Clean Sweep:
Informed Trading through Intermarket Sweep Orders

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An ISO is a limit order designated for automatic execution in a specific market center even when another market center is publishing a better quotation, as long as the trader submits concurrent orders to the other market. We find that ISOs represent 46% of trades and 41% of volume in our sample. ISO trades have significantly larger information share despite their small trade size relative to non-ISO trades. Post trade return analysis suggests that informed institutions are the main users of ISO trades.

The study of how informed traders conduct their trading to best take advantage of short lived information is of continual interest to both practitioners and academics studying financial markets.[1] This paper examines the use of the Intermarket Sweep Orders (ISOs) and, in particular, whether ISOs are primarily used by informed or uninformed traders. While the specific attributes of ISOs are nuanced, its general properties are as follows. An ISO is a limit order designated for quick and automatic execution in a specific market center and can be executed at the target market even when another market center is publishing a better quotation. When submitting an ISO, however, the submitting investor also needs to fulfill Reg. NMS order-protection obligations by concurrently sending orders to other market centers with better prices. Each order in the package must be marked as an ISO and the orders sent to the market(s) posting better prices must be of sufficient quantity to match their displayed depth at the top of the book Importantly, ISO orders are not subject to auto-routing and are identified with a trade indicator of "F" by the trade initiator.

The benefits of ISO usage include faster execution speed and the ability to capture larger counterparty depth, relative to non-ISO orders. However, the use of ISOs also entails some risks. Specifically, the ISO initiator runs the risk of liquidity depletion before the order is executed. If there is no liquidity available at the targeted market center, within the limit price, the submitted sweep order will not execute. Prices can also move against a trader between the routing decision of an ISO order and when the order actually hits the targeted market center. An

[1] There is a vibrant theoretical and empirical literature modeling and documenting the various ways informed traders may attempt to hide their trades while exploiting their short-lived private information. See, for example, Kyle (1985), Easley and O'Hara (1987), Seppi (1990), Foster and Viswanathan (1990), Barclay and Warner (1993), Chakravarty and Holden (1995), Chakravarty (2001), Chakravarty, Gulen, and Mayhew (2004), Back and Baruch (2007), Anand and Chakravarty (2007), and Alexander and Peterson (2007).

ISO will execute at the targeted market, at a possibly inferior price, while a non-ISO trade would be automatically re-routed to a market center posting the best price.

Our research focuses on three primary economic concerns related to ISO trades. First, we wish to examine if the ISO exemption is widely used in the market. We find that 46% of trades are identified as ISOs, represent 41% of the 146 billion shares traded in our sample. It is clear that the new ISO orders are being extensively employed in the market. Second, we investigate the information content of ISO trades relative to the non-ISO counterpart. We find that ISO trades are more informed than non-ISO trades. While ISO trades have significantly higher effective spreads than non-ISO trades, they also have significantly lower realized spreads after 5 minutes. ISO trades also have a significantly higher information share, based on the information share method of Hasbrouck (1995), than non-ISO trades after controlling for volume effects. And this is true even while the average trade size of ISO trades is significantly smaller than non-ISO trades. Finally we examine if ISO trades represent an institution's attempt to subdivide large orders into many small trade lots in an attempt to hide trading intentions. The ISO exemption was instituted mainly at the request of large institutional traders to allow for efficient filling of large positions. We analyze trade-direction autocorrelation for ISO, and non-ISO transactions using the structural price formation model of Madhavan, Richardson, and Roomans (1997) and find that ISOs have a significantly higher autocorrelation which implies that small ISO trades are fragmented components of large institutional orders. Overall, we conclude that informed institutions pervasively use ISOs in a post Reg NMS marketplace. ISOs may have gained so much popularity primarily because they provide a way to split orders and also allow for faster order executions in today's markets that trade at millisecond speeds.

It is, of course, possible that the ISOs, while intended for institutional traders, have the unintended consequence of being used to simply designate order flow to a particular market center. A key aspect of the ISOs is that it allows the order initiator to designate the market that the order executes in. One of the reasons why some brokers may designate order flow to a particular market is that they may receive a small compensation for such preferenced order flow, based on the assumption that such order flow is uninformed – a highly desirable feature from the market maker's perspective. Therefore, it is possible that ISOs are simply uninformed preferenced order flow? Our findings suggest the opposite. i.e., ISOs are informed transactions. We adopt the Preferencing Measure (*PM*), defined as the ratio of the realized spread and the effective spread (see He, Odders-White, and Ready (2006)), to further evaluate the execution quality of ISO trades. We find that the *PM* is uniformly smaller for ISO trades compared to non-ISO trades, indicating that ISO trades have better market execution quality. The better execution quality of ISO trades and lower realized spreads, relative to non-ISO trades, implies that ISO trades are typically used by the informed traders.

We contribute to the literature in several ways in addition to being the first to characterize the properties, and the use, of ISO type trades. By showing that ISO trades overall have higher information content than non-ISO trades, we underscore the potential importance of ISOs in studies of informational events like firms' quarterly earnings announcements or merger and acquisition announcements. Given the power of ISOs to obtain quicker trade executions, our findings also underscore the importance of ISO use to policy makers and those responsible for market surveillance. Close attention should be paid to changes in sweep order usage — especially prior to significant, price sensitive, information releases in the market.

The rest of the paper is structured as follows: Section I gives background and regulatory motivation for the ISO exemption to the order protection rule. Section II describes the sample, gives a brief description of the DTAQ database used in the analysis, and discusses the trade quote alignment under the current information systems used in the market. Section III presents the results of our analysis. We conclude our investigation of sweep orders in section IV.

I. The ISO mechanism.

To understand the relevance of ISOs, it is useful to consider the provisions of Regulation National Market System (Reg NMS), which was adopted by the Securities and Exchange Commission in June, 2005, and fully implemented by October, 2007. It consists of four main parts; Rule 610, the Access Rule; Rule 611, the Order Protection Rule; Rule 612, the Sub-Penny Rule; and the Market Data Rule.[2] These rules were designed to modernize and strengthen the equity markets in the United States. The order protection rule establishes a price priority in the market, whereby orders submitted to the general market must be routed to the market center(s) posting the best price. ISO orders are an exemption to the Order Protection Rule of Regulation NMS and differ from non-ISO orders in that they are designated for immediate execution on the indicated market center without any re-routing. Table 1 outlines the properties of ISO trades and compares these properties with the properties of non-ISO trades.

****** Insert Table 1 about here ******

The execution venue for an ISO order is designated and is the same as the submission venue, while the execution venue for the non-ISO order can change based on the current price priority of the market, irrespective of initial submission venue. In addition, the routing of orders from one market center to another market center with price priority is not free. Currently, most

[2] The formal definition of an ISO can be found in SEC Rule 600(b)(30).

exchanges charge a fee of roughly 30 cents per 100 shares routed. Since ISO trades must execute on the selected exchange, they avoid potential re-routing charges.

**** Insert Figure 1 about here ****

Figure 1 demonstrates the parallel processing aspects of ISO trades. The ISO exemption allows a trader to simultaneously access the display book of all market centers and was adopted to allow institutional investors immediate access to liquidity at multiple price levels, in multiple markets, to fill large block trades with parallel submission of orders. Non-ISO trades are sequentially processed in the market, routed to the market(s) with the best quoted price, which can change during the processing of the order, causing a delay in execution. This distinction is especially important in a market condition where a single market center holds the price priority on a stock but the posted depth on this market is much smaller than the total size of the desired trade position. The ISO initiator can direct sweep orders to the price priority market that match the posted depth of the market, and simultaneously submit additional sweep orders to markets with slightly inferior, but acceptable, prices. In selecting an ISO order, the initiator can gain trade execution speed at the cost of potentially inferior trade execution prices. In this respect, the ISO order represents the most aggressive order type available in the Reg NMS market.

II. Data and sample

A. Sample and data sources

The implementation of the Order Protection Rule began on July 9, 2007 for a group of 250 pilot stocks. Full implementation for all NMS stocks began on August 20, 2007. We analyze the use of ISO transactions between the period of August 20, 2007 and May 30, 2008, representing 197 trading days. In selecting our sample stocks, we apply the following filters. The stock must exist in the intersection set of the CRSP and DTAQ universes. Stocks are

matched between the CRSP and DTAQ databases by CUSIP. We consider only common stocks in the study, which have CRSP stock code of 10 or 11. To be considered, stocks must have a closing price greater than 10 dollars and less than 1,000 dollars on the last trading day of 2007. We further group stocks of firms into three size classes: large, medium, and small, based on the CRSP market capitalization on the last trading day of 2007. We then take the 40 largest stocks from each group, resulting in a final sample of 120 stocks, 72 of which are listed on the NYSE and 48 on the NASDAQ. For the full sample, the average market capitalization is $50.3 Billion.

We obtain trade and quote data for our sample stocks from the DTAQ database. The DTAQ database is slightly richer than the monthly trade and quote (MTAQ) database used in most microstructure research. The DTAQ database has more extensive condition codes than the MTAQ database, contains time stamps to the millisecond, and also includes the exchange calculated NBBO (posted-NBBO hereafter) for each stock that is traded. ISO trades are identified in the DTAQ database with the condition code F.

Although the DTAQ database has time stamps for quotes and trades to the millisecond, a simple integration of trades and quotes based on this time stamp may not yield the true alignment.[3] Since trades and quotes are controlled by separate systems (SIAC and UTP), and by separate trade and quote plans with varying message bandwidths within each system, it is possible that a reporting lag will exist between trades and quotes.[4] We address this issue first because much of our subsequent analysis is based on inferring trade direction (buys and sells) and accurate trade quote alignment is critical to accurate trade inference.

[3] We thank the editor and an anonymous referee for pointing out this issue.

[4] While the trade and quote data are generated by each market center, for the NYSE listed stocks, the controlling party is the Securities Industry Automation Corporation (SIAC) and for NASDAQ stocks it is NASDAQ Market Data Distribution. Each of these entities produces two plans to control for the dissemination and formatting of the data feed -- a trade plan and a quote plan. For the NASDAQ listed securities, there is the UTP (unlisted trading privileges) Plan, and for the SIAC stocks there is the Consolidated Quote Plan and the Consolidated Trade Plan.

To evaluate any reporting lag between trades and quotes, we follow the basic methods developed in Bessembinder (2003b) and evaluate the price grid location of trades measured against exchange calculated NBBO quotes at several time lags prior to the time stamp of a trade. For each stock day in the sample, we calculate the percentage of trades that are at the quote (bid or ask), outside the quote, or inside the quote for both ISO and non-ISO trades. Quote lags of 0, 10, 50, 500, 1000, and 5000 milliseconds are used to determine the quote that could potentially be in force at the time of the trade. The vast majority of trade executions occur inside the exchange computerized matching engine with no human interaction and the engine executes trades only against existing limit orders. The most appropriate quote lag should therefore be the one that produces the highest level of trades executing at the quote.

******Insert Table 2 about here ********

Panel A of Table 2 shows the price grid results for the full sample and subgroups. In panels B, C, and D, the price grid location results are separated by our firm size groupings. For the large firms in our sample, the highest percentage of ISO trades at the quotes has a value of 50 milliseconds; . At this lag, 78.3% of the trades occur at the posted NBBO, although this value is only 0.3% higher than those at the 10 millisecond lag. Non-ISO trades associated with large size firms display a peak at the quote value at a lag of 500 milliseconds, also at 78.3%, but this level is only 0.3% larger than at a lag of 50 milliseconds. Similar results for the medium and small size companies indicate that the joint peak of trades at the quotes (both ISO and non-ISO) occurs at a quote lag of 1000 milliseconds. Note that this does not imply that trades for medium and small size firms are occurring at a slower pace than those for the large size firms because the issue at hand is merely that of a delayed reporting of trades.

Since the trade and quote data plans and system infrastructure differ for the NYSE and NASDAQ listed securities, we also assess the price grid locations based on the listing exchange. These results are shown in panel E. The joint peak in trades at the quotes for the NASDAQ stocks is found at a quote lag of 50 milliseconds while, for the NYSE listed securities, it is at 1000 milliseconds. In addition, the NASDAQ listed securities have relatively fewer trades outside the quote than the NYSE listed securities. Overall, these results indicate that there may be some misalignment in the time stamps of trades and quotes. Consequently, in the interest of thoroughness, we conduct our transaction cost analysis for quote lags of 0, 50, and 1000 milliseconds.

III. Results

We first examine to what degree the ISO exemption is used in the post Reg NMS market. Descriptive statistics for our sample stocks and the level of ISO use are shown in Table 3. Our sample includes 508.7 million trades producing a trading volume of 145.6 billion shares in our sample period. Of this, 46% of the trades and 41% of the volume are driven by ISO trades. Trades and volume statistics are aggregated at the daily level and then averaged over the sample period. We also break out the trade statistics based on firm size. While there is a wide range in the market capitalization and market volume between the large, medium, and small firm size designations, we find no substantial difference in the use of ISO trades in either the percentage of trades or volume initiated by sweep orders. We also condition the descriptive statistics based on the listing exchange of the sample stock. As one might expect, the average market capitalization, the average number of trades, and the average share volume are all significantly larger for the NYSE listed securities. We also find that the ISO trades are more prevalent in the NASDAQ listed stocks. While 44% of trades in NYSE listed stocks are sweep orders, 52% of trades in

NASDAQ stocks are ISOs. ISO volume, as a percentage of total volume, are also higher on the NASDAQ listed stocks, 48% versus 38% on the NYSE listed stocks.

****** Insert Table 3 about here ******

A. Trade size and distribution of ISO trades

Trade size is a key strategic decision for both informed and liquidity traders. In examining the trade size of ISOs relative to the non-ISOs, we wish to see if there are additional trade characteristics that are selected by the trade initiator. The separating equilibrium in Easley and O'Hara (1987) characterizes the intuition that informed traders will choose large size trades and pay higher spreads while uninformed liquidity based investors will choose small size trades and pay lower spreads.[5]

In order to examine the strategic properties of ISO trades, we compare the trade size characteristics of ISO and non-ISO trades in Table 4. For the full sample, the average size of an ISO trade is 178.8 shares, but for a non-ISO trade, the average size is 217.3 shares. The difference of 38.4 shares is statistically significant at the 1% level. We find that ISO trades, on average, are significantly smaller than non-ISO trades, regardless of the market capitalization of each sub-sample.

****** Insert Table 4 about here ******

Table 4 also shows the median value of the time weighted average NBBO posted depth. We provide this statistic in order to examine if the relative trade sizes of ISO versus non-ISO trades are driven by the availability of market depth (i.e., mechanical in nature) or are a strategic choice by market participants. In calculating this value, we first find the total depth posted on all

[5] The stealth trading literature (see, for example, Chakravarty (2001)) argues that informed traders will choose trade sizes that are intermediate in size – not too large so as to not attract attention and not too small to unduly increase execution costs. The essence of these papers is order splitting over time. However, ISOs allow order splitting across multiple venues as well. In that sense, the findings in our paper extend the literature on the optimal order and trade size choice of informed traders.

markets that match the NBBO ask and bid prices. The time weighted average total depth (ask + bid) is then calculated for each stock day in the sample and the median of this distribution is reported. For example, at any given instant in the market for large stocks, the median expected value of the market depth is 63 round lots or 6300 shares. This measure is the 'reserve supply' in the sense that it represents the residual supply after the contemporaneous demand is satisfied. The depth is relatively large compared to the average trade size of either ISO or non-ISO trades. Thus, liquidity supply is not a binding constraint for either the ISO or non-ISO trades and the choice appears to be driven by other strategic considerations.

***** Insert Table 5 about here *****

In Table 5 we evaluate the frequency distribution of ISO and non-ISO trades. We count the number of trades, conditioned on trade size, for the sample period and then generate a cumulative distribution of the results. While we would wish to select a relatively narrow band of trades in order to better quantify the trade size distribution, odd lot trades do represent a small proportion of the overall trading volume in the markets of about 0.5% and should be accounted for.[6] We therefore select break points that bracket round lot trade sizes. Specifically, we consider trade groupings of <150, 151-250, 251-350, 351-450, 451-650, and >650 shares.

Panel A of Table 5 shows the trade size distribution results for our full sample. For ISO trades, 62.2% are under the 150 share break point while for non-ISO trades 57.7% of trades are less than 150 shares and the difference is statistically significant. We find that 93.8% of ISO trades and 91.8% of non-ISO trades are below the 650 share trade size break point. Although a greater proportion of ISO trades appear to be smaller, we further conduct a non-parametric Kolmogorov-Smirnov (K-S) test to see if the overall trade distributions of ISO and non-ISOs

[6] For example, from http://www.nyxdata.com/nysedata/Default.aspx?tabid=833#oddlot we compared the odd lot volume on March 15, 2010, of 5 million shares to the total NYSE volume of 939 million shares on that day.

differ statistically. The null hypothesis of identical distributions is rejected both for the overall distribution and most order size breakpoints at the 1% level with the exception of the two smallest break point segments for the small stock grouping. Our results imply that ISO transactions represent a statistically distinct subgroup in the market.

B. Are ISO trades informed or preferenced?

Since ISOs are by rule limited to executing in a specified market, they could simply represent preferencing agreements for order flow and, therefore, have little or no incremental informational content over the non-ISO transactions. In this section, we investigate the use of ISOs as order preferencing tools by evaluating the transaction costs associated with ISO and non-ISO trades.

To assess whether ISOs have features similar to uniformed preferenced order flow or informed institutional order flow, we must first infer the buy or sell direction of each trade in our database. To do so, we adopt the trade inference method proposed by Ellis, Michaely, and O'Hara (2000). Specifically, the inference is conducted against the posted NBBO, which is included with the DTAQ database. We follow the methods outlined in the previous section and conduct trade inferences based on quote lags of 0, 50, and 1000 milliseconds.[7]

Effective half spreads are defined as $D_{it}(P_{it} - M_{it})$, where D_{it} is the trade direction indicator that equals 1 for buys and -1 for sells , P_{it} is the trade price, and M_{it} is the exchange posted-NBBO mid-point. The realized half spread is calculated as $D_{it}(P_{it} - M_{it+5})$, where M_{it+5} is the prevailing posted-NBBO quote mid-point 5 minutes after the trade. If there are less than 5 minutes left before the market close (4:00 pm EST), the prevailing NBBO quote at the close of the market is used. Following He, Odders-White, and Ready (2006), the Preferencing Measure

[7] Additional quote lags were analyzed with identical results to those presented and are available from the authors upon request. We limit the presented results to conserve space.

(*PM*) is defined as the ratio of realized spread to effective spread. The advantage of the *PM* measure, over effective and realized spreads, is that it controls for the information asymmetry that underlies the order initiation. This allows the *PM* measure to be used for comparisons between stocks and also between market centers; comparisons that are problematic when using the realized and effective spreads by themselves. If ISO trades are dominated by preferenced order flow then these trades should have a higher preferencing measure compared to the non-ISO trades. On the other hand, if ISOs are used primarily by the informed traders, their preferencing measure should be lower than that for the non-ISO trades.

Table 6 shows the transaction cost results for our sample.[8] While our discussion is focused on the large cap stocks shown in panel B with a 0 millisecond lag in the time stamp of the reference quote, the results of the other Panels are similar. We test if the daily averages of spread and PM measures are statistically different, using a paired t-test, for the ISO and non-ISO trades. The effective half spread for ISO trades is 0.710 cents while that for non-ISO trades is 0.684 cents, for a statistically significant difference of 0.027 cents per share. Although ISO trade initiators pay slightly higher effective spreads at the time of the trade, the realized half spread for ISO trades is much lower at only 0.235 cents, compared to 0.327 cents for the non-ISO trades. The preferencing measure for the ISO trades is also smaller than the preferencing measure for the non-ISO trades, with a statistically significant difference of -0.098. Our results remain consistent with an increase in the lag time for the reference quotes. In sum, we find that ISO execution quality is better, with higher information content, than non-ISO trades, reducing the likelihood that a typical ISO order is preferenced.

****** Insert Table 6 about here ******

[8] Our levels of effective and realized spreads and the levels of the preferencing measure are in line with those presented in He, Odders-White, and Ready (2006).

The differences in effective and realized spreads are economically, as well as statistically, significant. In our sample, large stocks are associated with 136.55 billion share volume, 41% of which were ISO trades. The increase in transaction costs paid by the ISO order initiators, over non-ISO orders, is roughly $16.8M for the 40 largest market capitalization stocks.[9] The realized spread (measuring the profitability of trades to liquidity suppliers) for ISO trades on large cap stocks is smaller than that for non-ISO trades by about 0.091 cents.[10] Results follow the same pattern as the large cap stocks for the other partitions of our analysis. These results indicate that ISO trades are likely to be driven more by informational considerations than the non-ISO trades.[11]

C. Serial correlation and estimated spreads

It is the large institutional orders that are likely to be broken up into small ISO trades and parallel processed through the market in order to quickly capture counter party depth and minimizing price impact. The preceding analysis on spreads and preferencing does not directly take into account the impacts of the serial correlation of trades -- buys followed by more buys and sells followed by more sells -- which is likely if ISO trading is dominated by institutions. The positive serial correlation of trades can lead to an overestimation of the effective spreads for ISO trades. In order to estimate the trading costs associated with ISO versus non-ISO transactions in the face of significant serial correlation (or, trade persistence) likely to be

[9] This number is obtained as follows: 136.55 billion shares x 41% x 0.027 cents per share effective spread difference (based on the 0 millisecond lag).

[10] Based on the realized spread difference, ISO trades for large stocks are 50.4 million dollars more profitable for trade initiators and less profitable for liquidity suppliers than non-ISO trades for the same transaction volume. 136.55 billion shares x 41% x -0.091 cents per share realized spread difference is 50.4 million dollars less profit to liquidity suppliers.

[11] As an additional robustness test, we calculate median values of each spread measure and conduct a Wilcoxon signed rank test to compare ISO and non-ISO trade measures. The non-parametric results, not tabulated for brevity, imply findings similar to those reported in our parametric tests -- ISO trades have higher effective spreads, lower realized spreads, and a better execution quality as measured by the *PM* statistic.

associated with the ISO transactions, we adopt the methodology developed by Madhavan, Richardson, and Roomans (1997), hereafter MRR.[12]

In paticular, the parameters of interest, derived from the MRR method, are S, the implied spread, S^E, the effective spread, r, the fraction of implied spread attributed to asymmetric information, and ρ (Rho), the serial correlation parameter of signed order flow. If ISO transactions are dominated by informed institutional traders, we would expect to find that ISO trades have significantly higher serial correlation of order flow (large orders split into small ISO trades), a higher asymmetric information component of spreads (more informed order flow), and lower spreads (due to the serial correlation of signed order flows). The estimation of the MRR model depends in large measure on the accuracy of trade inference. Additionally, the model estimation is also computationally intensive. We therefore select two reference quote time lags to infer trade direction. First, we use a lag of 0 milliseconds. Second, we use a variable time lag scheme as follows. For large stocks, and NASDAQ listed securities, we use a time lag of 50 milliseconds; for medium and small NYSE listed stocks, we use a time lag of 1000 milliseconds to select the prevailing NBBO quote in order to infer trade direction. We have shown previously that these variable time lags correspond to the lags which result in the highest joint (ISO and non-ISO) proportion of trades executing at the NBBO quotes. The results are shown in Table 7.

********** Insert Table 7 about Here**********

The regression and parameter estimates are very similar between the 0 millisecond lag results and the variable quote lag results. We confine our discussion to the variable lag results. Our first question is whether ISO trades have a higher serial correlation of signed trades than the

[12] MRR assume that order flow follows a general Markov chain process and that it is the unexpected order flow component that is a surprise conveying a permanent impact on the true asset value. In our case, we estimate this unexpected component of the ISO versus non-ISO transactions.

non-ISO trades, consistent with the intuition that institutional traders might be breaking up order flow with ISO trades. We find that rho (ρ), the serial correlation of order flow, is significantly higher for ISO trades than for non-ISO trades for all firm sizes included in our sample, although the magnitude of this difference decreases with firm size. This finding supports our contention that ISO trades are driven by institutional traders breaking up large orders into small ISO transactions. Our results also indicate, that once serial correlation of trades is taken into consideration, both the implied spread, S, and the implied effective spread, S^E, are lower for ISO trades than for non-ISO trades. In other words, ISO trades may not only allow traders to capture counterparty depth quicker, they may also have lower execution cost than non-ISO trades. The last parameter we consider is *r*, the ratio of the implied spread attributable to asymmetric information. Uniformly we find that a greater proportion of the implied spread is driven by asymmetric information for ISO trades than for the non-ISO trades. For example, we show that, for large stocks, the proportion of the spread attributable to asymmetric information for ISO trades is 0.899 or roughly 90% while, for non-ISO trades, the proportion is only 0.343, or about 34%. These results strengthen our primary assertion that ISO orders represent a popular trading choice for informed traders in a post Reg NMS market.

D. Information share of ISO trades

While the lower realized spreads of ISO trades imply that these trades are, *ex-post*, more informed than non-ISO trades, a key effect of informed traders in the market is to improve the price discovery process. If ISO trades are dominated by informed institutional traders, then we should expect to see greater price discovery associated with these transactions. To address the issue of relative price discovery between ISO and non-ISO trades, we turn to the *Information Shares* method developed by Hasbrouck (1995). In particular, Hasbrouck's method uses a

vector autoregressive error correction model to decompose the random walk contribution from each price vector into the efficient price evolution process. In essence, if the price of non-ISO trades reacts to the price change of ISO trades, then ISO trades have a higher contribution to the price discovery process.

Operationally, we use the last transaction price of ISO (non-ISO) trades for each second. The use of transaction prices follows the application in Hasbrouck (2003), Anand and Chakravarty, Gulen, and Mayhew (2004), and Goldstein, Shkilko, Van Ness, and Van Ness (2008), among others. Our transaction prices can vary 'across' markets as well as 'within' markets. The fact that transaction prices can come from any market center for each price vector is similar to Hasbrouck (1995) using the best price from all regional markets as one price channel in his analysis. Unless the resulting variance co-variance matrix is diagonal, the information share estimate for each order type is not uniquely identified. We therefore take the average of the upper and lower bounds as our point estimate of information share. Information shares are estimated for each stock-day in our sample.

To help aid in the information shares analysis we define the following Information Ratio metric:

$$InfoRatio_{i,t} = \frac{TradeTypeInfoShare_{i,t}}{TradeTypeVolume_{i,t}} \qquad (1)$$

where *Trade Type InfoShare*$_{i,t}$ is the point estimate of Hasbrouck's information share for stock *i* on day *t* and *Trade Type Volume*$_{i,t}$ is the percentage of total share volume of the type of trade, ISO or non-ISO, observed for the day. An information ratio that is greater than 1.0 indicates that the trade type carries information above and beyond its simple volume, while an information share below 1.0 indicates that the trade type carries less information.

****** Figure 2 about here ******

Figure 2, shows the proportionate information ratio of ISO and non-ISO trades for the full sample of stocks. It also shows the percentage of volume traded with ISO orders for the sample period.[13] We also include the pre-sample period, representing the pilot period of the ISO implementation. Adoption of the ISO trade mechanism moved quickly over this period. On the first day of the implementation, ISO trading represented 12% of trading volume, but by the end of the first week of the pilot period ISO volumes increase to 30% of the total and continue to rise until full implementation on August 20. Throughout the remainder of the sample period, ISO volumes remain relatively constant. We feel that most of the learning process involved for ISO trading occurred in the pilot period with only detail refinements after the August 20 implementation date.

We formally test the implications of Figure 2 in Table 8. In introducing the information share method, Hasbrouck (1995) finds that the price discovery process is under represented in the regional exchanges because the proportion of the information share is well below the percentage of the transaction volume executed on these exchanges. We formalize this intuition by conducting a paired t-test comparing the proportion of ISO trade volume to the information share of the ISO trades. Each sample point in the test represents one stock-day of our sample. Results are presented, conditional on the market capitalization grouping of the firms in our sample. The results are most striking for the large stocks. While ISO trades represent over half of the information share of trades, with an equally weighted average information share of 0.508, the equally weighted average proportion of ISO volume is only 0.402.[14] The difference of 0.106

[13] ISO and non-ISO volume completely partition the sample. The proportion of non-ISO volume is simply one minus the proportion of ISO volume.

[14] This volume proportion differs slightly from the value in Table 2 because the ISO volume proportion is first calculated by each stock and then averaged, while in Table 2 all trade volumes are summed to create a market level proportion of ISO volume.

is significant at the 1% level. Although our analysis does not specifically control for the trade sizes of ISO versus non-ISO trades, to confirm that larger trade sizes are not driving our results, we calculate the average trade size of each trade included in the information share analysis. For large cap stocks, the ISO trades included in the sample are in fact 93.7 shares smaller, on average, than the non-ISO trades in the analysis. For each of the market capitalization groups considered in our analysis, trades sizes of the ISO trades are consistently smaller than those of the non-ISO trades included in the information shares analysis. [15] This finding differs markedly from previous findings reported in the stealth trading literature that shows that medium sized trades have the largest impact on the price discovery process. In our analysis, smaller ISO trades appear to fulfill a similar role. These results hold for each of the market capitalization groups in our study, although the differences are smaller for smaller firms, and also when the results are partitioned by the listing exchange.

****** Insert Table 9 about here ******

E. Intraday variations

Up to this point we have shown that ISO trades are widely used in the market, have better trade execution quality, and carry significantly more information than non-ISO trades. In addition, from the MRR regression, we have shown that ISO trades likely represent order splitting of much larger order positions into multiple ISO trades of small sizes. We next examine the intraday usage of ISOs.

To conduct the intraday analysis we divide the trading day into 78 five minute segments. Since the presented evidence indicates that ISO trades are components of significantly larger orders, we expect that ISO use will have a positive serial correlation. After all, it will take time

[15] In a related trade size analysis, Blau, Van Ness, and Van Ness (2009) find that while larger trades dominate intraday returns at the open and close, smaller trades dominate intraday returns during the afternoon when markets tend to be thin.

to fill a large order with an average trade size of only 179 shares. We therefore include the percent of ISO volume traded in the three previous periods as a determinant of the current period ISO use. Among the several advantages of ISO trades is the ability to parallel process order flow through multiple exchanges simultaneously as shown in Figure 1, even if the posted liquidity on some exchanges is outside the best prices. In order to capture the market conditions that allow for the parallel processing ability of ISO trades we define the variable *Brdth*. $Brdth_{i,t}$ is the time weighted average number of market centers that offer depth at, or within, the flicker quote as a percentage of market centers that can quote for the stock.[16] A quote is at, or within, the flicker if the quote price (ask or bid) is equal to or better than the least aggressive NBBO ask or bid quote over the previous one second.[17]

The amount of posted depth is another factor that could impact the choice between ISO and non-ISO trades. High posted depth at a market center that matches the best price of the market might lead to the use of non-ISO trades to access the large liquidity reservoir. To examine this possible determinant, we include the peak level of quoted depth, *PkDpth*. For each market center we calculate the time weighted depth (ask+bid) that matches the NBBO for each time segment. *PkDpth* is then the single largest time weighted depth of the market centers contained in the DTAQ database for each of the 78 period of the day. Also included is the time weighted relative spread, based on the NBBO quote, *Rsprd*, and the NBBO quote mid-point volatility for the period. To investigate time of day effect of ISO use we also include *TimeDum*; intraday dummies for each ½ hour of the trading day with the middle period 8 dropped from the

[16] Market breadth has also been examined in the form of quote competitiveness in Bessembinder (2003a).
[17] Rule 611 restricts trade throughs, however, with the speed at which trading occurs currently, measuring trade throughs based on an instantaneous price in the market is problematic. The SEC therefore adopted the flickering quotes rule whereby trade throughs are measured against the least aggressive ask and bid prices over the previous one second of trading. All liquidity posted within the flicker quotes is available for immediate execution without violating the order protection rule.

regression as the base case. We estimate the following equation using fixed effects in pooled data. Alternatively, we also estimate the equation for each individual equity and report the average of the estimated coefficients. Our formal estimation model is as follows:

$$\begin{aligned} \%ISO_{i,t} = \alpha + \sum_{k=1}^{3} \beta_k \%ISO_{i,t-k} + \beta_4 Brdth_{i,t} + \beta_5 PkDpth_{i,t} + \beta_6 Rsprd_{i,t} \\ + \beta_7 MpVar_{i,t} + \sum TimeDum + \varepsilon_t \end{aligned} \tag{2}$$

The results of these regressions are shown in Table 9.

**** Insert Table 9 about here ****

For the fixed effects regression we estimate three specifications. The first specification, S1, includes only the intraday time dummy variables. The results indicate that ISO use is somewhat curtailed at the initial stages of the trading day and then increases after that. All subsequent statistically significant intraday time dummy variables, after the first period dummy dd1, are positive. ISO use appears to peak during the last part of the trading day just before market close. Our second specification, S2, includes the lagged values of ISO use. This specification significantly increases the explanatory power of the regression. The coefficients of each of the lagged use variables are positive and significant with decreasing size of the coefficients indicating the ISO use has a positive serial correlation that tends to decay over time.

Our third specification, S3, includes our proxies for market liquidity conditions that impact the selection of ISO trades by order initiators. The coefficient for *Brdth* is negative and significant indicating that ISO use increases as market breadth narrows. It is our position that the most liquid markets are those with narrow spreads, large posted depth, and many market centers posting liquidity at the best prices in the markets. Under these conditions, informed traders can self route non-ISO trades to these market centers that will be executed because all market centers have price priority. However, when markets breadth narrows, the amount of protected liquidity

available for immediate execution decreases.[18] Informed institutional traders with large share demand turn to the more aggressive ISO trade type to simultaneously access posted liquidity that is at, and outside of, protected prices in order to meet their demand. In short, our findings indicate that traders become more aggressive as markets narrow. The coefficient for *PkDpth* is negative and significant for the S3 fixed effects regression. We interpret our finding as follows. When a market center posts a large reservoir of liquidity, informed institutional traders can access that liquidity using non-ISO orders, which, based on our results, convey less information to the market.

The last two liquidity variables that we consider are the relative spread variable, *Rsprd*, and the NBBO quote mid-point volatility, *MpVar*. We find that, as spreads widen, the use of ISO transactions decreases. As spreads widen the cost of demanding immediacy increases, but the costs of reaching additional liquidity past best prices with ISO trades increase even more, curtailing the benefits of ISO trades by increasing the associated costs. Although ISO use decreases as spreads widen, ISO use increases as quote mid-point volatility increase. As quote mid-points begin to trend away from the average, informed traders face a choice of trading now at known prices, or waiting to trade later, hoping that the price trend will mean revert back to the average. Our results indicate that informed traders prefer to trade now, opting for the aggressive ISO trades, and seizing liquidity at current prices, before prices trend away to their new mean values based on new information.

We also estimate specification three, S3, for each individual stock in the sample. We then present the average of each of the coefficients from the 120 regressions and test if the average estimates are statistically different from zero. The results are shown in Table 9 under the column labeled 'Individual'. The results of the individual regressions are very similar to the

[18] In unreported results we find that the correlation between market breadth and protected quote depth is 0.96.

cross sectional fixed effects time series regression, with no significant sign reversals. Overall the coefficients are of approximately the same magnitude with the exception of the *Rsprd* and *MpVar* coefficients. This may indicate that ISO use is more sensitive to these variables than would be indicated by the fixed effects regression. The results from the intraday dummy variables indicate that ISO use is lower during the early part of the trading day and then increases towards the end of the trading day, as the time available to fill orders decreases. The adjusted R^2 presented for this column represents the average R^2 from all of the regressions.

Over all our regression analysis indicates that the selection of ISO type trades is sensitive to the liquidity conditions prevailing in the market at the time of the trade-type choice. When there are relatively large reservoirs of posted liquidity available, informed traders migrate to non-ISO trades to limit exposure to potentially inferior trade execution prices. Traders also migrate to non-ISO trades when the transaction costs associated with ISO-type transactions increase, i.e., spreads widen. However, ISO use increases when markets become more volatile or when markets become narrower.

IV. Conclusion

In this paper we investigate the properties of the new Intermarket Sweep Order (ISO), an important exemption to the Order Protection Rule of Regulation NMS, Rule 611. We find that the ISO transactions are associated with both statistically and economically significant lower realized (higher effective) spreads when compared to non-ISO trades and that they are not likely to be preferenced trades originating from uninformed traders. We also find that ISO trades dominate the information share component of the efficient price as estimated by the Hasbrouck (1995) methodology, even though ISO transactions are significantly smaller than non-ISO transactions. Further, from an examination of the serial correlation of signed order flow from

transaction data associated with ISO and non-ISO trades, we find that ISO transactions display a significantly higher serial correlation of signed trades than non-ISO transactions. This finding implies that institutional traders use ISO transactions in bunches, submitted simultaneously, in order to fill large stock positions.

We find that ISO use is lower at the front end of the trading day and picks up towards the back end of it. In addition, ISO use decreases when spreads widen but increases as the volatility of the quote mid-point increases. Our results also imply that when a single market center offers a large liquidity reservoir, traders are more likely to select non-ISO orders. Likewise, when the market narrows, i.e., fewer market centers offering competitive prices, traders shift to ISO transactions in order to tap into liquidity outside of the best prices in order to fill demand.

While the current research takes a modest first step in understanding the usage of ISOs, future research should examine the role of ISOs in periods surrounding corporate events such as earnings announcements or mergers and acquisitions and market events such as the flash crash or other periods of extreme liquidity crisis in order to better understand investor behavior around such events. At a minimum, our analysis implies that future empirical and theoretical research will need to consider the potential usage of ISOs as a trading strategy by informed traders.

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FIGURE 1
Non-ISO and ISO trade routing and execution

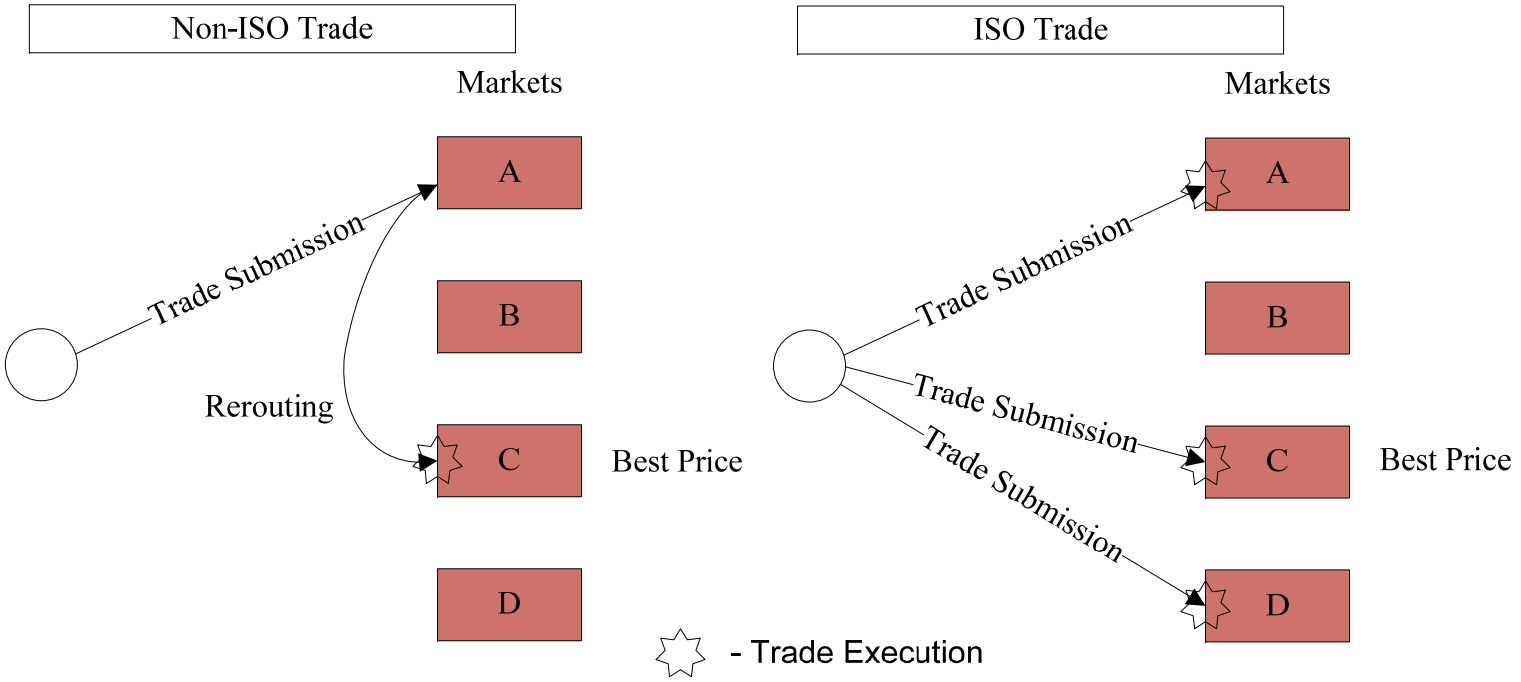

FIGURE 2

Time Series of Information Ratio

Time series plot of the information ratio for each trade type, Non-ISO and ISO. The information ratio is defined as the information share of a given trade type divided by the volume share of that trade type. We plot the equally weighted average information ratio for each day in our sample.

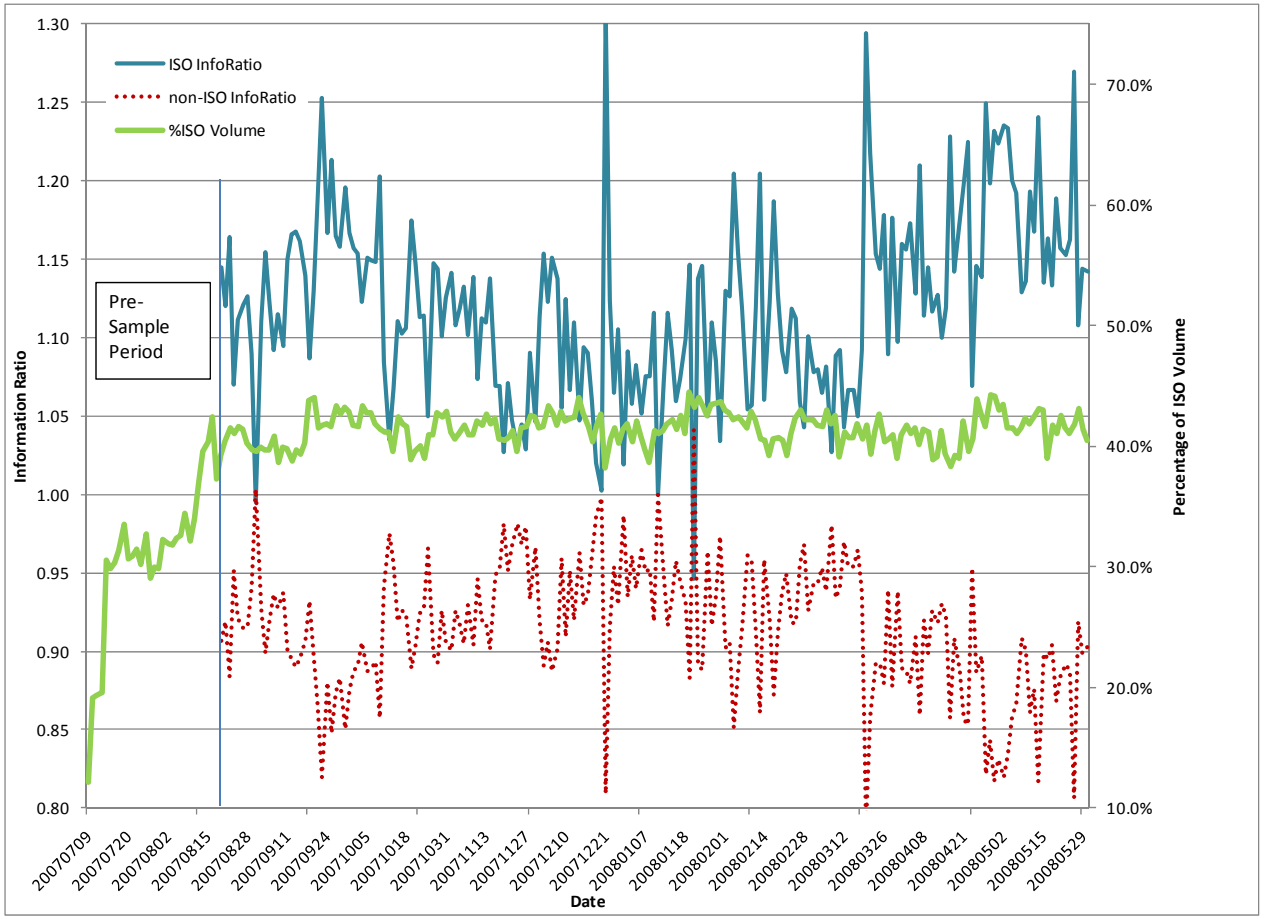

Table 1
ISO orders versus non-ISO orders

We compare the properties of ISO and non-ISO orders based on the sweep order exemption of the Order Protection Rule, Rule 611 of Regulation NMS.

		ISO Order	Non-ISO Order
1	Submission venue	Specific instruction to execute at the market center where submitted	Always searches for the price priority market irrespective of submission venue
2	Execution Venue	Executes at submission venue	Reroutes to market center with price priority, if necessary
3	Order Type	Has to be a limit order	Can be market, limit, or any other type of order
4	Execution method	Allows parallel processing across multiple markets	Sequential processing. Price priority market is established before and after every partial trade
5	Execution Speed	Faster	Slower
6	Execution Quantity	Helps capture bigger counterparty depth through parallel processing	Some order quantity can remain unexecuted or execute at changed prices
7	Execution price	Executes at the current quote within each market center	Can only execute at best prices within the previous one second or get rerouted to the center with price priority
8	Trade Through	Allowed with concurrent execution of all better posted prices	Not allowed

Table 2
Trade grid location

The trade grid represents the price that a trade is executed at relative to the exchange calculated NBBO. At Quotes means that the trade price is at the NBBO bid or ask, Inside Quotes means that the trade price is between the bid and ask, and Outside Quotes means that the trade price is either greater than the NBBO ask or less than the NBBO bid. Lag represents the number of milliseconds, prior to the trade time stamp, that the in force NBBO reference quote is selected. If there is less than the Lag period between the trade time stamp and the open of the market, the opening NBBO quote is used.

	ISO			Non-ISO		
Lag	At Quotes	Inside Quotes	Outside Quotes	At Quotes	Inside Quotes	Outside Quotes
Panel A: Full Sample						
0	68.7%	24.2%	7.1%	68.3%	26.7%	5.0%
10	71.8%	20.9%	7.3%	70.6%	24.3%	5.1%
50	73.4%	18.5%	8.1%	72.4%	22.3%	5.3%
500	74.0%	14.4%	11.6%	73.8%	19.5%	6.6%
1000	75.2%	8.8%	16.0%	75.9%	14.6%	9.5%
5000	60.6%	11.2%	28.2%	59.7%	16.8%	23.5%
Panel B: Large Stocks						
0	77.7%	10.9%	11.4%	77.0%	14.0%	9.0%
10	78.0%	10.5%	11.5%	77.3%	13.7%	9.0%
50	78.3%	9.7%	12.0%	78.0%	13.1%	8.9%
500	77.5%	7.6%	14.9%	78.3%	12.0%	9.8%
1000	73.8%	4.4%	21.8%	76.3%	9.4%	14.4%
5000	54.7%	4.6%	40.6%	55.1%	8.2%	36.8%
Panel C: Medium Stocks						
0	64.2%	29.6%	6.1%	64.6%	31.3%	4.1%
10	65.8%	28.0%	6.2%	65.6%	30.2%	4.1%
50	67.5%	25.7%	6.8%	67.3%	28.5%	4.2%
500	71.3%	19.2%	9.5%	70.7%	24.2%	5.2%
1000	77.6%	8.7%	13.7%	77.7%	14.7%	7.5%
5000	62.7%	12.1%	25.2%	61.0%	18.5%	20.5%
Panel D: Small Stocks						
0	64.2%	32.0%	3.7%	63.3%	34.7%	2.0%
10	71.8%	24.1%	4.1%	68.8%	28.9%	2.2%
50	74.5%	20.1%	5.4%	72.0%	25.3%	2.7%
500	73.2%	16.5%	10.3%	72.5%	22.5%	5.0%
1000	74.3%	13.2%	12.4%	73.8%	19.7%	6.5%
5000	64.2%	16.9%	18.9%	63.1%	23.7%	13.2%

Table 2 Continued						
Panel E: By listing exchange						
NYSE						
0	66.8%	24.0%	9.2%	67.6%	25.4%	7.0%
10	67.2%	23.6%	9.2%	68.0%	25.1%	6.9%
50	68.6%	22.1%	9.3%	69.2%	24.0%	6.8%
500	72.8%	16.5%	10.7%	72.9%	20.6%	6.4%
1000	76.4%	6.8%	16.8%	78.1%	12.1%	9.8%
5000	58.5%	9.1%	32.3%	57.8%	14.3%	27.9%
NASDAQ						
0	71.6%	24.5%	3.9%	69.3%	28.6%	2.1%
10	78.8%	16.8%	4.4%	74.5%	23.1%	2.4%
50	80.7%	13.1%	6.2%	77.3%	19.8%	3.0%
500	75.8%	11.3%	12.9%	75.1%	17.9%	7.0%
1000	73.4%	11.7%	14.8%	72.7%	18.4%	8.9%
5000	63.6%	14.3%	22.1%	62.6%	20.6%	16.8%

Table 3
Sample descriptive statistics

Our sample period consists of 197 trading days starting August 20, 2007 and ending May 30, 2008. Market capitalization values are based on the last trading day of 2007. Sample stocks are selected based on the following criteria. First, the stocks must exist in the intersection set of the DTAQ and CRSP databases. The stock must have a closing price greater than ten dollars and less than 1,000 dollars on the last trading day of 2007 and must be a common stock (CRSP share code 10 or 11). Stocks are then grouped as large, medium, or small based on market capitalization. The top 40 stocks, based on market capitalization, from each grouping form the sample of 120 stocks considered in this study. ISO trades are identified in the DTAQ database as condition code F.

	Number of firms	Average market capitalization (billions)	Number of trades (millions)	Percent ISO Trades	Share volume (billions)	Percent ISO volume
Full Sample	120	50.30	508.70	46%	145.60	41%
by firm size						
Large	40	148.55	460.39	47%	136.55	41%
Medium	40	1.89	39.07	44%	7.45	40%
Small	40	0.45	9.24	50%	1.61	45%
by listing exchange						
NYSE	72	67.13	363.64	44%	96.38	38%
NASDAQ	48	25.05	145.06	52%	49.23	48%

Table 4
Comparison of trade size for sweep and non-sweep trades

A comparison of average trade size of ISO and Non-ISO trades. T-values are based on a means difference t-test. The median NBBO quoted depth represents the total (top of the book) quoted depth, ask plus bid, from all market centers matching the NBBO ask or bid price in shares.

Sample	ISO	Non-ISO	Difference	t-value	p-value	Median NBBO Quoted Depth
Full Sample	178.8	217.3	-38.4	-46.2	0.0000	1,300
Large Stocks	235.5	291.8	-56.9	-32.3	0.0000	6,300
Medium Stocks	157.4	187.3	-29.9	-39.1	0.0000	1,200
Small Stocks	143.5	172.7	-29.2	-30.6	0.0000	700

Table 5
Trade size distribution for ISO and Non-ISO trades

Comparison of trade size for ISO and Non-ISO trades. ISO Trades represents the count of trades that occur in the indicated trade size grouping. Our sample period consists of 197 trading days starting August 20, 2007 and ending May 30, 2008. Market capitalization values are based on the last trading day of 2007. Sample stocks are selected based on the following criteria. First, the stocks must exist in the intersection set of the DTAQ and CRSP databases. The stock must have a closing price greater than ten dollars and less than 1,000 dollars on the last trading day of 2007 and must be a common stock (CRSP share code 10 or 11). Stocks are then grouped as large, medium, or small based on market capitalization. The top 40 stocks, based on market capitalization, from each of the 3 groupings form the sample of 120 stocks considered in this study. K-S test is the p-value of a Kolmogorov-Smirnov distribution test where the null hypothesis is that the distributions of ISO and non-ISO trades are equal. We reject this hypothesis for the full and all sub samples.

Trade Size	ISO Trades (millions)	Percent	Non-ISO Trades (millions)	Percent	K-S Test
Panel A: Full Sample					
<150	146.97	62.2%	157.24	57.7%	<0.0001
151-250	39.16	16.6%	44.97	16.5%	<0.0001
251-351	14.26	6.0%	19.06	7.0%	<0.0001
351-450	9.58	4.1%	12.67	4.7%	<0.0001
451-650	11.59	4.9%	16.08	5.9%	<0.0001
>650	14.77	6.2%	22.35	8.2%	<0.0001
Total	236.33	100.0%	272.37	100.0%	<0.0001
Panel B: Large Stocks					
<150	130.44	60.8%	138.08	56.1%	<0.0001
151-250	36.28	16.9%	41.39	16.8%	<0.0001
251-351	13.26	6.2%	17.68	7.2%	<0.0001
351-450	9.06	4.2%	11.94	4.9%	<0.0001
451-650	11.13	5.2%	15.34	6.2%	<0.0001
>650	14.29	6.7%	21.50	8.7%	<0.0001
Total	214.46	100.0%	245.94	100.0%	<0.0001
Panel C : Medium Stocks					
<150	12.78	74.0%	15.51	71.2%	<0.0001
151-250	2.43	14.0%	3.12	14.3%	<0.0001
251-351	0.84	4.9%	1.20	5.5%	<0.0001
351-450	0.44	2.6%	0.64	2.9%	<0.0001
451-650	0.39	2.3%	0.63	2.9%	<0.0001
>650	0.40	2.3%	0.70	3.2%	<0.0001
Total	17.27	100.0%	21.80	100.0%	<0.0001
Panel D: Small Stocks					
<150	3.75	81.5%	3.65	78.7%	0.077
151-250	0.46	10.0%	0.47	10.1%	0.081
251-351	0.15	3.4%	0.18	3.9%	<0.0001
351-450	0.08	1.7%	0.10	2.1%	<0.0001
451-650	0.07	1.6%	0.11	2.3%	<0.0001
>650	0.08	1.8%	0.14	3.0%	<0.0001
Total	4.60	100.0%	4.64	100.0%	<0.0001

Table 6

Half-spread analysis of ISO and Non-ISO trades

All spread calculations are based on the exchange posted NBBO contained in the DTAQ database. Lag represents the number of milliseconds, prior to the trade time stamp, that the in force NBBO reference quote is selected for both effective and realized spreads. If there is less than the Lag period between the trade time stamp and the open of the market, the opening NBBO quote is used. Trade direction inference is based on Ellis, Michaely, and O'Hara (2000). Effective half spreads are defined as $D_{it}(P_{it} - M_{it})$, where D_{it} is the trade direction indicator, P_{it} is the trade price, and M_{it} is the exchange posted NBBO mid-point. The realized half spread is calculated as $D_{it}(P_{it} - M_{it+5})$, where M_{it+5} is the prevailing NBBO quote mid-point 5 minutes after the trade adjusted based on the NBBO quote lag level. If there are less than 5 minutes left before the market close (4:00 pm EST), the prevailing NBBO quote at the close of the market is used. The Preferencing Measure is defined as the ratio of realized spread to effective spread from He, Odders-White, and Ready (2006). We calculate the time weighted effective and realized spreads for each stock day in our sample and then conduct a paired t-test between ISO and Non-ISO spread measures. The results of this paired difference t-test are shown in the Paired Dif column.

	Effective Spreads			Realized Spreads			Preferencing Measure		
Lag	ISO	Non-ISO	Paired Dif	ISO	Non-ISO	Paired Dif	ISO	Non-ISO	Paired Dif
Panel A; All stocks by lag									
0	1.108	1.010	0.098**	0.062	0.178	-0.116**	0.136	0.242	-0.106**
50	1.244	1.099	0.146**	0.009	0.139	-0.130**	0.105	0.206	-0.101**
1000	1.610	1.312	0.298**	-0.193	-0.033	-0.160**	-0.132	-0.029	-0.104**
Panel B: Large stocks by lag									
0	0.710	0.684	0.027**	0.235	0.327	-0.091**	0.393	0.491	-0.098**
50	0.762	0.711	0.051**	0.204	0.301	-0.097**	0.350	0.450	-0.100**
1000	1.107	0.893	0.214**	-0.050	0.072	-0.122**	-0.102	0.030	-0.133**
Panel C: Medium stocks by lag									
0	1.012	0.909	0.102**	0.235	0.327	-0.084**	0.393	0.491	-0.112**
50	1.078	0.948	0.130**	0.204	0.301	-0.094**	0.350	0.450	-0.109**
1000	1.525	1.233	0.292**	-0.050	0.072	-0.126**	-0.102	0.030	-0.091**
Panel D: Small stocks by lag									
0	1.603	1.437	0.166**	-0.179	-0.007	-0.172**	-0.105	0.003	-0.108**
50	1.893	1.637	0.256**	-0.269	-0.070	-0.199**	-0.123	-0.028	-0.095**
1000	2.199	1.810	0.389**	-0.395	-0.163	-0.232**	-0.180	-0.092	-0.087**

Table 6 continued									
Panel E: NYSE listed by lag									
0	0.861	0.795	0.066**	0.235	0.286	-0.051**	0.326	0.406	-0.079**
50	0.897	0.815	0.083**	0.211	0.267	-0.056**	0.296	0.378	-0.082**
1000	1.340	1.081	0.259**	-0.092	0.012	-0.104**	-0.093	0.014	-0.107**
Panel F: NASDAQ listed by lag									
0	1.479	1.333	0.146**	-0.198	0.016	-0.213**	-0.150	-0.003	-0.147**
50	1.765	1.525	0.240**	-0.294	-0.052	-0.242**	-0.183	-0.053	-0.130**
1000	2.016	1.657	0.358**	-0.346	-0.102	-0.244**	-0.191	-0.093	-0.099**

* - statistically significant at the 5% level
** - statistically significant at the 1% level

Table 7
MRR regression results

We analyze the implied spreads of ISO and non-ISO trades using the method of Madhavan, Richardson, and Roomans (1997). They propose estimating the following regression:

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

Subject to the following moment constraints:

$$E\left(x_t x_{t-1} - x_t^2\rho, |x_t| - (1-\lambda), u_t - \alpha, (u_t - \alpha)x_t, (u_t - \alpha)x_{t-1}\right) = 0$$

Where p_t is the trade price, θ is the asymmetric information parameter, ϕ is the cost of supplying liquidity, λ is the probability a trade occurs inside the quote, ρ is the autocorrelation of order flow, $u_t = p_t - p_{t-1} - (\phi + \theta)x_t + (\phi + \rho\theta)x_{t-1}$, α is a constant (drift) parameter, and x_t is a trade direction indicator. In particular, x_t is 1 if the trade is buyer initiated (at or above the NBBO ask), -1 if the trade is seller initiated (at or below the NBBO bid), and 0 if the trade is inside the NBBO quote. The implied spread, S, can this be consistently estimated as $S = 2(\phi + \theta)$, the effective spread, S^E, can be estimated as $S^E = (1-\lambda)(2\phi + \theta)$, and the fraction of implied spread attributed to asymmetric information, r, can be estimated as $r = \theta / (\phi + \theta)$. We estimate the equation separately for ISO and non-ISO trades. To calculate the price change, p_t - p_{t-1}, p_t is always the trade price from the trade type that we are estimating, but p_{t-1} is simply the last trade price and can be either ISO or non-ISO trades. We drop December 24, 2007 from the analysis because it is only a partial trading day, leaving 196 sample days. For large stocks we estimate the equation for every 10 minutes of the trading day, spanning every 7 days. For medium stocks we estimate ever hour of the trading day, except 1.5 hours for the last segment of the day, spanning every 14 trading days. For small stocks it is again every hour, except for the last 1.5 hour segment, spanning every 28 trading days. Spread results are displayed in cents.

	S			S^E			r			Rho		
Firm Rank	Iso	Niso	Paired Dif	Iso	Niso	Paired Dif	Iso	Niso	Paired Dif	Iso	Niso	Paired Dif
Panel A: 0 millisecond quote lag												
Large	0.98	1.24	-0.264**	0.56	0.85	-0.286**	0.479	0.151	0.328**	0.672	0.546	0.126**
Medium	2.02	2.01	0.009	1.18	1.26	-0.077**	0.206	0.060	0.146**	0.474	0.368	0.106**
Small	2.64	2.98	-0.341**	1.24	1.46	-0.218**	0.503	0.378	0.124**	0.450	0.370	0.080**
Panel B: 1000 millisecond quote lag for medium and small NYSE stocks, 50 millisecond lag for all others												
Large	1.11	1.30	-0.198**	0.52	0.85	-0.329**	0.899	0.343	0.556**	0.718	0.583	0.135**
Medium	1.78	1.83	-0.059**	0.73	1.02	-0.289**	0.972	0.547	0.425**	0.529	0.420	0.110**
Small	2.40	2.49	-0.084**	0.91	1.12	-0.211**	1.039	0.764	0.275**	0.496	0.403	0.093**

* - statistically significant at the 5% level
** - statistically significant at the 1% level

Table 8
Information share evaluation

The table contains the evaluation of the impact of ISO trades on the price discovery process using the information share method of Hasbrouck (1995, pp 1182). The method uses a vector autoregressive error correction model to decompose the random walk contribution from each price vector of a two price channel input into the overall efficient price evolution process. The mean information share is the contribution of ISO trades in the overall variance of ISO and non-ISO trades. We conduct a paired t-test comparing the proportion of information share to the proportion of ISO trade volume. Each sample point in the test represents one of the 23,622 stock days in the sample. In conducting the information share analysis, we use the last ISO (non-ISO) trade price for each second containing one or more trades. Information shares are estimated for each stock day in the sample. We present the mean trade size for ISO (non-ISO) trades used in the information share analysis. We also conduct a paired t-test comparing the trade size of ISO and non-ISO trades included in the information share analysis. We first calculate the average trade size for each trade type on each stock day in the sample. The paired t-test is then conducted on the resulting time series.

	Mean Information Share	Mean ISO Volume Proportion	Paired Difference (Info Share)	Mean ISO Trade Size	Mean non-ISO Trade Size	Paired Difference (Trade Size)
Panel A: Market Capitalization						
Large Stocks	0.508	0.402	0.106*	261.7	355.4	-93.7*
Medium Stocks	0.399	0.380	0.020*	157.6	199.7	-42.0*
Small Stocks	0.487	0.461	0.026*	141.6	182.4	-40.8*
Panel B: Listing Exchange						
NYSE Listed	0.399	0.360	0.039*	196.4	252.0	-55.5*
NASDAQ Listed	0.564	0.496	0.068*	172.8	236.6	-63.8*

*Difference is statistically significant at the 1% level

Table 9

Intraday Regression of ISO use

We conduct an intraday analysis of ISO use. Each day is divided into 78 five minute periods. We estimate the following fixed effects regression:

$$\%ISO_{i,t} = \alpha + \sum_{k=1}^{3} \beta_k \%ISO_{i,t-k} + \beta_4 Brdth_{i,t} + \beta_5 PkDpth_{i,t} + \beta_6 Rsprd_{i,t} + \beta_7 MpVar_{i,t} + \sum TimeDum + \varepsilon_t$$

Where $\%ISO_{i,t}$ is then current percentage of ISO volume, $\%ISO_{i,t-k}$ is the lagged ISO volume percentage, *Brdth* is the market breadth, $PkDpth_{i,t}$ is the maximum time weighted quoted depth from the market centers for the period, $Rsprd_{i,t}$ is the time weighted NBBO relative spread, and $MpVar_{i,t}$ is the NBBO quote midpoint volatility. We include 13 time dummies for each ½ hour of the market with td8 dropped from the regression. In addition to the three cross sectional time series fixed effects specifications, we also run specification 3 individually for each sample equity. We then calculate the average coefficient for these regressions and test if they are reliably different from zero. The results are shown under the Individual column heading.

	Fixed Effects			
Variable	S1	S2	S3	Individual
Intercept	0.4904**	0.2795**	0.3107**	0.2581**
$\%ISO_{t-1}$		0.1864**	0.1849**	0.2136**
$\%ISO_{t-2}$		0.1292**	0.1281**	0.1280**
$\%ISO_{t-3}$		0.1121**	0.1113**	0.1113**
Brdth			-0.1390**	-0.0948**
PkDpth			-0.0158**	-0.5529**
RSprd			-0.3808*	-8.7192**
MpVar			0.1004**	22.1464**
Intraday				
td1	-0.0104**	-0.0001	-0.0052**	-0.0126**
td2	-0.0002	0.0030**	0.0000	-0.0054
td3	0.0046**	0.0033**	0.0018*	-0.0010**
td4	0.0008	0.0006	-0.0005	-0.0025
td5	0.0005	0.0012	0.0005	-0.0005
td6	0.0020*	0.0021**	0.0017*	0.0015
td7	-0.0001	0.0008	0.0007	0.0003*
td9	0.0024**	0.0023**	0.0026**	0.0019
td10	-0.0014	-0.0006	-0.0001	-0.0012*
td11	0.0014	0.0021**	0.0029**	0.0022
td12	0.0005	0.0006	0.0022**	0.0013**
td13	0.0104**	0.0078**	0.0097**	0.0087**
Adj R2	0.142	0.229	0.231	0.146

* - significant at the 5% level

** - significant at the 1% level