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Futures trading and market microstructure of the underlying security: A high frequency experiment at the single stock future level

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Abstract

This paper examines the differences in volume, volatility and liquidity in the underlying market between intervals when futures trade and intervals when there is no futures trading using high frequency proprietary data. We find that although the bid-ask spreads decrease, this is not due to a fall in information asymmetries and a fall in the adverse selection costs. We find supporting evidence that the fall in the spread could be due to lower inventory holding costs as a result of lower depth when futures trade. We also find volatility to increase when futures trade accompanied by increases in trading volume supporting the scenario that institutional investors take large positions in both derivative and the underlying markets creating price pressures. This paper has indicated that market quality might not necessarily improve with futures trading, in contrast to the results of previous studies, which applied a pre-post futures listing analysis and used lower frequency data.

JEL classification: G10; G14

Keywords: Futures market; Market microstructure

1. Introduction

The introduction of single stock futures in the various exchanges is a recent phenomenon. In the U.S. it was only in November 2002 that single stock futures started trading on OneChicago and NASDAQ-LIFFE market after the Commodity Futures Modernization Act of 2000 repealed the Shad-Johnson Accord and made it legal to trade single stock futures (SSFs). In the UK SSFs were introduced on the London Financial Futures and Options Exchange (LIFFE) in January 2001 with universal stock futures (USFs), i.e. futures contracts whose underlying securities might be traded in other markets other than the London Stock Exchange. The reasons of why the emergence of SSFs has been delayed goes back to concerns that futures might have a destabilizing impact on the cash market via the provision of low-cost speculation opportunities, which allows institutional investors to take large positions in both the derivative and the underlying markets to take advantage of price discrepancies. This large volume in turn creates price pressures in the underlying security and increases its volatility. The higher stock market volatility, which is a perception of higher risk, can potentially raise the cost of capital and have a negative impact on the economy.[1] Futures trading can also have a negative impact on the liquidity of the stock market if enough liquidity-motivated traders are attracted to the futures market, which may reduce the liquidity in the stock market and increase the specialist's inventory-related costs (see e.g. Stoll, 1978a, 1978b). In this

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[1] Although a number of papers focus on the relation between options and underlying security markets, similar arguments can be made for the relation between the futures and underlying security markets.

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case, stock dealers will be motivated to increase the spreads for the underlying stock.

The purpose of this paper is to examine the impact of SSFs on the microstructure of the underlying stocks using high frequency proprietary data. We perform an experiment and examine whether the behaviour of the underlying stock, its volatility, liquidity and order flow change when futures trade using 1 min intervals. So we examine how the behaviour of underlying stocks changes if during the 1 min interval there was trading in the future of that particular stock. We are using Jones, Kaul, and Lipson (1994) definition of a non-trading period as one in which the markets are open but traders endogenously choose not to trade. Since traders are not prevented from trading in the futures market at any interval, the generation and release of public and private information remains unchanged between intervals when there is future trading and intervals when there is no futures trading. Thus, an improvement in market quality during intervals when there is futures trading will most likely reflect the release of additional information, which will lower information asymmetry and improve the efficiency of the underlying market. In contrast, the event methodology and the pre-post listing analysis used in earlier studies compares a period when futures trading is not available with a period when futures trading is available. If the possibility of futures trading contributes to the information gathering then the production and release of information is likely to be different between the two periods and one will not be able to discern the impact of futures trading on the underlying stock.

Our experiment is based on 11 futures contracts in the Greek capital market. Single stock futures contracts were introduced in Greece in August 1999. Their introduction coincided however with a slowdown of the cash market, and that raised various questions at the time relating to the impact of the futures contracts on the liquidity and volatility of the cash market. This provides an additional motivation for our examination into the impact of futures on the cash market.

We show that the previously documented improvement in market quality of the underlying stocks following derivative listings in terms of a decrease in bid-ask spreads and increases in the number of contracts the specialist is willing to trade at the quoted prices (quoted depth), decreases in volatility and increases in volume and transaction size, do not carry over to the impact of SSF on the underlying stock in our experiment with high frequency data. Our results show that although bid-ask spreads decrease, this is not due to a fall in information asymmetries. We find that the adverse selection component of the bid-ask spread applying the method developed by Huang and Stoll (1996) and Bacidore and Sofianos (2002), does not decrease when futures trade. The decrease in the bid-ask spread could be due to lower inventory risk as a result of dealers providing lower depth. Indeed, we find that futures trading when it impacts on the market depth of stocks has a negative effect supporting our conjecture that the fall in the spread could be the result of lower inventory holding costs.

Furthermore, we find volatility increases when futures trade. This suggests that at the margin, futures trading has an effect of increasing price movements in the underlying security. As mentioned above, this increase in volatility could be the result of institutional investors taking large positions in both the derivative and the underlying markets, increasing trading volume and creating price pressures in the underlying security. Indeed, we find an increase in trading volume when futures trade supporting this scenario.

The paper is structured as follows. The next section reviews the literature. Section 3, describes the data, while Section 4, provides the empirical results on the impact of future trading on various dimensions of market quality of the underlying security: intra-day trading volume (and its components that include trade size and number of trades), volatility, bid-ask spread and quoted depth, and adverse selection component of the spread. Section 5 summarizes and concludes the paper.

2. Review of literature

Although the arguments given earlier support the view that the existence of speculators in futures markets may have destabilising effects, there are arguments, which support an alternative view. If informed trading is skewed toward futures markets because informed traders view futures as superior speculative vehicles,[2] then dealers' anticipated losses from informed traders will decline (reducing adverse selection costs), thus providing an incentive to reduce the underlying stocks' quoted spreads (see e.g. Glosten & Milgrom, 1985). Spreads might also be lowered and liquidity in the underlying market might improve through the reduction of the market maker's inventory costs, since futures provide a mechanism for hedging their inventory position (see Silber, 1985).

Finally, futures may improve the efficiency of the underlying market by increasing the level of public information in the market. Specifically, the marginal benefit of becoming informed after the introduction of futures is greater given the superiority of futures as a speculative vehicle. This increase in marginal benefit results in greater information search by traders. In turn, this increase in public information lowers information asymmetry, lowers the spread, improves liquidity, and reduces the variance of the pricing error, thereby making the underlying market more efficient.

Numerous studies have been written, which examine the impact of derivatives market on the underlying market.[3] On the whole the evidence shows that market quality of the underlying stocks improves. For example, Kumar, Sarin, and Shastri (1998) examine 174 options using an event

[2] This superiority of derivatives stems from the relatively low transactions costs of establishing a derivatives position, due to the trading on the margin, which offers leveraged positions, the ease of closing out the position and cash settlement, rather than physical delivery as in the case of cash securities, and by the fact that one can take a bearish position in a derivative without being subject to short sale restrictions which exist in the stock market (see John, Koticha, Narayanan, & Subrahmanyam, 2003).

[3] See Damodaran and Subrahmanyam (1992) for a review of the studies, which examine the impact of options on underlying securities, and Mayhew (1999) for a review of both options and futures on underlying securities. Subsequent work includes Sorescu (2000).

Table 1
Descriptive statistics for Single Stock Futures in the Athens Stock Exchange.

Name of the stock	Code	Start of futures trading	Start date for sample	End date for sample	Market capitalisation of underlying stock (in Euro) on 2nd Jan 2004
Hellenic Telecom. Organisation	HTO	19/11/2001	2/1/2004	6/7/2005	5,484,109,685.12
National Bank Of Greece S.A.	ETE	19/11/2001	2/1/2004	6/7/2005	5,397,029,078.60
Efg Eurobank Ergasias S.A.	EUROB	16/2/2004	16/2/2004	6/7/2005	4,957,321,947.60
Alpha Bank S.A.	ALPHA	2/4/2002	2/1/2004	6/7/2005	4,833,230,875.80
PPC S.A.	PPC	16/2/2004	16/2/2004	6/7/2005	4,565,760,000.00
Coca-Cola E.E.E. S.A.	EEEK	19/11/2001	2/1/2004	6/7/2005	4,013,899,388.16
OPAP S.A.	OPAP	16/2/2004	16/2/2004	6/7/2005	3,706,780,000.00
Cosmote-Mobile Telecommunications S.A.	COSMO	14/6/2004	14/6/2004	6/7/2005	3,578,708,060.80
Piraeus Bank S.A.	TPEIR	14/6/2004	14/6/2004	6/7/2005	1,952,071,637.88
Intracom S.A. Holdings	INTRK	2/4/2002	2/1/2004	6/7/2005	715,868,152.12
Hellenic Exchanges S.A. Holding	EXAE	14/6/2004	14/6/2004	6/7/2005	480,556,049.48

Source: ASE Fact Book, various issues.

methodology and daily values, which are the weighted average of all relative values in a day, and conclude that the introduction of options is accompanied by decreases in stock volatility, bid-ask spread and information asymmetry, and increases in quoted depth, trading frequency and transaction size. Another study, Shastri, Thirumalai, and Zutter (2008) confirm those results by concentrating on SSF and their impact on the underlying stock. They use 137 single stock futures traded on the OneChicago exchange and whose underlying stocks are listed on the NYSE and NASDAQ over the period January 2003 to July 2005. They examine on the one hand, the effects of futures trading on information revelation in the underlying stock by examining whether futures market contributes significantly to price discovery in underlying stocks using the Hasbrouck (1995) methodology, and on the other hand, they examine whether the underlying stock market quality improves with futures trading. They perform a pre and post SSF listing analysis and compare market quality during periods with and without trading in the SSF's market. They find that futures trading contributes to price discovery in the underlying stock and improves market quality in terms of volatility and bid-ask spreads. Chau, Holmes, and Paudyal (2008) also arrive at the conclusion that the listing of USFs has not impacted negatively on the underlying market. They examined the impact of 80 USFs at LIFFE on feedback trading and volatility over the period 2001–2006 and found a small reduction in feedback trading, while changes in volatility dynamics post-listing have been the same for USF stocks and for control stocks.[4] Using a sample of 21 stocks in the Karachi Stock Exchange Siddiqi, Nouman, Khan, and Khan (2012) examine the impact of the introduction of SSFs on the liquidity of the underlying stocks by looking at two years before and two years after the introduction of the SSFs. They find that liquidity, namely volume, trading value, number of trades and value per trade improve. However, it should be noted that they do not control for other determinants of liquidity.

Our study extends the earlier literature in several ways. First, as in Shastri et al. (2008), Chau et al. (2008) and Siddiqi et al. (2012) it concentrates on SSF and explores its impact on market quality of the underlying stock. The rest of the studies on futures have been contacted on the trading of market wide instruments such as index contracts. Effects however, can be dissipated across the many constituent assets of an index making it difficult to detect the impact of the derivative market at the single stock level.[5] Second and most importantly our study uses high frequency data, which provides greater insight into the dynamic behaviour of the two markets. It also gets away from the event methodology and the pre and post listing analysis, and compares stock price dynamics in periods in which futures on the stock trade, with those in periods in which market participants choose not to trade in the futures. In the study we use Jones et al. (1994) definition of a non-trading period as one in which the markets are open but traders endogenously choose not to trade. This has implications for the generation and release of public and private information as explained earlier.

3. Data

Our sample consists of eleven stocks, which are listed on the Athens Stock Exchange and had futures contracts in the Athens Derivatives Exchange during our sample period.[6] All stocks with futures contracts at the time of the study are included in our sample. The eleven stocks and some descriptive statistics are shown in Table 1. As it can be seen 8 of the

[4] It should be noted that Danielsen, Van Ness, and Warr (2007) draw attention to the fact that changes in market quality might take place gradually over time. That is market quality changes "drift through" rather than "shift" on the event date. They find volatility for NASDAQ firms to increase shortly before the option listing.

[5] See Chau et al. (2008). Furthermore, it is also the case that a particular stock is less liquid than the index and as a result the impact of derivatives could be greater.

[6] The Athens Stock Exchange (ASE S.A.) and the Athens Derivatives Exchange (ADEX S.A.) were merged in July 17, 2002 to form a new company, the Athens Exchange S.A. (ATHEX). The Athens Derivatives Exchange Clearing House S.A. (ADECH) continued to operate as a separate company.

Table 2
Relative frequency of intra-day order flow for futures and stocks. RTF_Futures: fraction of each 1 h period in which there is non-zero trading volume in the futures market. RTF_FuturesTrade: is the fraction of each one period in which there is non-zero trading volume in the underlying market but for intervals in which futures trade. RTF_FuturesNoTrade: is the fraction of each one period in which there is non-zero trading volume in the underlying market but for intervals in which futures do not trade.

StartTime	EndTime	RTF_Futures	RTF_Futures Trade	RTF_Futures NoTrade
HTO: Electricity				
11:00:00	11:59:59	19.32%	89.87%	75.38%
12:00:00	12:59:59	14.99%	86.61%	68.71%
13:00:00	13:59:59	13.30%	83.55%	66.86%
14:00:00	14:59:59	12.18%	81.21%	65.35%
15:00:00	15:59:59	18.76%	88.76%	75.98%
ALPHA: ALPHA Bank				
11:00:00	11:59:59	14.64%	92.03%	83.10%
12:00:00	12:59:59	12.07%	87.98%	75.26%
13:00:00	13:59:59	11.36%	86.15%	73.79%
14:00:00	14:59:59	10.73%	86.92%	72.16%
15:00:00	15:59:59	15.29%	91.25%	80.95%
ETE: National Bank of Greece				
11:00:00	11:59:59	15.84%	96.34%	88.42%
12:00:00	12:59:59	12.97%	93.16%	82.52%
13:00:00	13:59:59	11.61%	91.16%	80.20%
14:00:00	14:59:59	10.82%	90.27%	79.13%
15:00:00	15:59:59	16.30%	93.82%	85.76%
INTRK: Intracom				
11:00:00	11:59:59	11.97%	73.53%	51.28%
12:00:00	12:59:59	9.95%	65.74%	43.21%
13:00:00	13:59:59	9.47%	62.02%	41.05%
14:00:00	14:59:59	8.59%	65.07%	40.80%
15:00:00	15:59:59	12.26%	71.65%	53.21%
EEEK: Coca Cola				
11:00:00	11:59:59	4.74%	64.90%	40.43%
12:00:00	12:59:59	3.32%	67.27%	37.71%
13:00:00	13:59:59	3.08%	64.70%	36.80%
14:00:00	14:59:59	2.99%	66.03%	37.26%
15:00:00	15:59:59	4.75%	73.52%	50.65%
PPC: Public Power Corporation				
11:00:00	11:59:59	6.89%	83.12%	61.82%
12:00:00	12:59:59	6.06%	82.16%	57.23%
13:00:00	13:59:59	5.39%	77.89%	55.30%
14:00:00	14:59:59	4.82%	75.34%	53.36%
15:00:00	15:59:59	7.69%	84.27%	64.94%
EUROB: EuroBank				
11:00:00	11:59:59	8.09%	89.61%	76.19%
12:00:00	12:59:59	6.38%	86.64%	70.35%
13:00:00	13:59:59	5.53%	84.60%	66.27%
14:00:00	14:59:59	5.32%	82.53%	62.82%
15:00:00	15:59:59	8.15%	86.34%	71.69%
OPAP: Greek Organisation of Football Prognostics				
11:00:00	11:59:59	8.03%	88.33%	68.68%
12:00:00	12:59:59	5.91%	83.40%	62.14%
13:00:00	13:59:59	5.30%	79.21%	59.43%
14:00:00	14:59:59	4.96%	80.32%	59.32%
15:00:00	15:59:59	7.17%	88.49%	70.48%
COSMO: Cosmote				
11:00:00	11:59:59	2.62%	82.32%	55.24%
12:00:00	12:59:59	2.60%	76.12%	49.02%
13:00:00	13:59:59	2.03%	77.32%	47.00%
14:00:00	14:59:59	2.24%	79.67%	45.89%
15:00:00	15:59:59	3.49%	84.82%	59.00%
EXAE: Hellenic Exchanges				
11:00:00	11:59:59	5.74%	62.63%	37.20%
12:00:00	12:59:59	5.04%	61.70%	34.39%
13:00:00	13:59:59	4.23%	56.25%	33.47%
14:00:00	14:59:59	3.94%	60.14%	33.74%
15:00:00	15:59:59	6.18%	69.32%	45.02%
TPEIR: Piraeus Bank				
11:00:00	11:59:59	8.62%	88.47%	70.78%
12:00:00	12:59:59	6.74%	85.78%	65.01%
13:00:00	13:59:59	6.70%	82.37%	61.92%
14:00:00	14:59:59	6.29%	82.96%	59.84%
15:00:00	15:59:59	8.74%	87.56%	68.73%

11 stocks have high market capitalisation with HTO and ETE being at the top, while TPEIR, EXAE and INTRK have the smallest market capitalisation.

In our analysis we use transaction data at 1 min interval for the cash and futures markets: transaction volume, transaction frequency, transaction size, price, bid-ask spread and quoted depth for the stocks. The data cover the period 02.01.2004–06.07.2005 for 5 of the stocks giving us 379 trading days; for 3 of the stocks the sample starts at 16.02.2004 and ends at the same time as the other stocks, giving us 349 trading days, and for the rest of the stocks it starts at 14.06.2004 giving us 269 trading days.

In Table 2 and Fig. 1, we present some information on the relative frequency of intra-day trading for futures and stocks. We split the trading day into five 1 h periods starting at 11:00 o'clock, the beginning of the trading day, to 16:00, the end of the trading day. We find for each 1 min interval whether there was futures trading. We examine the trading frequency of the stock in the cash market during each 1 h period for intervals when there was future trading and for intervals when there was no future trading. We report the following information:

1. RTF_Futures: The relative trading frequency (RTF) for futures, which is the fraction of each 1 h period in which there is non-zero trading volume in the futures market. This is expressed as percent of time the futures are trading for every 1 h period.
2. RTF_FuturesTrade: The relative trading frequency for stocks in the cash market (otherwise called underlying stocks) in intervals in which futures trade. Similarly as above it is the fraction of each 1 h period in which there is non-zero trading volume in the cash market but for intervals in which futures trade.
3. RTF_FuturesNoTrade: The relative trading frequency for underlying stocks in intervals in which futures do not trade. Once again it is the fraction of each 1 h period in which there is non-zero trading volume in the cash market but for intervals in which futures do not trade.

We can make the following observations: First, the average RTF for futures ranges from about 16% (average for the hour intervals) for HTO to about 2.5% for COSMO. Secondly, The RTF for futures exhibits a U shaped pattern with the lowest

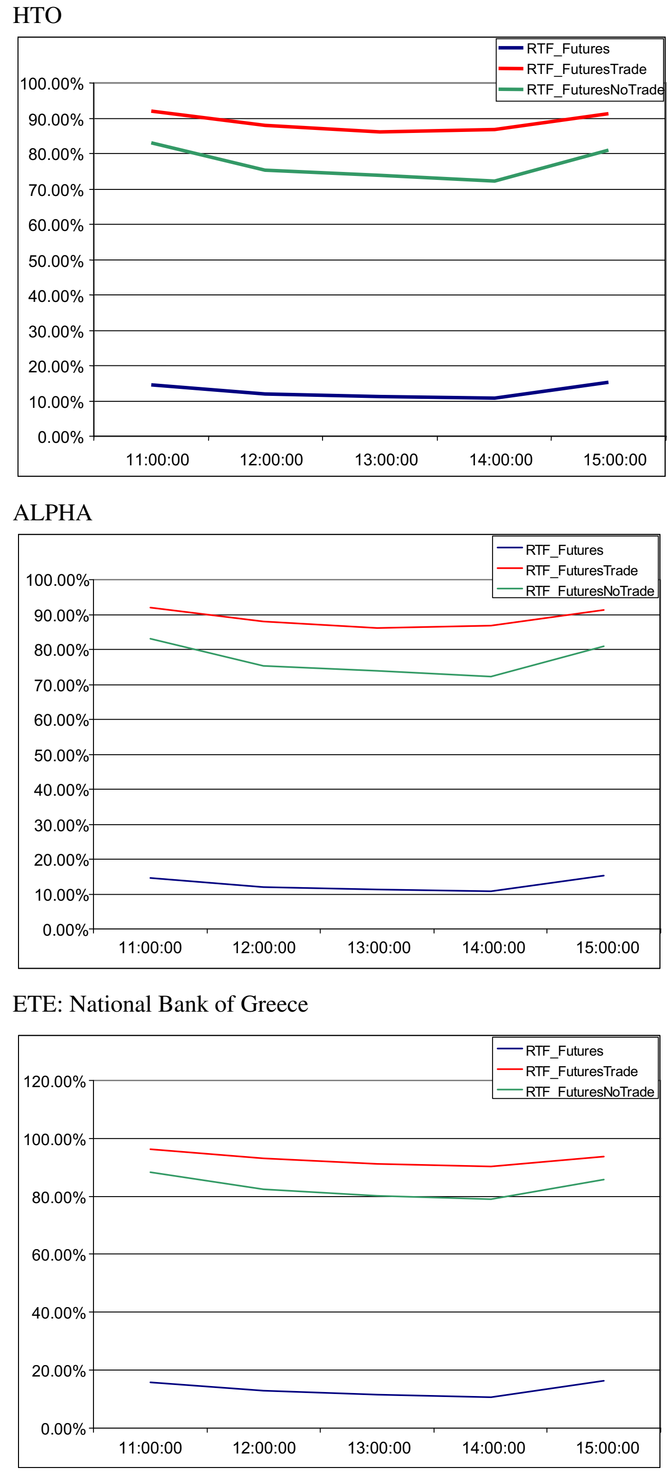

Fig. 1. Relative frequency of intra-day order flow for futures and stocks. RTF Futures: fraction of each 1 h period in which there is non-zero trading volume in the futures market. RTF_FuturesTrade: is the fraction of each one period in which there is non-zero trading volume in the underlying market but for intervals in which futures trade. RTF_FuturesNoTrade: is the fraction of each one period in which there is non-zero trading volume in the underlying market but for intervals in which futures do not trade.

percent during the interval 14.00–15.00. Thirdly, the RTF for stocks when future trade are substantially higher compared to those when futures do not trade for all 11 stocks and for all 1 h periods. Finally, the RTF for stocks when futures do not trade also exhibit a U shaped pattern[7](see Fig. 1). The U-shaped patterns confirm the market closure theory developed by Brock and Kleidon (1992) and extended to derivatives market by Daigler (1997). In this model the liquidity demand from traders for rebalancing their portfolios before and after market closures creates larger bid-ask spreads at the open and close as well as U-shaped patterns in volume and volatility. In the extended model the market makers close their position before the market closes for the day. Arbitrageurs need to match their futures trades with trades in the underlying assets; cash market dealers often hedge their inventory with futures just before the futures market close. These activities imply that the opening and closing time for both the underlying and futures markets will have large volume and large volatility.

4. Empirical analysis

4.1. The impact of futures trading on liquidity of the underlying stock

In this section, we examine the impact of futures trading on two measures of liquidity, bid-ask spread and quoted depth. If futures trading improves market quality of the underlying asset, then we should observe both a decrease in the bid-ask spread and an increase in depth. As Lee, Mucklow, and Ready (1993) show an observed change in either the spread or the quoted depth without any associated information on the behaviour of the other parameter, is an ambiguous signal for inferring changes in liquidity. In our empirical analysis we first examine the impact of futures trading on liquidity measures by comparing the impact on the mean value of each measure of liquidity in the underlying stock when futures trade and when futures do not trade and then we proceed to do regression analysis and control for other determinants, which may affect liquidity, apart from futures trading.

4.1.1. The impact on bid-ask spreads

To examine the impact of futures trading on the underlying stock's bid-ask spread we adopt Mclnish and Wood (1992) and calculate the weighted average bid-ask spread. We first calculate for each stock the relative bid-ask spread defined as the difference between the ask and bid prices divided by the average of the bid and ask prices for every quotation in a particular time interval. We then calculate the weighted average bid-ask spread where the weight for each quotation is the number of seconds the quotation is outstanding divided by the total number of seconds for which all quotes are outstanding in that interval. We present information for intervals when futures trade and for intervals when futures do not trade. We test whether the difference in the bid-ask spread between periods in which futures trade and periods in which

[7] We present the graphs for 3 of the stocks but similar patterns are observed for all the stocks.

Table 3
The impact of futures trading on bid-ask spreads and quoted depth. To calculate the weighted spread we first calculate the relative bid-ask spread defined as the difference between the ask and bid prices divided by the average of the bid and ask prices for every quotation in a particular time interval. We then calculate the weighted average bid-ask spread where the weight for each quotation is the number of seconds the quotation is outstanding divided by the total number of seconds for which all quotes are outstanding in that interval. Quoted depth is defined as the number of shares a market maker is willing to purchase or sell at the quoted bid-ask prices.

	X: mean value when futures trade	Y: mean value when futures do not trade	X−Y	Wilcoxon signed rank test: mean of X−Y = 0	
				Value	Probability
HTO					
Weighted spread	0.177	0.180	−0.003	−6.840	0
Quoted depth	9736.49	9057.44	679.04	6.843	0
ALPHA					
Weighted spread	0.115	0.110	0.005	8.831	0
Quoted depth	2562.40	2486.47	75.93	2.826	0.005
ETE					
Weighted spread	0.112	0.109	0.003	5.774	0
Quoted depth	2801.96	2742.18	59.78	1.920	0.056
INTRK					
Weighted spread	0.500	0.516	−0.016	−10.364	0
Quoted depth	6438.47	5677.60	760.87	15.705	0
EEEK					
Weighted spread	0.233	0.205	0.028	8.043	0
Quoted depth	1675.40	1759.10	−83.70	−1.921	0.056
PPC					
Weighted spread	0.140	0.144	−0.003	−2.124	0.034
Quoted depth	3189.88	2928.06	261.82	5.869	0
EUROB					
Weighted spread	0.132	0.131	0.001	1.087	0.277
Quoted depth	2282.82	2264.89	17.92	0.5170	0.605
OPAP					
Weighted spread	0.147	0.149	−0.002	−1.621	0.106
Quoted depth	4008.93	4168.42	−159.49	−1.977	0.049
COSMO					
Weighted spread	0.183	0.187	−0.004	−1.336	0.182
Quoted depth	5356.95	4957.09	399.87	2.566	0.011
EXAE					
Weighted spread	0.335	0.340	−0.005	−1.496	0.135
Quoted depth	3760.24	3332.76	427.48	6.975	0
TPEIR					
Weighted spread	0.185	0.202	−0.0017	−9.592	0
Quoted depth	3878.22	3630.59	247.62	4.478	0

futures do not trade is statistically significant using the Wilcoxon signed rank test.

The results are reported in Table 3. In seven of the stocks there is a reduction in the spread in intervals when futures trade compared to when futures do not trade, but in two of them the difference is not statistically significant. In the rest, there is an increase in the spread, but in one of them the difference is not statistically significant. These mixed results could be due to other factors affecting the spread such as stock volatility and transaction volume. High trading volume implies greater flexibility to the market to offset inventory imbalances and therefore should result in a lower spread. A larger return variance entails higher inventory risk as well as greater potential profits for informed traders and therefore implies higher spreads.[8] Thus, we run the following log linear regression for the weighted average bid-ask spread − *ln (spot spread)* − for each stock controlling for these factors for 1-min intervals of our sample,

$$\ln(spot\ spread)_{it} = \beta_1 + \beta_2 \ln(spot\ volume)_{it} + \beta_3 \ln(spot\ volaltity)_{it} + \beta_4 (futures\ trade)_{it} + \varepsilon_{it}, \tag{1}$$

where ln (*spot volume*) is the value of trading, ln (*spot volatility*) is the squared return in the spot market and (*futures trade*) is a dummy variable, which takes the value of one for the intervals for which there is futures trading and zero otherwise. Our main interest is the value of β_4. A negative value will indicate that futures trading reduce the bid-ask spread in the spot market. Based on the earlier discussion we will expect $\beta_2 < 0$ and $\beta_3 > 0$.

[8] For a theoretical investigation into the determinants of spreads see Stoll (1978a, 2003); for empirical evidence see Mayhew, Sarin, and Shastri (1995), Kumar et al. (1998), Ranaldo (2004) and Linnainmaa and Rosu (2009).

Table 4
The impact of futures trading on bid-ask spreads after controlling for trading volume and volatility. The regression estimated is given below: $\ln(spot\ spread)_{it} = \beta_1 + \beta_2 \ln(spot\ volume)_{it} + \beta_3 \ln(spot\ volatility)_{it} + \beta_4 (futures\ trade)_{it} + \varepsilon_{it}$. (Spot spread) is the weighted average bid-ask spread. We first calculate for each stock the relative bid-ask spread defined as the difference between the ask and bid prices divided by the average of the bid and ask prices for every quotation in a particular time interval. We then calculate the weighted average bid-ask spread where the weight for each quotation is the number of seconds the quotation is outstanding divided by the total number of seconds for which all quotes are outstanding in that interval. (Spot volatility) is the squared return in the spot market; (spot volume) is the value of trading and (futures trade) is a dummy variable, which is equal to one for intervals for which there is futures trading and zero otherwise. *P*-values estimated using heteroskedasticity consistent standard errors and are given in brackets. Regression is estimated using TSLS and instruments the lagged values of independent variables.

	Intercept	Spot volume	Spot volatility	Futures trade
HTO	−0.460 (0.04)	−0.016 (0.00)	0.453 (0.00)	−0.050 (0.00)
ALPHA:	0.941 (0.00)	−0.029 (0.00)	0.552 (0.00)	−0.097 (0.00)
ETE	0.392 (0.02)	−0.028 (0.00)	0.514 (0.00)	−0.059 (0.00)
INTRK	−0.054 (0.76)	0.003 (0.72)	0.496 (0.00)	−0.037 (0.00)
EEEK[a]	1.678 (0.00)	0.0266 (0.20)	0.627 (0.00)	−0.164 (0.00)
PPC	2.315 (0.00)	−0.0317 (0.01)	0.649 (0.00)	−0.125 (0.00)
EUROB[a]	0.586 (0.00)	0.003 (0.76)	0.542 (0.00)	−0.093 (0.00)
OPAP	1.484 (0.00)	−0.054 (0.00)	0.580 (0.00)	−0.099 (0.00)
COSMO[a]	1.210 (0.01)	−0.020 (0.14)	0.579 (0.00)	−0.118 (0.00)
EXAE[a]	0.816 (0.05)	−0.017 (0.35)	0.557 (0.00)	−0.017 (0.47)
TPEIR	0.318 (0.15)	−0.017 (0.02)	0.514 (0.00)	−0.047 (0.00)

[a] When using other measures of volatility spot volume was found to be negative and statistically significant.

We performed a Hausman test to test the consistency of OLS estimates.[9] In every case we reject the hypothesis that the OLS estimates are consistent. We thus proceed to estimate the regression using Two Stage Least Squares to take into account the possible endogeneity. As Linnainmaa and Rosu (2009) say *we hypothesize that a stock has a lower bid-ask spread because it has more trading, or is the converse true and it has more trading because lower spreads invite more trading activity?* We use lagged values of the independent variables as instruments. The results are shown in Table 4. We present the results when using squared returns as a measure of volatility. It should be noted that adjusted R^2 is not valid for regressions using instrumental variable technique and thus is not presented.

All coefficients have been found to be statistically significant with very few exceptions regarding spot volume. Even in those cases, when using other measures of volatility (described in the next section) a statistically significant coefficient was found. The results show that Spot Trading Volume reduces spot spreads, spot trading volatility increases spot spreads, and futures trading reduces spot spreads.[10] These results are consistent with the argument that futures markets provide a venue for information-based trading and/or trading in futures reduces the information asymmetry associated with the underlying stock. The results were invariant to the other measures of volatility, such as absolute return, price range and number of quote revisions.

We also tested the robustness of our results using instead of a dummy variable, which takes zero one value, a dummy variable which is equal to the trading volume in the futures market for the intervals that there is futures trading and zero otherwise. This can be considered as a multi-step dummy variable. Once again the results confirmed the negative impact of futures trading on the bid-ask spread.[11]

We test in the next section whether indeed the fall in the bid-ask spread is due to a reduction of information asymmetries and a reduction in the adverse selection component.

Table 5
The impact of futures trading on adverse selection component. The adverse selection component of the spread is measured as the difference between the effective and realized spreads. The effective spread is calculated as twice the absolute value of the difference between the trade price and the mid-quote at the time of the trade. The realized spread is calculated as twice the difference between the trade price and the mid-quote prevailing T minutes after the trade, multiplied by −1 if the trade is seller-initiated. A trade is considered seller-initiated if the trade price is below the quoted midpoint. We set T equal to 30 min. All spreads are standardized by the mid-quote at the time of the trade and are expressed in percentage terms.

	X: mean value when futures trade	Y: mean value when futures do not trade	X−Y	Wilcoxon signed rank test: mean of X−Y = 0	
				Value	Probability
HTO	0.0996	0.0795	0.0201	2.2862	0.0230
ETE	0.0956	0.0661	0.0294	3.4742	0.0006
EUROB	0.0953	0.0773	0.0179	1.4922	0.1368
ALPHA	0.0976	0.0688	0.0289	3.1221	0.0020
PPC	0.0876	0.1001	−0.0124	−1.0866	0.2782
EEEK	0.1624	0.1327	0.0297	1.2616	0.2082
OPAP	0.1152	0.0906	0.0246	1.6296	0.1043
COSMO	0.0582	0.1092	−0.0511	−1.7449	0.0821
TPEIR	0.1136	0.1076	0.0060	0.3559	0.7221
INTRK	0.2490	0.2829	−0.0339	−1.6420	0.1017
EXAE	0.1792	0.1996	−0.0204	−0.8171	0.4146

4.1.2. Decomposition of the spread

We follow Huang and Stoll (1996) and Bacidore and Sofianos (2002) and calculate for each stock the adverse selection component of the spread measured as the difference between the effective and realized spreads. The effective spread is calculated as twice the absolute value of the difference between the trade price and the mid-quote at the time of the trade. More formally the effective spread at time t, $\boldsymbol{ES_t}$ is defined as

[9] To carry out the Hausman test we follow Davidson and MacKinnon (1993) and run two OLS regressions. In the first regression, we regress the spot volume on all exogenous variables and instruments and retrieve the residuals. In the second regression, we re-estimate equation (1) including the residuals from the first regression. If the OLS estimates are consistent, then the coefficient on the first stage residuals should not be significantly different from zero.

[10] The impact of trading volume and volatility on the bid-ask spread is consistent with Jegadeesh and Subrahmanyam (1993), Chordia, Roll, and Subrahmanyam (2000), Ranaldo (2004) and Linnainmaa and Rosu (2009).

[11] Results are not reported but can be made available on request.

Table 6
The impact of futures trading on adverse selection component after controlling for trading volume and volatility. $\ln(\textit{adverse selection component})_{it} = \beta_1 + \beta_2 \ln(\textit{spot volume})_{it} + \beta_3 \ln(\textit{spot volatility})_{it} + \beta_4(\textit{futures trade})_{it} + \varepsilon_{it}$. (Adverse selection component) of the spread is measured as the difference between the effective and realized spreads. The effective and realized spreads are as defined in Table 5. (Spot volatility) is the squared return in the spot market; (spot volume) is the value of trading and (futures trade) is a dummy variable, which is equal to one for intervals for which there is futures trading and zero otherwise. *P*-values estimated using heteroskedasticity consistent standard errors and are given in brackets. Regression is estimated using TSLS and instruments the lagged values of independent variables.

	Intercept	Spot volume	Spot volatility	Futures trade
HTO[a]	−3.717 (0.01)	0.091 (0.01)	0.160 (0.17)	−0.015 (0.77)
ALPHA	−1.287 (0.04)	0.067 (0.02)	0.328 (0.00)	−0.037 (0.29)
ETE	−3.128 (0.00)	0.117 (0.00)	0.221 (0.00)	−0.002 (0.94)
INTRK	−1.961 (0.00)	0.125 (0.01)	0.305 (0.00)	−0.026 (0.58)
EEEK	−7.555 (0.00)	0.084 (0.37)	−0.125 (0.29)	0.073 (0.62)
PPC	−3.945 (0.01)	−0.009 (0.85)	0.102 (0.31)	0.135 (0.04)
EUROB	−5.231 (0.00)	0.238 (0.00)	0.128 (0.02)	−0.184 (0.06)
OPAP	−4.295 (0.00)	0.140 (0.00)	0.144 (0.03)	0.054 (0.36)
COSMO[a]	−11.977 (0.03)	0.379 (0.00)	−0.312 (0.42)	0.047 (0.67)
EXAE	−2.363 (0.04)	−0.002 (0.96)	0.212 (0.02)	0.063 (0.35)
TPEIR[a]	−6.219 (0.00)	0.154 (0.00)	−0.004 (0.97)	0.048 (0.47)

[a] When using other measures of volatility spot volume was found to be negative and statistically significant.

Table 7
The impact of futures trading on quoted depth after controlling for trading volume and volatility. The regression estimated is given below: $\ln(\textit{spot quoted depth})_{it} = \beta_1 + \beta_2 \ln(\textit{spot volume})_{it} + \beta_3 \ln(\textit{spot volatility})_{it} + \beta_4(\textit{futures trade})_{iy} + \varepsilon_{it}$ The regression estimated is given below:
(Spot quoted depth) is the number of shares a market maker is willing to purchase or sell at the quoted bid-ask prices, weighted by the number of seconds the quotation is outstanding divided by the total number of seconds for which all quotes are outstanding in that interval; (Spot volatility) is the squared return in the spot market; (spot volume) is the value of trading and (futures trade) is a dummy variable, which is equal to one for intervals for which there is futures trading and zero otherwise. *P*-values estimated using heteroskedasticity consistent standard errors and are given in brackets. Regression is estimated using TSLS and as instruments the lagged values of independent variables.

	Intercept	Spot volume	Spot volatility	Futures trade
HTO	−2.208 (0.00)	0.231 (0.00)	−0.720 (0.00)	−0.001 (0.96)
ALPHA	−2.684 (0.00)	0.334 (0.00)	−0.563 (0.00)	−0.015 (0.45)
ETE	−1.591 (0.00)	0.257 (0.00)	−0.531 (0.00)	−0.041 (0.01)
INTRK	9.045 (0.00)	0.058 (0.04)	0.100 (0.01)	0.032 (0.33)
EEEK	0.667 (0.11)	0.457 (0.00)	−0.257 (0.00)	−0.244 (0.00)
PPC	−3.403 (0.00)	0.369 (0.00)	−0.622 (0.00)	−0.045 (0.18)
EUROB	0.434 (0.15)	0.310 (0.00)	−0.358 (0.00)	−0.169 (0.00)
OPAP	−1.694 (0.00)	0.320 (0.00)	−0.538 (0.00)	−0.129 (0.00)
COSMO	−5.380 (0.00)	0.329 (0.00)	−0.860 (0.00)	0.034 (0.56)
EXAE	1.971 (0.02)	0.156 (0.00)	−0.419 (0.00)	−0.101 (0.05)
TPEIR	2.172 (0.00)	0.202 (0.00)	−0.336 (0.00)	−0.080 (0.00)

$$ES_t = 2x(|P_t - M_t|) \tag{2}$$

where P_t is the trade price at time t, and M_t is the mid-quote price at time t.

The realized spread is calculated as twice the difference between the trade price and the mid-quote prevailing T minutes after the trade, multiplied by −1 if the trade is seller-initiated. A trade is considered seller-initiated if the trade price is below the quoted midpoint. More formally, the realized spread at time t, RS_t is defined as

$$RS_t = \begin{array}{ll} 2x(P_t - M_{t+T}) & \text{if buyer initiated,} \\ 2x(M_{t+T} - P_t) & \text{if seller initiated,} \end{array} \tag{3}$$

where M_{t+T} is the mid-quote price T minutes after the trade. We set T equal to 30 min.[12] All spreads are standardized by the mid-quote at the time of the trade. We calculate the adverse selection component of the spread for intervals when there is futures trading and for intervals when there is no futures trading. If futures trading contributes to a reduction in information asymmetries we should expect to find a reduction in the adverse selection component when there is futures trading.

Table 5 reports the results. The results are contrary to our expectations. We find the adverse selection component to be less when there is futures trading for only 2 of the stocks and the difference with when futures do not trade to be statistically significant only at the 10 percent level. In 5 of the stocks the adverse selection component does not change at all, and in 4 of the stocks the adverse selection component is greater when there is future trading. For example, for HTO, it is 10 percent when futures trade and 8% when futures do not trade. Similarly, for ETE, it is 9.6% when futures trade and 6.6% when futures do not trade. This is contrary to our expectations that the lower bid-ask spread when futures trade is due to lower information asymmetries. The higher adverse selection component found for some of the stocks could be the result of well diversified uninformed traders being drawn to the futures market so that the proportion of potentially informed traders in the underlying stock market increases.[13]

As with bid-ask spread we expand the analysis by controlling for other variables, which have an impact on the adverse selection component. We run equation (1) using TSLS but using the adverse selection component as our dependent variable. The results are shown in Table 6. In only one stock we find futures trading to have a statistically significant impact on the adverse selection component and that is positive. We find trading volume and volatility to have on the whole a positive impact.

Thus, the lower bid-ask spreads when futures trade found previously may be due to either lower inventory holding costs, or lower processing costs, or lower excess profits.[14] It could be that dealers provide lower depth and as a consequence take

[12] The analysis based on realised spreads calculated with a 5-min lag yields qualitatively and quantitatively similar results.

[13] See Subrahmanyam (1991).

[14] Due to the nature of the exercise we are not able to use a three way decomposition to explore all components of the spread, such as in Huang and Stoll (1997).

Table 8
The impact of futures trading on volatility. Squared Return: the square of the return in a time interval, where the return is computed as the difference between the last trade price before the interval and the last trade price in the interval; Absolute Return: the absolute return is computed similarly to squared return; Price Range: the absolute difference between the highest and the lowest price; and Number of Quote Revisions: the number of revisions to the mid-spread (midpoint between the bid and ask prices) of the specialist's quote.

	X: mean value when futures trade	Y: mean value when futures do not trade	X−Y	Wilcoxon signed rank test: mean of X−Y = 0	
				Value	Probability
HTO					
Squared return	2.12E-06	1.08E-06	1.04E-06	17.774	0
Price range	1.10E-02	5.05E-03	0.006	32.723	0
Number of quote reviews	1.87	1.30	0.568	29.665	0
Absolute return	8.34E-04	5.16E-04	3.18E-04	29.859	0
ALPHA					
Squared return	1.57E-06	6.99E-07	8.69E-07	18.261	0
Price range	1.90E-02	9.29E-03	0.009	38.157	0
Number of quote reviews	2.53	1.68	0.848	38.383	0
Absolute return	7.40E-04	4.43E-04	2.97E-04	32.451	0
ETE					
Squared return	1.46E-06	7.45E-07	7.19E-07	14.055	0
Price range	2.02E-02	1.11E-02	0.009	39.309	0
Number of quote reviews	2.57	1.78	0.790	36.648	0
Absolute return	7.36E-04	4.87E-04	2.49E-04	30.648	0
INTRK					
Squared return	9.39E-06	4.54E-06	4.85E-06	19.158	0
Price range	5.06E-03	1.72E-03	0.003	30.031	0
Number of quote reviews	1.25	0.85	0.404	37.254	0
Absolute return	1.56E-03	8.38E-04	7.18E-04	26.534	0
EEEK					
Squared return	3.97E-06	8.64E-07	3.11E-06	13.052	0
Price range	1.35E-02	3.05E-03	0.010	23.695	0
Number of quote reviews	1.98	0.96	1.017	30.177	0
Absolute return	9.54E-04	3.23E-04	6.32E-04	23.646	0
PPC					
Squared return	1.76E-06	6.65E-07	1.09E-06	10.710	0
Price range	1.31E-02	4.64E-03	0.008	25.405	0
Number of quote reviews	2.09	1.27	0.820	31.529	0
Absolute return	7.00E-04	3.54E-04	3.46E-04	22.581	0
EUROB					
Squared return	1.98E-06	8.43E-07	1.14E-06	11.422	0
Price range	1.63E-02	6.90E-03	0.009	27.951	0
Number of quote reviews	2.12	1.35	0.769	34.450	0
Absolute return	7.71E-04	4.44E-04	3.27E-04	21.885	0
OPAP					
Squared return	2.33E-06	8.58E-07	1.47E-06	11.303	0
Price range	1.69E-02	5.68E-03	0.011	28.938	0
Number of quote reviews	2.53	1.42	1.114	33.285	0
Absolute return	8.34E-04	4.26E-04	4.08E-04	25.373	0
COSMO					
Squared return	2.82E-06	9.27E-07	1.89E-06	5.357	0
Price range	1.07E-02	2.92E-03	0.007	15.123	0
Number of quote reviews	1.93	1.07	0.854	18.665	0
Absolute return	8.49E-04	3.70E-04	4.79E-04	13.244	0
EXAE					
Squared return	5.02E-06	1.53E-06	3.50E-06	12.553	0
Price range	5.65E-03	1.32E-03	0.004	18.161	0
Number of quote reviews	1.25	0.72	0.529	22.050	0
Absolute Return	1.10E-03	4.30E-04	6.71E-04	20.060	0
TPEIR					
Squared return	2.52E-06	1.27E-06	1.25E-06	11.339	0
Price range	1.28E-02	5.28E-03	0.007	28.701	0
Number of quote reviews	1.96	1.23	0.736	28.993	0
Absolute return	9.23E-04	5.43E-04	3.80E-04	20.77604	0

lower inventory risk. We explore in the next section the impact of futures trading on quoted depth.

4.1.3. Impact on quoted depth

According to Lee et al. (1993) bid-ask spread and quoted depth jointly describe market liquidity and increases in depth are associated with improvements in liquidity. Depth is defined as the number of shares a market maker is willing to purchase or sell at the quoted bid-ask prices. We calculate the weighted average depth using the same technique as that used for the estimation of weighted bid-ask spreads. We present information for intervals when futures trade and for intervals when futures do not trade.

Results show that quoted depth is statistically significantly higher in intervals when futures trade in 8 of the 11 stocks (see Table 3). In one of the other cases no difference was found and in the other two there was a fall in the quoted depth, which was marginally significant. We then check the robustness of our results by running the same regression as for bid-ask spreads and controlling for spot trading volume and spot trading volatility and including a dummy variable (futures trade), which takes the value of one for the intervals for which there is futures trading and zero otherwise.

$$\ln(\textit{quoted depth})_{it} = \beta_1 + \beta_2 \ln(\textit{spot volume})_{it} + \beta_3 \ln(\textit{spot volatility})_{it} + \beta_4 (\textit{futures trade})_{it} + \varepsilon_{it} \quad (4)$$

Our main interest is the value of β_4. A positive value will indicate that futures trading increase quoted depth in the spot market. Based on our earlier discussion we will expect $\beta_2 > 0$ and $\beta_3 < 0$.

Results are presented in Table 7. All coefficients have been found to be statistically significant. Spot Trading Volume increases depth and spot trading volatility reduces depth. Surprisingly, we find futures trading not to have an impact on quoted depth in half the cases and in the other half to have a negative impact. That is futures trading reduces depth when it has an effect. Dealers provide lower depth and as a consequence take lower inventory risk. Thus, our results provide support for the conjecture that lower bid-ask spreads during futures trading are due to lower inventory holding costs and are not an indicator of an improvement in liquidity.

4.2. Impact of futures trading on the volatility of the underlying stock

In this section, we explore the impact of futures trading on the volatility of the underlying stock. It is not clear whether the impact should be positive or negative. One argument supports the view that futures trading raises volatility through the provision of low-cost speculation opportunities (see e.g. Harris, 1989; Stein, 1989). On the other hand, the introduction of futures results in a decrease in volatility. Futures trading may lead to more complete markets, which enhances information flows and improves investment choices facing investors. Futures contracts allow for new positions and expanded investment sets, or enable existing positions to be taken at lower costs. Futures trading may bring more information to the market and allow for quicker dissemination of information. In addition, futures contracts facilitate hedging so that less reliance is placed on spot hedging strategies. The transfer of speculative activity from the spot to the futures market may also dampen spot market volatility.[15] Empirically the earlier evidence is also mixed.[16] However, Kumar et al. (1998) and Shastri et al. (2008) confirm a decrease in volatility.

In our paper we use four measures of volatility as in Lee, Ready, and Seguin (1994). These measures are described below:

(i) Squared Return: the square of the return in a time interval, where the return is computed as the difference between the last trade price before the interval and the last trade price in the interval.
(ii) Absolute Return: the absolute return is the absolute value of the return computed similarly to (i).
(iii) Price Range: the absolute difference between the highest and the lowest price.
(iv) Number of Quote Revisions: the number of revisions to the mid-spread (midpoint between the bid and ask prices) of the specialist's quote.

We estimate these measures for periods in which futures trade and for periods in which futures do not trade. The results

Table 9
The impact of futures trading on volatility controlling for trading volume. The equation estimated is $\ln(\textit{spot volatility})_{it} = c_1 + c_2\ln(\textit{spot volume})_{it} + c_2(\textit{futures trade})_{it} + \varepsilon_{it}$.
Spot volatility is squared return and futures trade is equal to one for intervals for which there is futures trading and zero otherwise. *P*-values estimated using heteroskedasticity consistent standard errors are given in brackets. The regression is estimated using TSLS and instruments the lagged values of independent variables.

Spot volatility	Intercept	Spot volume	Futures trade
HTO	−13.641 (0.00)	0.125 (0.00)	0.064 (0.00)
ALPHA	−14.101 (0.00)	0.050 (0.00)	0.291 (0.00)
ETE	−14.487 (0.00)	0.108 (0.00)	0.177 (0.00)
INTRK[a]	−11.156 (0.00)	0.064 (0.00)	0.025 (0.17)
EEEK	−14.180 (0.00)	0.151 (0.00)	0.417 (0.00)
PPC	−14.442 (0.00)	0.135 (0.00)	0.168 (0.00)
EUROB	−13.890 (0.00)	0.063 (0.00)	0.169 (0.00)
OPAP	−14.670 (0.00)	0.195 (0.00)	0.110 (0.00)
COSMO	−13.684 (0.00)	0.119 (0.00)	0.164 (0.00)
EXAE	−11.874 (0.00)	0.032 (0.00)	0.115 (0.00)
TPEIR[a]	−13.103 (0.00)	0.062 (0.00)	0.021 (0.29)

[a] It should be noted that futures trade is statistically significant when using other measures of volatility.

[15] See Damodaran and Subrahmanyam (1992) for a detailed discussion of the arguments.
[16] See McKenzie, Brailsford, and Faff (2001) and Sutcliffe (2006) for a review.

Table 10
Impact of futures trading on the transaction volume, transaction frequency and transaction size on the underlying stock. Transaction volume (shares): number of shares traded during one interval; Transaction volume (value): value of shares traded during one interval; transaction frequency: number of trades during one interval; transaction size (value): value of shares per trade during one interval; transaction size (shares): number of shares per trade during one interval.

	X: mean value when futures trade	Y: mean value when futures do not trade	X−Y	Wilcoxon signed rank test: mean of X−Y = 0	
				Value	Probability
HTO					
Transaction volume (value)	79,915.19	31,731.57	48,183.63	36.858	0
Transaction volume (shares)	6444	2542	3901	35.772	0
Transaction frequency	7.39	3.22	4.17	45.937	0
Transaction size (value)	7950.23	5672.77	2277.46	22.816	0
Transaction size (shares)	630.87	454.35	176.52	23.431	0
ALPHA					
Transaction volume (value)	76,392.52	34,655.34	41,737.17	37.337	0
Transaction volume (shares)	3193	1440	1752	36.355	0
Transaction frequency	8.04	3.82	4.22	42.062	0
Transaction size (value)	7752.66	6124.81	1627.85	21.327	0
Transaction size (shares)	323.21	256.23	66.98	21.050	0
ETE					
Transaction volume (value)	84,259.75	40,922.23	43,337.52	32.889	0
Transaction volume (shares)	3494	1714	1779	33.076	0
Transaction frequency	8.95	4.66	4.28	44.464	0
Transaction size (value)	7757.75	6164.89	1592.85	20.439	0
Transaction size (shares)	324.45	261.73	62.72	20.211	0
INTRK					
Transaction volume (value)	10,969.98	3572.68	7397.29	26.739	0
Transaction volume (shares)	2500	838	1661	26.148	0
Transaction frequency	3.50	1.40	2.10	34.726	0
Transaction size (value)	1785.01	1026.14	758.86	31.741	0
Transaction size (shares)	411.11	244.06	167.05	29.940	0
EEEK					
Transaction volume (value)	32,215.30	10,391.93	21,823.36	19.400	0
Transaction volume (shares)	1647	531	1116.12	19.557	0
Transaction frequency	3.55	1.21	2.34	27.258	0
Transaction size (value)	5374.81	3073.46	2301.35	19.033	0
Transaction size (shares)	275.29	156.96	118.32	19.189	0
PPC					
Transaction volume (value)	59,138.10	23,205.85	35,932.25	23.590	0
Transaction volume (shares)	2852	1118	1734	23.416	0
Transaction frequency	5.73	2.26	3.47	31.979	0
Transaction size (value)	7436.32	5158.65	2277.67	16.012	0
Transaction size (shares)	358.30	248.94	109.35	15.802	0
EUROB					
Transaction volume (value)	52,467.15	21,439.03	31,028.12	24.567	0
Transaction volume (shares)	2325	1003	1322	23.696	0
Transaction frequency	5.88	2.72	3.15	33.152	0
Transaction size (value)	6543.43	4505.15	2038.28	20.460	0
Transaction size (shares)	292.57	213.68	78.88	17.350	0
OPAP					
Transaction volume (value)	86,410.92	31,410.01	55,000.90	23.937	0
Transaction volume (shares)	4479	1708	2770	23.144	0
Transaction frequency	7.22	2.83	4.39	34.757	0
Transaction size (value)	8723.42	5928.79	2794.63	19.033	0
Transaction size (shares)	453.24	328.56	124.68	16.532	0
COSMO					
Transaction volume (value)	52,263.50	18,414.58	33,848.92	15.278	0
Transaction volume (shares)	3701	1310	2391	15.265	0
Transaction frequency	5.62	1.89	3.73	19.282	0
Transaction size (value)	6548.01	4143.03	2404.97	12.977	0
Transaction size (shares)	463.39	294.94	168.44	12.774	0
EXAE					
Transaction volume (value)	12,763.13	4064.88	8698.24	16.561	0
Transaction volume (shares)	1658	548	1110	16.696	0
Transaction frequency	3.04	1.05	1.98	21.198	0

(*continued on next page*)

Table 10 (*continued*)

	X: mean value when futures trade	Y: mean value when futures do not trade	X−Y	Wilcoxon signed rank test: mean of X−Y = 0	
				Value	Probability
Transaction size (value)	2393.36	1255.06	1138.29	13.613	0
Transaction size (shares)	315.26	169.90	145.36	12.077	0
TPEIR					
Transaction volume (value)	46,687.12	16,035.01	30,652.11	26.268	0
Transaction volume (shares)	3489	1255	2234	25.503	0
Transaction frequency	6.87	2.75	4.12	33.348	0
Transaction size (value)	4918.27	3040.03	1878.24	23.621	0
Transaction size (shares)	369.88	244.08	125.80	20.552	0

are presented in Table 8. As it can be seen the periods in which futures trade are associated with significantly higher stock volatility irrespective of the measure used. The difference in volatility between the periods in which futures trade and periods in which futures do not trade is statistically significant as shown by the Wilcoxon signed rank test.

However, periods of high volatility are also associated with high trading volume. Thus, the observed increase in stock volatility may be the consequence of higher trading volume in the underlying stock market. We run then a regression of spot volatility on spot trading volume and include a dummy variable, (futures trade), as in the previous exercises, which takes the value of one for the intervals for which there is futures trading and zero otherwise. We thus, test whether volatility increases when there is futures trading when controlling for the impact of trading volume. The log linear regression is given below:

$$\ln(\textit{spot volatility})_{it} = c_1 + c_2 \ln(\textit{spot volume})_{it} + c_3(\textit{futures trade})_{it} + \varepsilon_{it} \quad (5)$$

The exercise has been performed for all measures of volatility but we present results only for the measure of squared return as the results are invariant. We estimate the regression using Two Stage Least Squares since the Hausman test rejected the hypothesis that the OLS estimates are consistent. We use lagged values of the independent variables as instruments. The results are presented in Table 9.

All coefficients are statistically significant. Spot trading volume exerts a positive impact on stock trading volatility. However, we find for all measures of stock trading volatility that futures trading has also a positive impact on stock trading volatility. Thus, futures trading increases volatility of the underlying market at the margin. Our result supports the view that futures trading might be destabilising the market through the provision of low cost speculation and increasing information asymmetry in the underlying stock.

As in the previous analysis for other measures of market quality we tested the robustness of our results using instead of a dummy variable, which takes zero one value, a dummy variable which is equal to the trading volume in the futures market for the intervals that there is futures trading and zero otherwise. Once again the results confirmed the positive impact of futures trading on volatility. This increase in volatility could be the result of institutional investors taking large positions in both the derivative and the underlying markets, increasing trading volume and creating price pressures in the underlying security. In the next section, we examine whether in fact futures trading increases trading volume in the underlying security.

4.3. Impact of futures trading on transaction volume, transaction frequency and transaction size for the underlying stock

We have argued earlier that futures trading can provide additional information about the underlying security. This suggests that trading activity in the futures market should have an impact on the order flow in the underlying security. We calculate for each stock separately the mean value of each measure of order flow (transaction volume, transaction frequency, transaction size) across all intervals in which futures trade and for intervals for which futures do not trade.

The results are presented in Table 10. As in the previous exercises we report values for each order flow measure when futures trade (column 2) and when futures do not trade (column 3). In column 4 we report the difference between these values and in the last two columns we test the statistical significance of the difference using the Wilcoxon signed rank test.

The following comments can be made. For all the stocks trading volume in the underlying stock in terms of both value and shares is significantly higher when there is futures trading. The difference is statistically significant, with a very low p-value for a t-test (Wilcoxon signed rank test). This increase in transaction volume is driven by increases in both transaction frequency and transaction size. These conclusions are not only valid for average values over the whole period, but for the whole trading day as shown in Fig. 2 for one of the stocks (HTO). The rest of the stocks have the same results. It is

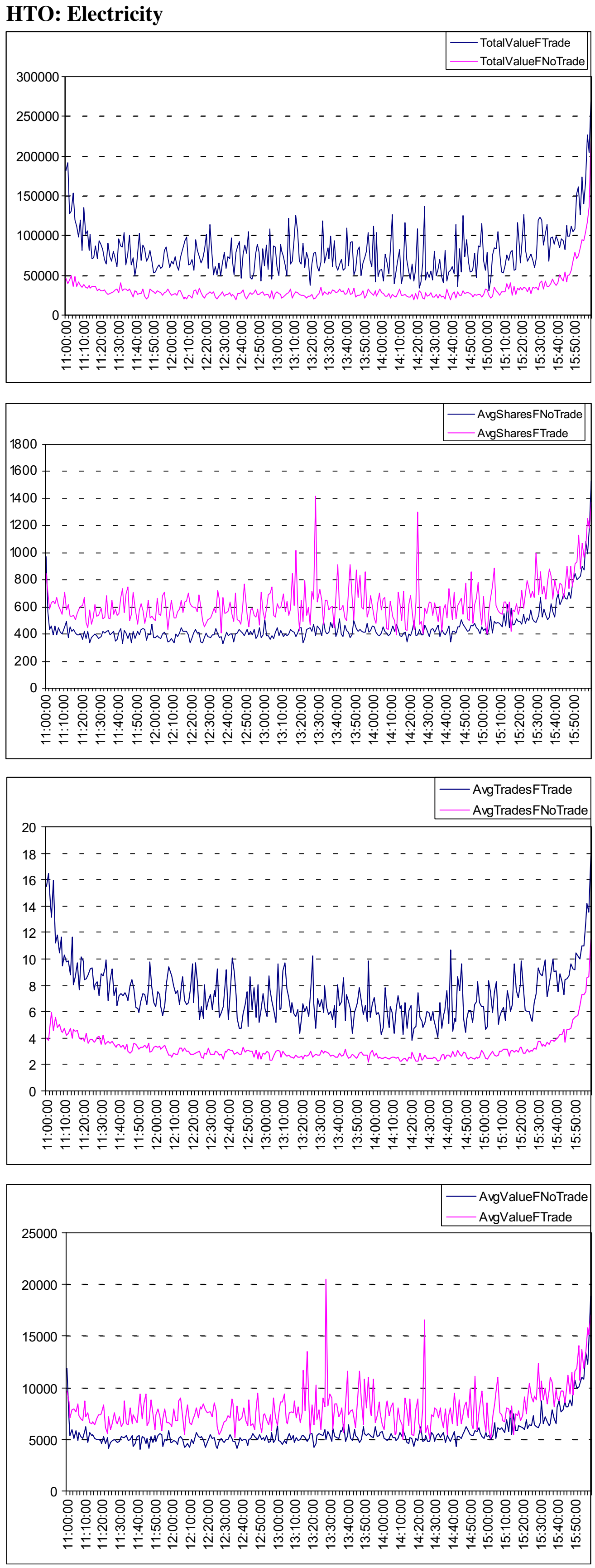

Fig. 2. Impact of futures trading on the transaction volume, transaction frequency and transaction size on the underlying stock.

interesting to note that each measure follows a U shaped pattern.[17]

5. Conclusion

In this paper, we explored the impact of futures trading on the underlying stock by contacting an experiment of comparing market quality for intervals when futures trade with intervals when futures do not trade using high frequency proprietary data at the single stock level. Our results show that although the bid-ask spreads decrease, this is not due to a fall in information asymmetries. We find that the adverse selection component of the bid-ask spread does not decrease when futures trade. We find supporting evidence that the fall in the spread could be due to lower inventory holding costs as a result of lower depth when futures trade.

We also find volatility to increase when futures trade. This could be the result of institutional investors taking large positions in both the derivative and the underlying markets, increasing trading volume and creating price pressures on the underlying security. Indeed, we find an increase in trading volume when futures trade supporting this scenario. Anecdotal evidence has also provided further support for our conjecture that institutional and private investors take large positions. At the same time, market makers not wanting to carry the risk of the open positions, possibly because they are undercapitalised, hedge their position right away creating price pressures, increasing volatility and adding trading volume in the cash market.

In summary, our study of futures trading at the single stock level using high frequency data and comparing the behaviour of the underlying stock during intervals when there is futures trading with intervals when there is no futures trading does not corroborate the results found by earlier studies, which have concentrated on lower frequency data and applied a pre-post futures trading investigation. This paper has indicated that market volatility in the cash market did not decrease as a result of the operations of the futures market. This has policy implications for financial market regulators and raises the question of whether further regulations on derivatives, such as higher margins, are desirable.

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[17] Results using median values are qualitatively similar (can be made available by the authors).

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