Electronic Trading, Transaction Costs and Price Discovery*

This version: March 5, 2006

Siu-Kai Choy
Joseph L. Rotman School of Management
University Toronto, 105 St. Gorge Street
Toronto, Ontario, Canada M5S 3E6
Tel: 416-834-6117
E-mail: Siu.Choy05@Rotman.Utoronto.Ca

Hua Zhang
Department of Finance
The Chinese University of Hong Kong
Shatin, NT, Hong Kong
Tel: (852)2609-7760
E-mail: hzhang@cuhk.edu.hk

* The authors would like to thank Wai-ming Fong, Li-ming Han, Raymond So, and Leslie Young for their helpful comments and Joel Hasbrouck for providing part of the computing programs. The usual disclaimer applies.

Electronic Trading, Transaction Costs and Price Discovery

Abstract

In Hong Kong, both regular futures and mini futures contracts as well as their underlying spot market index portfolio are traded on electronic trading platforms, in comparison to the U.S. where, under current arrangements, regular futures contracts are traded on open outcry floors while the mini futures contracts are traded on an electronic platform. This study examines the price discovery dynamics in Hong Kong equity index markets. Using Hasbrouck's (1995) information share approach, it is found that in Hong Kong, the regular futures contracts market plays a dominant role in price discovery and, the mini futures and cash index markets play minor roles. The results in this paper are in contrast to those in Hasbrouck (2003) and Kurov and Lasser (2004) who found that the E-mini contracts in the U.S. actually played a leading role in price discovery despite their lower market share in terms of dollar value traded. The evidence in this paper provides a strong support to the trading costs hypothesis by Fleming, Ostdiek and Whaley (1996).

Key words: price discovery, information share, equity index markets

Electronic Trading, Transaction Costs and Price Discovery

1. **Introduction**

In recent years, there has been an ongoing transition from open outcry trading floors to electronic trading platforms in futures trading around the world. However, in the U.S. most of the futures trading is still conducted through the traditional open outcry method. In September 1997, the Chicago Mercantile Exchange (CME) introduced the E-mini S&P 500 futures, which can be traded around the clock on the electronic Globex trading system. E-mini futures contracts are one-fifth the size of regular futures contracts and are intended for traders with small margin accounts. When the E-mini futures contracts were introduced, the regular futures contracts were expected to function as the price leader for the E-mini contracts. Hasbrouck (2003) examined high frequency intraday transaction data from the U.S. equity index markets for the period from March 1 to May 31, 2000, and found that rather than being an informational satellite, the E-mini contracts actually played a leading role in price discovery. This was an unexpected finding because the regular futures contracts had a dominant market share and relatively lower transaction costs. Kurov and Lasser (2004) obtained similar results using data from the U.S. markets for the period from May 7 to September 7, 2001. Kurov and Lasser's study also found that in the E-mini futures market, trades initiated by exchange locals seemed to be more informative than those initiated by off-exchange traders. They suggested that local traders observed the order flow in the open-outcry pit, and then submitted trades through the high speed Globex trading system.

As Hasbrouck (2003) and others pointed out, the pit and electronic markets are fundamentally different in several ways. First, the Globex trading system reports trading information (order flows, and transaction prices and volumes) in real time while the pit market reports the price only if it differs from the previous trade. Therefore, the information reported in the pit market is coarser than that in the Globex system. Second, in the pit market, prices are relayed verbally or by hand signals to a pit reporter who then types them manually into the system. As a result, there is typically, up to a 5 second delay in reporting (Kurov and Lasser (2003)). Third, the reported trading volumes in the two different markets are not directly comparable. For example, in a pit market, an outside customer order may lead to multiple trades before it gets passed on to another outside investor, while investors can interact directly with each other in an electronic limit book market. Therefore, some interesting questions remains unanswered on this subject. Will the main results in Hasbrouck (2003) remain unchanged if both the regular and mini futures contracts are traded on a same trading platform? Can the mini futures market continue to play a leading role in the incorporation of new information when the regular futures contracts market migrates to an electronic platform? Can the mini futures market even survive when it eventually loses the speed of execution advantage? Despite being hypothetical, these questions are important, given the ongoing worldwide trend towards electronic trading.

In this paper, we investigate the price discovery dynamics in the Hong Kong equity index markets where regular futures contracts, mini futures contracts and the underlying Hang Seng Index (HSI) stocks are all traded on electronic trading platforms. The mini HSI futures contracts are one-fifth the size of the regular futures contracts. Both trading positions and margin account balances are fungible for the two types of contracts, in that one regular contract can offset five mini contracts. All aspects of the trading arrangements for the two types of contracts are identical, except that it costs slightly more to trade the mini contracts on a per dollar basis[1]. The Hong Kong equity index futures markets provide us with a unique setting where we can ***isolate*** the impacts of transaction costs on price discovery and leadership in futures trading.

Fleming, Ostdiek and Whaley's (1996) trading cost hypothesis postulates that for securities with the same underlying asset, the market that provides the lowest trading costs should dominate. The unique trading arrangement in Hong Kong futures markets provides an idea setting for conducting a "clean" test on the trading costs hypothesis. In Hong Kong, both regular and mini futures contracts are traded on the same electronic platform. However, because the regular futures contracts have a much higher trading volume and a slightly lower transaction cost on a per dollar basis, we predict that most of the new information would be first incorporated into the regular contracts rather than into the mini contracts. As expected, we found that the regular HSI futures contracts did play a major role in price discovery while the mini futures contracts were a minor information contributor. Our results are consistent across different sub-sample periods as well as at different data observation time intervals. It is interesting to note that even though the mini futures contracts are with a slight disadvantage in trading cost on a per dollar basis, they have in fact survived and have gained in popularity in terms of number of contracts traded over time. The findings in this study complement those in the studies by Hasbrouck (2003), and Kurov and Lasser (2004). The combined evidence from the U.S. and Hong Kong markets tends to support the notion that it is the combination of market factors such as execution speed, trading costs, price transparency, liquidity and trading anonymity that determines which market plays a leading role in price discovery and leadership; that is,

---

[1] For the relevant trading costs in the Hong Kong equity index markets, please see Table 1.

price discovery takes place mainly in the market where conditions are most favorable to informed traders. Under current trading arrangements in the U.S. equity index markets, factors such as execution speed, and trader anonymity in the mini futures market are presumably more important to informed traders than the slightly higher transaction costs on a per dollar value basis in comparison to the regular futures market, whereas in Hong Kong the trading costs per dollar value is the deciding factor, because it is the only difference between the regular and mini contracts markets.

The remainder of the paper is organized as follows. Section 2 provides a brief literature review. Section 3 provides some background information about the Hong Kong equity index markets and data description. Section 4 describes the methodology of this study. Section 5 presents the empirical results. Finally, Section 6 concludes the paper.

2. Literature Review

Price discovery is the process of incorporating new information into prices, and is the process by which markets attempt to arrive at equilibrium prices. In a perfect and frictionless market, securities with the same underlying asset should react to new information related to that underlying asset in a simultaneous and instantaneous way or otherwise there will be arbitrage opportunities. However, the presence of institutional factors such as bid-ask spreads, short selling restrictions, transaction costs, or differences in trading platforms, makes it possible that a certain market will react to new information faster than another market, although each market may be involved in the price discovery process.

It is well recognized that trading in index futures contracts is less costly than trading in the underlying cash index portfolio. There is also a leverage effect associated with a position in the futures market, whereby investors are only required to deposit a margin, rather than the full value of the contract. As a result, most new information that is related to the overall market should be incorporated into index futures prices before it is reflected in the stock index. There have been many studies on the price dynamics between stock indexes and their corresponding futures markets (e.g., Stoll and Whaley (1990), Chan (1992), and Fleming, Ostdiek, and Whaley (1996)). In general, the extant literature suggests that index futures contracts lead underlying stock index portfolios in price discovery.

Traditionally, the methodology used to analyze price discovery relationships among securities with the same underlying assets, such as cash index portfolios, index futures and index options, has been lead-lag regression. However, lead-lag regression is a bivariate analysis in which only two securities can be analyzed at one time. The lead-lag regression methodology cannot quantify the exact proportion that each of the related markets contributes to the efficient price discovery. Developments in multivariate time series analysis allow a clearer interpretation of dynamics in all related security markets. Engle and Granger (1987) provide the important concepts of cointegration and error correction for use in these types of multivariate analyses. For example, the price quotes for a stock that is traded in different markets are said to be cointegrated because all quoted prices are driven by a common efficient price. A vector error correction model (VECM) can be estimated and the relationships among securities can be found from estimated coefficients of error correction terms (e.g., see, Harris, McInish and Wood (1995)). Hasbrouck (1995) further proposed a concept of "information shares". The information share associated with a particular security is defined as the percentage contribution of that security's innovations to the innovation in the common efficient price. The information share approach has now become an important tool for analyzing price dynamics among a set of related securities or markets (e.g., Hasbrouck (1995), Hasbrouck (2003), Covrig, Ding and Low (2004)).

The study by Hasbrouck (2003), that examined high frequency intraday transaction data of the exchange traded S&P 500 index fund (SPDR), floor-traded regular S&P 500 futures contracts, and E-mini futures contracts traded on the Globex market, for the period from March 1 to May 31, 2000, was particularly interesting. Despite the fact that floor-traded futures had a predominant market share in terms of dollar value traded, Hasbrouck found that the E-mini contracts played a leading role in price discovery for both the S&P 500 and the Nasdaq-100 index markets. Kurov and Lasser (2004) reported similar findings and suggested that the E-mini futures contracts played a leading role in price discovery because exchange locals traded E-mini futures contracts by using their proximity to the order flow in the pit, and then took advantage of the superior execution speed of the Globex market system. As discussed in the introduction, in this paper we investigate the price formation process in the Hong Kong index equity markets which all operate on electronic trading platforms.

3. An Overview of Hong Kong Index Futures Market and Data Description

3.A. The Equity Index Market in Hong Kong

The Hang Seng Index (HSI) is a value-weighted index compiled by Hang Seng Index Services Limited. It comprises 33 blue-chip stocks listed on the Hong Kong Stock Exchange. It is considered to be an indicator of the overall performance of the Hong Kong stock market. The aggregate market capitalization of HSI stocks accounts for about 70% of the total market capitalization of the Hong Kong stock market. The HSI was reported at 15 seconds intervals in our sample period[2].

[2] It was reported every minute before October 1999.

HSI futures contracts were introduced in 1986 with a contract multiplier of HK$50 per index point. To meet the needs of retail investors, the Hong Kong Futures Exchange (HKFE) introduced a mini-HSI futures contract with a contract multiplier of HK$10 per index point on 9 October, 2000[3]. The minimum price increment, or the tick size, for both the regular and the mini contracts is one index point[4]. The mini futures contract is, in every respect, the same as the regular futures contracts, except that it is one-fifth the size of a regular futures contract. Both the regular and mini futures are traded electronically on the Hong Kong Futures Automatic Trading System (HKATS), where all orders are matched, based on price and time priority, and bid, offer and transaction prices are disseminated in real-time to the public, providing the highest level of price and market transparency. The HSI futures contract and the mini-HSI futures contract are fungible in that, for example, investors can close out of a short position of five mini contracts by longing one regular futures contract. In addition, the margins for both types of contracts are also fungible. This arrangement has the advantage of enhancing liquidity and arbitrage trading. Since any position in the two futures markets is fungible, an arbitrager could realize riskless profit immediately, rather than having to close out contracts in separate markets. According to a survey by Hong Kong Exchanges and Clearing Limited (HKEx) for the period July 2002 to June 2003, the majority of those trading mini futures were local retail investors (74%), with overseas or institutional investors being in the minority. In contrast 39 % of regular futures contracts were traded by overseas institutional investors, and 36% by local retail investors. The survey findings suggest that the mini futures contracts, because of

---

[3] HKFE is now part of the Hong Kong Exchange and Clearing Limited (HKEx). Contract Specifications for the regular and mini Hang Seng Index Futures can be found at the website of HKEx: http://www.hkex.com.hk/prod/equityip/equityindexproducts.htm

[4] The HSI has been traded within the range of 8,200-15,000 during the sample period.

their lower capital requirements, have served as a convenient trading instrument for retail investors.

The Tracker Fund of Hong Kong (TraHK), which is an exchange-traded fund that is modeled on the S&P500 Depository Receipts (SPDR) that was the first exchange-traded fund (ETF) established in the U.S. The TraHK was established to dispose stocks acquired by the Hong Kong government during a large market operation at the height of the Asian financial crises in August 1998. The aim of the trust, whose components are exclusively the 33 HSI component stocks, is to replicate both the yield and the price of the HSI. TraHK is a listed security on the Hong Kong exchange and its trading cost is therefore the same as for those of other stocks listed on that exchange. The minimum tick for TraHK is HK$0.05 and each share is one-thousandth of the size of the HSI portfolio. Compared to the SPDR, which has a relative tick size of only about 2 basis points, one tick in TraHK corresponds to 50 points in the index or a relative tick size of about 40 basis points[5]. As a result, the TraHK price changes infrequently on an intraday basis and it is unlikely to contribute much to price discovery[6]. Therefore, the Tracker Fund is not included in our analyses.

3.B The Data

The data used for analyses included intraday transaction data for HSI futures contracts and mini-HSI futures contracts, available at finest time resolution of one second, from 9 October 2000 to 31 December 2003, which covered a period of 791 trading days. Our empirical analyses consist of two parts. In the first part, we

---

[5] The tick size for both regular and mini futures contract is one index point, or less than one basis point on average during our sample period since the average HSI level during the sample period is higher than 10,000 index points.

[6] In fact, in the analysis of HSI, regular futures and TraHK by So and Tse (2004), they found that the Tracker Fund contributes very little to price discovery even at a time resolution of one-minute interval.

examine the information shares in a two-security setting of regular and mini futures. In the second part of the analyses, the underlying cash market index, available at 15-second intervals, is also used. The data for futures contracts was obtained from HKEx. The transaction data for HSI was obtained from Hang Seng Index Services Limited. Any transaction data that was time-stamped outside the official trading hour was discarded. In the analysis of index and futures contracts, only transaction data that was time-stamped while both futures and equity markets were operating simultaneously was used. As in many other countries, investors tend to shift trading activity to the next month's contract only several days before the expiration day and this pattern of shift in trading activity was similar for both the regular and mini futures. Following Kurov and Lasser (2004) and others, the contract with the highest volume is used for empirical analyses.

Table 1 depicts the trading cost and margin requirements for trading futures contracts, compared with those for trading stocks. The trading costs for futures contracts are about one-twentieth of the costs for trading stocks. Furthermore, only margins, rather than the full value of the contracts are required to initiate a position. Therefore, it is presumably more sensible to trade futures contracts on market-wide information, rather than to trade a basket of component stocks. Margin requirements and all trading costs of the regular contracts, except for the exchange fee, are five times that of the mini contracts. However, the exchange fee for trading five mini contracts is HK$17.5, and is higher than the HK$10 exchange fee for trading a regular contract. Therefore, the regular contracts are less costly to trade than the mini contracts on a per dollar basis.

Figure 1 plots the trading volume (the monthly median number of contracts per day) of both the regular and mini futures contracts since the inception of the mini futures contracts on 9 October 2000. The graph indicates that the trading volume of both the regular and mini futures contracts has increased. The steady increase in trading volume for mini futures indicates that the contract has gained in popularity during the sample period. Table 2 reports the daily trading volume (the main entry in each cell) and the number of trades (numbers in parentheses) for both contracts within the whole sample period and in three sub-periods. For the whole sample period, the median and the mean daily volume for regular futures contracts is 16,043 and 18,688 contracts, respectively; whereas for the mini-futures contracts, that are not trading as actively, the median and mean daily volume are 4,079 and 4,031 contracts, respectively. When the whole sample period is divided into three sub-periods (9 Oct 2000 to 31 Oct 2001, 1 Nov 2001 to 31 Oct 2002, and 1 Nov 2002 to 31 Dec 2003), the trading activities for the regular contracts are similar in the first two periods, but become more active in the last period, with a median daily volume increase from 14,404 contracts in the first sub-period to 21,303 contracts in the third sub-period. The median daily volume of the mini futures contracts increases from 2,637 contracts in the first sub-period to 4,944 contracts in the third sub-period. The statistics for number of trades follows a similar pattern to those of daily volume. On average over the whole period, each regular contract trade accounted for 1.75 contracts, while each mini contract trade accounted for 1.23 contracts. From this data, it can be concluded that regular contracts accounted for most of the HSI futures trading activity. This dominance of the regular contracts is more pronounced if the underlying dollar value of the contracts is taken into account. The number of trades per minute is also reported in Table 2. For the full sample period, the average number of trades per minute is 40.8 and 12.3 for the regular and mini futures, respectively.

4. Methodology

To determine the relative contributions to price discovery of different securities with the same underlying asset, we employ the information share approach introduced by Hasbrouck (1995). This approach assumes that there is an "implicit efficient price" underlying those price variables that are co-integrated. Within Hasbrouck's framework, those related price variables are assumed to be closely related to a single security, each price series is assumed to be integrated of order one and the price changes are assumed to be covariance stationary. There exists a vector moving average (VMA) representation for the variables:

$$\Delta p_t = \Psi(L)e_t \ , \qquad (1)$$

where e_t is a zero-mean vector of serially uncorrelated disturbances with covariance matrix Ω, and Ψ is a lag polynomial.

The price difference between two price variables with the same underlying asset should be stationary. Therefore, the cointegrating vector β' can be written as

$$\beta' = [\iota_{(n-1)} \quad -I_{(n-1)}].$$

where $I_{(n-1)}$ is an identity matrix, $\iota_{(n-1)}$ is a column unit vector, and n is the number of price variables. Using the Granger Representation Theorem (Engle and Granger (1987)), an error correction model exists in the form:

$$\Delta p_t = \alpha(\beta' p_{t-1} - E\beta' p_t) + \Gamma_1 \Delta p_{t-1} + \Gamma_2 \Delta p_{t-2} + \ldots + \Gamma_{K-1} \Delta p_{t-K+1} + e_t \ , \quad (2)$$

where $E\beta' p_t$ is the long-term equilibrium relationship. $E\beta' p_t$ is estimated by the sample average $\overline{\beta' p_t}$, and then the error correction model is estimated using the linear least squares method. After equation (2) is estimated, the VMA representation can be constructed numerically from the estimated error correction model. The variance of the innovation to the implicit efficient price is $\psi\Omega\psi'$. If the market innovations are uncorrelated, then market j's information share of the total price discovery process is defined as

$$S_j = \frac{\psi_j^2 \Omega_{jj}}{\psi \Omega \psi'},$$

where ψ_j is the *j*th element of ψ.

When the price innovations are correlated, then Ω will not be diagonal and the information share cannot be uniquely determined. Hasbrouck (1995) proposed that the Cholesky decomposition of covariance matrix Ω could be used to determine the maximum and minimum bounds of the information share of each security. That is Ω is decomposed into a product of two matrixes:

$$\Omega = FF',$$

where *F* is a lower triangular matrix and *F'* is the transpose of *F*. For this structural specification, the information share contributed by market *j* is defined as:

$$S_j = \frac{([\psi F]_j)^2}{\psi \Omega \psi'},$$

where $[\psi F]_j$ is the *j*th element of the row matrix ψF. A range of information share for each market is obtained by permutation of the market in the structural decomposition. For one-second time resolution, the range is usually small (for example, Hasbrouck (1995) reports very close upper and lower bounds). However, the range of information share is often found to be quite wide for coarser time intervals. For example, Huang (2002) uses one-minute intervals to examine the nature of the price discovery between electronic communications networks (ECNs) and various Nasdaq dealers. In 1998, for the month of January, the upper and lower bounds of the Island (an ECN) for Yahoo are 79.5% and 30.6%, respectively. Baillie et al (2002), using three analytical examples with different degrees of innovation cross-correlations, show that the mean of estimated information share is the appropriate measure to use when the information share is not unique and the range is wide.

There are some practical issues to consider when applying the model to intraday data. First, with a lag of M periods and n price variables, the number of parameters that need to be estimated is Mn^2, which poses a dimension problem. To manage this problem, polynomial distributed lags were employed. The coefficients were assumed to lie on quadratic polynomial segments, so that the number of parameters could be reduced. In this paper, we report the results for M=9[7]. The second issue is the basis stationary problem. The basis is defined as $F_t - S_t$, where F_t and S_t are futures price and index level respectively. For the error correction model to be correctly specified, the basis should be stationary. Hasbrouck (2003) notes that the basis is nonstationary over the life of the futures contract due to forward-spot convergence, although the intraday basis is stationary. Therefore, in this paper we follow Hasbrouck (2003); instead of estimating the model using the whole sample period, information share is estimated for each day. This means that rather than obtaining one estimate of information share, the above procedure gives a whole picture of how information shares vary over the sample period.

Another important issue in empirical analyses is time resolution. For finer intervals, the innovations are less cross-correlated and the range of information share is narrower. As noted by Hasbrouck (2003), using time aggregation of data is a kind of data thinning in which some of the data for a more actively traded security is discarded to cope with the data for a more thinly traded security. Therefore, a one-second interval is chosen for the analyses of relative information share in the two-

[7] We only report the results for M=9. In this case, for the two-security setting, total 12 parameters were estimated for each of the 791 trading days. We have also tried different lag length other than 9 and assumed parameters lie on a cubic segment, the results are not sensitive to those changes.

futures setting since this is the finest time resolution possible in the dataset. Analyses using coarser intervals, such as a five-second interval and 15-second interval are also conducted to see the affect of using longer time intervals[8]. For the analyses of the three-securities setting (regular and mini futures plus the cash index), a 15-second time interval is used because it is the finest data available for the HSI index. If several trades are time stamped within a second, only the last stamped trade is used. If there is no trade for the security within the time interval, the last traded price of the prior intervals is used.

Using the above procedure, equation (2) is estimated and the corresponding VMA representation (1) is worked out numerically by introducing a shock to one security at one time and then forecasting the effects for later periods. In this way, the covariance matrix Ω can be estimated and information shares for each market can be calculated. Impulse response functions are obtained and plots of mean impulse response functions for each day were also graphed.

5. Empirical Results

This section presents the results of empirical analyses. Part A presents the results for the two-security setting (regular and mini futures markets). Part B reports the empirical results for the three-security setting that also includes the cash index market. In each case, the analyses are conducted on the whole sample period, and the three sub-periods (9 Oct 2000 to 31 Oct 2001, 1 Nov 2001 to 31 Oct 2002 and 1 Nov 2002 to 31 Dec 2003), to see whether there is a change in price discovery mechanism during the sample period. Since we estimate the model on a daily basis, the summary

---

[8] The results for the 15-second interval are reported to facilitate comparisons between the results for the two-security and three security settings. But, the results for the 5-second interval will not be reported to conserve space.

statistics are obtained from daily estimates in each sample period. Disturbance correlation matrix is the daily average of estimated cross-correlations between innovations for different securities, and the coefficients of efficient price is the (daily average) long run impact for each security after a unit shock is imposed on one of the securities.

5.A. Information Share in the Two-Security Setting

Table 3 reports on price discovery in the regular and mini HSI futures markets at a one-second time interval. Panel A shows the summary statistics for daily information share, with the minimum (Min) and maximum (Max) value of information share for each security, for each day, calculated using Hasbrouck's methodology. For regular futures, for the whole sample period, the average values (across days) of lower and upper bounds of information share are 0.927 and 0.952, respectively. The gap between lower and upper bounds is quite small because the off-diagonal correlation is only 0.054 (see, Panel B). Following a suggestion by Baillie et al (2002), we also report the summary statistics for the midpoint of the lower and upper bounds of daily information share (see Panel C). In sum, the regular and mini futures contribute about 94% and 6%, respectively, of the price discovery in the futures market. Panel D reports the coefficients of efficient price that represent the cumulative impact of a unit change, in either of the two prices, on the long-run efficient price. The magnitudes are identical to the cumulative impulse functions depicted in Figure 2. The first graph in Figure 2 plots the cumulative impact of a unit shock on the regular futures price. The long-run persistent impact of a unit shock on the regular futures price is about 70%. The regular futures price reverts to the persistent level in less than 5 seconds while it takes about one minute for the mini futures price to reach the long-run efficient price level. The second graph plots the impulse response function for a unit shock on the mini futures price. It can be seen that the persistent impact of the shock is much smaller at about 0.2.

Although for the whole period and the three sub-periods, the regular futures contracts play a dominant role in price discovery, the relative importance of the mini futures contracts has increased over time. The mean of daily information share for the mini futures has increased from 3% in the first sub-sample period, to 6.1% in the second period, and has further increased to 8.8% in the third period. The innovation correlation has also increased over the three sub-sample periods. This increase means that the mini futures market was becoming better at absorbing and reflecting market-wide information. This finding is consistent with results reported in Table 2 and Figure 1 where the relative trading volume of the mini futures has increased somewhat over the same period. Nevertheless, the regular futures market still plays a dominant role in price discovery.

Similar analyses were also conducted at 5-second and 15-second time intervals. As expected, the correlation between price innovations in the two markets increases as we move towards coarser time intervals. The results for the 15-second interval were reported in Table 4 so that comparisons with the results from the three-security setting can be made later. It can be seen that the regular contracts contribute from 51.7% to 95.9% (the range of mean information share) for the whole period, compared with from 92.7% to 95.2% for the one-second interval. The innovations between the contracts are much more correlated with a correlation coefficient of 0.572 for the fifteen-second interval compared to 0.054 for the one-second interval. The evidence suggests that a considerable amount of information is passed between the two markets in the 15-second interval[9]. The mean of the daily midpoint of information share for the

[9] Huang (2002) and Booth et al. (2002) also find that the range of estimated information share becomes

main and regular futures markets are 73.8% and 26.2%, respectively, at the 15-second interval compared to 93.9% and 6.1%, respectively, at the one-second interval. The coefficients of efficient price at the 15-second interval are 0.844 and 0.211 compared to 0.701 and 0.170 at the one-second interval. The difference between the coefficients of efficient price of the two time intervals is much smaller than the differences seen in the statistics on information shares, suggesting that the long-run persistent impact of a unit shock on either security is less affected by the choice of the data observation interval. In sum, the qualitative results from the 15-second interval remain the same; i.e., the regular futures contract plays a dominant role in price discovery while the mini futures contract plays only a supplementary role.

5.B. Information Share in the Three-Security Setting

The results for the three-security setting that includes the regular and mini futures as well as the cash index are reported in Table 5. Since there are cross correlations for innovations, information shares can only be estimated through the rotation of the specification of the structure of innovation. In this case, the fifteen-second interval produces a considerable cross-correlation (0.572 for the regular and mini futures) and a wider range of estimated information shares. The regular futures contracts account for most of the price discovery, with the median ranging from 36.5% to 81.2%. The range of information shares is from 1.5% to 37.1% for the mini futures, and from 14.2% to 20.9% for the cash index. The coefficients of efficient price are 0.727, 0.165 and 0.297 for the regular contracts, mini contracts and cash index, respectively. This means that if a unit shock is applied to each of the three securities, the long-run impact on the efficient price adjustment would be 0.727 for the regular contracts, 0.165 for the mini contracts and 0.297 for the cash index. Panel C of Table

---

wider when the observation time interval becomes coarser.

5 exhibits the statistics for the daily mean (the midpoint of the maximum and the minimum) of information share. The mean information shares for the regular futures, mini futures and cash index are 56.0%, 20.2 % and 25.1%, respectively.

In fact, when comparing two futures price settings at the same 15-second time interval, the results in 5.B for futures contracts are qualitatively the same. The ratios of mean information share of regular to mini contracts are similar in both 5.A and 5.B (2.82 in 5.A and 2.77 in 5.B). With the addition of the HSI, the futures contracts (both regular and mini contracts) account for about three quarters of the information share (0.762) while the spot index accounts for about a quarter of the information share (0.251).

Despite the relatively coarser data observation interval (fifteen seconds), the correlations between the cash index innovation and the two types of futures are low (0.078 and 0.062 for the regular and mini futures, respectively), whereas in the case of the futures contracts themselves, the innovation correlation is as high as 0.0572. This interesting finding indicates that the interaction between the cash index and the futures market is weak even at the 15-second time resolution, although the cash index accounts for about a quarter of the information share. This weak interaction may be due to the fact that it is relatively easier and less costly to do arbitrage trading between the two futures markets than between the futures markets and the cash index market.

Overall, our analyses indicate that the regular futures market played a predominant role in price formation and leadership, while the mini futures and cash markets played a supplementary role. The qualitative results are similar for different sub-periods, and at different time observation intervals, whether or not the cash market is included.

6. Concluding Remarks

This paper, using Hasbrouck's (1995) information share approach, examines the price discovery dynamics in Hong Kong equity index markets. It is found that the regular futures contract plays a dominant and leading role in price discovery, while the mini futures and cash index play minor roles. The findings differ from those in Hasbrouck (2003). However, the different results obtained from the Hong Kong and U.S. equity index markets can be explained by the differences in trading arrangements in those markets. Kurov and Lasser (2004) suggest that E-mini futures contracts contribute a dominant share to price discovery in the U.S. because regular futures contracts are traded through an open outcry system, while the mini futures contracts are traded in the electronic Globex system. Locals in the floor-traded exchange utilize the high execution speed of Globex to trade on information observed in the pit, resulting in the E-mini contract being the dominant information contributor. In Hong Kong, both the regular and mini contracts are traded on the same electronic platform with the same execution speed, and the fact that regular futures market plays a leading role in price discovery can be explained by its lower transaction costs on a per dollar basis. Therefore, although the results in this paper are different from Hasbrouck's, both are consistent with the notion that for securities with the same underlying asset, the market that provides a combination of lowest trading costs, greatest liquidity and highest execution speed should dominate. Under current trading arrangements in the U.S. equity index markets, factors such as execution speed, and trader anonymity in the mini futures market are presumably more important to informed traders than the slightly higher transaction costs on a per dollar value basis in comparison to the regular futures market, whereas in Hong Kong the trading costs per dollar value is the deciding factor, because it is the only difference between the regular and mini contracts markets. The evidence in this paper supports the trading costs hypothesis by Fleming, Ostdiek and Whaley (1996).

References

Baillie, R.T., Booth, G.G., Tse, Y., Zabotina, T., 2002, "Price discovery and common factor models", Journal of Financial Markets 5, 309-321.

Booth, G.G., So, R.W., Tse, Y., 1999, "Price discovery in the German equity index derivative markets", Journal of Futures Markets 19, 619-643.

Chan, K., 1992, " A further analysis of the lead-lag relationship between the cash market and stock index futures market", Review of Financial Studies 5, 123-152.

Covrig, V., Ding, D.K., Low, B.S., 2004, " The contribution of a satellite market to price discovery: evidence from the Singapore exchange", Journal of Futures Markets 24, 981-1004.

Engle, R.F., Granger, C.W.J., 1987, "Co-integration and error correction: representation, estimation and testing", Econometrica 55, 251-276.

Fleming, J., Ostdiek, B., Whaley, R.E., 1996, "Trading costs and the relative rates of price discovery in stock, futures and option markets", Journal of Futures Markets 16, 353-387.

Harris, F.H.D., McInish, T.H., Shoesmith, G.L., Wood, R.A., 1995, "Cointegration, error correction, and price discovery on informationally linked security markets", Journal of Financial and Quantitative Analysis 30, 563-579.

Hasbrouck, J., 1995, "One security, many markets: determining the contributions to price discovery", Journal of Finance 50, 1175-1199.

Hasbrouck, J., 2003, "Intraday price formation in U.S. equity index markets", Journal of Finance 58, 2375-2400.

Huang, R.D., 2002, "The quality of ECN and Nasdaq market maker quotes", Journal of Finance 57, 1285-1319.

Kurov, A., Lasser, D., 2004, "Price dynamics in the regular and E-mini futures markets", Journal of Financial and Quantitative Analysis 39, 365-384.

So, R. W., Tse, Y., 2004, "Price discovery in the Hang Seng Index markets: index, futures and the tracker fund", Journal of Futures Markets 24, 887-907.

Stoll, H.R., Whaley, R.E., 1990, "The dynamics of stock index and stock index futures returns", Journal of Financial and Quantitative Analysis 25, 441-468.

Table 1

Trading Costs and Margin Requirements

in Hong Kong Stock and Index Futures Markets

This table reports transaction costs for trading regular HSI futures, mini HSI futures and stocks as well as margin requirements for trading futures. The transaction costs for trading futures are reported in dollars per contract while transaction costs for stocks are in percentage terms.

	Regular HSIF Contracts (Per contract)	Mini HSIF Contracts (Per contract)	Stocks
Exchange Fee	HK$10	HK$3.50	0.005%
SFC Levy	HK$1	HK$0.20	0.005%
Investor Compensation Levy	HK$0.5	HK$0.10	0.002%
Stamp duty	N/A	N/A	0.11%
Commission Rate (Minimum) (Per contract per side for futures)	Before 1 Apr 2003 HK$100 (closed out overnight) HK$60 (closed out within the same day) After 1 Apr 2003 Negotiable	Before 1 Apr 2003 HK$20 (closed out overnight) HK$12 (closed out within the same day) After 1 Apr 2003 Negotiable	Before 1 Apr 2003 0.25% After 1 Apr 2003 Negotiable
Estimated total trading costs (Before April 1 2003)	**HK$111.5 or 0.0186%** (assume HSI at 12,000 points)	**HK$23.8 or 0.0198%** (assume HSI at 12,000 points)	**0.372%**
Client Margin (Full rate / lot)	HK$44,500 (Initial) HK$35,600 (Maintenance)	HK$8,900 (Initial) HK$7,120 (Maintenance)	N/A
Client Margin (Spread rate / spread)	HK$7,500 (Initial) HK$6,000 (Maintenance)	HK$1,500 (Initial) HK$1,200 (Maintenance)	N/A

Table 2

Summary Statistics of HSI Futures Trading Volume

For the first five columns, the first number in each cell is the number of contracts that were traded, and the number in parentheses is the number of trades. The last column reports the average number of trades per second per minute.

	Contract Type	Daily Median	Daily Mean	Daily Minimum	Daily Maximum	Standard Deviation	No. of Trades Per Minute
Whole period	Regular	16,043 (10,312)	18,688 (10,658)	4,416 (2,322)	10,3377 (25,324)	10,883 (2,933)	40.8
	Mini	4,079 (3,318)	4,031 (3,273)	986 (622)	8,824 (6,891)	1,361 (1,051)	12.3
9 Oct 2000 to 31 Oct 2001	Regular	14,405 (9,625)	14,512 (9,720)	6,145 (4,150)	23,427 (15,195)	3,041 (1,913)	34.3
	Mini	2,637 (2,257)	2,763 (2,343)	986 (622)	5,100 (4,392)	817 (713)	8.22
1 Nov 2001 to 31 Oct 2002	Regular	14,961 (9,613.5)	15,083 (9,610)	4,673 (3,012)	31,035 (17,365)	4,075 (2,307)	33.7
	Mini	4,259 (3,436)	4,283 (3,479)	1,283 (1113)	7,772 (5,922)	1,050 (821)	12.1
1 Nov 2002 to 31 Dec 2003	Regular	21,303 (12,248)	25,457 (12,380)	4,416 (2322)	103,377 (25,324)	15,166 (3,336)	56.2
	Mini	4,944 (3,915)	4,941 (3,921)	1,216 (893)	8,824 (6,891)	1,106 (884)	17.4

Table 3
Price Discovery in the Regular and Mini Hang Seng Index Futures Markets – One-second Intervals

The statistics are based on a vector error correction model of prices for the regular HSI futures contract (HSIF) and the mini HSI futures contract (MHI), estimated at a time resolution of one second. The model is estimated each day in the sample period (9 Oct 2000 to 31 Dec 2003). Panel A reports for daily estimates (the minimum and maximum information shares) for the whole period and 3 sub-periods. Panel B contains the estimated correlation matrix of the disturbance e_t in (1). Panel C shows the statistics for the daily mean of information share, or the midpoint of the daily minimum and maximum information shares. Panel D contains the coefficients of efficient price, which are the long-run price revisions given a unit shock on either price variable.

Panel A – Summary Statistics for Information Share

HSIF								
Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Info share	Min	Max	Min	Max	Min	Max	Min	Max
Median	0.943	0.965	0.972	0.983	0.931	0.957	0.923	0.954
Mean	0.927	0.952	0.964	0.976	0.925	0.953	0.896	0.930
SEM	0.0026	0.0022	0.0024	0.0020	0.0033	0.0024	0.0056	0.0050
STD	0.073	0.061	0.038	0.031	0.0518	0.0383	0.095	0.085

MHI								
Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Info share	Min	Max	Min	Max	Min	Max	Min	Max
Median	0.035	0.057	0.017	0.028	0.043	0.069	0.046	0.077
Mean	0.048	0.073	0.024	0.036	0.047	0.075	0.070	0.104
SEM	0.0022	0.0026	0.0020	0.0024	0.0024	0.0033	0.0050	0.0056
STD	0.061	0.073	0.031	0.038	0.0383	0.0518	0.085	0.095

Panel B – Disturbance Correlation Matrix

Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
	HSIF	MHI	HSIF	MHI	HSIF	MHI	HSIF	MHI
HSIF	1	0.054	1	0.035	1	0.0606	1	0.066
MHI	0.054	1	0.035	1	0.0606	1	0.066	1

Panel C – Statistics for the Daily Mean of Information Share

Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Security	HSIF	MHI	HSIF	MHI	HSIF	MHI	HSIF	MHI
Median	0.955	0.045	0.977	0.023	0.944	0.056	0.938	0.062
Mean	0.939	0.061	0.970	0.030	0.939	0.061	0.913	0.087
Std Dev.	0.067	0.067	0.034	0.034	0.044	0.044	0.089	0.089

Panel D – Coefficients of Efficient Price

Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Security	HSIF	MHI	HSIF	MHI	HSIF	MHI	HSIF	MHI
Coeff of Efficient Price	0.701	0.170	0.726	0.115	0.713	0.185	0.668	0.207

Table 4

Price Discovery in the Regular and Mini Hang Seng Index Futures – Fifteen-second Intervals

The statistics are based on a vector error correction model of prices for the regular HSI futures contract (HSIF) and the mini HSI futures contract (MHI), estimated at a time resolution of 15 seconds. The model is estimated each day in the sample period (9 Oct 2000 to 31 Dec 2003). Panel A reports for daily estimates (the minimum and maximum information shares) for the whole periods and 3 sub-periods. Panel B contains the estimated correlation matrix of the disturbance e_t in (1). Panel C shows the statistics for the daily mean of information share, or the midpoint of the daily minimum and maximum information shares. Panel D contains the coefficients of efficient price, which are the long-run price revisions given a unit shock on either price variable.

Panel A – Summary Statistics for Information Share

HSIF								
Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Info share	Min	Max	Min	Max	Min	Max	Min	Max
Median	0.499	0.979	0.696	0.983	0.459	0.977	0.421	0.976
Mean	0.517	0.959	0.680	0.971	0.453	0.958	0.426	0.951
SEM	0.007	0.002	0.010	0.002	0.009	0.004	0.009	0.004
STD	0.186	0.057	0.162	0.040	0.134	0.056	0.146	0.069

MHI								
Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Info share	Min	Max	Min	Max	Min	Max	Min	Max
Median	0.021	0.501	0.017	0.304	0.023	0.541	0.024	0.579
Mean	0.041	0.483	0.029	0.320	0.042	0.547	0.049	0.574
SEM	0.002	0.007	0.002	0.010	0.004	0.009	0.004	0.009
STD	0.057	0.186	0.040	0.162	0.056	0.134	0.069	0.146

Panel B – Disturbance Correlation Matrix

Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
	HSIF	MHI	HSIF	MHI	HSIF	MHI	HSIF	MHI
HSIF	1.000	0.572	1.000	0.453	1.000	0.623	1.000	0.632
MHI	0.572	1.000	0.453	1.000	0.623	1.000	0.632	1.000

Panel C – Statistics for the Daily Mean of Information Share

Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Security	HSIF	MHI	HSIF	MHI	HSIF	MHI	HSIF	MHI
Median	0.736	0.264	0.840	0.160	0.713	0.287	0.693	0.307
Mean	0.738	0.262	0.825	0.175	0.705	0.295	0.688	0.312
Std Dev.	0.112	0.112	0.094	0.094	0.087	0.087	0.098	0.098

Panel D – Coefficients of Efficient Price

Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Security	HSIF	MHI	HSIF	MHI	HSIF	MHI	HSIF	MHI
Coeff of Efficient Price	0.844	0.211	0.917	0.149	0.824	0.229	0.796	0.251

Table 5

Price Discovery in Hang Seng Index Spot, Regular and Mini Futures Markets – Fifteen-second Intervals

The statistics are based on a vector error correction model of prices for the regular HSI futures contract (HSIF) and the mini HSI futures contract (MHI), estimated at a time resolution of 15 seconds. The model is estimated each day in the sample period (9 Oct 2000 to 31 Dec 2003). Panel A reports for daily estimates (the minimum and maximum information shares) for the whole periods and 3 sub-periods. Panel B contains the estimated correlation matrix of the disturbance e_t in (1). Panel C shows the statistics for the daily mean of information share, or the midpoint of the daily minimum and maximum information shares. Panel D contains the coefficients of efficient price, which are the long-run price revisions given a unit shock on either price variable.

Panel A – Summary Statistics for Information Share

HSIF								
Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Info share	Min	Max	Min	Max	Min	Max	Min	Max
Median	0.365	0.812	0.518	0.841	0.330	0.773	0.297	0.813
Mean	0.379	0.740	0.510	0.769	0.319	0.719	0.314	0.733
SEM	0.007	0.008	0.0133	0.0138	0.011	0.015	0.010	0.014
Std Dev.	0.204	0.233	0.213	0.221	0.165	0.236	0.168	0.240

MHI								
Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Info share	Min	Max	Min	Max	Min	Max	Min	Max
Median	0.015	0.371	0.011	0.213	0.013	0.408	0.021	0.447
Mean	0.032	0.373	0.024	0.255	0.033	0.412	0.037	0.445
SEM	0.002	0.007	0.002	0.010	0.003	0.012	0.003	0.010
Std Dev.	0.042	0.195	0.034	0.163	0.046	0.188	0.044	0.178

Index								
Sample Period	Whole Period		9 Oct 2000 to 31 Oct 2001		1 Nov 2001 to 31 Oct 2002		1 Nov 2002 to 31 Dec 2003	
Info share	Min	Max	Min	Max	Min	Max	Min	Max
Median	0.142	0.209	0.122	0.194	0.180	0.252	0.137	0.179
Mean	0.223	0.279	0.202	0.260	0.243	0.309	0.225	0.269
SEM	0.008	0.009	0.014	0.015	0.015	0.017	0.014	0.015
Std Dev.	0.232	0.248	0.218	0.234	0.241	0.260	0.235	0.245

Panel B – Disturbance Correlation Matrix

Sample Period	Whole Period			9 Oct 2000 to 31 Oct 2001			1 Nov 2001 to 31 Oct 2002			1 Nov 2002 to 31 Dec 2003		
	HSIF	MHI	Index	HSIF	MHI	Index	HSIF	MHI	Index	HSIF	MHI	Index
HSIF	1.000	0.572	0.078	1.000	0.458	0.087	1.000	0.619	0.090	1.000	0.633	0.061
MHI	0.572	1.000	0.062	0.458	1.000	0.061	0.619	1.000	0.077	0.633	1.000	0.050
Index	0.078	0.062	1.000	0.087	0.061	1.000	0.090	0.077	1.000	0.061	0.050	1.000

Panel C – Statistics for the Daily Mean of Information Share

Sample Period	Whole Period			9 Oct 2000 to 31 Oct 2001			1 Nov 2001 to 31 Oct 2002			1 Nov 2002 to 31 Dec 2003		
Security	HSIF	MHI	Index	HSIF	MHI	Index	HSIF	MHI	Index	HSIF	MHI	Index
Median	0.587	0.195	0.174	0.676	0.114	0.159	0.546	0.210	0.215	0.562	0.236	0.157
Mean	0.560	0.202	0.251	0.640	0.140	0.231	0.519	0.223	0.276	0.523	0.241	0.247
StdDev.	0.202	0.110	0.239	0.205	0.091	0.225	0.188	0.110	0.249	0.191	0.102	0.242

Panel D – Coefficients of Efficient Price

Sample Period	Whole Period			9 Oct 2000 to 31 Oct 2001			1 Nov 2001 to 31 Oct 2002			1 Nov 2002 to 31 Dec 2003		
Security	HSIF	MHI	Index	HSIF	MHI	Index	HSIF	MHI	Index	HSIF	MHI	Index
Coeff of Efficient Price	0.727	0.165	0.297	0.809	0.108	0.295	0.680	0.177	0.363	0.695	0.206	0.243

Figure 1. Monthly Median Trading Volume

The solid line represents the monthly median trading volume (number of contracts) for mini contracts (LHS), and the dotted line represents the monthly median trading volume for regular contracts (RHS).

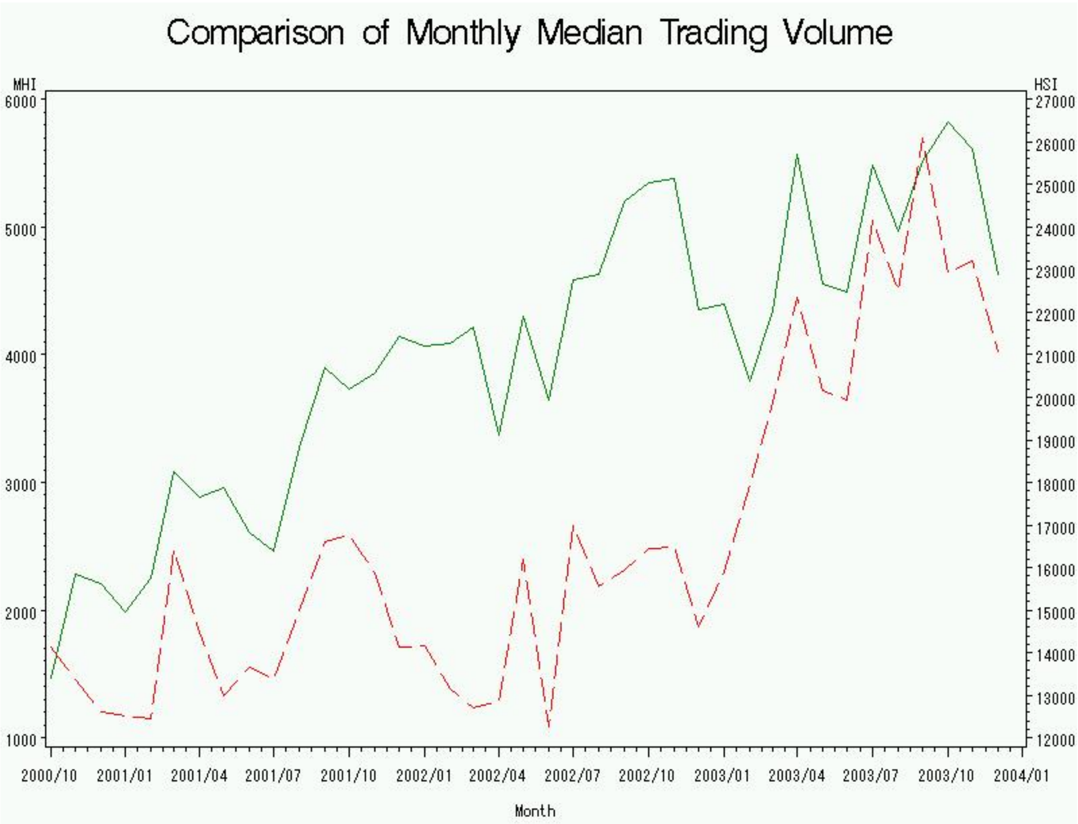
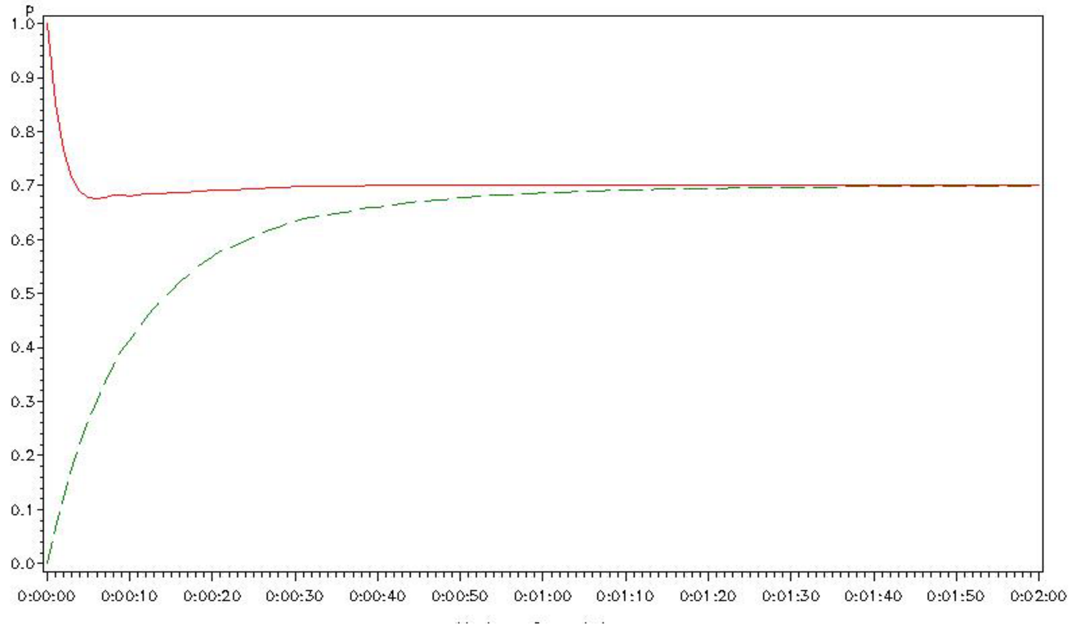


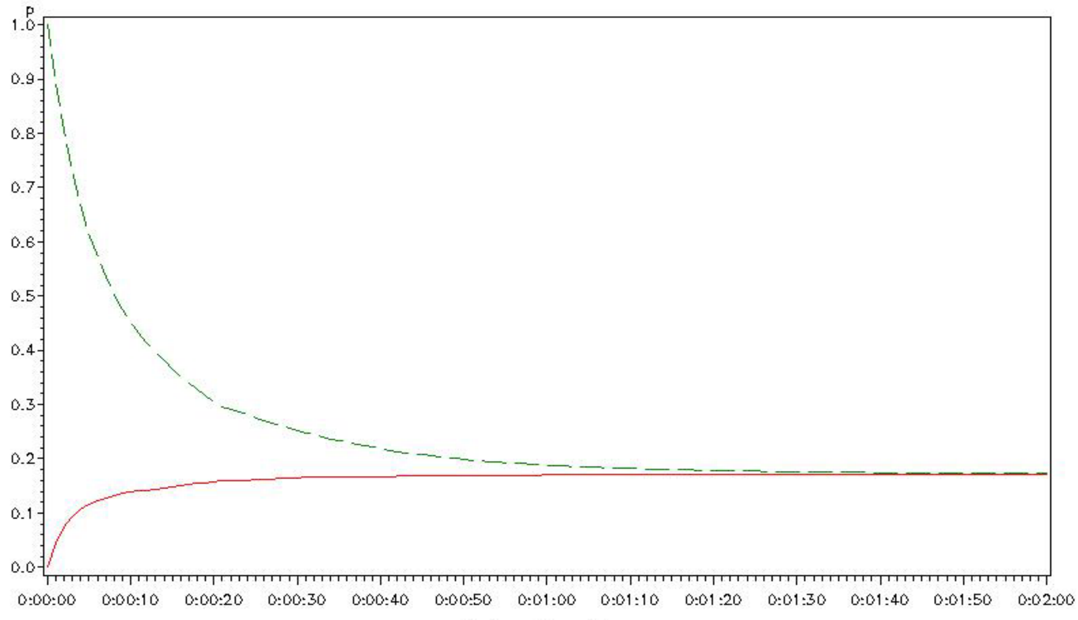
Fig. 2. Impulse Response Functions for Regular and Mini Futures (One-second resolution)

The impulse response functions are constructed by applying a unit shock to regular futures or mini futures at time zero.



Time after a unit shock to regular futures is applied (in hh:mm:ss)

—— Regular Futures — — Mini Futures



Time after a unit shock to mini futures is applied (in hh:mm:ss)

—— Regular Futures — — Mini Futures