Volatility and Trading Activity Following Changes in the Size of Futures Contracts

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Abstract

This paper examines the relationship between daily price volatility and trading activity one year before and after a change in the size of selected futures contracts. The following three contracts are included in this study: the Stock Price Index traded on the Sydney Futures Exchange (SFE), which had a contract split on October 11, 1993; the FTSE-100 index traded on the London International Financial Futures Exchange (LIFFE), which had a contract split on March 23, 1998; and the 90-Day Bank Acceptance Bill (BAB) traded on the SFE, which had a reverse split on May 1, 1995. We obtain several interesting empirical results. We observe that there is a positive relationship between daily price volatility and the number of trades (trading frequency) before and after a change in the size of the examined futures contracts. We find that the increase (decrease) in total trading frequency has the power to explain the increase (decrease) of daily price volatility after a contract split (reverse split). Most of the average trade size variable has an immaterial impact on price volatility. Decomposing the total trading frequencies into four trade size classes, we find that the trading frequencies for small and large trade size categories are highly significant in explaining changes in daily price volatility after the index futures contracts' splits. These results are consistent with the noise trading hypothesis (Black (1986)) and the hypothesis on less informed trading in index futures markets. For the BAB case, we find that the trading frequencies for small, medium and large sizes impact price volatility before and after the reverse contract split.

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1. Introduction

Specification of the correct contract size is one of the essential elements for optimal futures contract design (Silber (1981)). A contract size that is too large will prohibit small traders from entering the market and prevent some traders from fine tuning their hedging portfolios. On the other hand, a contract size that is too small will increase transaction costs. Futures exchanges have used contract splits or reverse contract splits to adjust the contract size of existing contracts to achieve an optimal contract size.

A study by Karagozoglu and Martell (1999) was one of the first to examine the effect of changes in the dollar value of a futures contract on market behavior. Their study focused on liquidity. They took advantage of a unique natural laboratory experiment provided by the Sydney Futures Exchange (SFE), which reduced the size of their All Ordinaries Share Price Index (SPI) futures contract in 1993 and increased the size of their Bank Accepted Bill (BAB) futures contract in 1995. They documented that greater liquidity (i.e., lower spreads and higher trading volume) is associated with a smaller contract size, even after controlling for the known determinants of liquidity.

This early work was subsequently extended by Karagozoglu, Martell and Wang (2003) who examined the effect of changes in futures contract size on price volatility (in addition to liquidity) by examining the reduction in the size of the S&P 500 futures contract traded on the Chicago Mercantile Exchange (CME) in November 1997. Their study was motivated by Huang and Stoll (1998) who predicted that a decrease in the futures contract size allows new (smaller) investors, who previously may have had capital constraints, to enter the market, thereby increasing liquidity and smoothing out price fluctuations. They were unable to document any significant impact on price volatility from the change in the size of the S&P 500 futures contract. However, the event they examined is close in proximity to the introduction of the E-mini S&P 500 futures contract on the CME in September 1997, which de-facto amounted to a reduction in contract size and which may have confounded their analysis[1].

Previous literature on stock splits has documented the fact that price volatility increases after a stock split (Ohlson and Penman (1985), Dubofsky (1991) and others). Kryzanowski and Zhang (1996) and Schultz (1998) have found an increase in the number of small trades, but not in the number of large trades, following a stock split. Desai, Nimalendran and Venkataraman (1998) and Kamara and Koski (2001) have found a positive relation between price volatility and trading activity after stock splits. To the best of our knowledge, there is no prior work on the examination of price volatility and trading activity before and after contract splits in the futures market literature.

In this paper, we utilize a clean natural experiment afforded by the change in the size of futures contracts on the Sydney Futures Exchange and the London International Financial Futures Exchange (LIFFE) to examine the relationship between daily price volatility and trading activity before and after a change in the size of the following three futures contracts: (1) the SPI futures contract traded on the SFE, which had a one to four contract split on October11, 1993; (2) the BAB futures contract traded on the SFE, which had a two to one reverse contract split on May 1, 1995; and (3) the FTSE-100 index futures contract traded on LIFFE, which had a one to 2.5 contract split on March 23, 1998. These events provide a unique opportunity to document

[1] Bollen, Smith and Whaley (2003) and Chen and Locke (2004) investigated the behavior of the bid-ask spread and the trading volume before and after the impact of the S&P 500 futures contract split, and they did not take account of the impact that the introduction of the E-mini S&P 500 futures contract had on the liquidity of the S&P 500 index futures market.

the relationship between daily volatility and trading activity following a change in the size of a futures contract and to test alternative hypotheses to explain this relationship.

We obtain three interesting results. First, we find that daily price volatility and the number of trades increased after the contract split for the SPI and FTSE-100 index futures and decreased after the reverse contract split for the BAB contract. Second, daily price volatility is primarily and positively related to trading frequency (number of trades), and the average size of trade has minimal impact on price volatility. These findings are consistent with the findings of Jones, Kaul and Lipson (1994) and Huang and Masulis (2004) in the equity markets. Finally, the trading frequencies for both small size trades and large size trades affect price volatility, but the trading frequency of medium size trades has minimal effect on price volatility after the index futures contract splits. These results are consistent with the noise trading hypothesis and the hypothesis on less informed trading in index futures markets. For the reverse split of the BAB interest rate futures, we find that the number of trades of each trade size category is associated with changes in price volatility.

Our paper is organized as follows. Section 2 presents a literature review and testable hypotheses. Section 3 describes the data and variable measurements. Section 4 presents the empirical methodology. Empirical results are reported in Section 5. This is followed by a conclusion in Section 6.

2. Previous Literature and Testable Hypotheses

Previous literature has documented that there is a positive relationship between price volatility and trading volume in financial markets (equity, currency, and futures markets) for various time intervals (hourly, daily and weekly). Karpoff (1987) reviewed literature on this relationship prior to 1987. Recent studies in this area include Gallant, Rossi and Tauchen (1992), Foster and Vishwanathan (1995), Anderson (1996), Wang, Yau and Baptiste (1997) and many others.

Based on an examination of a large number of NASDAQ stocks using daily data from 1986 to 1991, Jones, Kaul and Lipson (JKL) (1994) found that after decomposing trading volume into the number of trades and average trade size, price volatility is primarily and positively related to the number of trades and less related to the average size of trades. Desai, et al. (1998) have successfully applied JKL's argument to explain that a change in price volatility is primarily associated with a change in the number of trades after stock splits.

Barclay and Warner (1993) have proposed the stealth trading hypothesis to explain the causes of price volatility by informed traders' private information. They present evidence that most of a stock price cumulative change (price volatility) in a sample of NYSE firms is mainly taking place in medium size trades. They argue that private informed traders concentrate their trades in medium sizes for the following reasons: (1) private traders attempt to camouflage their trades by spreading them over time (Kyle (1985)); and (2) the expected price impact of a trade (price concessions) increases with trade size, and thus, a medium-size position is likely to be executed in a single trade since the price concession of a medium-size trade is small. Chan and Fong (2000) provide additional evidence of the significance of the size of trades, beyond the number of trades, in explaining the volatility and volume relationship in both NYSE and NASDAQ stocks. These two papers use the trade size to infer the motives of trading by information or liquidity.

Black (1986, p. 534) indicates that noise trading increases after stock splits since noise traders prefer to trade low-priced rather than high-priced stocks. Noise traders often trade in small trades, which can add to price volatility of financial assets.[2] Kamara and Koski (2003) provide evidence that stock splits in equity markets result in an increase in the number of small trades. They demonstrate that the increase of small trades is associated with an increase in price volatility after stock splits.

The literature reviewed above leads us to formulate the following hypotheses on the relationship between price volatility and trading activity following changes in the size of futures contracts.

Hypothesis 1: A change in price volatility is primarily and positively associated with a change in the number of trades before and after a change in the size of a futures contract.

This hypothesis gives us a direct test of the generality of JKL hypothesis to explain the relationship between price volatility and trading activity in the futures markets.

Hypothesis 2: Following a change in size of a futures contract, it is expected that a change in the number of small trades will be primarily associated with a change in price volatility, and the number of trades of other size categories will have less association with a change in price volatility.

Hypothesis 2 provides a direct test on the noise trading hypothesis with a conflicting hypothesis suggested by Huang and Stoll (1998). They predict that decreasing the size of a future contract allows small investors to enter the market, thereby providing additional liquidity that can decrease price fluctuations. It also provides a test to examine the extent to which the change in price volatility associated with a change in contract size is explained by a change in the frequency of small traders entering or leaving the market.

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[2] Further discussion on the concept of noise traders and noise trading affecting price volatility is referred to Truman (1988) and DeLong, Shleifer, Summers and Waldmann (1989, 1990a, 1990b).

3. Data Description and Variable Measurements

We examine price volatility and trading activity before and after a change in the size of the following three contracts: the SFE's SPI futures contract, the SFE's BAB futures contract, and the LIFFE's FTSE-100.

SPI was introduced by the SFE in February 1983. During the time period considered in this study, the contract was based on the Australian Stock Exchange's All Ordinary Share Price Index (AOI), which is the benchmark indicator of the Australian stock market. AOI was a capitalization weighted index; at the time of the study, it was based on the market prices of about 318 companies listed on the Australian Stock Exchange.

On October 11, 1993, the SPI futures contract multiplier was reduced from A$100 to A$25, which lowered the dollar value of a contract unit to one-fourth of its previous value. The purpose of this contract split was to attract small traders' participation in the market. The minimum price fluctuation was increased by a factor of ten, to one index point; thus, the dollar value of the minimum tick increased from A$10 to A$25. The redesign of the contract is detailed in Table A.1 in the appendix.

In 1979, the SFE launched the BAB futures contract as the first interest rate futures contract to be listed outside the United States. The BAB futures product is viewed as a benchmark indicator for short-term interest rates and is an efficient way to gain exposure to the Australian debt markets. Bank Accepted Bills of Exchange and Negotiable Certificates of Deposit are eligible for delivery. These short term securities are used for short term financing for periods typically ranging from one to six months. The futures contract is quoted as an index equal to 100 minus the yield per annum. The value of a physical 90-Day Bank Acceptance Bill is calculated according to a yield maturity formula that discounts the face value to establish the interest cost over the maturity. The price of a contract is given by

$$P = \frac{365FV}{365 + yT/100}, \qquad (1)$$

where FV is the face value, y is the yield to maturity, and T denotes days to maturity.

On May 1, 1995, SFE redesigned the BAB futures contract and doubled its face value. The motivation for increasing the size was to strengthen the commercial participation in the SFE market by reducing the direct transaction cost. The face value was increased from A$500,000 to A$1,000,000. The minimum tick remained constant at 0.01%; thus, the dollar value of the minimum tick doubled. Notice, the dollar value of the minimum price movement varies along with the underlying interest rate. Table A.2 in the appendix describes the details of the modifications made to the BAB futures contract.

LIFFE introduced the FTSE-100 index futures contract in September 1984. The underlying index is a market-value weighted index of the 100 largest British companies ranked by market capitalization traded on the London Stock Exchange. During the time considered in this study, the FTSE-100 index futures contract was traded on the floor at LIFFE from 8:35 a.m. to 4:10 p.m. Additional after-hours trading (4:32 p.m. to 5:30 p.m.) took place over the computerized After Pit Trading (APT) system. We do not consider the trades made over the APT system. The FTSE-100 index futures are settled in cash based on the Exchange Delivery Settlement Price (EDSP). The EDSP is based on the average values of the FTSE-100 index on the last trading day. The value of the futures contract is determined by multiplying the FTSE-100 index level by a contract multiplier. Initially, the multiplier was 25 and the minimum price fluctuation was 0.5 index point, yielding a minimum tick value of £12.50. On March 23, 1998, LIFFE lowered the multiplier to 10. The minimum tick was held constant at 0.5 index point, resulting in a decrease in the tick value by a factor of 2.5. Table A.3 in the appendix summarizes the terms of the FTSE-100 index futures contract and the changes made to the specifications.

The data for all contracts are intraday data that span a period extending from about one year prior to the date of the contract redesign to one year following the date of the contract redesign. The SPI data range from October 11, 1992 to October 11, 1994; the BAB dataset cover the period May 1, 1994 to May 1, 1996; and the FTSE-100 data span March 23, 1997 to April 23, 1999.

The recorded transactions for the SPI and BAB are extracted from the electronic settlement system of SFE known as OM Secur. These datasets have bid-ask quotes along with price, volume and trading time. Similarly, the FTSE-100 time and sales records that are acquired from LIFFE contain bid, ask, and trade prices, volume, and a date/time stamp. For the FTSE-100 data, however, the bids and offers are not formal quotes but prices at which traders announce they are willing to trade. Furthermore, the bids and asks may not be quoted simultaneously nor originated by the same trader. Following Tse (1999), a quote at time t is formed by the latest bid and offer auctioned prior to, or at, t. The time stamps are to the nearest second for all contracts.

In our analysis, we use data from nearby contract months. We employ trading volume as a switch indictor to shift the first deferred contract month to become the nearby futures contract month. To control the quality of our data, trades are omitted if the prices, quotes or volumes are non-positive, or if the bids exceed asks. During this period, the BAB and SPI were traded on the floor at 9:50 a.m.- 12:30 p.m. and 2:00 p.m.- 4:10 p.m. SFE introduced lunchtime trading between May 5, 1994, and September 20, 1994, for the SPI futures contract. These transactions are eliminated. Finally, transactions with prices outside five standard deviations are excluded.

For robustness, four alternative measures of price volatility are used. Following Schwert (1989), a conditional volatility estimate $\hat{\sigma}_t$ is obtained in two steps by

$$r_t = \alpha_0 + \sum_{i=1}^{4} \alpha_i WD_{it} + \sum_{j=1}^{5} \beta_j r_{t-j} + \varepsilon_t \qquad (2)$$
$$\hat{\sigma}_t = \left| \varepsilon_t \right|$$

where r_t is the estimated return on day t and WD_{it} are dummy variables for the days of the week. Both daily and daytime returns are considered where the daily return is estimated as $r_t = Ln(P_{close,t}) - Ln(P_{close,t-1})$ and the daytime return as $r_t = Ln(P_{close,t}) - Ln(P_{open,t})$.[3] The mean of the first bid-ask quote of day t is used as the opening price $P_{open,t}$ and the mean of the last bid-ask quote is used as the closing price $P_{close,t}$. Using the midpoint of the quote as a proxy for the equilibrium price is a simple way to minimize the influence of bid-ask quote bounce.

Furthermore, two unconditional volatility measures are used. Andersen, et al. (2001) proposed an estimator for realized volatility as

$$\hat{\sigma}_t = \sqrt{\sum_{i=1}^{n_t} \left(r_{it} \right)^2} \qquad (3)$$

where $r_i = Ln(M_i) - Ln(M_{i-1})$ is the intraday return of every five minutes, and M_i is the mean of the bid-ask quote at the end of the ith five-minute interval. Another unconditional measure for the daily volatility is the high-low estimator proposed by Parkinson (1980), which is given by

$$\hat{\sigma}_t = \left(\frac{Ln(P_{high,t}) - Ln(P_{low,t}))^2}{4Ln(2)} \right)^{1/2} \qquad (4)$$

[3] Jones, Kaul and Lipson (1994) and Chan and Fong (2000) use close to close prices to calculate the return. Huang and Masulis (2003) argue that daytime return based on close to open prices is more related to the trading activity for the same day.

where $P_{high,t}$ and $P_{low,t}$ are the maximum respective minimum trade prices on day t.[4]

4. Empirical Methodology

To examine the relationship between daily price volatility and trading activity before and after a contract split, our statistical procedure consists of three steps.

First, we use a one-way analysis of variance model to document daily volatility before and after a contract split. The model is specified as follows:

$$V_{it} = \alpha_0 + \alpha_1 D_{it} + \varepsilon_{it} \qquad (5)$$

where V_{it} represents either a conditional volatility measure or an unconditional volatility measure of the i^{th} contract; D_{it} denotes a dummy variable equal to zero before the date of the split of the i^{th} contract and equal to one after the date of the split; and ε_{it} is the error term. We use OLS to estimate the parameter of equation (5).

The Newey and West procedure is used to calculate consistent standard errors under serial correlation and heteroskedasticity error process.

Second, we follow the Jones, Kaul and Lipson (1994) procedure to decompose the total trading volume into two components: (1) average trading size (AS_t); and (2) total trading frequency (NT_t). We test the relative power of average trading size and total trading frequency (number of trades) variables to explain the daily price volatility after a change in the size of a futures contract. The regression equation is specified as follows:

$$V_{it} = \beta_0 + \beta_1 D_{it} + \beta_2 AS_{it} + \beta_3 NT_{it} + \beta_4 DM_{it} + \sum_{j=1}^{m_i} \theta_j V_{i,t-j} + \upsilon_{it} \qquad (6)$$

[4] Jones, et al. (1994) and Chan and Fong (2000) use conditional volatility measures in their study, while Huang and Masulis (2003) and Downing and Zhang (2004) use both conditional and unconditional volatility measures in their studies. Bollen and Inder (2002) examine alternative measures of unconditional daily volatility using intraday data.

where AS_{it} denotes the average trading volume size of the i^{th} contract; NT_{it} represents the total trading frequency of the i^{th} contract; DM_{it} denotes the dummy variable for the maturity month effect; $V_{i,t-j}$ is the j^{th} lag of a daily volatility measure; and ν_{it} is the error term of equation (6).

The lagged volatility measures are used to take account of persistent volatility. It should be mentioned that if a change in trading frequency and/or average trading size can explain the change in daily volatility after a contract split, the coefficient of the contract split dummy variable D_{it} would be statistically insignificant. This result will provide us with a test on whether the change in total trading frequency is responsible for the change in daily volatility after the contract split.

Third, we follow Barclay and Warner (1993) and Chan and Fong (2000) to decompose the trading frequency into four classes based on trade size.[5] They are supra small (the group entering (leaving) the market after a contract split (a reverse contract split)), small, medium and large trade sizes. The frequency distributions of the trade size for each futures contract provide the basis for classification. This classification allows us to test the relative importance of trading frequency by trade size on daily volatility. These results can also provide information to test the noise trading versus stealth trading hypotheses in explaining the change in daily volatility before and after a change in the size of the index futures and interest rate futures contracts. Our third regression model is formulated as follows:

$$V_{it} = \beta_0 + \beta_1 D_{it} + \beta_2 AS_{it} + \beta_3 DM_{it} + \sum_{k=1}^{4} \phi_{ki} NT_{k,i,t} + \sum_{j=1}^{m_i} \theta_j V_{i,t-j} + e_{it} \qquad (7)$$

[5] Barclay and Warner (1993) decompose trading frequency of equity into three size classes (small, medium and large) and Chan and Fong (2000) decompose total trading frequency into five classes.

where $NT_{k,i,t}$ denotes the number of trades of the i^{th} contract in the k^{th} size class, k = 1 (supra small), 2 (small), 3 (medium) and 4 (large). e_{it} is the error term of equation (7). The other variables are defined in equations (5) and (6).

5. Empirical Results

Table 1 reports alternative measures of the mean of daily price volatility before and after the change in the size of the examined futures contracts. For robustness, we use two conditional volatility measures: (1) $\left|Residual_1\right|$ denotes the absolute value of residuals from the returns based on close to close prices from equation (2); and (2) $\left|Residual_2\right|$ denotes the absolute value of residuals from the daily returns based on daily close to open prices. The realized volatility and Parkinson volatility are two unconditional volatility measures and they are reported in column four and five, respectively.

We find that all the means of the volatility measures in the post-split periods are higher than the corresponding means in the pre-split periods for the SPI and FTSE-100 index futures. Most of the differences are statistically significant at least at the 5% level. It is interesting to observe that all measures of the means of volatility are smaller in the reverse split period than the corresponding measures in the pre-reverse split period for the BAB contract. Our results clearly demonstrate the fact that daily volatility changes following a change in the size of a futures contract.

Table 2 presents empirical results on the means of trading activity before and after the change in the size of the examined futures contracts. As expected, the trading volume, average trade size and total trading frequency (number of trades) have increased after the reduction in the size of the SPI and FTSE-100 index futures contracts. Our results are consistent with the results that researchers have found for stock splits in the equity markets. We find that the means of trading volume, average size and trading frequency decrease after the increase in size (two for one) of the BAB interest rate futures.

To examine the effect of a change in the size of a contract on the trading frequency by trade size categories, we decompose the total trading frequency into trading frequencies of four trade size categories: supra small, small, medium and large. We use the cumulative frequency distribution of the adjusted trade size to decide the boundaries for our categories for each futures contract used in this study.[6] The class labeled supra small denotes the smallest trades that were made available by the splits of the SPI and FTSE-100 contracts, and the trades that were no longer available after the reverse split of the BAB contract. The details of the size boundaries of the four classes for each of the three contracts are described in the bottom of table 2.

The mean of the trading frequency of the supra small-size class for the SPI index futures is 388.8 after the contract split. This result suggests that the contract split of the SPI achieved the goal of attracting small traders to the market. We find that the contract split of the FTSE-100 also attracted some small traders in the supra small class, but the magnitude of the increase in the trading frequency for the FTSE-100 is smaller than the magnitude of the trading frequency of the SPI in the supra small class. This is expected since SPI had a one to four split while the FTSE-100 had a one to 2.5 contract split. The average trading frequency of the small-size class for the FTSE-100 increased by one third of the mean of the pre-split time period. Both means of the medium and large trading frequencies decreased in comparison with the corresponding classes in the pre-split time period. These results confirm that the contract split of the FTSE-100 attracted small traders and allowed traders to fine tune their hedging portfolios.

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[6] For the SPI and FTSE-100, the traded size after the contract split is multiplied by 0.25 and 0.4, respectively; for the BAB, the trade size after the change is multiplied by two. Further discussion on the adjusted trade size is presented in Table 2.

We find that the trading frequency of the large-size category has increased and the trading frequencies of the small and medium-size categories have decreased following the increase in the size of the BAB futures contract. This result is consistent with the expectation that market participants prefer to trade this contract in a larger size than before.

Table 3 reports the regression results of daily volatility on the parameters of the dummy variable to denote the time periods before and after the change in contract size, average trade size and trading frequency (i.e., equation (6) in section 4). To save space, we do not report the coefficients of lagged daily volatility variables.[7]

For the contract splits of the SPI and FTSE-100, we find that the coefficients of the dummy variables are positive and significant for both volatility measures (see column (1) under the headings of $\left|Residual_2\right|$ and Realized Volatility respectively). The coefficients of the dummy variables become insignificant or turn into negative signs in the regressions which include the additional variables number of trades and average size. The coefficients of the number of trades are highly significant, while most of the coefficients of average trade size are highly insignificant (see columns (2) and (3) under the heading of $\left|Residual_2\right|$ and Realized Volatility). These results suggest that the increase in the number of trades (trading frequency) is the primarily associated with the increase in price volatility after the contract splits.

For the BAB futures, we find that the coefficients of the dummy variables are negative and highly significant after the reverse contract split, but the coefficients of the dummy variables become insignificant or turn into positive signs after we include the number of trades and average trade size variables in the regressions. In short, our empirical results are consistent with

[7] We have used six lags in our daily volatility variables in the equations. The diagnostic checking of residuals indicates that the residuals are white noise.

the findings of JKL that price volatility is primarily and positively related to the number of trades and less related to the average size of trades.

From Table 2, we observe that the trade frequency of the different trade sizes have altered following the change in the size of the examined futures contracts. Table 4 presents regression analyses of daily volatility measures on trading frequency of the different trade size categories.

For the SPI futures (under Panel A), we observe that the coefficients of the dummy variables are insignificant and the coefficients of the trading frequency of the supra small and small trade categories are positive and statistically significant. This result suggests that the new groups of small traders contribute to the increase in daily volatility. Our results support the noise trader hypothesis suggested by Black (1986) and reject the smooth volatility hypothesis suggested by Huang and Stoll (1999), following the contract splits. The coefficients of trading frequency of medium-size trades are insignificant. This result is consistent with previous findings that there are less informed traders in index futures (see Berkman, Brailsford and Frino (2005)). The coefficients of trading frequency of large-size trades are significant for all volatility measures. If informed traders break up large trades into medium trade sizes to gain better price execution (the stealth trading hypothesis), then any remaining large trades are likely to be liquidity-driven trades who accept large price concessions for the immediacy. We find similar results for the FTSE-100 contract split with one exception: the coefficient of the supra small-size category is insignificant. This may be due to the fact that the trading frequency of the new group of small traders is relatively low in comparison with the trading frequency of other sizes.

For the BAB futures contract, we find that the coefficients of the dummy variables are insignificant and the coefficients of the trading frequency of the small, medium and large-size categories are positive and significant for all measures of volatility. However, the coefficients of the supra small class are insignificant. These results suggest that the trading frequency for respective trade size has a positive relationship with daily price volatility in the BAB interest rate futures market. Finally, we test whether there is a change in the relationship between price volatility and trading frequency of all size categories before and after a change in the size of a futures contract by adding the interaction terms of the dummy variable with the trading frequency of all sizes in the regression. From the t-statistics of the coefficients of the interaction terms and F statistics to test the null hypothesis that all coefficients of the interaction terms are equal to zero, we find that the relationship between daily price volatility and trading frequency variables of different sizes have not changed after the change in the size of the examined futures contracts.

6. Conclusions

Our empirical analysis of the contract splits of the SPI and FTSE-100 index futures and the reverse contract split of the BAB interest rate futures has obtained several interesting results, which have not been found in previous futures market literature. We observe that the daily price volatility has increased after the contract splits and decreased after the reverse contract split. There is a positive relationship between the number of trades (trading frequency) and daily price volatility. Decomposing the trading volume into two components, trading frequency and average trade size, we find that a change in total trading frequency has the power to explain a change in daily price volatility before and after a change in the size of a futures contract. Most of the average volume size variable has an immaterial impact on price volatility. These results are consistent with the previous findings of Jones, Kaul and Lipson (1994) and Huang and Masulis (2004) in equity markets. Finally, the trading frequencies of both small-size trades and large-size trades affect price volatility, but the trading frequency of medium-size trades has minimal effects on price volatility after the index futures contract splits. These results are consistent with the noise trading hypothesis suggested by Black (1986) and the hypothesis on less informed trading in index futures markets. Furthermore, our results do not support the smooth trading hypothesis by Huang and Stoll (1999). For the reverse split of the BAB interest rate futures, we find that the trade frequencies for all size categories are associated with changes in price volatility. This result may suggest that both noise traders and informed traders are participating equally in the interest rate future markets.

The size of a futures contract is an important element of contract specification, and one that many futures exchanges re-assess from time to time. Despite this, very little research has been done to examine the impact of a change in contract size on market price volatility. The empirical results of this paper provide additional insights into this issue.

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Table 1
Descriptive statistics by alternative measures of daily price volatility

	$\lvert Residual_1 \rvert$	$\lvert Residual_2 \rvert$	Realized Volatility	Parkinson Volatility
Panel A: (Au)				
SPI				
pre-split	0.7736×10^{-2}	0.6553×10^{-2}	0.7004	0.7895
post-split	0.9290×10^{-2}	0.7491×10^{-2}	0.7706	0.8816
t-statistic	1.97	1.41	1.10	1.63
BAB				
pre-reverse split	0.1068	0.5757×10^{-1}	0.3114×10^{-1}	0.8058×10^{-2}
post-reverse split	0.6285×10^{-1}	0.3114×10^{-1}	0.4155×10^{-2}	0.3868×10^{-2}
t-statistic	-2.45	-2.97	-2.62	-2.95
Panel B: (U.K.)				
FTSE-100				
pre-split	0.8649×10^{-2}	0.7080×10^{-2}	0.8440	0.8592
post-split	0.1142×10^{-1}	0.9498×10^{-2}	1.0991	1.1109
t-statistic	1.98	2.53	2.28	2.27

The table reports the mean values of four alternative measures of daily price volatility prior to and following changes in the size of three futures contracts. Panel A reports the estimates for the Australian (Au) futures contracts SPI and BAB; Panel B presents the results for the FTSE-100. $\lvert Residual_1 \rvert$ denotes the estimates based on close to close returns while $\lvert Residual_2 \rvert$ refers to results derived from close to open returns. The volatility is estimated in two steps:

$$r_t = \alpha_0 + \sum_{i=1}^{4} \alpha_i WD_{it} + \sum_{j=1}^{5} \beta_j r_{t-j} + \varepsilon_t$$

$$\hat{\sigma}_t = \lvert \varepsilon_t \rvert$$

where r_t is the estimated return on day t, r_{t-j} is the jth lag of the daily return, and WD_{it} are dummy variables for the days of the week. The realized volatility is given by $\hat{\sigma}_t = \sqrt{\sum_{i=1}^{n_t} (r_{it})^2}$ where r_i are five-minute intraday returns. The Parkinson estimate is

$$\hat{\sigma}_t = \left(\frac{Ln(P_{high,t}) - Ln(P_{low,t}))^2}{4Ln(2)} \right)^{1/2}$$

where $P_{high,\mathrm{t}}$ and $P_{low,t}$ are the maximum respective minimum trade prices on day t. Newey and West t-statistic is reported for the difference between pre- and post-contract redesign levels in volatility.

Table 2
Descriptive statistics by trading activity

	Trading Volume	Adjusted Volume	Average Trade Size (Adjusted)	Trading Frequency	Trade Frequency			
					Supra Small	Small	Medium	Large
Panel A: (Au)								
SPI								
pre-split	1,278.233	1,278.233	2.850	453.057	0	317.647	108.629	23.580
post-split	6,429.706	1,607.426	1.905	853.875	388.817	224.102	215.342	22.882
t-statistic	31.84	6.46	-14.83	20.79	47.89	-12.13	17.10	-0.48
BAB								
pre-reverse split	10,478.000	10,478.000	48.444	232.704	14.965	120.446	86.699	7.350
post-reverse split	3,622.064	7,243.687	61.798	120.156	0	70.852	40.000	9.378
t-statistic	-13.83	-5.54	9.20	-9.53	-13.84	-7.62	-11.07	2.51
Panel B: (U.K.)								
FTSE-100								
pre-split	5,695.476	5,695.476	4.359	1,295.139	0	1,182.147	16.504	92.417
post-split	19,360.480	7,744.196	4.243	1,815.362	112.014	1,617.369	8.487	77.491
t-statistic	34.72	10.40	-1.60	13.94	31.06	12.19	-11.25	-3.70

The table reports the mean values of trading activities prior to and following changes in the size of three futures contracts. Panel A reports the estimates for the Australian (Au) futures contracts SPI and BAB; Panel B presents the results for the FTSE-100. The four first columns report the daily trading volume, adjusted volume, adjusted average trade size, and daily trading frequency. The following columns present the trading frequency decomposed into four categories. Each transaction is classified as supra small, small, medium or large based on the trade size after adjusting for change in sizes of the futures contracts. Let s denote the adjusted trade size. For the SPI, s is set to the trade size before the contract split and 0.25 times the size after the split since the cost per contract was reduced by a factor of four. Since the BAB had a two to one reverse split, s is equal to the trade size before the contract redesign and the trade size multiplied by two after. The FTSE-100 contract was reduced by a factor of 2.5, thus s is set to the trade size before and 0.4 times the size after the split. The classes for respective futures contract are defined as follows:

SPI: Supra Small: $s < 1$; Small $1 \leq s < 2.25$; Medium: $2.25 \leq s < 9$; Large: $9 \leq s$
BAB: Supra Small: $s < 2$; Small $2 \leq s < 50$; Medium: $50 \leq s < 162$; Large: $162 \leq s$
FTSE-100: Supra Small: $s < 1$; Small $1 \leq s < 4.4$; Medium: $4.4 \leq s < 8$; Large: $8 \leq s$

Notice, the class labeled supra small denotes the smallest trades that were made available by the splits of the SPI and FTSE-100 contracts, and the trades that were no longer available after the reverse split of the BAB contract. The t-statistic is reported for the difference between pre- and post-split levels of the trade activities.

Table 3
Regression analysis of daily price volatility on dummy variable (D), average trade size (AS_t) and trading frequency (NT_t)

	|Residual$_2$|			Realized Volatility		
	(1)	(2)	(3)	(1)	(2)	(3)
Panel A: (Au)						
SPI						
Intercept	0.6600×10^{-2}	0.1740×10^{-2}	0.2620×10^{-2}	0.6998	0.1082	0.1208
	(16.92)	(1.63)	(2.75)	(42.07)	(2.36)	(2.97)
D	0.8903×10^{-3}	-0.4330×10^{-2}	-0.2950×10^{-2}	0.7075×10^{-1}	-0.2004	-0.1847
	(1.67)	(-4.14)	(-4.13)	(3.09)	(-5.58)	(-7.53)
AS_t	–	0.28641	–	–	0.3320×10^{-2}	–
	–	(1.80)	–	–	(0.60)	–
NT_t	–	0.1000×10^{-4}	0.1000×10^{-4}	–	0.5677×10^{-3}	0.5694×10^{-3}
	–	(7.60)	(7.60)	–	(12.19)	(12.26)
$\bar{R}^2$	0.0038	0.1361	0.1318	0.0180	0.4564	0.4571
BAB						
Intercept	0.5851×10^{-1}	-0.2466×10^{-1}	0.1503×10^{-1}	0.7540×10^{-2}	-0.1380×10^{-2}	0.4053×10^{-3}
	(13.32)	(-1.63)	(1.76)	(19.56)	(-1.47)	(0.80)
D	-0.2737×10^{-1}	0.1467×10^{-1}	-0.1838×10^{-3}	-0.3390×10^{-2}	0.1110×10^{-2}	0.4421×10^{-3}
	(-4.48)	(2.02)	(-0.03)	(-6.28)	(2.53)	(1.36)
AS_t	–	0.7307×10^{-3}	–	–	0.3111×10^{-4}	–
	–	(3.17)	–	–	(2.26)	–
NT_t	–	0.2803×10^{-3}	0.2726×10^{-3}	–	0.2721×10^{-4}	0.2701×10^{-4}
	–	(12.20)	(11.81)	–	(19.91)	(19.71)
$\bar{R}^2$	0.0413	0.4083	0.3960	0.0786	0.7529	0.7505

Table 3 (continue)

	$\lvert Residual_2 \rvert$			Realized Volatility		
	(1)	(2)	(3)	(1)	(2)	(3)
Panel B: (U.K.)						
FTSE-100						
Intercept	0.7150×10^{-2}	-0.1660×10^{-2}	-0.1170×10^{-2}	0.8515	-0.6168×10^{-1}	-0.1154
	(16.66)	(-1.16)	(-1.10)	(39.85)	(-1.14)	(-2.85)
D	0.2300×10^{-2}	-0.1660×10^{-2}	-0.8857×10^{-3}	0.2476	-0.1930×10^{-2}	-0.8144×10^{-1}
	(3.95)	(-1.00)	(-1.35)	(8.33)	(-0.03)	(-3.56)
AS_t	–	0.1269×10^{-3}	–	–	-0.1289×10^{-1}	–
	–	(0.51)	–	–	(-1.50)	–
NT_t	–	0.5980×10^{-5}	0.6030×10^{-5}	–	0.3108×10^{-3}	0.3047×10^{-3}
	–	(8.79)	(8.97)	–	(13.12)	(13.04)
$\overline{R}^2$	0.0267	0.1587	0.1599	0.1126	0.6414	0.6405

The table reports the regression analysis of daily price volatility on trade activities. Two measures of volatility are considered: $\lvert Residual_2 \rvert$ refers to the conditional volatility estimates based on close to open returns and Realized Volatility is the unconditional volatility based on five-minute returns. Panel A reports the estimates for the Australian (Au) futures contracts SPI and BAB; Panel B presents the results for the FTSE-100. The columns labeled (1) present the OLS estimates of the parameters in the model $V_{it} = \alpha_0 + \alpha_1 D_{it} + \varepsilon_{it}$ where $V_{i,t}$ represents either the conditional volatility measure or the unconditional volatility measure of the i^th^ contract; D_{it} denotes a dummy variable equal to zero (one) before (after) the date of the i^th^ contract redesign; and ε_t is the error term. The estimates in the columns labeled (2) are the OLS results of the model specified as

$$V_{it} = \beta_0 + \beta_1 D_{it} + \beta_2 AS_{it} + \beta_3 NT_{it} + \beta_4 DM_{it} + \sum_{j=1}^{m_i} \theta_j V_{i,t-j} + \upsilon_{it}$$

where V_{it} and $D_{i,t}$ are defined as above, AS_{it} denotes the average trading volume of the i^{th} contract; NT_{it} represents the total daily trading frequency of the i^{th} contract; DM_{it} denotes the dummy variable for maturity month effect; $V_{i,t-j}$ is the j^{th} lag of the daily volatility measure; and $\upsilon_{i,t}$ is the error. The t-statistic is reported in parentheses for each estimate.

Table 4
Regression analysis of daily price volatility measures on different size of trading frequency

	$\lvert Residual_2 \rvert$		Realized Volatility	
	(1)	(2)	(1)	(2)
Panel A: (Au)				
SPI				
Intercept	0.8511×10^{-3}	0.6931×10^{-3}	0.3116×10^{-1}	-0.1150×10^{-1}
	(0.62)	(0.48)	(0.59)	(-0.21)
D	-0.1617×10^{-3}	-0.1408×10^{-3}	-0.5766×10^{-1}	-0.5730×10^{-2}
	(-0.10)	(-0.08)	(-1.03)	(-0.10)
Supra Small	0.6660×10^{-5}	0.7910×10^{-5}	0.5490×10^{-3}	0.1180×10^{-2}
$s < 1$	(1.80)	(1.41)	(4.22)	(6.13)
Small	0.1440×10^{-4}	0.1081×10^{-4}	0.9965×10^{-3}	0.1170×10^{-2}
$1 \leq s < 2.25$	(3.17)	(1.73)	(6.35)	(5.42)
Medium	0.5660×10^{-6}	0.1607×10^{-4}	-0.1393×10^{-3}	0.1519×10^{-3}
$2.25 \leq s < 9$	(0.09)	(0.97)	(-0.62)	(0.27)
Large	0.6640×10^{-4}	0.4814×10^{-4}	0.2240×10^{-2}	0.8362×10^{-3}
$9 \leq s$	(2.99)	(1.57)	(2.94)	(0.82)
D×Small	–	0.4040×10^{-5}	–	-0.1670×10^{-2}
		(0.29)		(-3.58)
D×Medium	–	-0.1900×10^{-4}	–	-0.3792×10^{-4}
		(-1.01)		(-0.06)
D×Large	–	0.2976×10^{-4}	–	0.3150×10^{-2}
		(0.67)		(2.12)
$\overline{R}^2$	0.1469	0.1433	0.4709	0.4896
F statistics	7.66	6.17	35.57	30.80
BAB				
Intercept	0.1096×10^{-1}	0.1161×10^{-1}	0.4773×10^{-3}	0.3291×10^{-3}
	(1.32)	(1.34)	(0.93)	(0.62)
D	-0.5990×10^{-2}	-0.7850×10^{-2}	-0.3446×10^{-3}	0.1076×10^{-3}
	(-0.94)	(-0.90)	(-0.90)	(0.21)
Supra Small	0.2597×10^{-3}	0.4770×10^{-3}	-0.2440×10^{-4}	-0.3604×10^{-4}
$s < 2$	(0.96)	(1.55)	(-1.53)	(-2.01)
Small	0.1976×10^{-4}	0.1970×10^{-5}	0.3215×10^{-4}	0.3596×10^{-4}
$2 \leq s < 50$	(0.27)	(0.02)	(7.13)	(5.96)
Medium	0.4214×10^{-3}	0.3111×10^{-3}	0.2174×10^{-4}	0.2102×10^{-4}
$50 \leq s < 162$	(3.74)	(2.03)	(3.24)	(2.30)
Large	0.1970×10^{-2}	0.3040×10^{-2}	0.7330×10^{-4}	0.6961×10^{-4}
$162 \leq s$	(5.42)	(4.16)	(3.38)	(1.59)
D×Small	–	0.1078×10^{-3}	–	-0.5030×10^{-5}
		(0.69)		-0.54)
D×Medium	–	0.9405×10^{-4}	–	-0.8460×10^{-5}
		(0.29)		(-0.44)
D×Large	–	-0.1540×10^{-2}	–	0.2303×10^{-4}
		(-1.77)		(0.44)

$\overline{R}^2$	0.4492	0.4512	0.7603	0.7598
F statistics	31.11	25.28	119.94	95.91

Panel B: (U.K)

FTSE-100				
Intercept	-0.1990×10^{-2}	-0.2870×10^{-2}	-0.1396	-0.2664
	(-1.64)	(-1.57)	(-3.09)	(-4.06)
D	0.6738×10^{-3}	0.2260×10^{-2}	-0.5717×10^{-1}	0.1110
	(0.61)	(0.96)	(-1.48)	(1.39)
Supra Small	-0.5280×10^{-5}	-0.5370×10^{-5}	0.1498×10^{-3}	0.6506×10^{-4}
s < 1	(-0.76)	(-0.69)	(0.62)	(0.24)
Small	0.5790×10^{-5}	0.6640×10^{-5}	0.2873×10^{-3}	0.3990×10^{-3}
1 ≤ s < 4.4	(8.07)	(4.83)	(11.3)	(8.56)
Medium	0.7360×10^{-5}	0.2064×10^{-4}	-0.3159×10^{-3}	-0.6466×10^{-3}
4.4 ≤ s < 8	(0.20)	(0.52)	(-0.25)	(-0.47)
Large	0.1712×10^{-4}	0.1385×10^{-4}	0.7783×10^{-3}	0.6430×10^{-3}
8 ≤ s	(2.55)	(1.82)	(3.36)	(2.47)
D×Small	–	-0.1420×10^{-5}	–	-0.1549×10^{-3}
		(-0.89)		(-2.85)
D×Medium	–	-0.1023×10^{-3}	–	0.4851×10^{-3}
		(-0.99)		(0.14)
D×Large	–	0.1715×10^{-4}	–	0.4294×10^{-3}
		(1.04)		(0.76)
$\overline{R}^2$	0.1623	0.1603	0.6414	0.6451
F statistics	9.62	7.79	81.35	66.32

The table reports the regression analysis of daily price volatilities on trading frequency decomposed into four categories based on trade size. Two measures of volatility are considered: $|Residual_2|$ refers to the conditional volatility estimates based on close to open returns and Realized Volatility is the unconditional volatility measure based on five-minute returns. Panel A reports the estimates for the Australian (Au) futures contracts SPI and BAB; Panel B details the results for the FTSE-100. Each transaction is classified as supra small, small, medium or large based on the trade size after adjusting for change in sizes of the futures contracts. Let s denote the adjusted trade size. For the SPI, s is set to the trade size before the contract split and 0.25 times the size after the split since the cost per contract was reduced by a factor of four. Since the BAB had a two to one reverse split, s is equal to the trade size before the contract redesign and the trade size multiplied by two after. The FTSE-100 contract was reduced by a factor of 2.5, thus s is set to the trade size before and 0.4 times the size after the split. The classes for respective futures contract are defined as follows:

SPI: Supra Small: s < 1; Small 1 ≤ s < 2.25; Medium: 2.25 ≤ s < 9; Large: 9 ≤ s
BAB: Supra Small: s < 2; Small 2 ≤ s < 50; Medium: 50 ≤ s < 162; Large: 162 ≤ s
FTSE-100: Supra Small: s < 1; Small 1 ≤ s < 4.4; Medium: 4.4 ≤ s < 8; Large: 8 ≤ s

The columns labeled (1) present the OLS estimates of the parameters in the model

$$V_{it} = \beta_0 + \beta_1 D_{it} + \beta_2 AS_{it} + \beta_3 DM_{it} + \sum_{k=1}^{4} \phi_{k,i} NT_{k,i,t} + \sum_{j=1}^{m_i} \theta_j V_{i,t-j} + e_{it}$$

where V_{it} represents either the conditional volatility or the unconditional volatility measure of the ith contract; D_{it} denotes a dummy variable equal to zero (one) before (after) the date of ith contract redesign; AS_{it} denotes the average trading volume size of ith contract; DM_{it} denotes the dummy variable for maturity month effect;$NT_{k,it}$ denotes the number of trades of ith contract by the kth size class, k = 1 (supra small), 2 (small) , 3 (medium) and 4 (large); $V_{i,t-j}$ is the jth lag of the daily volatility measure; and e_{it} is the error. The OLS estimates when adding the interaction variables D_{it}×Small, D_{it}×Medium, and D_{it}×Large to the model above are reported in the columns labeled (2). The t-statistic is reported in parentheses for each estimate.

Appendix

Table A.1
The contract specification for the Share Price Index futures traded on the Sydney Futures Exchange before and after October 11, 1993.

	Before October 11, 1993	After October 11, 1993
Contract unit	100 x All Ordinary Index	25 x All Ordinary Index
Price quotes	In index points to one decimal	In index points to full point
Minimum price Fluctuation (Tick)	0.1 index point	1 index point
Value of minimum tick	A$10	A$25
Settlement day	Second business day after expiry	Same as before
Settlement	Settled in cash to the closing quotation for the AOI on the last day of trading	Same as before
Contract months	March/June/September/December up to twenty quarter months ahead	Same as before
Termination of Trading	12:00 p.m. on the business day immediately prior to settlement day	Same as before
Trading hours	9:50 a.m.-12:30 p.m. and 2:00 p.m.-4:10 p.m.; SYCOM trading: 4:40 p.m.-7:00 a.m.	Same as before

Table A.2
The contract specification for the Australian 90-Day Bank Accepted Bill futures traded on the Sydney Futures Exchange before and after May 1, 1995.

	Before May 1, 1995	After May 1, 1995
Contract unit	A$500,000 face value of 90-Day Bank Accepted Bills of exchange or Electronic Bank Acceptances (EBA)	A$1,000,000 face value of 90-Day Bank Accepted Bills of exchange or EBAs
Price quotes	100 minus the percentage yield to maturity	100 minus the percentage yield to maturity
Minimum price Fluctuation (Tick)	0.01%	0.01%
Value of minimum tick	Approximately A$12; varies with the yield	Approximately A$24
Settlement day	The second Friday of the delivery month	Same as before
Settlement	Ten (two or one) bank accepted bills, EBAs, negotiable certificates of deposit or ECDs each of face value A$100,000 (A$500,000 or A$1,000,000) maturing 85-90 days from settlement day.	Same as before
Contract months	March/June/September/December up to six quarter months ahead	Same as before
Termination of Trading	4:15 p.m. on the last business day of the contract month	Same as before
Trading hours	9:50 a.m.-12:30 p.m. and 2:00 p.m.-4:10 p.m.; SYCOM trading: 4:40 p.m.-7:00 a.m.	Same as before

Table A.3
The contract specification for the FTSE-100 Index futures traded on the London International Financial Futures Exchange (LIFFE) before and after March 23, 1998.

	Before March 23, 1998	After March 23, 1998
Contract unit	£25 per FTSE-100 index point	£10 per FTSE-100 index point
Price quotes	Index points	Index points
Minimum price Fluctuation (Tick)	0.5 index point	0.5 index point
Value of minimum tick	£12.50	£5.00
Settlement day	First market day following the last trading day	Same as before
Settlement	Cash settlement based on the Exchange Delivery Settlement Price	Same as before
Contract months	March/June/September/December (nearest four are traded)	Same as before
Termination of Trading	Third Friday in the delivery month	Same as before
Trading hours	Floor trading: 8:35 a.m.-4:10 p.m.; Automated Pit Trading: 4:32 p.m.-5:30 p.m.	Same as before