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Price Dynamics in the Regular and E-Mini Futures Markets

Alexander Kurov and Dennis J. Lasser*

Abstract

This paper examines the price dynamics in the S&P 500 and Nasdaq-100 index futures contracts. By utilizing transactions data with attached trader type identification codes, we are able to analyze price dynamics for trades initiated by exchange locals and off-exchange customers. The empirical results show that price discovery appears to be initiated in the E-mini index futures contracts and that trades initiated by exchange locals seem to be more informative than those initiated by off-exchange traders. Furthermore, results show that exchange locals appear to make informed trades on the E-mini contracts around large trades that occur on the open outcry floor. We maintain that the exchange locals' ability to observe pit dynamics may contribute toward explaining the price leadership of the E-mini contracts. Overall, the results are consistent with the notion that exchange locals are informed traders who derive their informational advantage from the proximity to order flow.

I. Introduction

Price discovery, or transmission of information into prices, is a crucial function of financial markets. Price discovery takes place when order flow from different types of traders is aggregated in a single market, which can be a physical exchange floor or an electronic trading system. This aggregation of trading interests allows for trade prices to correctly represent supply and demand, although market frictions, noise trading, and investor psychology ensure that observed prices are imperfect proxies for the underlying asset values. As markets evolve, it is imperative that the new market structures and trading protocols continue to provide reliable price discovery.

The primary contribution of this paper is to lend evidence on the transmission of information into prices by analyzing information contributions of trades

*Kurov, akurov@binghamton.edu, and Lasser, dlasser@binghamton.edu, School of Management, SUNY-Binghamton, Binghamton, New York, 13902-6000. We thank Erik Devos, Grigori Erenburg, Robert Jennings, Paul Malatesta (the editor), Kristian Rydqvist, Yiuman Tse, Tatyana Zabotina, and especially Joel Hasbrouck (the referee) for helpful comments and suggestions. Thanks also to Joel Hasbrouck for making available the SAS programs for the price discovery analysis. We are also grateful to the Commodity Futures Trading Commission staff for their help in obtaining the data used in this paper. Errors or omissions are our responsibility.

initiated by futures markets exchange locals and off-exchange traders. Specifically, we employ a detailed data set that identifies contra party trader type for each transaction in order to directly test the notion suggested by Manaster and Mann (1996), (1999) that exchange locals have an informational advantage over off-exchange traders. The results also lend evidence toward explaining the result found here and in Hasbrouck (2003) of price leadership in the E-mini futures market.

There has been an ongoing transition from open outcry to electronic trading by equity and futures exchanges around the world. Several studies have looked at relative rates of price discovery in electronic and open outcry markets. Grünbichler, Longstaff, and Schwartz (1994) report that futures prices lead spot prices more when futures are traded electronically. They interpret this finding as evidence that electronic trading accelerates price discovery. Breedon and Holland (1998) and Kofman and Moser (1997) examine the German Bund futures that trade on both the London International Financial Futures Exchange (LIFFE) and the Deutsche Terminborse (DTB), which are floor-based and electronic markets, respectively.[1] The studies show that LIFFE and DTB make similar contributions to the price discovery of the Bund futures. In his study of price discovery on LIFFE and DTB, Martens (1998) shows that when volatility is high the contribution of open outcry market to price discovery increases. The paper concludes that open outcry has an advantage over electronic trading systems in volatile periods because floor traders can observe actions of other traders and that helps them to react faster.

Although most futures industry participants share the view that a permanent move from open outcry to electronic trading in most futures markets is all but inevitable,[2] the majority of the futures trading in the U.S. is still done through traditional open outcry. However, faced with a threat of losing market share to new electronic trading systems and attempting to expand its retail customer base, the Chicago Mercantile Exchange (CME) pioneered the approach of "side-by-side trading." In this hybrid trading model so-called "E-mini" versions of several of the CME's high-volume futures contracts trade virtually around the clock on the electronic GLOBEX trading system. The E-mini S&P 500 futures contract was introduced in September 1997 and the E-mini Nasdaq-100 futures started trading in June 1999. E-mini futures contracts are sized at one-fifth of their floor-traded counterparts to make E-mini trading affordable to traders with small margin accounts. These contracts are the fastest growing products in the CME's history.[3]

When the E-mini contracts were introduced, the full-sized contracts traded through open outcry were expected to serve as the price discovery mechanism for the new electronic markets.[4] GLOBEX monitors were installed around the trading pits, so that the exchange locals could use the price established through open outcry trading to make the market in the electronic system. However, Hasbrouck

[1] LIFFE moved to electronic trading in May 1999.

[2] See, for example, Slutsky (1999), who interviews a number of prominent futures players.

[3] Since 1999, the CME has introduced E-mini versions of futures contracts on the Russell 2000 Index, S&P MidCap 400 Index, Euro FX, Japanese Yen, Lean Hogs, and Feeder Cattle. In addition, electronic daytime trading of Eurodollar futures was initiated in 1999.

[4] See Panel Discussion on Chicago Mercantile Exchange Technology, CNNFN Transcript # 97090409FN-L03, September 4, 1997, 11:30AM EST.

(2003) demonstrates that instead of being an informational satellite of the trading floor the electronic trading system appears to play an important role in the price discovery process for the S&P 500 and Nasdaq-100 indexes. The fact that he examines a period when the floor-traded contracts had a dominant market share in terms of dollar volume makes this finding even more striking.

The empirical results of this paper indicate that price discovery is initiated in the E-mini index futures contracts (consistent with Hasbrouck (2003)) and that price dynamics appear to be driven by trades initiated by exchange locals. These exchange local-initiated trades in the E-mini contracts are found to be more informative than trades initiated by off-exchange traders. Furthermore, the results support the hypothesis that exchange locals trading E-mini contracts use their proximity to the order flow into the pit and superior execution speed of GLOBEX to take advantage of information from large trades that occur on the floor. This trading activity employed by exchange locals seems to at least partially explain why the E-mini contracts appear to be price leaders.

The remainder of the paper is as follows. Section II describes the mechanics of the E-mini market, reviews relevant literature, and suggests testable hypotheses for the paper. Section III describes the data used in the paper. Section IV discusses the methodology and the empirical results. Section V provides a brief summary and conclusions.

II. Background and Hypotheses

The regular and E-mini futures contracts are essentially identical instruments. Traders can liquidate E-mini positions against offsetting positions in the regular futures. The two main differences between the regular and E-mini futures are the smaller size of the E-mini contracts and the fact that, as opposed to the regular futures, the E-minis are traded electronically through GLOBEX. [5]

Important advantages of E-mini trading that could lead to significant improvements in price discovery include increased speed of execution, timely and accurate reporting of fills, improved pricing transparency, high liquidity, and trader anonymity. E-mini traders report that even when they execute trades in GLOBEX through an electronic broker, market orders take only one–two seconds to be filled. Traders in the electronic system receive accurate and instantaneous feedback about the status of their orders. Alternatively, speed of execution in open outcry markets is limited by the mechanics of pit trading. The process of order submission, execution, and relaying the trade information to the customer may take several minutes, especially in periods of high activity in the pit.

Furthermore, GLOBEX trading improves pricing transparency. Even in periods of average trading activity different prices may prevail simultaneously in different areas of the futures pit. This inefficiency is likely to be exacerbated in

[5] GLOBEX is an electronic limit order book market. The system prioritizes limit orders first by price and then by time. Traders can see five best bids and offers in the limit order book. Depending on the depth available at the best bid or offer (BBO), an order can receive a full or partial fill. A partially filled market order in GLOBEX becomes a limit order at that price. Coppejans and Domowitz (1999) describe operation of GLOBEX during the period when it was used as a strictly off-hours trading system.

periods of high volatility. All traders with access to GLOBEX are able to see current bid and offer quotes at all times and have their orders filled at the best available price on a first-in, first-out basis.[6]

Alternatively, E-mini trading has higher transaction costs for larger trades. Brokerage commissions are charged on a per contract basis. Therefore, even if bid-ask spreads in the E-mini market are somewhat smaller, the total transaction costs per dollar of trading volume are likely to be higher in the E-mini market. As a result, one may expect the trading in the E-mini market to be dominated by small retail traders who simply do not have sufficient capital to trade the full-size contracts, while large institutional traders may still actively trade in the lower cost regular contracts.[7]

Traders on the futures trading floor can often get an idea about the type of customer behind the order. At the same time, like most other automated trading systems, GLOBEX offers trader anonymity. Therefore, traders who possess an informational advantage may prefer the anonymous electronic system even if they have to pay higher commissions.[8]

Manaster and Mann (1996), (1999) lend evidence that exchange locals have informational advantage over the off-exchange traders. Locals in futures markets play an important role of providing liquidity by acting as voluntary market makers. However, Manaster and Mann (1999) show that market making is not the main source of their trading profits. Locals have an advantage in both timing their trades and execution costs. To fully exploit their advantage in timing, the locals often sacrifice execution profits. Ferguson and Mann (2001) suggest that, far from being passive order fillers, locals actively take positions based on their observations of order flow from off-exchange customers. Frino, Hill, Jarnecic, and Feletto (2000), Frino and Jarnecic (2000), and Fong (2001) report evidence supporting the notion that locals often trade aggressively to exploit their informational advantage. Alternatively, Daigler and Wiley (1999) suggest that in futures markets institutional traders with access to the trading floor are more informed than the off-exchange traders. In addition to their ability to infer information from the pit dynamics, these traders also have access to real-time information about the cash market and can therefore know the fair value of the contract at any time.

Massimb and Phelps (1994) argue that, given a choice between open outcry and electronic trading, locals are likely to prefer traditional open outcry because "compared with open outcry, an electronic matching system imposes additional costs and risks on the local" (p. 42). Chow, Lee, and Shyy (1996) report empirical evidence supporting this argument.

[6]The fact that unfilled quantities remain on the limit order book may prove to be a liability in "fast markets." Canceling and reentering orders could take some time.

[7]While our data does not identify trade contra parties as institutions or retail traders, the average trade sizes shown in Table 2 can be instructive in this regard. The average dollar value of a regular futures trade exceeds that of an E-mini trade by a factor of about eight.

[8]Huang (2002) shows that electronic communication networks (ECNs), which are electronic limit order books, make a dominant contribution in price discovery of actively traded stocks. Trader anonymity on ECNs is likely to contribute to better price discovery by attracting informed traders.

Trade data analysis from this study, as well as our conversations with traders and several CFTC staff, suggest that CME locals trade very actively in GLOBEX.[9] This evidence does not necessarily contradict the line of reasoning pursued by Massimb and Phelps (1994) given that CME operates electronic and open outcry markets side by side. The E-mini terminals on the CME floor are located in an area adjacent to the trading pits.[10] Floor traders can also use headsets to relay trades to GLOBEX while stationed in the pits. This direct access to open outcry trading produces a number of powerful reasons for the locals to trade in the electronic system. First, they can use order flow information from open outcry to take positions in the electronic system. Second, the locals may be able to profit by arbitraging between the pit and GLOBEX. Finally, if a local chooses to act as a market maker in GLOBEX by submitting limit orders instead of trading aggressively, her ability to observe order flow into the pit may allow her to quickly adjust the quotes and be one step ahead of the off-exchange traders.

The central hypotheses of this paper are that price discovery occurs primarily in the E-mini contracts and that price dynamics in those contracts are at least partially driven by exchange locals who take advantage of their proximity to order flow information and superior execution speed of the electronic system. Large trades move prices. Therefore, when the locals trading E-mini contracts see large orders being traded in the pit, they may be expected to respond quickly and trade in GLOBEX to take advantage of the price impact of the large trades. The above discussion leads to the following hypotheses.

Hypothesis 1. E-mini S&P 500 and E-mini Nasdaq-100 futures contracts make a dominant contribution to price discovery in their respective indexes, i.e., the result from our sample is consistent with Hasbrouck (2003).

Hypothesis 2. Trades initiated by exchange locals in the E-mini futures contracts are more informative than off-exchange initiated trades.

Hypothesis 3. Exchange locals trading E-mini contracts trade around large regular contract trades to profit from the price impact associated with the large orders.

III. Data and Descriptive Statistics

This study employs trade data for the regular and E-mini S&P 500 and Nasdaq-100 futures. These data are obtained from the Commodity Futures Trading Commission (CFTC) and contain the contract ticker symbol, trade date, trade time to the nearest second, the contract month, buy/sell code, number of contracts traded, trade price, customer type indicator (CTI), CTI of the opposite side of the trade, and session indicator (pit or GLOBEX). CTI ranges from 1 to 4 as follows:[11]

[9] CME's Chairman Emeritus Leo Melamed, describing the introduction of the E-mini S&P 500 futures, says: "The E-mini idea worked and that changed the whole view of our entire floor community . . . . All of a sudden, there were lines to sign up for computer training and to get a GLOBEX terminal. We literally had people waiting for months to get their hands on a terminal" (reported in Sales (2001)).

[10] According to the CME's 2000 Annual Report, "Some of our members trade the E-mini products from computer workstations surrounding the trading pits while flashing orders to the pits for the larger-sized contracts."

[11] Daigler and Wiley (1998), (1999) provide a detailed discussion of the four CTI categories.

CTI1: trade executed for a floor trader's personal account (local trade)
CTI2: trade executed for a clearing firm's account
CTI3: trade executed for a personal account of another floor trader
CTI4: trade executed for an account of an outside customer

Our sample period extends over the 86 trading days from May 7, 2001–September 7, 2001. We choose this period for two reasons. First, prior to May 7, 2001, the maximum size of a trade in the E-mini S&P 500 futures was limited to 30 contracts. Second, we want to exclude the period of abnormal market volatility that followed the September 11, 2001 events.

Open outcry trading opens at 8:30AM and closes at 3:15PM (Chicago time). Our analysis is limited to these regular trading hours. For every trading day, only the contract with the largest number of trades is considered.[12] For contracts traded through open outcry, the CME uses a computer algorithm that imputes execution time for every trade by using time and sales data, time stamps on order tickets, and other available audit trail data.[13] In contrast, E-mini trades are recorded in the exact sequence of occurrence. We eliminate observations reported out of time sequence, as they are likely to contain errors.

Table 1 reports average daily volume and number of trades for different counterparty combinations in regular and E-mini futures. Consistent with Manaster and Mann (1996) and Ferguson and Mann (2001), trades of locals (CTI1) with off-exchange customers (CTI4) account for the largest proportion of trades and volume in all four considered contracts. The second most frequent combination (ranging from 25.0% to 29.9% of total number of trades and from 14.5% to 33.9% of total volume) is trades of locals with other locals. Interestingly, for regular futures the volume share of this combination is only about half of the corresponding proportion of trades. This suggests that most of the trades between locals on the floor are small. CME traders attribute high local-to-local trading activity to arbitrage between the E-mini futures and their pit-traded counterparts. Customer-to-customer trading accounts for between 5.2% and 18.4% of the total number of trades and between 8.7% and 18.2% of the total volume.

Table 2 reports summary statistics for regular and E-mini futures. The trading of the E-mini contracts is much more frequent than that of the regular futures. For example, trading frequency of the E-mini Nasdaq-100 futures exceeds that of the regular Nasdaq-100 futures by a factor of 11. The open interest in the E-mini futures is smaller than the daily trading volume, while for the regular futures the opposite is true. This suggests that E-mini trading has a greater proportion of day traders who do not keep overnight positions. The open interest in the E-mini futures is still substantial, however, indicating that some institutional traders use these contracts for hedging purposes.

Table 2 also reports customer execution spreads calculated as mean customer buy price minus mean customer sell price for a five-minute interval, with prices

[12]Trading activity shifts from the futures contract approaching expiration to the next available contract during the second week of the expiring contract's month.

[13]Trade prices in the pit are reported verbally and by hand signals to pit reporters who type them manually. Our informal conversations with CFTC staff suggest that the reporting lag is typically under five seconds. Hasbrouck (2003) shows that when E-mini trade prices are delayed by five seconds the E-mini contracts are still the price leaders.

TABLE 1

Mean Number of Trades and Volume by CTI Counterparty Combination for Regular and E-Mini S&P 500 and Nasdaq-100 Futures

(May 7, 2001 to September 7, 2001)

	Local (CTI1) with				Customer (CTI4) with				
	CTI1	CTI2	CTI3	CTI4	CTI2	CTI3	CTI4	Other	Total
Panel A. S&P 500 Futures									
Mean trades	4,592	461	2,085	6,606	233	387	798	204	15,365
% of total	29.9%	3.0%	13.6%	43.0%	1.5%	2.5%	5.2%	1.3%	
Mean vol.	9,681	2,370	6,871	32,975	1,868	2,540	9,555	1,059	66,918
% of total	14.5%	3.5%	10.3%	49.3%	2.8%	3.8%	14.3%	1.6%	
Panel B. E-Mini S&P 500 Futures									
Mean trades	15,974	6,560	52	20,670	3,580	29	6,238	593	53,697
% of total	29.7%	12.2%	0.1%	38.5%	6.7%	0.1%	11.6%	1.1%	
Mean vol.	47,480	19,567	107	50,338	8,507	49	12,128	1,725	139,900
% of total	33.9%	14.0%	0.1%	36.0%	6.1%	0.0%	8.7%	1.2%	
Panel C. Nasdaq-100 Futures									
Mean trades	1,436	290	468	2,180	180	302	453	84	5,394
% of total	26.6%	5.4%	8.7%	40.4%	3.3%	5.6%	8.4%	1.6%	
Mean vol.	2,756	1,063	1,127	8,420	902	1,083	2,512	305	18,166
% of total	15.2%	5.9%	6.2%	46.3%	5.0%	6.0%	13.8%	1.7%	
Panel D. E-Mini Nasdaq-100 Futures									
Mean trades	15,297	5,027	50	25,237	3,900	44	11,276	351	61,182
% of total	25.0%	8.2%	0.1%	41.2%	6.4%	0.1%	18.4%	0.6%	
Mean vol.	29,034	11,861	69	51,016	9,430	66	22,812	1,079	125,367
% of total	23.2%	9.5%	0.1%	40.7%	7.5%	0.1%	18.2%	0.9%	

The CTI categories include local traders (CTI1), clearing members (CTI2), other floor traders (CTI3), and off-exchange customers (CTI4). All statistics are for regular trading hours.

TABLE 2

Summary Statistics of Regular and E-Mini S&P 500 and Nasdaq-100 Futures

(May 7, 2001 to September 7, 2001)

	S&P 500		Nasdaq-100	
Mean	Regular	E-Mini	Regular	E-Mini
No. of trades per day	15,365	53,697	5,394	61,182
No. of trades per minute	37.9	132.6	13.3	151.1
Trading vol. (contracts)	66,918	139,900	18,166	125,367
Trading vol. ($ billion)	20.40	8.50	3.16	4.33
Trade size (contracts)	4.36	2.60	3.37	2.05
Trade size ($ '000)	1,327.9	158.2	586.8	70.8
Open interest (contracts)	495,100	109,435	52,241	105,093
Open interest ($ billion)[a]	150.92	6.65	9.00	3.58
All-trade execution spread[b]	0.0073%	0.0035%	0.0152%	−0.0012%
Against-local spread[b]	0.0090%	0.0061%	0.0148%	−0.0061%
$ market share	70.5%	29.5%	42.0%	58.0%

[a]Based on closing prices.

[b]Percent of contract value. Execution spread is calculated as mean customer buy price minus mean customer sell price for a five-minute interval, with prices weighted by trade size.

All statistics are for regular trading hours.

weighted by trade size.[14] For both E-mini S&P 500 and E-mini Nasdaq-100 futures, the execution spreads are substantially smaller than for corresponding floor-traded contracts. Strikingly, the mean execution spread is negative for the

[14]This direct measure of transaction costs is used by Locke and Venkatesh (1997) and Ferguson and Mann (2001), among others.

E-mini Nasdaq-100 futures. Furthermore, the execution spread in trades with locals is even smaller, suggesting that in this market locals tend to trade aggressively against customer limit orders, effectively paying off-exchange traders for provision of liquidity. The negative execution spread result is consistent with the findings of Manaster and Mann (1999) and Ferguson and Mann (2001) who show that locals often sacrifice their advantage in execution to take positions ahead of favorable price movements. In contrast, for the E-mini S&P 500 futures the customer execution spread in trades with locals is greater than the all-trade spread. This suggests, unsurprisingly, that the timing advantage of locals is more important in the volatile Nasdaq-100 market. Table 2 also reveals that the E-minis have a large dollar market share ranging from 29.5% for E-mini S&P 500 to 58% for E-mini Nasdaq-100 futures.

IV. Methodology and Empirical Results

A. Price Discovery between Regular and E-Mini Futures

To test Hypothesis 1, that E-mini futures contracts make a dominant contribution to price discovery, we use the Hasbrouck (1995) model that calculates "information shares" as relative contributions of variance of a security in the variance of innovations of the (unobservable) efficient price. After estimating a vector error correction model (VECM), we use the approach suggested by Baillie, Booth, Tse, and Zabotina (2002) to calculate information shares directly from the VECM results without obtaining the vector moving average (VMA) representation. When the price innovations are correlated across VECM equations, it becomes impossible to attribute part of the variance of the underlying efficient price to either of the price series. Hasbrouck's model produces estimates of the upper and lower bounds of the information share.

We begin by calculating information shares of the regular and E-mini futures contracts. Hasbrouck (2003) performs price discovery calculations for each day separately and then averages the resulting information shares across days. We use a similar approach to make sure that the result of price leadership of the E-mini futures holds in our sample. We use trade prices for both regular and E-mini futures because bid-ask quotes are reported relatively infrequently and are short lived in the open outcry market. The initial data for the price discovery calculations between regular and E-mini futures are time and sales data derived from the trade data by eliminating repeated prices. As the input data for the VECM analysis, we use matched time series with one-second intervals between observations. If there is no price reported at a particular second, the previous available price is used. If there are several E-mini trades reported with the same time stamp, only the last trade price is used.[15]

[15]High frequency of the input series minimizes the correlation of VECM residuals, allowing for a more precise identification of the upper and lower bound of the information shares. Alternative matching algorithms, for example, the MINSPAN procedure suggested by Harris, McInish, Shoesmith, and Wood (1995), involve data thinning. Hasbrouck (2002), (2003) argues that data thinning can lead to incorrect inferences. A thorough analysis of methodological issues involved in calculation of information shares is offered by Hasbrouck (1995), (2002), (2003).

The results of the calculation of information shares are shown in Table 3. The average midpoint of the upper and lower bounds of the information share for our sample period is 97.9% for E-mini S&P 500 futures and 96.3% for E-mini Nasdaq-100 futures, suggesting that the E-mini contracts make a dominant contribution to price discovery in these two index markets.[16] This finding is consistent with the result from a different sample period reported by Hasbrouck (2003).

TABLE 3

Information Share Statistics of Regular and E-Mini S&P 500 and Nasdaq-100 Futures (May 7, 2001 to September 7, 2001)

	Regular			E-Mini		
	Upper Bound	Lower Bound	Midpoint	Upper Bound	Lower Bound	Midpoint
Panel A. S&P 500 Futures						
Median	1.3%	1.0%	1.1%	99.0%	98.7%	98.8%
Mean	2.3%	2.0%	2.1%	98.0%	97.7%	97.9%
Std. error of mean	0.27%	0.25%	0.26%	0.25%	0.27%	0.26%
Std. dev.	2.5%	2.3%	2.4%	2.3%	2.5%	2.4%
Panel B. Nasdaq-100 Futures						
Median	3.1%	2.5%	2.9%	97.5%	96.5%	97.1%
Mean	3.9%	3.4%	3.7%	96.6%	96.0%	96.3%
Std. error of mean	0.55%	0.50%	0.52%	0.50%	0.55%	0.52%
Std. dev.	5.1%	4.6%	4.9%	4.6%	5.1%	4.9%

The statistics are for regular trading hours. If several trades occur during one second, only the last trade is used in calculations.

B. Relative Information Content of E-Mini Trades Initiated by Locals and Off-Exchange Traders

Hasbrouck's (1995) model is also employed to test Hypothesis 2, which states that trades initiated by exchange locals in the E-mini futures contracts are more informative than off-exchange initiated trades. It is appropriate to use the model to examine relative information content of trades initiated by locals and off-exchange traders given that the time series of prices of trades initiated by different types of traders should be cointegrated. The Hasbrouck model was originally intended to analyze contributions to price discovery by multiple markets trading equivalent or closely linked securities. However, while markets often appear fragmented, in many cases they are so closely integrated informationally that in essence they function as a single market. For example, Huang (2002) analyzes information shares of various Nasdaq quote participants including ECNs and Nasdaq market makers. ECNs directly compete for order flow with Nasdaq dealers and the ECN quotes are displayed in Nasdaq. Similarly, CME locals and off-exchange customers compete for execution in GLOBEX.

Our application of the Hasbrouck (1995) model differs from those reported in previous research in one important respect. As opposed to the numerous existing applications, we estimate Hasbrouck's information shares using a set of prices

[16]Baillie et al. (2002) provide evidence that the midpoint between the upper and lower bounds of information shares is a reasonable measure of a market's contribution to price discovery. We use this measure in the current paper.

that is not public information.[17] Given the CTI trade data, one is able to classify E-mini trades by type of the trade initiator ex post; however, this information is not available to GLOBEX traders in real time and therefore cannot be used by traders in the price discovery process. Thus, the information shares of trades initiated by different types of traders calculated using the Hasbrouck (1995) model do not represent an adequate measure of the contribution of those trader types to price discovery. Still, by using Hasbrouck's methodology along with the data that include trader type identification codes, we are able to see whether information impounded into E-mini prices comes from trades initiated by exchange locals or from trades initiated by off-exchange customers. Trades initiated by exchange locals will have higher information share if trades initiated by off-exchange traders tend to error-correct to local-initiated trades. Such a result would suggest that the impounding of new information in the E-mini markets occurs primarily through local-initiated trades.

The E-mini trade data do not contain bid and ask quotes. Thus, we use the tick rule to classify trades as initiated by locals (CTI1), clearing members (CTI2), and off-exchange customers (CTI4). For example, a trade is classified as buyer-initiated if it occurs on an up-tick. If in a buyer-initiated trade the buyer is a local, then the trade is classified as a local-initiated buy trade. If a trade occurs on a zero-tick, i.e., if its price is equal to the price of the previous trade, the trade is excluded. Aitken and Frino (1996) and Finucane (2000) show that the tick rule performs well when zero-tick trades are removed.[18] Once the price time series of trades initiated by the three types of traders are identified, we calculate information shares of trades initiated by locals, clearing members, and off-exchange customers using the Hasbrouck (1995) model.[19] Furthermore, to avoid forcing predictive power on trades initiated by different trader types, we also include the total E-mini trade series in the VECM and in the calculation of information shares. The inclusion of this series, however, induces high contemporaneous correlation of residuals across equations and results in widely diverging upper and lower bounds of information shares.[20] Also, given that the total trade series is included in the specification, the lower bound for the CTI1 series, for example, represents the incremental predictive power associated with identifying the local-initiated trades.

Table 4 reports the information share statistics. Consistent with Hypothesis 2, for both E-mini S&P 500 and E-mini Nasdaq-100 futures the average information share of locals' trades exceeds that of the off-exchange customer trades.[21] For

[17]We are grateful to the referee for pointing this out.

[18]The accuracy of the tick rule for zero-tick trades ranges from 68.5% in Aitken and Frino (1996) to 76.6% in Finucane (2000), while the accuracy for trades that occur on non-zero ticks exceeds 90%. We have replicated the results using all trades including those that occur on zero ticks. The results (not reported but available upon request) appeared stronger.

[19]Trades initiated by CTI3 account for less than 0.5% of the total number of E-mini trades. Therefore, CTI3 trades were omitted.

[20]The average contemporaneous correlation of residuals of CTI1 and CTI4 equations with those of the total E-mini trade series equation exceeds 0.4.

[21]The informational advantage of locals increases in periods of high trading activity that are also characterized by substantial price changes. Therefore, during these periods of intense trading one would expect the E-mini trades initiated by locals to have the highest information share. To test this expectation, we calculated information shares in nine 45-minute intraday intervals. The results showed

example, in the E-mini S&P 500 futures market the mean midpoint of the upper and lower bounds of information share is about 22% for locals' trades vs. about 10% for CTI4-initiated trades. The mean upper bound of CTI1 information share in this market is 37.3% and the mean lower bound is 6.7%. The corresponding figures for CTI4 information share are 19.9% and 0.2%. CTI2 trades appear to have a small information share with the midpoint of the upper and lower bounds below 3% in both E-mini S&P 500 and E-mini Nasdaq-100 futures markets.

TABLE 4

Information Share Statistics of Trades Initiated by Locals (CTI1), Clearing Members (CTI2), and Off-Exchange Traders (CTI4) in S&P 500 and Nasdaq-100 E-Mini Futures

(May 7, 2001 to September 7, 2001)

	Upper Bound				Lower Bound				Midpoint of Upper and Lower Bounds			
	CTI1	CTI2	CTI4	All Trades	CTI1	CTI2	CTI4	All Trades	CTI1	CTI2	CTI4	All Trades
Panel A. E-Mini S&P 500 Futures												
Median	37.5%	2.9%	19.8%	91.9%	6.2%	0.8%	0.1%	41.0%	21.9%	1.8%	10.0%	66.5%
Mean	37.3%	3.9%	19.9%	91.6%	6.7%	1.4%	0.2%	40.4%	22.0%	2.6%	10.1%	66.0%
Std. error of mean	0.69%	0.38%	0.46%	0.32%	0.27%	0.21%	0.04%	0.70%	0.47%	0.29%	0.23%	0.47%
Std. dev.	6.4%	3.5%	4.3%	3.0%	2.5%	1.9%	0.3%	6.5%	4.3%	2.7%	2.2%	4.4%
Panel B. E-Mini Nasdaq-100 Futures												
Median	41.5%	0.4%	28.5%	94.8%	4.6%	0.2%	0.6%	32.8%	23.0%	0.3%	14.7%	63.8%
Mean	41.4%	0.9%	28.5%	94.2%	4.9%	0.6%	0.8%	33.1%	23.2%	0.8%	14.7%	63.7%
Std. error of mean	0.83%	0.16%	0.66%	0.32%	0.27%	0.16%	0.09%	0.75%	0.51%	0.16%	0.36%	0.49%
Std. dev.	7.7%	1.5%	6.1%	3.0%	2.5%	1.5%	0.8%	7.0%	4.7%	1.4%	3.3%	4.5%

The statistics are for regular trading hours. Zero-tick trades are omitted. If several trades of the same CTI type occur during one second, only the last trade is used in calculations.

It is also interesting to note that significant information share can be attributed to the all-trades price series. This result supports the notion that general characteristics that are inherent to the electronic trading mechanism and available to all traders, such as transaction speed and anonymity, are important aspects of the price formation process.

If locals are better informed than the off-exchange traders, we would also expect the ratio of information share of locals' trades to the percentage of trades initiated by locals to be larger than the similar ratio for the off-exchange customer trades.[22] Table 5 reports the mean percentage of trades and volume initiated by locals and off-exchange customers. It is clear that locals trade very actively. For example, in the E-mini S&P 500 market the locals initiate about 38% of trades that account for about 49% of the total volume. However, the ratio of midpoint of the upper and lower bounds of the CTI1 information share to the percentage of trades initiated by locals appears to be larger than the corresponding ratio for trades initiated by off-exchange traders. We use a nonparametric two-sample test

substantial intraday variation in the CTI1 information share. For both S&P 500 and Nasdaq-100 E-minis, CTI1 information shares exceed the daily averages in the beginning of the day, when a large percentage of the daily cumulative price change takes place, while the information shares fall below the daily averages mid-day. These results are not reported to conserve space but are available upon request.

[22]Similarly, Barclay and Warner (1993) suggest that, if informed traders concentrate their trades in medium sizes, medium-size trades should account for a disproportionately large cumulative price change.

of medians to compare the two ratios. The z-statistic of the test is significant at the 1% level, supporting the intuition that the trades initiated by locals are more informative than those initiated by off-exchange traders.[23] Large trades move prices more than small trades. Thus, it is possible that information share of locals is proportional to the percentage of volume initiated by locals. However, this alternative is also strongly rejected by the two-sample test of medians.

TABLE 5

Statistics of Trades Initiated by Locals (CTI1) and Off-Exchange Traders (CTI4) in S&P 500 and Nasdaq-100 E-Mini Futures

May 7, 2001 to September 7, 2001

E-Mini Futures	CTI1 % of Trades	CTI4 % of Trades	CTI1 IS Midpoint / CTI1 % of Trades	CTI4 IS Midpoint / CTI4 % of Trades	CTI1 % of Volume	CTI4 % of Volume	CTI1 IS Midpoint / CTI1 % of Volume	CTI4 IS Midpoint / CTI4 % of Volume
S&P 500	38.1%	50.0%	0.576*	0.202	49.1%	36.9%	0.447*	0.274
Nasdaq-100	44.6%	46.5%	0.519*	0.315	47.2%	43.0%	0.491*	0.341

The statistics are for regular trading hours. Mean values are shown. If several trades of the same CTI type occur during one second, only the last trade is used in calculations. * indicates that the linear rank sum z-statistic of the two-sample test for difference between medians of ratios of information share midpoint to number of trades or volume initiated by the respective CTI category is significant at the 1% level. This nonparametric test statistic is used because the normality assumptions for the t test are not satisfied. The z-statistic is calculated using the NPAR1WAY procedure in SAS.

To further test the relative information content of trades initiated by locals and off-exchange customers, we calculate the cumulative impulse response functions to initiated trades by forecasting the VECM after a unit shock to one of the CTI price series and the all-trade series. Impulse responses are calculated separately for each day in the sample and then averaged across days. Figure 1 shows that a shock to the prices of trades initiated by locals has a larger long-term impact than a shock to the prices of trades initiated by the off-exchange customers. This result is also consistent with the hypothesis that trades initiated by exchange locals are more informative.

It should also be noted that, based on the impulse responses, the trades of the off-exchange traders also appear informative. This result is likely to be explained by several factors. First, some of the E-mini traders are institutions taking advantage of anonymity and fast execution of GLOBEX. Second, off-exchange E-mini traders actively use direct audio feed from the CME floor (so-called "squawk box") to support their trading. While the locals stationed around the trading pits still have access to a much richer information set, the ability of the off-exchange traders to listen to market commentary and background noise of pit trading[24] may reduce the comparative advantage of locals.

C. Returns and Order Flows around Large Regular Contract Trades

Hypothesis 3 suggests that exchange locals trading E-mini contracts use information around large trades that occur on the regular contract floor. To test this hypothesis, we examine returns of regular and E-mini futures and E-mini order

[23]The same results are found using the upper and lower bounds of information share in place of the midpoint.

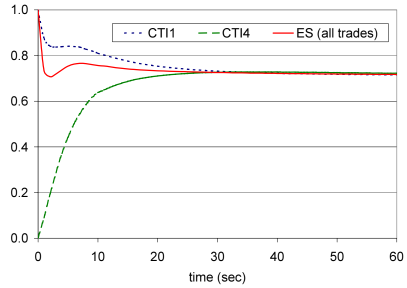
[24]Coval and Shumway (2001) show that the sound level in the futures trading pits conveys important information.

FIGURE 1

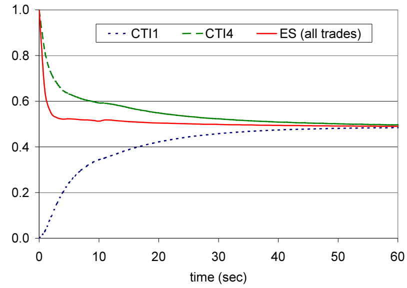
Cumulative Impulse Response Functions

Panel A. E-Mini S&P 500 Futures (ES)

Unit shock to the all-trade price series and prices of trades initiated by exchange locals (CTI1)

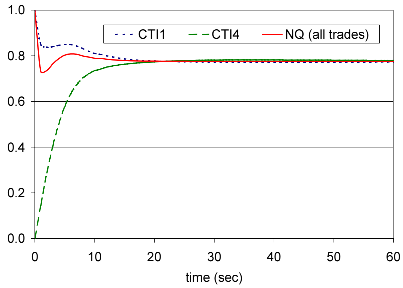


Unit shock to the all-trade price series and prices of trades initiated by exchange locals (CTI4)

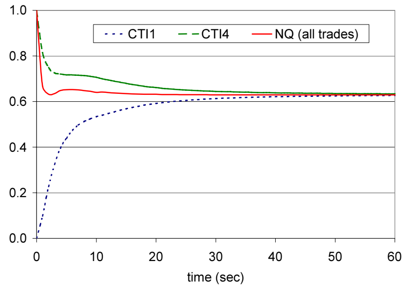


Panel B. E-Mini Nasdaq-100 Futures (NQ)

Unit shock to the all-trade price series and prices of trades initiated by exchange locals (CTI1)



Unit shock to the all-trade price series and prices of trades initiated by exchange locals (CTI4)



Impulse responses are calculated separately for each day in the sample and then averaged across days.

flows surrounding large trades on the floor. Similar to Booth, Lin, Martikainen, and Tse (2002), a large trade in regular futures is defined as a trade whose size is equal to or exceeds the 95th percentile. This corresponds to 11 contracts for the regular S&P 500 futures and 10 contracts for the regular Nasdaq-100 futures.

Large trades often occur in groups. If we use simple averaging of returns and order flows around large trades, the clustering of large trades is likely to affect the results. To account for clustering we use an approach similar to the one suggested by Harris, Sofianos, and Shapiro (1994). We estimate the following regression of five-second returns and order flows on 11 leads and 12 lags of large trades,

$$\text{(1)} \qquad \text{VAR}_t = \alpha_0 + \sum_{i=-12}^{11} \beta_i \text{cti1}_{t+i}^{\text{buy}} + \sum_{i=-12}^{11} \gamma_i \text{cti1}_{t+i}^{\text{sell}} + \sum_{i=-12}^{11} \delta_i \text{cti4}_{t+i}^{\text{buy}} + \sum_{i=-12}^{11} \omega_i \text{cti4}_{t+i}^{\text{sell}} + \varepsilon_t,$$

where VAR is analysis variable (return of regular or E-mini futures in five-second intervals or E-mini order flow in five-second intervals), and $cti1^{buy}$, $cti1^{sell}$, $cti4^{buy}$, and $cti4^{sell}$ are (0, 1) indicator variables for large buy and sell trades initiated by locals and off-exchange customers, respectively.[25] Equation (1) is estimated using the generalized method of moments (GMM) and the Newey and West (1987) heteroskedasticity and autocorrelation consistent covariance matrix. Similar to Booth et al. (2002), we calculate returns based on trade prices[26] and use the tick rule to identify the trade initiator.

Accurate timing of large trades is important for our analysis. Many trades often occur in quick succession at the same price on the floor. The CME's Computerized Trade Reconstruction (CTR) algorithm matches trades to the last price change. Therefore, several trades are often reported for the same second, while in reality most of those trades occurred during the interval between the price change they are matched to and the next price change. When one of the trades reported for the same second is relatively large, it is likely that the large trade was the trade that triggered the price change and was therefore the first trade in the sequence. When several large trades are reported for the same second, we cannot assume that they all occurred simultaneously. Furthermore, identifying the initiating party is also difficult in this case, as some of these trades occurred on a zero tick and the tick rule performs poorly with zero-tick trades. Therefore, we do not include instances when several large trades are reported for the same second.

To synchronize the returns of the regular futures with returns of their E-mini counterparts, we use five-second intervals rather than transaction time. We use the price of the large trade as the price at time zero to observe the full price impact of the large trades. Instances when several large trades occur during the same five-second interval are eliminated.[27]

Figure 2 plots regular and E-mini S&P 500 and Nasdaq-100 returns around large trades initiated by off-exchange customers and locals. The figure shows that the E-mini price starts moving in the direction of the large trade about 15 to 20 seconds before the reported time stamp of the trade. Consistent with Hypothesis 3, this finding provides evidence that exchange locals are transferring inferred

[25]This specification does not account for the size of the large trades. Larger trades are typically associated with larger price impacts. However, Hasbrouck (1991) and others show that price impact is a concave rather than linear function of trade size. Therefore, (0, 1) indicator variables are used to simplify the analysis. To make sure the results are not driven by a small number of extremely large trades, we have replicated the analysis after removing the trades in the top 1st percentile. The results (not reported but available upon request) were qualitatively unchanged.

[26]Returns calculated using transaction prices are affected by the so-called bid-ask bounce. Trade prices fluctuate between the bid and ask quotes, inducing a large negative correlation in returns that has a potential to affect inferences. To make sure the bid-ask bounce does not significantly influence the results, we repeated the analysis using returns based on so-called "pseudo-equilibrium prices" as suggested by Ederington and Lee (1995). Pseudo-equilibrium price is calculated as a moving average of the last two prices on the five-second grid. This technique reduces the negative correlation in returns induced by the bid-ask bounce. For example, for E-mini S&P 500 futures the first-order correlation of returns based on trade prices is -0.1471, while the corresponding correlation of returns based on pseudo-equilibrium prices is only -0.0173. The results (not reported but available upon request) were qualitatively unchanged.

[27]While large trades around the clustered trades are not dropped from the sample since they may contain order flow information, we repeated the analysis after removing all of the large trades within a ± 60-second window around the occurrences of multiple large trades. Although this reduced the sample by about 50%, the results appeared to be unchanged.

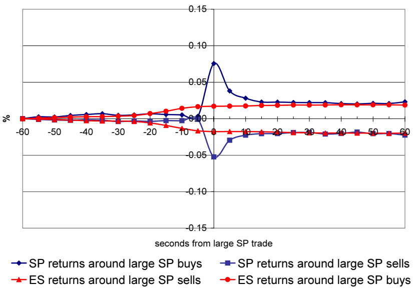
information around large trades that are being executed on the regular exchange from the floor to GLOBEX.[28]

FIGURE 2

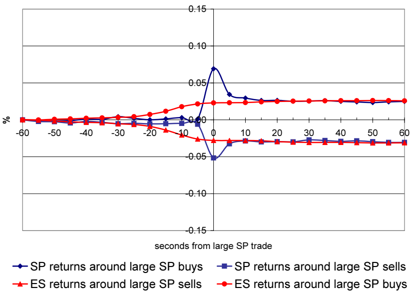
Cumulative Average Returns around Large Trades in Regular Futures

Panel A. Large Trades in Regular S&P 500 Futures (SP)

Trades initiated by off-exchange customers (CTI4)

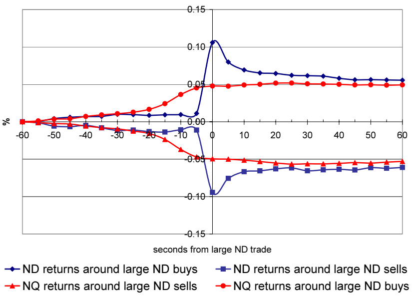


Trades initiated by exchange locals (CTI1)

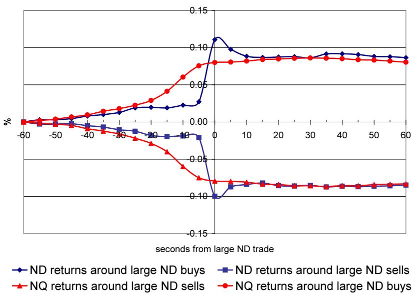


Panel B. Large Trades in Regular Nasdaq-100 Futures (ND)

Trades initiated by off-exchange customers (CTI4)



Trades initiated by exchange locals (CTI1)



The estimates are obtained from regressions of returns on 11 leads and 12 lags of large trades in regular futures. (0, 1) indicator variables are used for large buy and sell trades initiated by locals and off-exchange customers.

Figure 2 also reveals that the temporary price impacts of the large trades initiated by locals in the regular contracts are smaller and the permanent impacts are larger than for the trades initiated by off-exchange traders. The smaller temporary impacts of local-initiated trades suggest that locals are able to obtain better execution than brokers (representing off-exchange traders). The larger permanent impacts of local trades are consistent with the hypothesis that these trades have higher information content than trades initiated by off-exchange traders.

Table 6 reports a summary of lead-lag regression results for both S&P 500 and Nasdaq-100 markets. The standard errors of cumulative returns indicate that

[28]One could argue that the lack of return drift in regular futures before large trades could be explained by the fact that trading on the floor is relatively infrequent compared to trading in GLOBEX. However, large trades tend to occur during periods of extremely active trading on the floor. For example, the average number of trades during the 30-second interval preceding the large trades is 28.8 for regular S&P 500 futures and 12.1 for regular Nasdaq-100 futures.

the drift in E-mini returns around large floor trades is statistically significant. The results for both markets are qualitatively similar. However, we observe substantially larger permanent price impacts in the Nasdaq-100 market. For example, the total cumulative return over the two-minute period surrounding large customer-initiated buy trades in the regular S&P 500 futures is about 2.3 basis points, while the corresponding Nasdaq-100 futures return is about 5.6 basis points. This finding suggests that the order flow is more informative in the Nasdaq-100 market than in the S&P 500 market. The cumulative returns from $t = +5$ to $t = +20$ reported in Table 6 confirm the intuition that the temporary price effect is smaller for large trades initiated by locals. For example, this transitory liquidity effect is about 3.1 basis points for customer-initiated Nasdaq-100 futures sell trades, while for the sell trades initiated by locals it is only about 1.4 basis points.

The observed patterns in E-mini returns relative to large trades provide evidence of information transmission from the floor to the electronic market.[29] To check if these return patterns are related to locals' trading, we examine order flows of locals and off-exchange traders in GLOBEX around the large trades on the floor. The E-mini order flows of locals and off-exchange traders, calculated as the number of buys less the number of sells in five-second intervals, are used as analysis variables in regressions on leads and lags of the large floor trades.[30] The results presented in Figure 3 support the hypothesis that locals take "correct" positions in GLOBEX around the large trades on the floor. For example, locals become net buyers around the reported time of a large buy trade. Similarly, they become net sellers around the reported time of a large sell trade. The off-exchange traders, on the other hand, appear to be net sellers around large buy trades and net buyers around large sell trades.

The above results suggest that the trading activity used by locals around large trades is likely to at least partially explain the price discovery dominance of the E-mini contracts. Consequently, it should be noted that the order flow arriving into the trading pits still plays an important informational role, even though the information share calculations suggest that price discovery occurs predominantly in the E-mini futures. It appears to be the proximity of the locals trading E-mini contracts to the trading pits coupled with the fast execution in GLOBEX that ensures that the prices of E-mini futures contracts reflect the open outcry order flow information before it is fully incorporated into the prices of the floor-traded contracts. A summary of the order flow regression results is reported in Table 7.

[29]We also examined return patterns around large E-mini trades. The results, which are not reported for brevity but available upon request, do not show similar evidence of information transmission from GLOBEX to the floor. In support of Hypothesis 2, the temporary price impacts are smaller and permanent impacts are greater for the large E-mini trades initiated by locals.

[30]This measure of order flow (buys minus sells) is used to simplify the analysis. We repeated the analysis calculating order flow as buy volume minus sell volume. The results (not reported but available upon request) were qualitatively unchanged. We also repeated the analysis calculating CTI1 and CTI4 order flows as the number of buyer-initiated trades minus the number of seller-initiated trades and using the tick rule to classify trades. The results (not reported but available upon request) show that, while both locals and off-exchange traders tend to initiate trades in the "correct" direction around the large trades on the floor, the order flow of locals clearly dominates.

TABLE 6

Estimated Cumulative Event-Time Returns Surrounding Large Trades in Regular S&P 500 and Nasdaq-100 Futures in Hundredths of a Percent

(May 7, 2001 to September 7, 2001)

Event Time Interval, Seconds	Customer-Initiated Trades Up-Tick	Customer-Initiated Trades Down-Tick	Local-Initiated Trades Up-Tick	Local-Initiated Trades Down-Tick
Panel A. Large Trades in Regular S& P 500 Futures				
Regular Futures Returns				
−60 to +60	2.31	−2.25	2.50	−3.06
	(0.196)	(0.191)	(0.217)	(0.217)
−60 to −5	0.33	−0.09	0.11	0.60
	(0.175)	(0.179)	(0.185)	(0.199)
0 to +60	1.98	−2.16	2.39	−2.46
	(0.183)	(0.189)	(0.188)	(0.195)
+5 to +20	−5.28	3.19	−4.28	2.20
	(0.251)	(0.190)	(0.282)	(0.198)
E-Mini Futures Returns				
−60 to +60	1.86	−1.98	2.57	−3.11
	(0.074)	(0.075)	(0.086)	(0.092)
−60 to −5	1.64	−1.67	2.16	−2.60
	(0.056)	(0.058)	(0.068)	(0.068)
0 to +60	0.22	−0.31	0.41	−0.51
	(0.059)	(0.058)	(0.065)	(0.070)
No. of trades	7,940	7,672	6,619	6,312
Mean size, contracts	28.1	25.5	23.1	21.9
Panel B. Large Trades in Regular Nasdaq-100 Futures				
Regular Futures Returns				
−60 to +60	5.56	−6.11	8.64	−8.47
	(0.342)	(0.333)	(0.411)	(0.371)
−60 to −5	1.11	−1.11	2.72	−2.12
	(0.288)	(0.291)	(0.295)	(0.323)
0 to +60	4.44	−5.00	5.92	−6.36
	(0.329)	(0.299)	(0.363)	(0.327)
+5 to +20	−4.13	3.14	−2.34	1.41
	(0.357)	(0.272)	(0.339)	(0.255)
E-Mini Futures Returns				
−60 to +60	4.93	−5.30	8.04	−8.32
	(0.213)	(0.209)	(0.260)	(0.242)
−60 to −5	4.52	−4.70	7.56	−7.50
	(0.170)	(0.177)	(0.211)	(0.187)
0 to +60	0.41	−0.60	0.48	−0.83
	(0.171)	(0.165)	(0.204)	(0.182)
No. of trades	5,493	5,400	4,228	4,428
Mean size, contracts	13.6	13.7	12.7	12.4

The estimates are obtained from regressions of returns on 11 leads and 12 lags of large trades in regular futures. Standard errors are given in parentheses. (0, 1) indicator variables are used for large buy and sell trades initiated by locals and off-exchange customers.

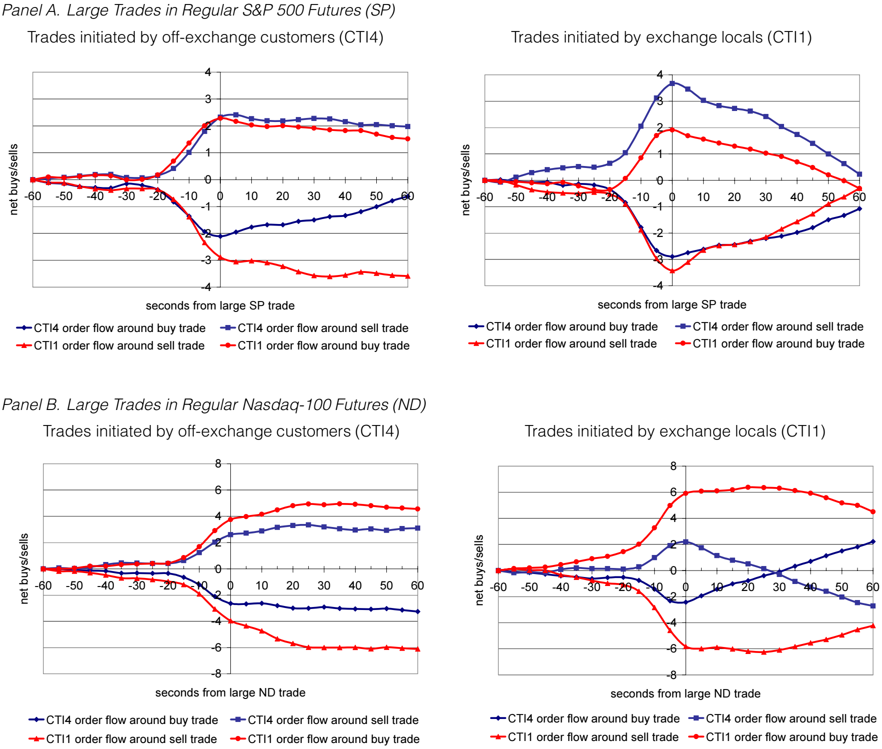
V. Summary and Conclusion

The CME employs a hybrid trading model in which so-called “E-mini” versions of several high-volume futures contracts trade on the electronic GLOBEX trading system. This paper examines the role of exchange locals in the E-mini futures markets by considering the S&P 500 and Nasdaq-100 floor-traded and E-mini futures contracts.

Our empirical results suggest that E-mini trades initiated by exchange locals are more informative than those initiated by off-exchange traders. We find infor-

FIGURE 3

Cumulative E-Mini Order Flows around Large Trades in Regular Futures



The estimates are obtained from regressions of E-mini order flows on 11 leads and 12 lags of large trades in regular futures. The order flows are calculated as the number of buys minus the number of sells in five-second intervals. Trades of clearing members (CTI2) and other floor traders (CTI3) account for the imbalance between local (CTI1) and customer (CTI4) order flows. (0, 1) indicator variables are used for large buy and sell trades initiated by locals and off-exchange customers.

mation shares calculated from Hasbrouck's methodology to be greater and price impacts to have a larger long-term effect for trades initiated by exchange locals relative to trades initiated by outside customers. The results also support the hypothesis that locals make trades in GLOBEX around large trades that occur on the floor. These findings lend evidence explaining the result of price leadership of the E-mini futures contracts reported here and by Hasbrouck (2003).

Taken together, the results of this paper support the notion that exchange locals are informed traders who derive their informational advantage from the proximity to order flow. Our findings also suggest that despite the exceptional growth of the E-mini markets in the last few years, they are still in an important sense satellite markets. The institutional order flow that arrives to the CME floor continues to represent an important source of information. However, because of the immediate access of exchange locals to the order flow into the pit and superior execution speed of the electronic system, the information contained in the incoming orders is first impounded into the E-mini prices.

TABLE 7

Estimated E-Mini Cumulative Order Flows surrounding Large Trades in Regular S&P 500 and Nasdaq-100 Futures

(May 7, 2001 to September 7, 2001)

Event Time Interval (seconds)	Customer-Initiated Trades		Local-Initiated Trades	
	Up-Tick	Down-Tick	Up-Tick	Down-Tick
Panel A. Large Trades in Regular S&P 500 Futures				
Local (CTI1) Order Flows				
−60 to +60	1.52	−3.59	−0.31	−0.30
	(0.447)	(0.449)	(0.500)	(0.536)
−60 to 0	2.29	−2.89	1.91	−3.43
	(0.304)	(0.315)	(0.346)	(0.359)
+5 to +60	−0.77	−0.70	−2.21	3.12
	(0.297)	(0.296)	(0.334)	(0.361)
Customer (CTI4) Order Flows				
−60 to +60	−0.62	1.98	−1.08	0.23
	(0.384)	(0.392)	(0.438)	(0.451)
−60 to 0	−2.11	2.32	−2.89	3.67
	(0.271)	(0.280)	(0.311)	(0.312)
+5 to +60	1.49	−0.35	1.81	−3.44
	(0.262)	(0.261)	(0.294)	(0.310)
No. of trades	7,940	7,672	6,619	6,312
Mean size, contracts	28.1	25.5	23.1	21.9
Panel B. Large Trades in Regular Nasdaq-100 Futures				
Local (CTI1) Order Flows				
−60 to +60	4.56	−6.11	4.50	−4.22
	(0.491)	(0.499)	(0.582)	(0.565)
−60 to 0	3.74	−3.97	5.91	−5.82
	(0.355)	(0.356)	(0.419)	(0.413)
+5 to +60	0.82	−2.15	−1.41	1.60
	(0.355)	(0.353)	(0.404)	(0.401)
Customer (CTI4) Order Flows				
−60 to +60	−3.26	3.10	2.22	−2.71
	(0.472)	(0.471)	(0.562)	(0.544)
−60 to 0	−2.65	2.60	−2.44	2.20
	(0.336)	(0.336)	(0.391)	(0.389)
+5 to +60	−0.61	0.50	4.65	−4.91
	(0.322)	(0.320)	(0.381)	(0.374)
No. of trades	5,493	5,400	4,228	4,428
Mean size, contracts	13.6	13.7	12.7	12.4

The estimates are obtained from regressions of order flows on 11 leads and 12 lags of large trades in regular futures. The order flows are calculated as the number of buys minus the number of sells in five-second intervals. Trades of clearing members (CTI2) and other floor traders (CTI3) account for the imbalance between local (CTI1) and customer (CTI4) order flows. (0, 1) indicator variables are used for large buy and sell trades initiated by locals and off-exchange customers. Standard errors are given in parentheses.

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