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Valeria Martinez
Department of Finance
Fairfield University

Zi Ning
Department of Finance
University of Texas at San Antonio

Yiuman Tse
Department of Finance
University of Texas at San Antonio

Department of Finance,
University of Texas at San Antonio,
San Antonio, TX 78249, U.S.A

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Valeria Martinez
Department of Finance
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Department of Finance
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Yiuman Tse
Department of Finance
University of Texas at San Antonio

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For Correspondence: Yiuman Tse, U.S. Global Investors, Inc. Research Fellow, College of Business, 501 West Durango Blvd., University of Texas, San Antonio, Texas 78207. Voice: 210-458-2503. Fax: 210-458-2515. Email: yiuman.tse@utsa.edu.

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Abstract

On December 4, 2006, the side-by-side trading of Commodities Exchange (COMEX) Division's gold and silver futures contracts was launched on Chicago Mercantile Exchange's Globex electronic trading platform, as a fight-back against the introduction of copies of these contracts from the Chicago Board of Trade (CBOT). The electronic COMEX saw an immediate surge and steady increase in market share, while market portions of the electronic CBOT and open outcry COMEX continued to drop. The market quality for both full-sized and mini-sized contracts is superior to that of their pit-traded counterparts. Despite its shrinking volume share, the electronic CBOT has comparable market quality conditions to the electronic COMEX. The theoretical models of multimarket trading suggest that a transparent electronic limit order market enhances market quality overall. Moreover, the primary market emerges as the dominant center for trading volume. Our results are broadly consistent with these theoretical predictions.

Competition for Order Flow and Market Quality in the Gold and Silver Futures Markets

The gold and silver futures contracts are two of the most actively traded precious metal futures contracts, which previously had been traded exclusively on Commodities Exchange (COMEX) Division of the New York Mercantile Exchange (NYMEX) via open-outcry trading. COMEX, the metal sector of the NYMEX, is the world's largest futures market for precious metals. In October 2004, Chicago Board of Trade (CBOT) began a campaign to introduce electronically-traded copies of COMEX's gold and silver full-sized futures contracts. In evaluating the consequences of competition, Martinez and Tse (2006) document that the best market quality conditions (i.e., narrower spreads and more price discovery) migrated from the COMEX open-outcry contract to the electronic CBOT contract. By August 2006, the electronic CBOT had already seized nearly half of the market share of gold futures.

Success of the electronic CBOT forced COMEX to launch side-by-side trading via the Chicago Mercantile Exchange (CME) Globex electronic platform in December 2006. These events present a unique opportunity to examine how increased competition between rival electronic exchanges versus traditional open outcry system affect market quality and order flow, and what are the underlying forces that enhance or deteriorate market quality. We compare the effects of competition for the same futures products trading in three different venues: COMEX open outcry, electronic COMEX, and electronic CBOT markets. More importantly, we focus on the competition between the two electronic exchanges backed by the world's most advanced trading platforms, CME Globex and LIFFE Connect. This situation enables us to examine transparency, liquidity externalities, market integration, and the adequacy of theoretical models in describing multimarket trading.

Besides fast execution, greater time and space flexibility, electronic markets are particularly characterized by a public limit order book that enhances market transparency. Market transparency refers to the public disclosure of information about quotes and trades. Transparency can be divided into pre- and post-trade dimensions. Pre-trade transparency mainly refers to the real-time quotes. Post-trade transparency mainly refers to the information on executed trades, such as execution time, volume and price (Madhavan, 2000). Transparency facilitates information flow between fragmented markets, which reduces the magnitude of adverse selection problem and hence spreads (Pagano and Roëll, 1996). Thus, a transparent electronic market should improve liquidity and price discovery. Alternatively, Domowitz, Glen, and Madhavan (1998) show that, in an opaque or semi-transparent market, the intermaket information linkage is poor, and hence the market quality will deteriorate. Hendershott and Jones (2005) provide empirical evidence that a reduction in transparency will harm the market quality overall, indicating that transparency itself is important. Bloomfield, O'Hara, and Saar (2005) use an experimental approach to examine the implications of liquidity generation in the electronic trading environment. They reveal that informed investors not only take but also provide liquidity to the market (even in the presence of information asymmetry), explaining why electronic markets are so successful in generating liquidity.

Consistent with the above analysis, we find that the market quality for both electronic COMEX and electronic CBOT markets are superior to the COMEX open outcry market, with lower effective spread, reduced price clustering, and more price discovery. The quality of open outcry market deteriorates as significant trading volumes move to the electronic markets, resulting in the widest spread, the most price clustering, and the least price discovery. [1]

The market conditions for CBOT mini-sized contract are secondary to the full-sized electronic contracts, but are superior to floor traded COMEX contract. Its substantial contributions to price discovery is impressive given the fact that CBOT mini-sized contracts accounts for only less than 4% market share.

Theoretical studies on multimarket trading typically assume similar market structures in examining traders' choice of venue. Traders tend to consolidate their trades in a particular trading venue, mainly due to liquidity externality consideration. Liquidity externalities arise when traders get together in space (or cyberspace) and time. The arrival of the additional traders facilitates the bilateral search between sellers and buyers, and hence reduces the trading costs. A market that attracts more order flows will tend to attract more market participants as the market becomes deeper, which is likely to become a center of significant trading volume (Mendelson, 1987; Pagano, 1989a and 1989b; and Chowdhry and Nanda, 1991).

Consistent with these theories, we find that, in the competition for order flows between electronic COMEX and electronic CBOT, the former emerges as the dominant center for trading volume. Both Globex and the electronic CBOT (supported by LIFFE Connect's trading engine) tout themselves as the world's best in term of exchange technology. Yet, the move by COMEX allowed it to steadily gain back its lost market share, while CBOT kept losing its proportions of market share, although both electronic markets operate under similar market conditions. That is, the two regular-sized electronic markets

[1] Related empirical works generally support the superiority of the electronic trading mechanism, which include Chung and Chiang (2006), Ates and Wang (2005), Gwylim, and Alibo (2003), Bloomfield, O'Hara,

provide comparable amount of price discovery and had insignificant price clustering. The bid-ask spreads are similar in both electronic gold markets. Thus, the success of COMEX in attracting more order flow indicates that the largest and oldest metal bourse is the preferred trading venue. The results demonstrate that, if two markets have similar trading mechanisms, the "winner-take-all" will be the outcome, as predicted by the theoretical model of Chowdhry and Nanda (1991). Moreover, although electronic CBOT keeps losing its trading volume, its market conditions remain superb. However, under the same circumstance, the less transparent COMEX open outcry market experiences deteriorated market conditions. Such results highlight the importance of transparency for market quality.

It is worth noting that the recent CBOT/CME merger contains a clause that prohibits the listing of products that compete with NYMEX Globex-traded products on the CME Globlex platform, either by the CME Holdings or any other third parties (Securities and Exchange Commission File No. 333-144371). This coincides with the equilibrium model developed by Glosten (1994), which shows that the competition on the electronic limit order book could result in negative expected profits. In an electronic market, competition mainly takes the form of liquidity supply in the provision of abundant limit orders. Any additional competition is unnecessary. In this sense, an equilibrium pure limit order market is "competiton-proof." Glosten (1994) concludes that the concentration of trading and liquidity in a single centralized electronic market is inevitably the end state of the financial market.

To date, there has been a clear trend toward market participants favoring electronic trading of derivatives, with major U.S. exchanges accelerating their migration away from

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and Saar (2005), Blennerhassett and Bowman (1998), Frino, McInish, and Toner (1998), and Pirrong (1996).

floor trading to electronic systems. Liquidity externalities are particularly strengthened in an electronic setting. Strong network externalities force exchanges to create linkages, which are likely to occur in the form of mergers and acquisitions, or strategic alliances.[2]

I. INSTITUTIONAL DETAILS AND DATA

A. Institutional Details

CME Globex started its full operation in 1992, becoming the first global electronic trading platform for futures contracts. To date, electronic trading has accounted for over 75% of total exchange volume. It was not until 1999 that the CBOT leased an electronic trading system known as a/c/e from Eurex. CBOT later shifted its electronic trading to LIFFE Connect in November, 2003. LIFFE Connect was developed and then launched in late 1997 by London International Financial Futures and Options Exchange. CME thus led Eurex and Euronext.LIFFE, its European rivals, in developing its own electronic models.

CME Globex parallels LIFFE Connect in terms of their functionality and technical architecture. Both systems provide superior trading capabilites. They are the world's most advanced and complete trading systems.

On April 6, 2006, NYMEX, the world's largest physical commodity futures exchange, signed a ten-year technology services agreement with CME. Pursuant to the agreement, NYMEX products would be traded exclusively on the CME Globex electronic-trading platform. Through this strategic alliance CME obtains access to an exchange that is rich in trading expertise in commodity futures. Meanwhile, the NYMEX

[2] In April 2007, NYSE completed a merger with Euronext, which became NYSE Euronext, creating the first global exchange. In July 2007, the CME group is formed as a result of the merger between the CME and the CBOT, which becomes the world's largest derivative exchange.

gains immediate access to the leading exchange technology, allowing it to withstand the fierce competition from its electronic rivals, such CBOT and IntercontinentalExchange.

B. Data and Summary Statistics

Transactions data are collected from September 2006 through June 2007 for the COMEX and CBOT full-sized gold (100 ounce) and silver (5,000 ounce) futures contracts as well as CBOT mini-sized gold and silver futures contracts. Transaction price and volume data for the COMEX contracts are obtained from Tick Data, and data for the CBOT contracts come from the CBOT. Only the most liquid nearby contracts are used for the current study. We use the total number of contracts traded daily from Commodity Systems Inc., to calculate volume for each type of futures contract.

All electronic futures contracts are listed for all months, corresponding with the pit-traded contracts. COMEX floor trading hours extend from 8:20 a.m. to 1:30 p.m. for gold futures, and from 8:25 a.m. to 1:25 p.m. for silver contracts, respectively. We use Eastern Standard Time throughout the paper. Since December 2006, COMEX full-sized gold and silver contracts have been offered for side-by-side trading on CME's electronic platform for a continuous 23-hour period, from 6:00 p.m. to 5:15 p.m. On the CBOT electronic trading platform, these products are available for trading 22 hours per day, from 7:16 p.m. to 5:00 p.m. To make an adequate comparison across markets, like Hasbrouck (2003) and Ates and Wang (2005), the analysis is based on the COMEX open outcry trading schedules. [3]

[3] The intraday patterns for all full-sized and mini-sized electronic contracts show that trades predominantly take place within the COMEX floor trading time frames (See Appendix for more details). This justifies our analysis that focuses on the floor trading hours.

Table 1 presents the descriptive statistics for gold futures and Table 2 for silver futures. The sample data is separated into three subperiods: one pre-period (September to November 2006) and two post-periods (January to March 2007 and April to June 2007). Average daily returns for the gold and silver futures contracts are insignificant (with *t*-statistics less than 1.0) in all subperiods. The gold and silver daily returns are highly correlated. The results suggest that the movements of gold and silver prices are driven by similar underlying forces. Volatility (measured by the standard deviation of returns) keeps decreasing over the entire study periods in both the gold and silver markets.

We first report the results for the three months prior to and after the introduction of the COMEX Globex-traded contracts. For both gold and silver contracts, the average daily numbers of transactions in the COMEX open-outcry market plunged dramatically (by 75% and 80%, respectively) after the automation. Notably, although average daily volume for these contracts also dropped significantly, the decline in volume (by 16% for gold and 34% for silver) was much less dramatic than the decline in the number of transactions. Also, even though the number of daily transactions on the electronic CBOT fell greatly in the post-period, the average daily volume largely remained similar. The evidence suggests that traders who submit small-sized trades were nimbler in making a fast move to the Globex. The newly launched electronic COMEX contract was highly successful, which immediately generated the highest daily trading volume. The volumes in thousand contracts of electronic COMEX, electronic CBOT, floor COMEX and CBOT mini-sized gold (silver) futures are 52.8 (14.3), 47.23 (7.96), 36.92 (9.05), and 2.14 (0.38), respectively.

For the second post period from April to June 2007, the momentum for the electronic COMEX contracts continued. Meanwhile, the daily volume for the CBOT gold futures contract reduced by another dramatic 41%, from 47.23 to 27.71 of thousand contracts, and daily volume for the silver futures contract further decreased by 26%, from 7.96 to 5.59 of thousand contracts. For the whole period, the daily trading volume for CBOT mini-sized gold futures contract kept declining while the volume for silver contract largely remained at the same level.

The intraday minute-by-minute data generally provides similar results. In particular, we notice that COMEX pit-traded contracts experienced a substantial decrease after the introduction of their electronic counterparts in Globex. The average number of trades per minute decreased substantially, from 19.4 to 6.0 and then to 2.4 for gold contracts, and from 8.9 to 2.2 and then to 0.8 for silver contracts. Throughout the entire study period, the electronic COMEX and electronic CBOT gold and silver contracts traded from 36 to 52 times and 12 to 15 times per minute, respectively. Thus, we use one-minute intervals to examine the price discovery process for these actively traded contracts.

II. METHODOLOGY AND EMPIRICAL FINDINGS

Following Martinez and Tse (2006), we focus on four major dimensions of market quality conditions, which are volume, spreads, price clustering, and price discovery. Before COMEX contracts were traded on Globex, we compare market quality conditions only for the CBOT electronically traded contracts, the COMEX pit-traded contracts and CBOT mini-sized contract. For the period after COMEX contracts started trading on Globex, we make comparisons for the four contracts that are traded on the electronic CBOT, Globex and the COMEX floor.

A. Market Share

Figure 1 presents the percentage of daily trading volume for COMEX (floor and electronic contracts combined) and CBOT full-sized and mini-sized gold and silver futures contracts for the period of September 2006 through June 2007. The mini-sized gold (silver) contract is one-third (one-fifth) the size of the full-sized contract. Accordingly, we divided the average daily volume by three (five) so as to make a fair comparison for all contracts. We use the total volume of all contracts.

December 2006 saw an immediate and steady increase of market share for COMEX futures contracts, while CBOT proportions kept declining. Panel A shows that the market share for COMEX gold futures contract increased progressively from around 50% to 80%. For silver futures contract the proportion rose from about 60% to nearly 90%, as illustrated in Panel B. [4] Despite some temporary fluctuations, it became clear that COMEX in aggregate was the ultimate winner. The story might be different from what had happened to CBOT, which launched copy of COMEX full-sized gold contract in October 2004. However, it was not until September 2005 did electronic CBOT start catching volume from COMEX. Thus, markets seemed to react much more quickly to the structural transition as time went by. Throughout the entire study period, CBOT mini-sized gold contract accounted for only 1.9% of the total daily volume, compared to the 1.3% for mini-sized silver contract.

Although electronic CBOT gold futures contract dominated COMEX for a few months, its success did not last long enough and the situation soon reversed after December

[4] Table 1 also shows that the electronic contracts greatly contributed to the increase of the aggregate COMEX volume.

2006. In contrast, the electronic CBOT silver futures contract never got a chance to be dominant in the market share. Even before the introduction of the electronic COMEX contract, the market share for COMEX was around 60% versus 40% for CBOT contracts. This is true, even though the trading costs for COMEX silver contracts, as measured by effective spreads in the following section, averaged several times the transaction costs for CBOT electronic contract, either before or after December 2006. Thus, investors for silver futures appear to have a strong preference for COMEX contracts. This seems to be consistent with the study of multiple-listed options by Battalio et al. (2000), who document that the dominant exchange continues to attract significant order flow although it involves higher trading costs. This implies that the market that has a comparative advantage could gain more order flow. Hendershott and Jones (2005) suggest the heterogeneous preferences of trading clienteles in electronic communications networks (ECNs).

Overall, the success of COMEX in becoming the center of significant trading volume appears to be consistent with the theoretical prediction of Chowdhry and Nanda (1991), which states that the primary market will continue to attract more order flows. As the market becomes deeper, the bilateral search for both buyers and sellers becomes more cost-efficient. This makes that market even more attractive.

B. Effective Spread

Bid-ask spreads are the common proxy for liquidity and transaction costs. A number of studies have investigated changes in the bid-ask spread under two vastly different trading mechanisms: open outcry versus electronic trading. Examples include Tse and Zabotina (2001), Frino et al. (1998), Pirrong (1996), Jain (2005), and Mizrach and

Neely (2006). Pagano and Roëll (1996) show theoretically that transparency reduces the transaction costs. This is further supported by the empirical study of Hendershott and Jones (2005). If liquidity externalities do matter, the liquidity externalities should increase in the markets that pick up order flow, resulting in decreased trading costs. Alternatively, the markets that experience the fragmentation of the order flow should induce increased trading costs. On the whole, the analysis indicates that improvement in execution efficiency and market transparency enhances competition and reduces the adverse selection costs on the electronic market, resulting in a narrower bid-ask spread.

Two approaches are adopted to compute the effective bid-ask spread, which are based on the same formula as follows:

$$\frac{1}{T}\sum_{t=1}^{T}\left|\Delta p_t\right|$$

where $\sum_{t=1}^{T}\left|\Delta p_t\right|$ is the sum of the absolute values of price changes. T is the number of transactions.

The Thompson and Waller (TW) (1988) approach measures the bid-ask spread as an average of the absolute value of non-zero price changes. Any price change that is equal to zero is removed from the observations. However, such approach does not differentiate the price changes caused by adjustments in equilibrium price from changes in the bid-ask spread. The Wang, Yau, and Baptiste (WYB) (1997) approach goes one step further by retaining only the price changes with reversals, which thus effectively separates the effects of true price changes.

Estimations of daily effective spreads are presented in Table 3. Both the TW and WYB approaches give similar results, and we focus on the TW results. For the pre-period, the spreads of CBOT contracts were much narrower than those of the floor-traded COMEX contracts for both gold (for example, 1.16% vs. 1.85% in November) and silver (3.19% vs. 10.68% in November).

In December 2006 when COMEX just launched side-by-side trading on Globex, the CBOT electronically traded gold contract had the narrowest daily average effective spread (1.11%), closely followed by COMEX electronic contract (1.19%). COMEX pit-traded gold contract had the widest daily spread (1.59%). Since then, the spreads for COMEX electronic contract kept declining, while the spreads on the open outcry market kept widening. By the end of June 2007, average spread for the electronic COMEX gold futures contract (1.06%) had become marginally narrower than that for the CBOT contract (1.12%), while the spread for floor COMEX contract was 2.27%. Thus, the declining volume share of the COMEX open-outcry contracts induces lower liquidity and higher transaction costs than for the other two electronic contracts.

Notably, for the electronic COMEX silver futures contract, the spreads of 6.29% in December 2006 and 5.37% in June 2007 were still much wider than those of its CBOT counterparts (2.99% and 3.10%), although they kept decreasing. The narrower spread in the CBOT silver market is resulted from its smaller price change (see footnote 5). Meanwhile, the spread for pit-traded COMEX contract rose from 10.45% to a sizable 13.16%. The *t*-statistics indicate that average spreads in all markets are significantly different from each other over the entire sample period. Thus, the electronic COMEX kept capturing significant trading volume of silver contracts from CBOT regardless of its higher trading costs, as demonstrated in the previous section.

The CBOT gold and silver mini-sized contracts had wider daily effective spread than their full-sized electronic counterparts, but narrower spreads than pit-traded COMEX contract. Over the entire period, the spread for silver mini-sized contract kept declining, while the spread for gold mini-sized contract continued to be constant.

C. Price Clustering

In examining the consequences of structural changes following automated trading, Gwilym and Alibo (2003), and Tse and Zabotina (2001) find that the extent of price clustering drops significantly in electronic markets. Decreased price clustering leads to narrower spreads, an indication of improved market quality. Pirrong (1996) argues that tacit collusion among locals in an open-outcry market could trigger more price clustering. Thus, a transparent electronic market should enhance the fairness of competition, resulting in higher market quality.

Harris (1991) shows that clustering is directly related to price level and volatility, and is inversely related to transaction frequency. Grossman et al. (1997) argue that more price clustering happens in volatile markets when participants need to act more quickly, and less price clustering in more liquid markets where trades occur more frequently.

Table 4 presents the percentage of futures prices with the last digit ending in zero and five for gold futures contracts. [5]The ending digits of prices tend to concentrate in these two values when there is price clustering. Moreover, the extent of price clustering for values ending of zero is slightly greater than that for values ending of five. No significant price clustering is observed for electronic COMEX (for example, in June 2007, about

[5] The minimum price changes for COMEX silver contracts are in multiples of one-half cent ($0.005) per troy ounce. For CBOT silver contract, the price changes are registered in multiples of one-tenth of a cent ($0.001) per troy ounce. Thus, no appropriate comparisons can be made in terms of price clustering.

10.9% and 10.8% of zero and five, respectively) and electronic CBOT contracts (about 11% and 10.6%). In the same month, the COMEX pit-traded contract has most price clustering (21.4% ending in zero and 16% ending in five). Electronically traded CBOT mini-sized contract basically shows no patterns of price clustering.

The evidence that all electronically traded contracts, either full-sized or mini-sized, effectively eliminate price clustering indicates that a transparent limit order market is less likely subject to the adverse selection problem. Price clustering analysis is generally consistent with the patterns we observe for volume and effective spread.

D. Price Discovery

The prices for the same financial instruments traded on various markets should be cointegrated and be driven by a common factor, the implicit efficient price. Price discovery, or how prices are determined, is closely associated with the process of price adjustment to incoming information and the determinants of transaction costs. Price discovery is important in that it reveals which market leads in forming new equilibrium prices after information is permanently incorporated into prices.

It has been recognized that transparency significantly improves the information efficiency of the markets. See the analytical results of Bloomfield and O'Hara (1999) and Madhavan (1995) and Pagano and Roëll (1996). Hendershott and Jones (2005) show that both quote transparency and concentration of order flow are associated with more efficient price discovery. Thus, market structure should have an important impact on price discovery process. A transparent and actively traded electronic market should greatly facilitate price discovery, particularly given its fast speed of execution.

Two widely used econometric methods are employed in measuring each market's contribution to price discovery for financial products traded in multiple markets. One is the information shares (IS) model developed in Hasbrouck (1995) and the other is the permanent-transitory (PT) model introduced by Gonzalo and Granger (1995).

The cointegrated prices from competiting trading venues can be formulated as a vector error correction model (VECM)

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{j=1}^{k} C_j \Delta X_{t-j} + e_t \tag{3}$$

where $X_t \equiv \{x_{it}\}$ is a n × 1 vector of cointegrated prices. α is the error correction vector, and β is the cointegrating vector. $\alpha\beta'$ and C_j are n × n matrices of parameters, and $e_t \sim (0, \Psi)$ is a n×1 zero-mean vector of serially-uncorrelated residuals with a covariance matrix, Ψ. $\alpha\beta' X_{t-1}$ represents the long-run relationship between the price series, and provides permanent price movements.

Hasbrouck (1995) and Gonzalo and Granger (1995) transform the VECM into the Stock and Watson (1988) common-factor model, decomposing X_t into a common factor and a temporary component. Hasbrouck (1995) defines a market's contribution to price discovery as its information share, or the proportion of the common factor innovation variance that can be attributed to that market. Gonzalo and Granger attribute the common factor innovations to the price changes of each series, and provide coefficients of the common factor. The higher the information share or the larger the common-factor coefficient, the more a market contributes to the price discovery process.

The Hasbrouck (1995) and Gonzalo and Granger (1995) models provide similar results if the residuals are uncorrelated. If there is a significant correlation among the contemporaneous cross-equation residuals, results from the two models can be substantially different (Baillie et al. 2002; De Jong, 2002; Harris, McInish and Wood, 2002; and Hasbrouck, 2002). With correlated residuals, results of the information shares depend on the ordering in which the variables are represented in the VECM. Following Baillie et al. (2002), we use the mean of the information shares of all orderings. The Gonzalo and Granger model does not decompose the covariance matrix of residuals, and the results do not depend on the ordering of the variables.

In this study, we use minute-by-minute trade price to estimate the daily information shares of Hasbrouck (1995) and the common-factor coefficients of Gonzalo and Granger (1995). As presented in Table 5, the results obtained from these two models are qualitatively the same. Therefore, we only describe the mean of the information share results. We also report the upper and lower bounds of information share for reference. It is worthwhile to mention that price discovery is a relative concept. Emphasis should be placed on the comparative contribution made by each market, rather than the absolute values themselves.

During the pre-period, the CBOT electronic contract provided more price discovery than the floor-traded COMEX contract. In November, the CBOT gold and silver contracts contributed 44% and 49% to the fundamental values, respectively, while the floor-traded COMEX contracts contributed 22% and 35%. The mean information share for CBOT mini-sized contract for gold (silver) futures is 34% (16%). During the post-period, the contributions of CBOT and electronic COMEX contracts are similar in both the gold and silver markets. In June 2007, the CBOT and electronic COMEX contributions were 32% and 34% for gold futures, and 38% and 38 for silver futures, respectively. The mean information share for CBOT mini-sized contract drops to 23% (14%) for gold (silver) futures. Again, the worst market quality occurred in the COMEX pit-traded contract, which made only limited contribution to the price discovery, with 11% (10%) for gold (silver) contract.

Overall, the full-sized electronic contracts have higher information shares than their mini-sized counterparts. The pit-traded COMEX contracts have the lowest information shares. The dominance of price discovery in the electronic markets demonstrates the importance of transparency, which facilitates the information flow and hence the process of price discovery. Martinez and Tse (2006) and Liu, Fung, and Tse (2008), among others, show that the market's information share contribution is positively related to its market share in their comparative study on electronic and floor trading. This suggests that the markets that obtain more order flow could enhance price discovery. Our findings show that, although the electronic COMEX dominates the electronic CBOT in terms of order flow, both markets make comparable contributions to the price discovery process. Such results are consistent with the view that transparency dominates volume effects, supporting the superiority of electronic trading.

III. CONCLUSIONS

On December 4, 2006, the side-by-side trading of COMEX gold and silver futures contracts was launched on the CME's Goblex electronic platform. This move was a response to the launch of copied contracts on the computerized CBOT in October 2004, which captured a large proportion of trading volume from open outcry COMEX. Martinez and Tse (2006) show that market quality of COMEX was severely undermined as a result of order flow migration.

We investigate the effects of competition for order flow and market quality on two homogeneous precious metals futures contracts on the traditional pit-based system and on the two rival electronic trading exchanges, COMEX and CBOT, before and after the launch of the COMEX electronic contracts. Essential market quality attributes such as trading volume, effective spread (proxied for trading costs), price clustering, and price discovery are carefully analyzed.

Overall, our empirical findings are broadly consistent with the common theoretical predictions. First, the transparent electronic markets have superior market quality conditions. The quality of open outcry COMEX deteriorates as more order flows migrate to the electronic markets. Second, the electronic COMEX as the primary market succeeds in attracting more order flow although both electronic COMEX and electronic CBOT have comparable market quality conditions. The migration of volume from the electronic CBOT to the electronic COMEX does not impair the market quality of the CBOT. Such results demonstrate the important link between transparency and market quality.

Since December 2006, the electronic CBOT and electronic COMEX contracts have similar bid-ask spreads in the gold market, while the CBOT silver contract has narrower spreads than the COMEX contract. They also provide equivalent contribution in the price discovery process in both the gold and silver markets. The price clustering in both electronic markets is not evident. Taken as a whole, the electronic CBOT contract and the COMEX electronic contract are comparable in terms of market quality. Yet, the market shares for Globex-traded COMEX gold and silver contracts increase steadily. Under similar market structures, the "winner market takes most" equilibrium in Chowdhry and

Nanda (1991) suggests that the primary market generally emerge as the dominant market for order flow, as the COMEX in our context. The floor-traded COMEX contracts have the poorest market quality in all measures. The overall results demonstrate that the alliance between NYMEX and CME was quite a success.

In evaluating the effects of multimarket trading, the dichotomy between integration and fragmentation has been the focus of substantial debates. For markets that operate under different trading mechanisms, our results show that, in a transparent electronic market, the integration effect is enhanced. Yet in a more opaque open outcry setting, fragmentation effects dominate. Indeed, in recent years, there has been a general move towards open electronic limit order book market. The development and growth of electronic platforms greatly facilitate online trading, which offers the advantages of transparency, fast speed of execution, time flexibility, and low transaction costs. In a new round of competition among electronic exchanges, the enhanced competitiveness of the financial markets forces exchanges to form alliances or to merge with each other.

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Table 1
Summary Statistics for Gold Futures

Summary statistics are provided for the periods three months before and six months after the launch of COMEX electronic contract in December 2006. COMEX stands for the COMEX pit-traded full-sized contract, COMEX_E stands for the full-sized contract traded on Globex, CBOT stands for the CBOT full-sized contract, and CBOT_M stands for CBOT mini-sized contract.

Panel A: Daily

	Sept 2006-Nov 2006		*Jan 2007-Mar 2007*		*Apr 2007-Jun 2007*	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Returns (%)						
COMEX	0.050	1.378	0.082	1.172	-0.044	0.865
CBOT	0.049	1.357	0.082	1.168	-0.042	0.860
CBOT_M	0.049	1.360	0.082	1.171	-0.042	0.862
COMEX_E			0.082	1.170	-0.042	0.859
Transactions (in thousands)						
COMEX	6.00	1.64	1.49	0.63	0.76	0.27
CBOT	16.27	5.80	10.14	3.28	11.20	5.98
CBOT_M	2.96	1.16	1.55	0.64	2.34	1.39
COMEX_E			8.96	4.30	11.88	3.43
Volume (in thousands)						
COMEX	44.21	21.25	36.92	22.11	27.97	26.19
CBOT	49.88	11.38	47.23	14.48	27.71	8.33
CBOT_M	2.50	0.74	2.14	0.74	1.86	0.74
COMEX_E			52.84	17.70	56.93	15.90

Panel B: Minute by Minute

	Sept 2006-Nov 2006		*Jan 2007-Mar 2007*		*Apr 2007-Jun 2007*	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Returns (%)						
COMEX	0.0002	0.0618	0.0002	0.0515	-0.0001	0.0429
CBOT	0.0001	0.0581	0.0002	0.0473	-0.0001	0.0388
CBOT_M	0.0001	0.0614	0.0002	0.0532	-0.0002	0.0417
COMEX_E			0.0002	0.0477	-0.0001	0.0388
Transactions						
COMEX	19.38	14.06	6.03	7.79	2.44	3.83
CBOT	52.47	47.49	41.13	41.68	36.13	48.72
CBOT_M	9.55	11.10	6.29	8.69	7.56	12.48
COMEX_E			36.32	37.65	38.33	41.02

Table 2
Summary Statistics for Silver Futures

Summary statistics are provided for the periods three months before and six months after the launch of COMEX electronic contract in December 2006. COMEX stands for the COMEX pit-traded full-sized contract, COMEX_E stands for the full-sized contract traded on Globex, CBOT stands for the CBOT full-sized contract, and CBOT_M stands for CBOT mini-sized contract.

Panel A: Daily

	Sept 2006-Nov 2006		Jan 2007-Mar 2007		Apr 2007-Jun 2007	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Returns (%)						
COMEX	0.123	2.225	0.064	1.758	-0.132	1.422
CBOT	0.121	2.219	0.064	1.754	-0.130	1.424
CBOT_M	0.119	2.257	0.052	1.779	-0.122	1.422
COMEX_E			0.064	1.758	-0.129	1.424
Transactions (in thousands)						
COMEX	2.68	0.85	0.53	0.24	0.25	0.11
CBOT	4.05	1.80	3.23	1.16	3.62	1.84
CBOT_M	0.66	0.34	0.50	0.24	0.73	0.37
COMEX_E			3.37	1.77	4.36	1.44
Volume (in thousands)						
COMEX	13.81	7.17	9.05	8.32	11.07	10.01
CBOT	7.30	2.04	7.96	3.14	5.89	2.36
CBOT_M	0.32	0.13	0.38	0.19	0.35	0.19
COMEX_E			14.34	5.68	16.40	6.19

Panel B: Minute by Minute

	Sept 2006-Nov 2006		Jan 2007-Mar 2007		Apr 2007-Jun 2007	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Returns (%)						
COMEX	0.0005	0.1130	0.0003	0.0952	-0.0005	0.0723
CBOT	0.0003	0.0994	-0.0002	0.0846	-0.0005	0.0695
CBOT_M	0.0003	0.1137	-0.0002	0.1131	-0.0004	0.0753
COMEX_E			-0.0003	0.0841	-0.0004	0.0702
Transactions						
COMEX	8.93	8.55	2.21	3.51	0.82	1.89
CBOT	13.51	15.62	13.46	15.72	12.06	19.03
CBOT_M	2.22	3.43	2.09	3.72	2.45	4.80
COMEX_E			14.06	15.24	14.55	18.31

Table 3
Daily Average Estimates of Effective Spreads

The effective bid-ask spreads are estimated by the Thompson and Waller (TW) (1988) and Wang, Yau, and Baptiste (WYB) (1997) models. We use the most liquid nearby contracts from September 2006 to June 2007 based on COMEX open outcry trading schedule.

Panel A: Gold Futures

	COMEX (a)		CBOT (b)		CBOT_M (c)		COMEX_E (d)		t- test for mean (a)-(b)		t- test for mean (a)-(c)		t- test for mean (b)-(c)		t- test for mean (a)-(d)		t- test for mean (b)-(d)		t- test for mean (c)-(d)	
	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB
Sep-06	1.91	1.99	1.14	1.18	1.59	1.71			-16.78	-16.29	6.2	5.14	-24.31	-24.72						
Oct-06	1.83	1.91	1.13	1.17	1.57	1.69			-21.15	-21.84	7.9	7.27	-26.59	-26.94						
Nov-06	1.85	1.94	1.16	1.18	1.48	1.54			-7.21	-7.57	4.52	4.12	-13.82	-14.12						
Dec-06	1.59	1.63	1.11	1.14	1.47	1.54	1.19	1.25	-18.36	-17.87	4.96	3.75	-18.52	-16.14	14.64	12.86	-5.15	-5.68	-17.47	-12.97
Jan-07	1.93	2.01	1.11	1.14	1.64	1.75	1.15	1.21	-8.16	-7.57	3.93	2.95	-12.39	-12.12	8.58	7.56	-3.41	-5.99	-12.9	-11.46
Feb-07	1.97	2.04	1.12	1.14	1.60	1.70	1.12	1.18	-21.86	-22.89	10.95	9.83	-22.05	-21.23	20.37	21.14	-0.38	-2.98	-20.36	-18.63
Mar-07	2.26	2.36	1.15	1.19	1.92	2.06	1.13	1.18	-10.76	-10.03	2.3	1.83	-5.88	-6.04	10.76	9.88	4.01	1.61	-5.99	-6.03
Apr-07	2.26	2.34	1.11	1.14	1.59	1.70	1.08	1.12	-32.1	-30.86	22.43	15.45	-20.78	-18.13	31.33	30.57	5.45	3.55	-21.38	-18.52
May-07	2.31	2.44	1.11	1.13	1.45	1.52	1.06	1.08	-25.33	-23.26	15.94	14.26	-12.03	-11.69	26.02	24.19	9.09	9.09	-14.44	-13.65
Jun-07	2.27	2.36	1.12	1.14	1.56	1.66	1.06	1.08	-25.4	-23.69	15.88	12.87	-20.17	-19.64	26.22	24.59	8.27	8.17	-18.15	-17.81

Panel B: Silver Futures

	COMEX (a)		CBOT (b)		CBOT_M (c)		COMEX_E (d)		t- test for mean (a)-(b)		t- test for mean (a)-(c)		t- test for mean (b)-(c)		t- test for mean (a)-(d)		t- test for mean (b)-(d)		t- test for mean (c)-(d)	
	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB	TW	WYB
Sep-06	10.58	10.83	3.82	4.54	9.59	11.04			-121.79	-86.21	2.43	-0.42	-15.11	-13.42						
Oct-06	10.23	10.49	3.50	4.15	9.95	11.56			-83.29	-67.55	0.76	-2.4	-18.77	-17.7						
Nov-06	10.68	10.98	3.19	3.52	7.05	7.52			-26.99	-22.58	9.57	7.43	-19.22	-15.36						
Dec-06	10.45	10.70	2.99	3.44	7.15	7.61	6.29	6.72	-64.19	-60.70	10.38	8.40	-12.79	-10.70	30.92	29.52	-44.58	-45.92	-2.44	-2.20
Jan-07	10.96	11.34	2.97	3.41	6.99	7.36	5.80	6.15	-66.13	-55.07	29.97	22.61	-25.30	-22.62	36.46	29.18	-61.64	-39.65	-6.54	-5.93
Feb-07	12.13	12.52	2.93	3.35	7.06	7.58	5.57	5.82	-16.58	-17.20	12.57	12.36	-10.90	-10.93	11.36	12.51	-71.29	-71.90	-3.70	-4.50
Mar-07	12.61	13.17	3.48	4.00	8.01	8.81	5.53	5.78	-41.52	-33.07	16.65	10.79	-13.17	-10.68	29.40	25.85	-24.71	-18.32	-6.48	-6.29
Apr-07	12.76	13.19	3.05	3.47	7.15	7.81	5.40	5.58	-34.33	-30.40	17.36	13.99	-17.59	-16.05	25.38	23.65	-47.78	-36.58	-6.77	-7.52
May-07	12.17	12.13	2.82	3.08	6.05	6.39	5.34	5.52	-38.54	-30.63	22.36	15.86	-14.90	-13.21	27.44	22.81	-64.95	-41.30	-3.35	-3.68
Jun-07	13.16	13.47	3.10	3.54	5.94	6.44	5.37	5.54	-23.31	-19.76	18.77	14.62	-19.52	-17.37	17.38	15.13	-65.66	-46.45	-3.44	-5.08

Table 4
Price Clustering for Gold Futures (in percentage)

Frequency distribution of the last digit of prices with ending values in 0 and 5 is presented for gold futures contract, extending from September 2006 to June 2007. CBOT refers to the full-sized contract in the CBOT, and CBOT_M refers to the CBOT mini-sized contract. COMEX is the pit-traded COMEX full-sized contract and COMEX_E is the COMEX Globex-traded full-sized contract. The comparison is based on the COMEX open outcry trading schedule.

Panel A: Price Clustering at Ending Values of Zero

	COMEX	CBOT	CBOT_M	COMEX_E
Sep 06	22.0	12.1	12.4	
Oct 06	22.0	11.8	13.0	
Nov 06	20.1	11.4	12.8	
Dec 06	18.7	11.4	11.9	12.9
Jan 07	20.8	11.2	12.1	12.5
Feb 07	21.1	11.3	12.3	12.1
Mar 07	23.8	11.2	12.2	11.3
Apr 07	22.1	11.2	12.3	11.0
May 07	19.7	10.5	11.1	10.3
Jun 07	21.4	11.0	11.9	10.9

Panel B: Price Clustering at Ending Values of Five

	COMEX	CBOT	CBOT_M	COMEX_E
Sep 06	18.9	10.5	10.6	
Oct 06	18.4	10.9	10.7	
Nov 06	17.1	10.4	10.9	
Dec 06	14.8	10.1	10.4	10.7
Jan 07	16.7	10.1	10.6	10.8
Feb 07	17.6	10.5	10.9	11.1
Mar 07	18.8	10.4	10.6	10.7
Apr 07	17.4	10.4	10.8	10.4
May 07	18.1	11.0	11.0	11.4
Jun 07	16.0	10.6	10.3	10.8

Table 5

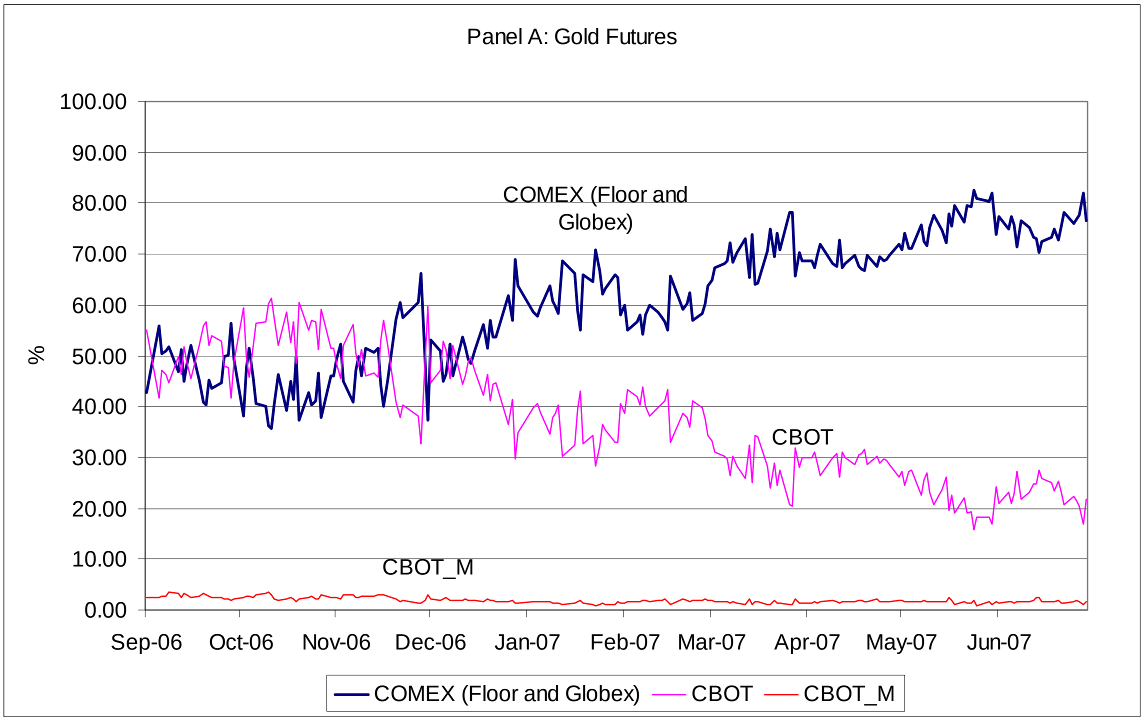
Price Discovery Analysis for Gold and Silver Futures

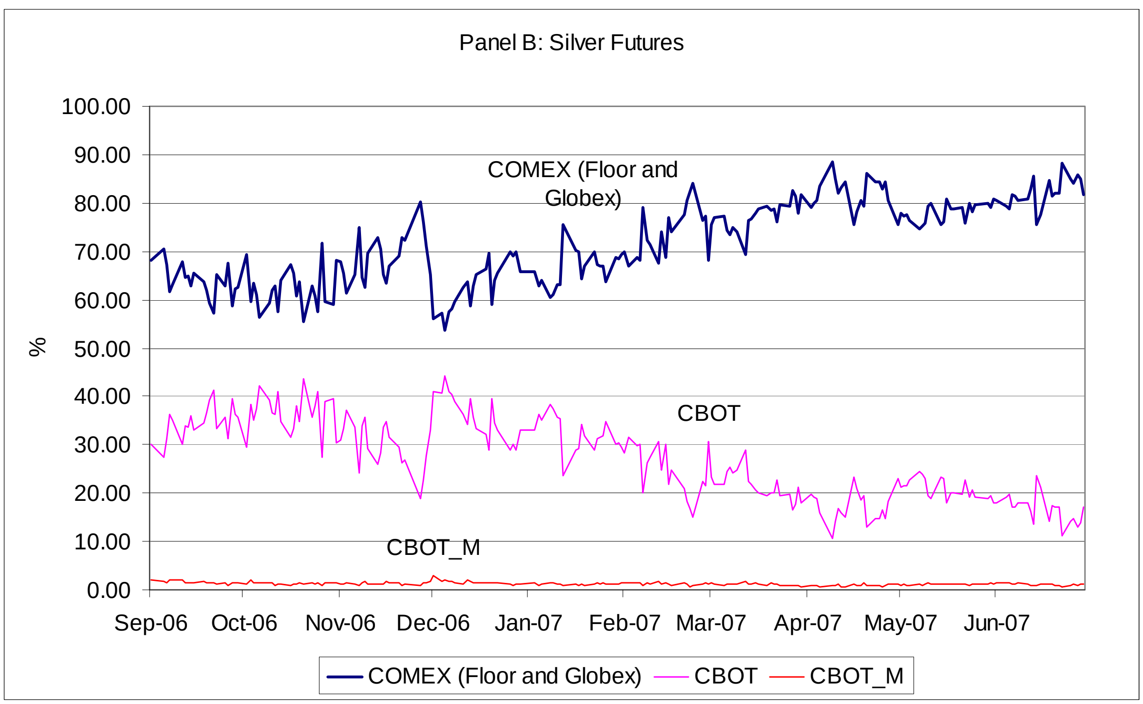
The table presents the price discovery contributions for gold and silver futures prices from the COMEX open outcry full-sized contracts (COMEX), the CBOT full-sized contracts (CBOT), the CBOT mini-sized contracts (CBOT_M), and the COMEX electronic traded full-sized contracts (COMEX_E), using the Hasbrouck (1995) Information Share model and the Gonzalo and Granger (1995) Permanent-Transitory model. The results are reported in the monthly average. One-minute intervals are constructed with transaction data from September 2006 to June 2007, using the most liquid nearby contracts based on COMEX open outcry trading schedule.

	Hasbrouck IS Model												Gonzalo-Granger PT Model			
	Mean Values				Upper Bound				Lower Bound				Mean Values			
	COMEX	CBOT	CBOT_M	COMEX_E	COMEX	CBOT	CBOT_M	COMEX_E	COMEX	CBOT	CBOT_M	COMEX_E	COMEX	CBOT	CBOT_M	COMEX_E
	Panel A: Gold Contracts															
Sep-06	0.27	0.40	0.33		0.72	0.89	0.79		0.03	0.09	0.05		0.19	0.48	0.33	
Oct-06	0.24	0.45	0.31		0.61	0.89	0.75		0.02	0.15	0.03		0.22	0.52	0.27	
Nov-06	0.22	0.44	0.34		0.59	0.93	0.83		0.02	0.12	0.04		0.22	0.47	0.31	
Dec-06	0.17	0.32	0.21	0.29	0.53	0.86	0.69	0.81	0.02	0.06	0.01	0.05	0.20	0.38	0.19	0.23
Jan-07	0.20	0.30	0.20	0.30	0.52	0.75	0.55	0.75	0.05	0.05	0.03	0.04	0.16	0.35	0.21	0.29
Feb-07	0.15	0.32	0.23	0.30	0.46	0.82	0.66	0.81	0.03	0.04	0.04	0.03	0.10	0.36	0.19	0.35
Mar-07	0.12	0.34	0.20	0.33	0.37	0.86	0.59	0.84	0.02	0.05	0.03	0.05	0.14	0.35	0.19	0.32
Apr-07	0.13	0.34	0.22	0.32	0.39	0.89	0.67	0.87	0.02	0.05	0.02	0.03	0.10	0.41	0.14	0.35
May-07	0.12	0.31	0.24	0.33	0.32	0.83	0.68	0.87	0.03	0.03	0.03	0.05	0.13	0.31	0.24	0.32
Jun-07	0.11	0.32	0.23	0.34	0.30	0.87	0.70	0.91	0.03	0.02	0.01	0.06	0.12	0.34	0.18	0.36
	Panel B: Silver Contracts															
Sep-06	0.38	0.43	0.19		0.82	0.87	0.48		0.08	0.12	0.03		0.40	0.41	0.18	
Oct-06	0.36	0.49	0.15		0.69	0.84	0.35		0.11	0.21	0.03		0.36	0.45	0.19	
Nov-06	0.35	0.49	0.16		0.68	0.84	0.38		0.12	0.23	0.02		0.35	0.48	0.18	
Dec-06	0.15	0.37	0.16	0.32	0.45	0.86	0.48	0.81	0.03	0.09	0.02	0.05	0.25	0.29	0.13	0.32
Jan-07	0.15	0.37	0.16	0.33	0.40	0.85	0.46	0.80	0.03	0.09	0.02	0.04	0.12	0.40	0.20	0.27
Feb-07	0.15	0.36	0.13	0.37	0.35	0.80	0.33	0.81	0.04	0.07	0.01	0.09	0.14	0.30	0.13	0.43
Mar-07	0.10	0.36	0.16	0.38	0.23	0.84	0.44	0.87	0.01	0.06	0.03	0.07	0.18	0.42	0.21	0.19
Apr-07	0.09	0.35	0.22	0.34	0.24	0.84	0.55	0.81	0.02	0.05	0.05	0.05	0.16	0.30	0.15	0.39
May-07	0.07	0.38	0.17	0.38	0.18	0.85	0.47	0.85	0.02	0.08	0.02	0.07	0.20	0.28	0.20	0.32
Jun-07	0.10	0.38	0.14	0.38	0.18	0.79	0.37	0.79	0.05	0.09	0.03	0.10	0.15	0.33	0.16	0.37

Figure 1
Percentage of Total Daily Volume

Percentage of total daily volume is estimated from September 2006 to June 2007. CBOT is the CBOT full-sized contracts, and CBOT_M is the CBOT mini-sized contract; COMEX is the full-sized contracts traded on both COMEX open outcry floor and the Globex electronic platform. Daily volume data are obtained from Commodity Systems Inc.





APPENDIX
Intraday Patterns for Number of Transactions

EST stands for Eastern Standard Time. The vertical axis represents the average number of transactions per minute.