a significant change in quoted depth occurred for various trading volume categories after the introduction of the Price Improvement rule. *Market Depth*$_{it}$ is defined as the time-weighted average of the arithmetic average of the number of shares offered at the bid price and the number of shares offered at the ask price for firm *i* in period *t* (pre- or post-event period).

	Sample Size	Pre	Post	Change	t- statistic
Overall	258	30.00	33.37	3.37	4.03***
Volume Quartile 1 (lowest)	64	15.15	17.81	2.66	2.71***
Volume Quartile 2	65	22.24	26.68	4.44	2.28**
Volume Quartile 3	65	29.73	32.00	2.27	2.04**
Volume Quartile 4 (highest)	64	48.96	57.12	8.16	2.27**

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

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Table 12. Time-Weighted Depth

Regression Analysis

This table shows the results of tests of the effect of the introduction of the Price Improvement rule on market depth using sample information described in Table 3. The strength of this effect is determined after controlling for the effects of other factors. Specifically, the model is given by $Depth_{it} = \beta_0 + \beta_1 L_{it} + \beta_2 lnV_{it} + \beta_3 \sigma_{it}^2 + \beta_4 D\_RULECH_{it} + \varepsilon_{it}$, where $Depth_{it}$ is the time-weighted average of the arithmetic average of the number of shares offered at the bid price and the number of shares offered at the ask price for firm i in period t (pre- or post-event period), L_{it} is the time-weighted daily average quoted spread for firm i in period t, lnV_{it} = the log of average daily trading volume (number of shares) for firm i in period t, σ_{ε}^2 = the return variance for firm i in period t, and D_RULECH_{it}= dummy variable with a value of 1 if the observation is in the post-event period, and 0 otherwise; and ε_{it} = error term, assumed to have distribution N (0, σ_{ε}).

Sample Size	Intercept	Spread	Volume	Volatility	Dummy	F–Statistic {Adjusted R^2 }
516	-103.43	-3.47	9.37	-1340.53	2.73	64.70
	(10.62***)	(-1.48)	(14.43***)	(-1.95*)	(1.42)	{0.34}

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Table 13
Return Volatility: F -Statistics

This table describes results of the F-statistic test for a change in return variance after introduction of the Price Improvement Rule. Specifically the F-statistic is defined as $F_i = \sigma_A^2 / \sigma_B^2$ where σ_A^2 is stock *i*'s return variance in the post-event period, and σ_B^2 is the stock's return variance in the pre-event period. The Wilcoxon one-tailed signed-ranks test is used to determine whether, on average, F is significantly less than one.

Total number of stocks	258
Mean F-value	0.75
Median F-value	0.48
Percentage of stocks with F-value significantly (at 5% level) less than one	32.17
Percentage of stocks with F-value significantly (at 5% level) greater than one	2.33
Percentage of statistically insignificant (at 5% level) F-values	65.50
One-tailed signed-ranks probability for decline in return variance over event:	
Overall	< 0.001
Volume Quartile 1 (lowest)	< 0.001
Volume Quartile 2	< 0.001
Volume Quartile 3	< 0.001
Volume Quartile 4 (highest)	< 0.001

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Table 14

Volatility: Regression Analysis

This table shows the results of a test of whether a significant change in return volatility occurred for stocks in various volume groups (described in Table 3) after controlling for the influence of trading activity. Specifically the following regression model is run: $\sigma_{it} = \beta_0 + \beta_1 N\_Trades_{it} + \beta_2 D\_RULECH_{it} + \varepsilon_{it}$, where σ_{it} is the standard deviation of returns for firm i in measurement period t (pre- or post event period), N_Trades_{it} is the number of transactions for firm i during measurement period t, and D_RULECH_{it} is a dummy variable assigned the value of 1 if the observation is from the post-event period, 0 otherwise, and ε_{it} is an error term.

	Intercept	Average Daily Number of Trades	Dummy	F–Statistic { Adjusted R^2 }
Overall	0.008	-2.16 E-6	-1.58 E-3	61.62
	(32.06***)	(-9.96***)	(-4.98***)	{0.19}
Volume Quartile 1 (lowest)	0.001	-2.1 E-6	-1.98 E-3	7.27
	(16.43***)	(-2.22**)	(-2.75***)	{0.10}
Volume Quartile 2	0.011	-2.96 E-6	-1.15 E-3	29.33
	(19.21***)	(-6.99***)	(-1.90*)	{0.32}
Volume Quartile 3	0.008	-1.03 E-6	-1.09 E-3	39.78
	(21.72***)	(-8.20***)	(-2.68***)	{0.39}
Volume Quartile 4 (highest)	0.004	-7.85 E-8	-7.39 E-4	32.40
	(19.68***)	(-7.68***)	(-2.92***)	{0.34}

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

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Table 15
Impact of Rule Change on the Variance of the Pricing Error

This table describes statistical results concerning the variance ratio $VR_i = \sigma_{S,A}^2 / \sigma_{S,B}^2$, where $\sigma_{S,B}^2$ is the variance of the pricing error for stock i in the pre-event period, and $\sigma_{S,A}^2$ is the variance of the pricing error for stock i in the post-event period. The variance of the pricing error is estimated using Vector Autoregression (VAR) model developed by Hasbrouck (1993), and is used as an overall measure of market quality. In particular, the standard deviation of the pricing error is used to measure how closely the transaction price tracks the efficient price. The Wilcoxon one-tailed signed-ranks test is used to determine whether, on average, VR is significantly less than one.

Total number of stocks	258
Mean VR-value	0.99
Median VR-value	0.67
Percentage of stocks with F-value significantly (at 5% level) less than one	69.38
Percentage of stocks with F-value significantly (at 5% level) greater than one	8.91
Percentage of statistically insignificant (at 5% level) F-values	21.71
One-tailed signed-ranks probability for change in pricing error variance over event:	
Overall	< 0.001
Volume Quartile 1 (lowest)	= 0.075
Volume Quartile 2	= 0.005
Volume Quartile 3	< 0.001
Volume Quartile 4 (highest)	< 0.001

APPENDIX A: Glossary

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APPENDIX A: Glossary

AMEX: The American stock Exchange.

BBO: Best (highest) quoted Bid and (lowest) quoted Offer prices across a system of financial centers

BN: Beveridge and Nelson restriction. Used to facilitate estimation in a VAR model.

CATS I: Computer Assisted Trading System. Automated trading system used by the Toronto Stock Exchange.

CATS II: Computer Assisted Trading System. Replaced CATS I.

CLOB: Central Limit Order Book. Facility used by auction markets to display limit orders.

CONSOB: Italy's National regulator of financial markets.

CQS: Consolidated Quotation System. A component of the National Market system which makes current quotations on NYSE-listed stocks widely available throughout the system.

CTA: Consolidated Tape which reports trading activity in NYSE – listed stocks and stocks listed on regional exchanges and Nasdaq. and the

ECN: Electronic Communication (or Crossing) Network. Electronic trading system.

EHS: Effective Half-Spread. Defined as the transaction price minus the midpoint of the quoted spread.

ITS: Intermarket Trading System. Facilitates the routing of orders across the National Market System.

NMS: National Market System. The System that links Financial markets in the United States.

Nasdaq: National Association of Security Dealers Automated Quotations. An over-the-counter (OTC) trading system.

NYSE: the New York Stock Exchange.

OMSs: Order Management Systems. Used by the Toronto Stock Exchange members to selectively and efficiently execute trades.

OTC: Over –the-Counter. Not transacted on an organized exchange.

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SEC: The Securities and Exchange Commission. The US's Government's primary regulatory body responsible for the oversight of financial market activity in the United States.

SC: Special Committee. A committee of experts assembled by the Toronto Stock Exchange to investigate and address the effects of market fragmentation.

SOES: Small Order Execution System. An automated trading system used by Nasdaq to trade small orders.

TSE: the Toronto Stock Exchange.

TTC: Total Trading Costs = per share commission + effective half-spread (EH)

VAR: Vector AutoRegressive model. Used to estimate the variance of pricing errors.

VWAP: Volume Weighted Average Price. The average price of a stock, calculated over a day, and weighted by the volume of each trade.

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Appendix B: TSE's Regulatory Notice of October 26, 1998.

REGULATORY NOTICE
98-033
October 26, 1998

Suggested Routing: Institutional, Legal & Compliance, Retail, Trading & Training

ORDER EXPOSURE AND CUSTOMER-PRINCIPAL TRADING RULES:
INTERNAL FIRM PROCEDURES

A number of members have asked for assistance in developing their in-house compliance procedures for the order exposure and customer-principal trading rules. Members in developing their policies may use the attached guidelines.

Members are reminded that they must have written compliance procedures in place. The TSE will review these procedures in trade desk reviews.

Questions regarding this notice and the rules may be directed to Timothy Baikie at 947-4570 (e-mail: tbaikie@tse.com), Tom Briant at 947-4579 (tbriant@tse.com), Bruce Sinclair at 947-4576 (bsinclair@tse.com) or Nick Vito at 947-4424 (nvito@tse.com).

LEONARD PETRILLO
VICE PRESIDENT,
GENERAL COUNSEL &
SECRETARY

Procedures for Handling Orders of 5000 Shares or Less
Guidelines for Members

The TSE has implemented two new and related rules for handling orders less than 5000 shares. The Order Exposure Rule pertains to orders less than or equal to 1200 shares and the Customer-Principal Trading Rule pertains to orders less than or equal to 5000 shares. Each member who engages in principal trading activity or which may be affected by these rules must implement procedures to comply. The procedures should be developed with specific reference to the member's trading practices and trading systems. These guidelines are intended to provide an overview of what areas should be addressed by the member when developing its own procedures.

The procedures should incorporate a description or the actual text of each rule even if only by reference to an attachment. Similarities and differences in the two rules should be highlighted in the description. The Exchange has published examples of situations where the rules would apply and has provided a list of answers to "frequently asked questions." Such examples and FAQ's may be incorporated into training material that explains the rules and the firm's order handling procedures to its trading personnel.

The rules apply to trading a TSE-listed security Other than classes of securities exempted from the order handling rule: debentures, preferred shares, limited partnership units, US funds issues and foreign-based interlisted issues exempt under s. 11.01(3) of the TSE General By-law. *in any market,* not just the TSE. In this sense, they are similar to sales compliance rules. In other words, a trader cannot avoid the application of the rules by trading on another exchange. The rules do not, however, require the member to trade on the TSE. For example, a member may comply with the order exposure rule by exposing a client order on the Montreal Exchange. Similarly, the customer-principal rule requires the member to give the client a *better* price than the client could obtain on *any* Canadian exchange (with one exception); as long as the pricing restrictions are observed, the member can execute a customer-principal trade on another exchange.

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The procedures must address the particular systems and methods that the member uses for trading orders. There are two basic methods for handling orders used by the members: OMS systems and trader managed orders. These must be addressed in the procedures.
In addition, the member must have programs to monitor compliance with the rules. These are discussed below.

Order Exposure Rule

OMS System Orders

When orders are handled by an OMS system the member can set filter levels to determine what orders the traders handle. The procedures must include what levels the filters will be set at by the member. It is a good practice to set the filters so that, at the very least, orders less than or equal to the MGF go directly into the trading engine and are automatically booked or executed. The trader may wish to manage tradable orders that are greater than the MGF to ensure the client gets best execution. Lower levels may be appropriate for better management of orders in some stocks. The firm's procedures should include how the particular levels are to be set, the procedure for changing them, and the procedure for compliance reviews of filters.

Trader Managed Orders

When handling an order manually the trader is required to enter it immediately into the TSE or another stock exchange on which the security is interlisted unless it meets the conditions of one of the three exceptions allowing the trader to withhold the order.

· The client has specifically instructed the member to not enter the order immediately. These instructions cannot be solicited from the client and must be specific to the order. The member must keep a record of instructions to withhold. Situations where client requests the member to withhold an order will be infrequent, and will usually be confined to situations where the client wishes to trade with a specific counterparty (e.g. a tax-related trade between spouses).

· The trader determines that based on market conditions entering the order as received would not give the customer best execution. For example, the spread is unreasonably wide or the quoted size is too small to fill the order at a reasonable price.

· The member executes the order at a better price than the client could have received on any Canadian exchange.

Determining the context of the market may require the trader to consider some or all of the following factors: previous trades, quoted size, size imbalances on either side of the market, current spread and its relation to the normal spread, price trend, volume trend, other markets and general market activity. However, the review must be for the benefit of the client and cannot be an opportunity to spot trading opportunities. If an order is held to assess market conditions, it must ultimately be entered on a public market (either as is or with the price and/or volume changed) or executed at a *better* price than the client could obtain on any Canadian exchange. The member, not the client, bears the risk that an execution opportunity may be missed while an order is held (unless the client has requested that the order be withheld).

The trader can, of course, withhold an order to check the order's terms with the RR or the client. Once the terms have been confirmed (or the correct order details obtained) the rule applies.

Customer-Principal Trading Rule

These procedures are particularly important for firms with Registered Traders, liability traders or NX traders. These traders must be clearly instructed when and under what circumstances they can trade with a client order subject to the rule. Examples, such as those provided by the TSE, would probably be useful in explaining the rule.

The procedures should describe the restrictions imposed on traders who want to cross client orders with a principal account and what steps the trader must take before crossing stock. At this time, the rule only applies to intentional crosses, which includes set-up customer-principal crosses where a trader holds up an order solely for the purpose of entering an offsetting pro order in the Book to trade with it. The firm's procedures must explicitly state that this activity is not permitted for orders subject to the rule.

The rule requires that the trader gives a client a better price than the client could obtain on any Canadian exchange unless the "best market spread" (the difference between the highest

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bid price and lowest offer price on any Canadian exchange) is the minimum trading increment for the security (normally, 5 cents). In all cases the price to the client must be justified by the market. The procedures must explain these requirements, and must point out that the posted market is not necessarily the best available price to the client. "Justified by the market" means the trader should consider some or all of the following factors: previous trades, quoted size, size imbalances on either side of the market, current spread and its relation to the normal spread, price trend, volume trend, other markets and general market activity. For example, if a stock with a wide spread has been trading heavily on the offering, buying a client order 5 cents above the bid price may not be "justified."

The procedures should clarify how the Customer-Principal rule and Order Exposure rules work together. That is, the Customer-Principal rule will operate in conjunction with the order exposure rule – if the order is for 1200 shares or less, a member cannot withhold the order to do a customer-principal trade unless the member improves the price, even if the current spread is the smallest possible trading increment. This point must be clearly made in the procedures and examples may be useful in explaining its application.

The procedures should define what the relevant size is in determining whether the rule applies to an order. Defining what a "client" is and what constitutes meaningful price improvement should also be in the procedures. There should also be procedures for the different types of specialty businesses done by the member, such as program trading.

Internal Compliance Programs

In addition to instructing traders and order handling staff of the correct procedures for handling orders, the firm must monitor its own compliance with the rules to ensure that its customers are getting best execution of their orders.

The TSE suggests that a specific compliance officer be made responsible for monitoring the firm's trading of small client orders. This person should regularly review the firm's OMS filter settings (and any changes) and OMS logs to determine whether orders that should be entered are withheld and, if they are withheld, whether it was in compliance with the rules. The compliance officer should review trading, paying particular attention to crosses of small orders to ensure that, if intentional, the customer received price improvement.

This review must not be restricted to trading on the TSE, but must include trading of TSE-listed securities on other exchanges.

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