# Block Trades in Options Markets

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## Abstract

This paper documents the evolution of block trading in the crude oil options market, following the reduction of the minimum permissible block size threshold in October 2012. Block trading, that was sparse prior to this change, currently accounts for over 30% of the trading volume in WTI crude oil options, a large portion of which involves option trading strategies. We compare the execution costs of large/block orders across trading venues before and after the October 2012 regulatory change, in order to gain a better understanding of the factors behind the recent increase in block trading. We find that the upstairs market attracts orders with lower information content. However, compared to large trades in the downstairs market, block trades face higher total execution costs, which potentially serve as compensation for the high search and negotiation costs surrounding the execution of option trading strategies.

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## Block Trades in Options Markets

### I. Introduction

When the Dodd Frank swap rules were introduced in October 2012, energy traders, who have been trading swaps for decades, diverted their order flow to the futures market[1]. This switch was facilitated by both the Intercontinental Exchange (ICE) and the Chicago Mercantile Exchange: they introduced new futures contracts similar to existing swaps and reduced the minimum block threshold for many futures and options. The reduction of the minimum block threshold became effective on October 15th 2012, in an attempt to retain the order flow associated with the execution of Exchange for Related Positions (EFRPs)[2], a type of privately negotiated transactions also affected by the new swap rules[3]. However, while the reduction in block sizes has been associated with the so-called futurization phenomenon, what might been missed in the popular press is that the fact that block trading might also have had an impact on the energy options market structure, as market participants with relatively small order sizes gained access to block trading.

The reduction in the block trade threshold was intended to preserve market participants' ability to engage in non-competitive, privately negotiated transactions. Block trades, which are likewise privately negotiated transactions executed away from the public auction market, are subject to minimum transaction size requirements and have been traditionally used by market participants to execute large orders for which the centralized ("downstairs") market might be unable to provide sufficient liquidity without commanding a significant liquidity premium. Similar to EFRPs, block trades are routed to the "upstairs market", an off-exchange network of broker/dealers and large institutional investors, who negotiate transactions privately primarily over the phone. Table 1 presents the reduction in the block sizes for major CME energy contracts. Noticeably, the minimum permissible block trade threshold for WTI crude oil options dropped from a thousand to a hundred contracts. This dramatic reduction could potentially allow market participants to divert order flow from the floor and/or the electronic order book to the upstairs market, potentially raising concerns over reduced market transparency and liquidity. To wit, Hranaiova, Haigh & Overdahl (2004)

[1] Philips, M., (2013, January 24). Traders take their swaps trades to futures exchanges. *Bloomberg Business.* Retrieved from http://www.bloomberg.com/news/articles/2013-01-24/traders-take-their-swaps-deals-to-futures-exchanges.

[2] Exchange for Related Positions refer to privately negotiated transactions, executed over the counter, which consist of two positions: a transaction in the organized exchange and a corresponding related OTC position, i.e. cash, OTC swap and OTC derivative. These are exchange transactions for bona fide business.

[3] The OTC leg of the transaction would subject market participants to CFTC swap regulation, while transitory exchange for related positions are prohibited based on rule 538.

report that many market participants a decade ago viewed block trades as order flow diverted from the floor. On the contrary, advocates of block trading argue that such trading does not necessarily take business away from the centralized market, but instead can increase liquidity as participants entering the market using block trades might subsequently trade in the centralized market to either hedge or offset their positions.

The objective of the present paper is to assess how the reduction in the minimum threshold for block trades may have affected liquidity and overall market quality. We focus on WTI options contracts, for which the minimum block order threshold was reduced from thousand to hundred contracts. Block trading in WTI crude oil options, which was very limited before October 2012, increased substantially thereafter, currently representing about 30% of the total volume. The increase in block trading volume could reflect solely the transition of EFRPs to blocks. However, it is also possible, that the lower minimum block thresholds have attracted additional order flow to the upstairs market; such order flow might have otherwise never have reached the market, but it might also represent trades that would otherwise have been directed in the electronic market and/or the pit. In this context, we investigate whether block trading is more popular for relatively less liquid orders, such as option trading strategies, and if so, whether block trading allows market participants to achieve lower execution costs compared to those offered in the electronic market and the pit. Interestingly, the execution difficulty associated with the complexity of option trading strategies is also commonly considered the primary reason for the slow transition of options trading from the pit to the electronic market, which supports the claims on the importance of human intermediation in reducing search costs and raises concerns over the potential migration of order flow from the floor to the less transparent block trading.

Our work provides empirical evidence on block trading in derivatives markets, complementing the existing academic literature on block trading, which focuses predominantly on the equity market. Glosten (1994) highlights the advantages of pooling liquidity, and predicts that the upstairs market could not survive. However, Seppi (1990) suggests that a separating equilibrium could arise where uninformed traders prefer the upstairs market and enjoy lower execution costs by certifying that they are uninformed and implicitly committing not to trade right after the block. Moreover, Grossman (1992) asserts that upstairs brokers are able to offer lower execution costs by tapping into unexpressed liquidity. Madhavan & Cheng (1997) examine empirically execution costs for large equity trades; while they document lower execution costs for large trades executed in the upstairs markets, they find this difference to be economically small. They find upstairs trades to have only a temporary impact on prices, indicating that they are primarily liquidity motivated, which supports the Seppi's (1990) theoretical prediction. Similar results are presented in Smith, Turnbull & White (2001), who study block trades in the Toronto Exchange and in Rose (2014) in the Australian Stock Exchange. According to Keim & Madhavan (1996), the temporary impact of a block trade

is positively related to the order size, the cost of locating counterparties, the degree of risk aversion and the variance of the risky asset's return. Fong, Madhavan & Swan (2004) compare the upstairs market, a crossing network and the downstairs electronic order book in the Australian Stock Exchange and find evidence against the filtering/certification hypothesis. Their results suggest that upstairs markets have no harmful effect on downstairs markets, as the permanent impact for large trades does not appear to be higher in the upstairs market. These authors highlight the search role of dealers in the upstairs market and argue that both markets can coexist as they offer various complementary ways to search for counterparties. The literature has also documented the asymmetry in the price impact following block trades: the price impact appears to be temporary when one examines aggressive sell trades but permanent for aggressive buy trades (Kraus & Stoll, 1972, Anderson, Cooper & Prevost, 2006).

Our study relates to Hranaiova, J. *et al.* (2004), who are the first to study block trades in the derivatives market. They focus on block trades on FTSE 100 index futures and options on futures on the three month Euribor contract, both trading on the Euronext – London International Financial Futures Exchange (LIFFE). They note that the use of block trades in futures and options is very different from equity markets and should be studied with a different light. Interestingly, they do not find block trading to increase with volatility, which is when one would expect human intermediation to result in lower execution costs. Futures block trades, which account for 10% of the volume, concentrate on rollover hedging strategies. Options block trades account for 40% of the volume in their sample and comprise primarily of speculative trading strategies. Their study concentrates primarily on FTSE 100 futures, where they do not find an increase in volume after the execution of block trades. Moreover, block trade prices appear to be very close to prices in the centralized markets. These findings indicate that the order flow in the upstairs market is two sided and robust and block trades do not result in a significant market impact. Therefore, consistent to the literature in the equity market, they find block trades on FTSE 100 futures to be liquidity driven. Our study focuses on the crude oil options market and is the first study to investigate the dynamics of block trading in the options market and evaluate the possible effects on liquidity and price discovery in the corresponding downstairs market. We explore the reasons behind block trading and we use the specific event of the reduction in the permissible block size to gain a better understanding of the options market structure.

The rest of this paper is organized as follows. Section II discusses block trading rules for WTI crude oil futures and options, while section III describes the data. Section IV presents the estimation methodology for execution cost measures. Section V presents the execution costs of large/block trades across trading venues. Section VI concludes the paper.

## II. The upstairs market (EFRPs and Block trades) in the futures and options markets

In derivatives markets the upstairs market handles privately negotiated transactions, which include exchange for related positions and block trades. Both types of transactions are executed away from the centralized market place and must be reported to the exchange within a certain time frame. However, only block trades have a minimum quantity threshold.

### Exchange for related positions

An Exchange for related position (EFRP) transaction allows futures contracts to be exchanged with an economically offsetting position in a related cash commodity or OTC derivative position. They include exchange for physical or cash commodities (EFP), exchange for swap (EFS), an exchange of over the counter options for exchange traded options (EOO) or an exchange for risk (EFR).

EFRPs were developed to allow flexibility for commercial users to make or take delivery outside of the standardized exchange delivery system. Their use had increased remarkably the past few decades (Dunsky, 2014). Their proliferation intensified in the early 2000s, when NYMEX started allowing the clearing of energy OTC swaps through EFS or EOO transactions, which would become exchange traded futures and options EFRPs were often used to allow transactions in illiquid or newly launched products until liquidity had become sufficient. However, with the implementation of the Dodd Frank Act, the swap leg of the EFRP would be subject to various new regulations. Moreover, transitory EFRPs and EOOs were prohibited in 2014 for all CME products. [4]

### Block Trades

In derivatives markets, block trades are large privately negotiated transactions between eligible market participants[5] that are executed away from the public auction market[6]. While market participants may use

[4] "Transitory EFRPs are EFRPs in which the execution of an EFRP is contingent upon the execution of another EFRP or related position transaction between the parties and where the transactions result in the offset of the related positions without the incurrence of market risk that is material in the context of the related position transactions". CME Group, June 27 2014, Market Regulation Advisory Notice RA1311-5RR, Retrieved from http://www.cmegroup.com/rulebook/files/ra1311-5rr-rule538.pdf

[5] Eligible participants for block trades generally include exchange members and member firms, broker/dealers, government entities, pension funds, commodity pools, corporations, investment companies, insurance companies, depository institutions and high net worth individuals.

[6] http://www.cmegroup.com/clearing/trading-practices/block-trades.html

communication technologies to bilaterally request block quotes, the actual execution of block trades has to be completed through human intermediation, because electronic matching is not allowed.

Block trades must meet some minimum quantity thresholds. The latter were revised downwards in October 2012, as discussed further below, in order to allow block trades to replace exchange for related positions (EFRPs), which were practically banned at around the same time (Dusnky, 2014). The newly set minimum threshold was determined by exchanges based on volume, transaction and order information and market participants' input in 2011. Commodity trading advisors are allowed to pool smaller customer orders in order to place a consolidated block order that meets the threshold for a particular contract, but the customer must have specified that he or she wishes to have it executed it as a block.

Block trades may be executed at any time during the day and must be transacted at prices that are "fair and reasonable" depending on the size of the order, the prices in other relevant markets, the circumstances of the markets and the market participants. However, contrary to the equity market, there is no explicit requirement for CME block trades to be executed at a price that falls within the contemporaneous bid - ask spread in the centralized market. Also, the trade price has to be consistent with the minimum tick increment for the market in question and every outright transaction or leg of any block eligible spread or combination trade must be executed at a single price[7].

Block trades must be reported to exchange within a certain timeframe after their execution, typically within five and fifteen minutes depending on the product. In a brokered transaction the reporting obligation is the broker's responsibility whereas in other cases it is the responsibility of the seller unless otherwise agreed to by the participants involved in the trade.

Block trade information is disseminated to the market, but prices are published separately from transactions in the regular market. Block trade information is also reported on the futures exchanges' website and displayed on the trading floor, where such floor exists. Market participants involved in the solicitation or negotiation of block trades must keep the related information confidential. Although anticipatory hedging is not allowed[8], parties in a block trade are allowed to hedge or offset the risk associated with the block trade during the period preceding to the public reporting of the block trade.

[7] CME Group, November 8 2013, Market Regulation Advisory Notice, Rule 526, Retrieved from https://www.cmegroup.com/rulebook/files/cme-cbot-ra1313-3-block-trades.pdf

[8] CME Group, November 8 2013, Market Regulation Advisory Notice, Rule 526, Retrieved from https://www.cmegroup.com/rulebook/files/cme-cbot-ra1313-3-block-trades.pdf

**The upstairs market for WTI Crude Oil derivatives**

On October 15th 2012, the minimum quantity threshold for WTI crude oil futures blocks was reduced from hundred to fifty contracts, while the minimum quantity threshold for WTI crude oil option outrights was reduced from thousand to hundred contracts. For all intra-commodity WTI futures or option spreads and combinations, the sum of the quantities of the legs of the transaction must meet the minimum block quantity threshold. For all inter-commodity futures or option spreads and combinations the sum of the quantities of the legs of the transaction must meet the larger of the threshold requirements for the individual contracts involved. Finally for spread trades involving both futures and options, the options component of the spread must meet the minimum quantity threshold for the outright option or option combination while the quantity of futures executed must be consistent with the delta of the options component of the spread.

The reporting timeframe for WTI crude oil futures is five minutes and for WTI crude oil options is fifteen minutes. If a block trade involves a spread or combination where at least one leg of the transaction falls in the fifteen minute requirement, the whole trade should be reported within that fifteen minute requirement. Like other NYMEX products, WTI futures and options can be reported to the exchange through CME Clearport, CME Direct and the floor.

## III. Data

In this study, we use the specific event of the reduction in the minimum permissible block size in WTI crude oil options, which occurred in response to the introduction of the Dodd Frank swap rules, to reveal the attractive features of block trading in the options market, while gaining a better understanding of the options market structure.

*Sample selection.* The dataset includes trade data on WTI crude oil options during the time period extending from January 1st 2012 to December 31st 2014. The dataset, constructed using the TSS database of the U.S. Commodity Futures Trading Commission (CFTC), includes the order id (CTR card order number for pit and block trades and EFRPs), which allows us to group executed trades belonging in the same order. Therefore, we can estimate the execution costs associated with all filled orders, even those having resulted in multiple trades; a common phenomenon for electronic orders. It also includes detailed transaction information, including the customer accounts and the traders involved in every leg of the trade, the trade prices and quantities, and whether the particular trade was part of an option trading strategy.

*Definition of large orders.* We focus most of our analysis on large orders that could have potentially been executed at any of the available trading venues: the trading floor, the electronic platform and off-exchange trades (blocks and EFRPs). Therefore, we define "large orders" as those orders that are either filled as blocks or are large enough to meet the post October 2012 minimum size criterion of one hundred contracts for trading as blocks even though they are in practice executed in the pit or on the electronic market. Our definition is arguably conservative as we do not take into account unexecuted orders. Moreover, if a trader places multiple orders to fulfill a single large order, the original order could escape our definition of a large order or its size might be underestimated. Even with these limitations, large orders comprise about 65% of the daily trading volume during our sample period before October 15th 2012, the day when the minimum threshold for block trades was reduced from a thousand to a hundred contracts. They comprise about 59% of the daily trading volume during our sample period following October 15th 2012. Each order often contains more than one contract (i.e. they are part of option trading strategies). As the dataset contains information that allows us to distinguish outright trades from those trades that were part of an option trading strategy, We also separate orders by contract and examine the differences in the execution of large outright and spread orders.

*Trade initiation.* In order to estimate execution costs, we need to determine if each trade is buyer or seller initiated. Our dataset provides an "aggressor" indicator for all electronic trades. In contrast, we do not have the same information for trades executed either in the pits or in the upstairs market. Since we only have access to trade data, we estimate trade initiation using the tick test, where the benchmark or reference price is the last electronic trade. When the previous electronic trade is at the same price as the volume weighted average price of the executed portion of the order (which we consider as the price of the order), our benchmark is the trade before the previous trade. If the price of the latter trade is also equal to the price of the original trade, we use the trade before that one. Beyond this point, if the prices of three consecutive trades are constant, we exclude the order.[9]

*Order initiation.* Our data set contains large orders, which are on opposite sides of the same trade. We focus just on the "aggressive" (i.e. liquidity demanding) side of each trade. We find that pit and upstairs trades typically involve a relatively limited number of trading counterparties for each large order[10]. Moreover, in most cases both sides of the trade are large orders. In order to avoid double counting, we keep the order on

[9] For electronic trades we provide results using the aggressor indicator using both the tick test and the actual aggressor indicator for robustness. We use the aggressor indicator based on the tick test to compare execution costs across venues, with the rational that the implicit bias affecting the estimation of execution costs is similar across at various trading venues. The tick test trade initiator coincides with the aggressor indicator for 60% of all the large aggressive electronic orders and 77% of the large aggressive electronic outrights.

[10] Most frequently there is just one trading counterparty for each large order.

the side of the trade with the largest executed quantity and we consider it a buyer (seller) initiated order if the executed price is higher (lower) than the last electronic trade in the specific option contract. However, disentangling the aggressive side of large electronic trades can be more challenging, as a large order can often be executed against many other smaller orders or against a fraction of other large electronic orders or even a combination of the two. Moreover, we observe passive electronic orders, which are resting on the limit order book and are eventually executed. In identifying the aggressive side of each large electronic trade, we keep those orders with at least fifty percent of the executed quantity designated as aggressive. When both sides of an order are deemed aggressive based on the fifty percent criterion, we keep the order with the largest executed quantity. While we focus on aggressive orders, we also report execution costs on electronic passive large orders, which we identify in a similar way.[11]

*Reporting time.* Trades executed in the pit or on the electronic markets are reported in real time to market participants. This is not the case for upstairs trades. Block trades in WTI crude oil options have to be reported within fifteen minutes. While our dataset includes the execution time for all trades, reporting times are not available. (i) After November 2013, our dataset contains the clearing time, which coincides with the reporting time for blocks entered in Globex. For these orders, we use the clearing time as reporting time. For all other block trades, we assume that the reporting time is equal to the maximum fifteen minutes after the reported execution time. (ii) EFRPs have to be reported for clearing within one hour of the transaction time when the transaction occurs between 7am and 4:45pm. EFRPs taking place outside of this window have to be reported the next day before 8 am. We estimate execution costs only for exchange for related position transactions that take place between 7am and 4:45pm, which constitute 98% of the sample. We estimate our price impact measures for exchange for related positions by adding the maximum one hour to the recorded transaction time.

## IV. Descriptive statistics: Trading activity in upstairs and downstairs markets

Figure 1 presents the share in the total volume in WTI crude oil options for EFRPs and blocks trades during our sample. EFRP and block trading volumes are reported in separate graphs. We also examine option outrights and option trading strategies ("spreads") separately in two additional graphs. Exchange for related positions, which account for about twenty percent of the daily trading volume in option outrights and option trading strategies at the beginning of our sample decline rapidly after the rule change and finally become virtually extinct. At the same time, trading volume in block trades, which was negligible, increased after

[11] Large electronic orders are considered passive when at least half of the order is passive. If both sides of the trade are designated as passive we only keep the order with the larger executed quantity.

the rule change. Block trading in outright options increases sharply right after the October 15th, 2012 rule change, but subsequently declines steadily to levels close to ten percent of the total daily volume. The increase in block trading is especially notable for option trading strategies, a type of trade that generally accounts for about forty percent of the total daily volume in crude oil options. These patterns together suggest that the order flow increase in block trades may not be solely attributed to the substitution of EFRPs with block trades. The question that rises is whether the increased volume in block option trading strategies represents order flow that has been attracted away from the floor, where option trading strategies have traditionally been traded.

Figure 2 shows, interestingly that the reduction in the minimum threshold does not seem to have affected in a similar way the activity of block trading in the WTI crude oil futures market, where block trades account for less than 8% of the daily trading volume. This could be the result of the relative simplicity of trading and related execution strategies for futures contracts that require less human intermediation. It could also be the result of the fact that the volume of EFRPs in the WTI crude oil futures market has been limited: the daily average was lower than four percent before the rule change and declined to less than 1.5% of the volume thereafter.

Figure 3 exhibits the daily proportion of trading in the pit and the electronic market during the time period examined. As in Figure 1, we present trading volume for option outrights and trading strategies separately. Trading volume in the pit is negligible for outrights in the entire sample period. In contrast, trading in option trading strategies which accounted for over forty percent of the total trading volume of crude options in 2011, has been declining steadily to levels lower than ten percent. Notably, we find no abrupt decline around the time of the reduction of the minimum block threshold. Rather, the share of electronic trading for both option outrights and option trading strategies increases steadily from 2011 to 2015. The proportion of trading volume in electronic option trading strategies often surpasses twenty percent of the daily trading volume, especially towards the end of our sample.

We revisit the trading activity by venue focusing on large orders, in order to understand the driving forces behind the choice of trading venue. We define large orders as orders larger than the minimum post October 2012 block threshold of hundred contracts. Table 2 presents the activity of large trades on each venue before and after October 15th 2012, when the minimum threshold for block trades was reduced. Panel A of Table 2 shows that the average size of block orders fell by five sixths, from 4,331 contracts to just 736 contracts after the minimum threshold declined, which implies that the block orders substantially smaller after October 15th 2012. It seems that these smaller orders mostly represent orders which would have traded as EFRPs had the rule not changed. However, it is also possible that some of these orders represent orders that

would have traded in the downstairs market, or even orders that may have never reached the market had the rule not changed. At the same time the average size of large orders executed in the pit and the electronic market have slightly increased. As expected, EFRPs, which accounted for half of large orders prior to the rule change, comprised just five percent of the volume of large trades after the change. Similarly, the trading volume of block trades jumped from just 7 percent of volume prior to the rule change to 52 percent thereafter. Interestingly, large orders executed on the electronic platform become more common, accounting for 27 percent of the large order volume, up from 11 percent prior to the rule change. The volume of large pit trades dropped from thirty percent to seventeen percent.

Next, we examine outrights and option trading strategies (separately). Panel B of Table 2 presents the relevant summary statistics. Our dataset differentiates option outrights from option trading strategies (spreads). While the volume of EFRPs was evenly distributed between outrights and option trading strategies prior to the rule change, we find that block trades are more frequently used to execute option trading strategies (accounting for 37 percent of large orders) than outrights (which represent just 14% of the daily trading volume of large trades). Moreover, most pit orders represent option trading strategies prior to the rule and the share of such pit trades to the daily volume of large trades is reduced from 25% to 16%, which could potentially indicate that some of the trading volume in option trading strategies has migrated from the pit to blocks. Electronic large orders increase symmetrically for outrights and spreads. It appears that the lower minimum threshold has encouraged more large trades in block option trading strategies, which cannot be explained just by the substitution of EFRPs with block trades. At the same, the increase in the volume of block outrights is not sufficient to explain the reduction of EFRP volume Therefore, it is possible that the increase of the block trade volume reflects only partly the transition of EFRPs to block trades. Another possible explanation is that the block trading has drawn order flow from the pit after the minimum threshold for blocks was reduced, contributing to its declining trading volume.

## V. Methodology: Execution Costs

We explore one of the possible driving forces for the choice of trading venue, execution costs. Similar to the literature (Bessembinder, 2003), we proxy execution cost with the effective half spread, which we estimated as:

$$Effective\ half\ spread = 100 * Di\ * (\log(P_{t_b}) - \log(P_{t_0})),$$

where *log* represents the natural logarithm, $P_{t_b}$ is the price of the volume weighted average price of the large order, $P_{t_0}$ is an appropriate benchmark price. For the latter, we use the price of the previous electronic

transaction in the corresponding contract. The variable $D_i$ is a trade direction indicator where $D_i$= 1 trade for a buyer initiated trade and $D_i$= - 1 for a seller initiated trade. For pit trades we use Lee and Ready (1991) "tick test" to sign trades. For electronic orders, we can use the actual aggressor indicator provided by our dataset. For comparative purposes across all trading venues, we also use the aggressor indicator estimated using the tick test.

We are also interested in decomposing the effective half spread into a temporary and permanent components. Following Kraus (1972), we have:

$$Temporary\ spread = 100 * D_i * (\log(P_{t_b}) - \log(P_{t_1}))\ ,$$

and

$$Permanent\ spread = \ D_i * (\log(P_{t_1}) - \log(P_{t_0}))$$

where $P_{t_1}$ is the price of the tenth electronic trade after the reporting time of the block/large trade. The temporary spread represents compensation for search and negotiation costs, while the permanent spread represents the permanent price impact. Similar to the literature, we consider orders informed (liquidity driven) when the permanent spread constitutes a high (low) proportion of the effective half spread. Our results include only those options for which the previous trade executes up to four hours prior to the large trade we are considering, while the tenth subsequent trade executes within four hours of the reported block trade. We do this, so that our results are not driven by illiquid option contracts, for which the tenth trade takes place substantially later. In this case the subsequent trade price could be driven by a number of other factors beyond the impact of the large trade we are considering.[12]

## VI. Results: Execution Costs

In this section, we present the average effective half spread, the temporary spread and the permanent spread of option trades belonging to a large/block order. While we present some preliminary measures on electronic orders resulting in passive trades, our analysis across trading venues focuses on orders resulting in aggressive trades.

[12] As a robustness test, we also estimate execution costs limiting our sample to options for which the previous trade takes place after the previous open and the subsequent tenth trade occurs prior to the next closing. Results are very similar and have been omitted.

For electronic large trades specifically, we compute the execution cost measures for both aggressive and passive trades. The results are presented in Table 3. Panel A presents measures of execution costs for electronic trades prior to October 15th 2012, when the block threshold was reduced. Panel B presents measures of execution costs for electronic trades after the rule changed. In each case, we present the average execution costs of all large electronic trades by option contract. We also present execution costs for aggressive and passive electronic orders separately, which are determined by the actual aggressor indicator in our dataset. Moreover, we compute execution costs for aggressive trades using both the actual aggressor indicator and the aggressor indicator, derived with the tick test. Orders are separated in option outrights and option trading strategies ("spreads").

The average estimated order size does not vary significantly between aggressive and passive orders. Orders associated with spreads have a smaller order size than outrights. Aggressive orders execute on average in less than a minute, while passive ones take on average over an hour to execute[13]. Outright passive orders take longer than spreads to execute, probably due to the larger size of outrights. There does not seem to be any substantial difference in the time to expiration and implied volatility of the respective options.

During the period of January 1st 2012 to October 15th 2012, the average half spread for large electronic outrights is positive for aggressive orders and negative for passive orders. The negative effective half spread associated with passive outright orders can be explained as reward for providing liquidity. On the contrary, aggressive outright orders represent orders by liquidity takers and thus have a much higher effective half spread. Moreover, the price impact persists, as the permanent spread comprises 63% of the effective half spread. These results can be interpreted as evidence of the presence of informed large traders in electronic market. The effective half spread for option trading strategies is very close to zero[14] and this holds for both aggressive and passive orders. Measuring execution costs with the aggressor indicator based on the tick test appears to overstate execution costs. However, the difference in the magnitude of execution costs between outright and spread orders is similar to the more accurate estimates for aggressive orders, which use the actual aggressor indicator. Therefore, we will be using the tick-test based measures of execution costs in order to compare them to the corresponding execution costs of orders at the pit and the upstairs market.

Although our sample contains a larger number of trades executing at the electronic market after the reduction of the minimum threshold of block trades (Table 3, Panel B), the average order size remains unchanged. The effective half spread for aggressive trades is similar, but the permanent spread increases for electronic outrights, which could be interpreted as an increase in the information content of large

[13] Execution time is estimated as the interval between the first and last trade belonging to the same order?
[14] It is not statistically significant.

aggressive outright orders. The average effective half spread for passive trades is close to zero, which could indicate that the compensation for providing liquidity through large orders is lower in the electronic market compared to other trading venues. At the same time, passive outright orders take slightly longer to execute. The average outright trade is closer to at the money. Generally, implied volatility is lower post October 15th, 2012.

In Table 4, we compare execution costs of large/block orders across all trading venues. Panel A presents execution costs prior to October 15th, 2012, while Panel B presents execution costs after the minimum block threshold was reduced. Prior to the rule change (Panel A), both the average effective half spread and the permanent spread were lower for large outright pit trades compared to electronic trades. For large pit spread trades the effective half spread is higher than the electronic market, while the permanent spread is slightly higher in the electronic market, which could potentially be attributed to the considerably larger size of the executed contracts. During this period, there is a small number of outright block orders with an effective half spread slightly higher and a permanent spread lower than the ones in the electronic order book. Given the substantially larger size of these orders, the execution costs are similar to the electronic market. During this period, upstairs orders are dominated by EFRPs exchange for related positions, which have an effective half spread higher than any type of trade and practically no permanent price impact. These results are intuitive, given the nature of EFRPs. Finally, the choice of venue seems does not appear to be driven by option characteristics such as time to expiration, implied volatility and moneyness[15] during our sample period.

After the minimum block threshold is reduced (Panel B), the permanent spread increases for electronic large outrights, whereas execution costs for electronic spreads remain unchanged. Effective half spread for pit outrights, which is lower compared to the electronic market, decreases further after the change of the block minimum threshold. In contrast, pit spread trades appear to face a higher effective half spread than in the electronic market, which could indicate that search costs associated with option spreads are higher resulting in liquidity providers commanding a higher compensation. However, it could also be the result of the larger average trade size, since the average trade size for option contracts belonging to a spread is 493 contracts at the pit and just 65 in the electronic order book. After the rule change, the effective half spread for block trades increases to a level substantially higher than effective half spread of large orders in the electronic market. This preliminary result is inconsistent with the findings of the academic literature in equity market (Madhavan & Cheng, 1997), where block trading is associated with lower effective spreads.

[15] Moneyness is measured by the absolute value of WTI Futures Price/Strike price - 1. A very small number indicates that the underlying price is close to the strike price, where as a larger number indicates that the underlying price is far from the strike price.

The substantially higher effective half spread in options block trading could potentially be explained by the larger size of block orders. However, it could also be associated with high search and negotiation costs arising from the specifics of option orders. At the same time, the permanent spread for both outrights and spreads constitutes a small fraction of the execution cost, which is consistent with the certification hypothesis (Seppi 1990), according to which brokers are able to distinguish liquidity driven trades, which are facilitated in the upstairs market and have minimal price impact in the downstairs market[16]. Finally, EFRPs, which decline dramatically following the regulatory change, face even higher execution costs than in the previous period.

Since blocks and large pit orders are substantially larger than electronic large orders we also explore to replicate our analysis by separating all orders into four size bins. Table 5 presents the execution costs of outrights across all venues before (Panel A) and after the rule change (Panel B). Table 6 presents the execution costs of option trading strategies across all venues before (Panel A) and after the rule change (Panel B).

Panel A of Table 5 shows the differences in effective half spreads between various trading venues before the rule change are driven by order size. When comparing large orders of similar size, we observe that large pit orders have the lowest effective half spread. Moreover, although the permanent spread for pit orders is lower than the corresponding ones in the electronic market, permanent spreads constitute more than fifty percent of the total execution cost, they are at least partly information driven. This pattern appears to be even stronger after October 15th, 2012 (Panel B). Consistent with the academic literature on block trading (Madhavan & Cheng, 1997), block outright trades prior to the rule change represent orders of substantial size. They exhibit a similar effective half spread compared to the downstairs market and a relatively low permanent spread, indicating that they are liquidity driven. After October 15th 2012 only larger orders have lower effective half spread than the electronic market. However, the permanent spread is consistently lower than all other trading venues irrespective of the order size, suggesting that outright block orders are liquidity driven. The cost structure of exchange for related positions appears to be different from block trades. Exchange for related positions exhibit much higher effective half spread and a practically zero permanent spread. On the contrary, block trades have a lower effective half spread and permanent spread while small constitutes a measureable portion of the execution cost.

Table 6 presents the execution costs of option trading strategies when size is considered. Prior to the rule change (Panel A) there are very few electronic spread orders in our sample, which are relatively small. For

[16] Seppi (1990) does not distinguish between the pit and electronic market, since the electronic market was not popular at the time the paper was written.

these small size trades (below 200 contracts), electronic spread orders have the lowest effective half spread compared to all other trading venues. Pit trades appear to be the dominant trading venue for option spreads and there are no spread orders trades as blocks. In the second part of our sample (Panel B), the frequency of smaller electronic option trading strategies increases while their effective half spread remains the lowest across all trading venues. The effective half spread for pit trades increases a little whereas the permanent component decreases. The effective half spread for block trades is higher than all other trading venues irrespective of size, which suggests that brokers providing liquidity command a large premium for search and negotiations costs. Finally, exchange for related positions both before and after the rule change exhibit higher total execution costs than all other trading venues.

## VII. Conclusion

We use a comprehensive dataset of trades in the crude oil option market between 2011 and 2015 to investigate large trades executing in the downstairs market (pit and electronic market) as well as EFRPs and blocks. We document that block trading has increased substantially after a reduction in the legal minimum block threshold in October 2012. Block trades have lower effective half spread than the corresponding effective half spread of exchange for related positions prior to the rule change. At the same time, while the permanent component of the EFRP spread is statistically insignificant, the permanent spread of block trades is positive and significant. However, it constitutes a small portion of the total execution costs, which suggests that while block trades reflect some information content, they are primarily liquidity driven. The high temporary component of the spread for blocks could be interpreted as compensation for search and negotiation costs. The execution costs of electronic option spreads are low compared to other trading venues and the volume of such trades in the electronic market increases. Still, electronic option spread trades are small compared to pit and block trades. These findings suggest that the electronic market provides a cost efficient trading venue for executing relatively large orders linked to option trading strategies. However, it is mostly able to absorb relatively smaller “large orders”. Finally, our results do not rule out the possibility that part of the volume associated with large option spread trades has been diverted from the pit to the upstairs market as pit volume has declined and total execution costs for pit orders appear to have increased following the regulatory change. Further research is required to support this claim.

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**Table 1: The reduction in block trade thresholds in energy contracts.**

This table describes the reduction in the minimum threshold for block trades in the energy market, which was introduced in October 2012. It shows the old and the revised block minimum threshold for eight prominent energy contracts trading at NYMEX.

| Contract | Commodity Code | Old block threshold | New block threshold |
|---|---|---|---|
| Light Sweet Crude Oil futures | CL | 100 contracts | 50 contracts |
| Light Sweet Crude Oil options | LO | 1000 contracts | 100 contracts |
| Brent Crude Oil Last Day Financial Futures | BZ | 100 contracts | 25 contracts |
| Henry Hub Natural Gas futures | NG | 100 contracts | 50 contracts |
| Henry Hub Natural Gas options | ON | 1,600 contracts | 100 contracts |
| New York Harbor ULSD Heating Oil futures | HO | 50 contracts | 25 contracts |
| RBOB Gasoline futures | RB | 50 contracts | 25 contracts |
| Henry Hub Natural Gas Look-Alike options | LN | 550 contracts | 15 contracts |

Source: CME Group. (2012, September 27). Certification Rule, Submission 12-292R, Retrieved from http://www.cmegroup.com/market-regulation/files/12-301_FINAL.pdf.

**Table 2: Summary statistics for large orders**

This table presents the activity of large orders on each venue before and after October 15th 2012, when the minimum threshold for block trades was reduced. We define large orders as those WTI Crude oil options trades that would meet the post October 2012 minimum block order threshold. Panel A presents summary statistics on all such orders during the period extending from January 1st 2012 to December 31st 2014. The sample is separated in orders placed and executed before and after October 15, 2012, which is when the minimum block trade threshold was reduced. Panel B separates these orders in outrights and option trading strategies.

Panel A: Summary statistics for large orders in WTI Crude oil options

| | Before Oct 15 2012 | | | | After October 15 2012 | | | |
|---|---|---|---|---|---|---|---|---|
| | Average Order Size | Average Daily Order Number | Average Daily Volume | Volume Percentage of Large Orders | Average Order Size | Average Daily Order Number | Average Daily Volume | Volume Percentage of Large Orders |
| EFRPS | 404.28 | 222.38 | 89,905.44 | 0.52 | 410.96 | 15.99 | 6,570.14 | 0.05 |
| Blocks | 4331.29 | 2.80 | 12,109.93 | 0.07 | 735.72 | 101.41 | 74,612.79 | 0.52 |
| Electronic | 143.70 | 131.85 | 18,946.47 | 0.11 | 162.03 | 237.39 | 38,463.57 | 0.27 |
| Pit | 321.33 | 158.10 | 50,800.54 | 0.30 | 368.51 | 67.39 | 24,833.38 | 0.17 |

Panel B: Summary statistics for large orders in WTI Crude oil options – Outrights vs. Trading Strategies

| | | Before Oct 15 2012 | | | | After Oct 15 2012 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Spread Dummy | Average Order Size | Average Daily Order Number | Average Daily Volume | Volume Percentage of Large Orders | Average Order Size | Average Daily Order Number | Average Daily Volume | Volume Percentage of Large Orders |
| EFRPs | 1 | 323.42 | 135.27 | 43,748.05 | 0.25 | 256.17 | 11.05 | 2,830.14 | 0.02 |
| Blocks | 1 | 4,326.80 | 2.82 | 12,204.55 | 0.07 | 1,055.31 | 18.86 | 19,903.69 | 0.14 |
| Electronic | 1 | 140.76 | 122.58 | 17,254.07 | 0.10 | 150.01 | 165.41 | 24,812.30 | 0.17 |
| Pit | 1 | 224.08 | 25.63 | 5,742.22 | 0.03 | 230.09 | 8.94 | 2,057.35 | 0.01 |
| EFRPs | 2 | 529.84 | 87.12 | 46,157.39 | 0.26 | 557.87 | 10.45 | 5,830.59 | 0.04 |
| Blocks | 2 | 5,250.00 | 1 | 5,250.00 | 0.03 | 663.67 | 82.76 | 54,923.12 | 0.37 |
| Electronic | 2 | 182.51 | 10.43 | 1,903.95 | 0.01 | 189.65 | 72.47 | 13,743.04 | 0.09 |
| Pit | 2 | 340.14 | 132.47 | 45,058.32 | 0.25 | 385.62 | 59.97 | 23,127.55 | 0.16 |

## Table 3 – Execution costs in electronic markets

Table 3 presents the execution cost measures (effective half spread, temporary impact, price impact) for both aggressive and passive large orders. We define large orders as those WTI Crude oil options trades that would meet the post October 2012 minimum block order threshold. Our dataset extends from January 1st 2012 to December 31st 2014. Panel A presents execution costs for electronic orders prior to October 15th 2012, when the block threshold was reduced. Panel B presents measures of execution costs for electronic large orders after the rule changed. In each case, we present the average execution costs of all large electronic orders by option contract. We also present execution costs for aggressive and passive electronic orders separately. Execution costs for aggressive orders are computed using both the actual aggressor indicator and the aggressor indicator, derived with the tick test. Orders are separated in option outrights and option trading strategies ("spreads").

### Panel A: Execution costs for electronic orders before the Rule Change

| Before October 15th, 2012 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Type | Effective Spread | Temporary | Permanent | Temporary % | Permanent % | Average Order size | Time to Expiration | Moneyness | Implied volatility | Obs | Number of accounts | Avg delay to execution (minutes) |
| All | Outright | 1.35 | 0.72 | 0.63 | 0.53 | 0.47 | 122 | 32 | 0.14 | 0.36 | 3101 | 290 | 45 |
| | Spread | -0.47 | -0.48 | 0.01 | 1.02 | -0.02 | 63 | 33 | 0.07 | 0.33 | 1409 | 66 | 33 |
| Aggressive | Outright | 4.66 | 2.09 | 2.57 | 0.45 | 0.55 | 130 | 33 | 0.16 | 0.37 | 1559 | 192 | 0 |
| | Spread | -0.48 | -0.63 | 0.15 | 1.32 | -0.32 | 64 | 34 | 0.08 | 0.33 | 771 | 38 | 0 |
| Non Aggressive | Outright | -2.10 | -0.71 | -1.39 | 0.34 | 0.66 | 114 | 31 | 0.13 | 0.35 | 1498 | 218 | 93 |
| | Spread | -0.47 | -0.31 | -0.16 | 0.66 | 0.34 | 62 | 33 | 0.07 | 0.33 | 634 | 57 | 73 |
| Aggressive by proxy | Outright | 7.03 | 2.39 | 4.64 | 0.34 | 0.66 | 130 | 33 | 0.16 | 0.37 | 1559 | 192 | 0 |
| | Spread | 2.67 | 0.88 | 1.79 | 0.33 | 0.67 | 64 | 34 | 0.08 | 0.33 | 771 | 38 | 0 |

### Panel B: Execution costs for electronic orders after the Rule Change

| After October 15th, 2012 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Type | Effective Spread | Temporary | Permanent | Temporary % | Permanent % | Average Order size | Time to Expiration | Moneyness | Implied volatility | Obs | Number of accounts | Avg delay to execution (minutes) |
| All | Outright | 2.96 | 0.80 | 2.16 | 0.27 | 0.73 | 124 | 49 | 0.08 | 0.25 | 10492 | 699 | 43 |
| | Spread | -0.06 | -0.33 | 0.27 | 5.25 | -4.25 | 66 | 77 | 0.05 | 0.22 | 29192 | 322 | 29 |
| Aggressive | Outright | 5.20 | 1.36 | 3.84 | 0.26 | 0.74 | 130 | 48 | 0.09 | 0.25 | 5908 | 516 | 0 |
| | Spread | -0.03 | -0.33 | 0.30 | 10.70 | -9.70 | 65 | 74 | 0.06 | 0.22 | 16584 | 167 | 0 |
| Non Aggressive | Outright | -0.12 | 0.03 | -0.16 | -0.27 | 1.27 | 116 | 52 | 0.08 | 0.25 | 4287 | 486 | 106 |
| | Spread | -0.11 | -0.33 | 0.22 | 3.11 | -2.11 | 66 | 82 | 0.05 | 0.22 | 12354 | 286 | 68 |
| Aggressive by proxy | Outright | 6.88 | 1.53 | 5.35 | 0.22 | 0.78 | 130 | 48 | 0.09 | 0.25 | 5908 | 516 | 0 |
| | Spread | 2.95 | 1.19 | 1.76 | 0.40 | 0.60 | 65 | 74 | 0.06 | 0.22 | 16584 | 167 | 0 |

## Table 4 – Execution costs in all trading venues

Table 4 compares execution costs (effective half spread, temporary impact, price impact) of large orders across all trading venues. We define large orders as those WTI Crude oil options trades that would meet the post October 2012 minimum block order threshold. Our dataset extends from January 1st 2012 to December 31st 2014. Orders are separated in outrights and option trading strategies. Panel A presents execution costs prior to October 15th, 2012, while Panel B presents execution costs after the minimum block threshold was reduced.

Panel A: Execution costs in all trading venues before the rule change

| Before October 15th, 2012 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Type | Effective Half Spread | Temporary | Permanent | Temporary % | Permanent % | Average trade size per contract | Time to Expiration | Moneyness | Implied volatility | Obs | Number of accounts |
| Electronic | Outright | 7.03 | 2.39 | 4.64 | 0.34 | 0.66 | 130 | 33 | 0.16 | 0.37 | 1559 | 192 |
| | Spread | 2.67 | 0.88 | 1.79 | 0.33 | 0.67 | 64 | 34 | 0.08 | 0.33 | 771 | 38 |
| Pit | Outright | 5.52 | 1.55 | 3.97 | 0.28 | 0.72 | 191 | 33 | 0.16 | 0.35 | 2082 | 146 |
| | Spread | 7.85 | 5.47 | 2.38 | 0.70 | 0.30 | 146 | 34 | 0.08 | 0.33 | 21525 | 322 |
| Block | Outright | 7.90 | 3.76 | 4.14 | 0.48 | 0.52 | 1381 | 20 | 0.13 | 0.36 | 406 | 16 |
| | Spread | | | | | | | | | | | |
| EFRP | Outright | 10.35 | 9.50 | 0.86 | 0.92 | 0.08 | 158 | 32 | 0.08 | 0.33 | 5098 | 306 |
| | Spread | 10.48 | 10.11 | 0.37 | 0.96 | 0.04 | 149 | 30 | 0.07 | 0.32 | 6390 | 228 |

Panel B: Execution costs in all trading venues after the rule change

| After October 15th, 2012 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Type | Effective Half Spread | Temporary | Permanent | Temporary % | Permanent % | Average trade size per contract | Time to Expiration | Moneyness | Implied volatility | Obs | Number of accounts |
| Electronic | Outright | 6.88 | 1.53 | 5.35 | 0.22 | 0.78 | 130 | 48 | 0.09 | 0.25 | 5908 | 516 |
| | Spread | 2.95 | 1.19 | 1.76 | 0.40 | 0.60 | 65 | 74 | 0.06 | 0.22 | 16584 | 167 |
| Pit | Outright | 4.04 | 1.14 | 2.90 | 0.28 | 0.72 | 231 | 43 | 0.09 | 0.26 | 1352 | 151 |
| | Spread | 8.68 | 7.00 | 1.68 | 0.81 | 0.19 | 493 | 37 | 0.05 | 0.24 | 25163 | 386 |
| Block | Outright | 8.09 | 5.75 | 2.34 | 0.71 | 0.29 | 1570 | 438 | 0.07 | 0.26 | 6006 | 348 |
| | Spread | 9.16 | 8.14 | 1.02 | 0.89 | 0.11 | 767 | 189 | 0.05 | 0.23 | 30590 | 556 |
| EFRP | Outright | 18.34 | 18.12 | 0.22 | 0.99 | 0.01 | 138 | 25 | 0.07 | 0.30 | 547 | 114 |
| | Spread | 14.27 | 15.10 | -0.84 | 1.06 | -0.06 | 142 | 21 | 0.05 | 0.31 | 946 | 125 |

## Table 5 – Execution costs for crude oil option outrights

Table 5 presents the execution costs (effective half spread, temporary impact, price impact) of WTI crude oil option outrights by size across all venues before (Panel A) and after the rule change (Panel B). Our sample consists of large option outright orders placed and executed during the period extending from January 1st 2012 to December 31st 2014. We define large orders as those WTI Crude oil options trades that would meet the post October 2012 minimum block order threshold. Orders are separated by size in four groups.

Panel A: Execution costs for crude oil option outrights by order size prior to the rule change

| | | | Before October 15th, 2012 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Outrights | | | | | | | | | | |
| | Order Size Bin | Order Size | Effective Half Spread | Temporary | Permanent | Temporary % | Permanent % | Average trade size by contract | Time to Expiration | Moneyness | Implied volatility | Obs | Number of accounts |
| Electronic | 1 | 0-200 | 6.49 | 2.42 | 4.07 | 0.37 | 0.63 | 108 | 32 | 0.15 | 0.37 | 1366 | 184 |
| | 2 | 200-400 | 10.17 | 2.38 | 7.79 | 0.23 | 0.77 | 227 | 30 | 0.19 | 0.40 | 159 | 44 |
| | 3 | 400-999 | 13.84 | 1.12 | 12.69 | 0.08 | 0.92 | 563 | 57 | 0.27 | 0.43 | 34 | 18 |
| Pit | 1 | 0-200 | 4.80 | 1.23 | 3.57 | 0.26 | 0.74 | 92 | 30 | 0.13 | 0.35 | 963 | 100 |
| | 2 | 200-400 | 4.71 | 1.54 | 3.18 | 0.33 | 0.67 | 237 | 31 | 0.15 | 0.36 | 326 | 66 |
| | 3 | 400-600 | 6.14 | 1.92 | 4.21 | 0.31 | 0.69 | 472 | 29 | 0.16 | 0.36 | 146 | 33 |
| | 4 | >=600 | 7.73 | 2.51 | 5.23 | 0.32 | 0.68 | 886 | 26 | 0.15 | 0.35 | 69 | 15 |
| Block | 1 | 0-200 | | | | | | | | | | | |
| | 2 | 200-400 | | | | | | | | | | | |
| | 3 | 400-600 | | | | | | | | | | | |
| | 4 | >=600 | 7.90 | 3.76 | 4.14 | 0.48 | 1.10 | 1381 | 20 | 0.13 | 0.36 | 406 | 16 |
| EFRP | 1 | 0-200 | 9.83 | 9.87 | -0.04 | 1.00 | 0.00 | 78 | 29 | 0.07 | 0.32 | 2145 | 227 |
| | 2 | 200-400 | 11.63 | 10.75 | 0.88 | 0.92 | 0.08 | 230 | 33 | 0.09 | 0.33 | 528 | 107 |
| | 3 | 400-600 | 12.19 | 11.58 | 0.61 | 0.95 | 0.05 | 460 | 40 | 0.10 | 0.34 | 149 | 53 |
| | 4 | >=600 | 15.32 | 15.98 | -0.66 | 1.04 | -0.04 | 1218 | 37 | 0.16 | 0.35 | 74 | 33 |

Panel B: Execution costs for crude oil option trading strategies by order size after the rule change

| | | | After October 15, 2012 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Outrights | | | | | | | | | | |
| | Order Size Bin | Order Size | Effective Spread | Temporary | Permanent | Temporary % | Permanent % | Average Order size | Time to Expiration | Moneyness | Implied volatility | Obs | Number of accounts |
| Electronic | 1 | 0-200 | 6.36 | 1.44 | 4.92 | 0.23 | 0.77 | 109 | 48 | 0.08 | 0.25 | 5075 | 484 |
| | 2 | 200-400 | 9.29 | 2.28 | 7.01 | 0.25 | 0.75 | 227 | 49 | 0.11 | 0.25 | 729 | 166 |
| | 3 | 400-600 | 14.89 | -0.54 | 15.42 | -0.04 | 1.04 | 445 | 42 | 0.14 | 0.27 | 88 | 36 |
| | 4 | >=600 | 17.57 | 8.67 | 8.90 | 0.49 | 0.51 | 760 | 42 | 0.21 | 0.33 | 16 | 9 |
| Pit | 1 | 0-200 | 3.19 | 1.00 | 2.19 | 0.31 | 0.69 | 91 | 40 | 0.08 | 0.25 | 664 | 104 |
| | 2 | 200-400 | 4.18 | 2.39 | 1.79 | 0.57 | 0.43 | 238 | 44 | 0.12 | 0.28 | 222 | 81 |
| | 3 | 400-600 | 3.90 | -0.60 | 4.49 | -0.15 | 1.15 | 471 | 54 | 0.12 | 0.27 | 74 | 31 |
| | 4 | >=600 | 5.25 | -0.32 | 5.58 | -0.06 | 1.06 | 947 | 44 | 0.15 | 0.28 | 33 | 16 |
| Block | 1 | 0-200 | 7.95 | 5.38 | 2.57 | 0.68 | 0.32 | 106 | 47 | 0.06 | 0.25 | 2283 | 282 |
| | 2 | 200-400 | 7.80 | 6.16 | 1.63 | 0.79 | 0.21 | 239 | 51 | 0.07 | 0.25 | 1573 | 216 |
| | 3 | 400-600 | 8.56 | 6.31 | 2.25 | 0.74 | 0.26 | 480 | 36 | 0.09 | 0.26 | 970 | 125 |
| | 4 | >=600 | 8.37 | 5.46 | 2.91 | 0.65 | 0.35 | 1310 | 36 | 0.10 | 0.27 | 1180 | 90 |
| EFRP | 1 | 0-200 | 18.19 | 17.34 | 0.84 | 0.95 | 0.05 | 54 | 26 | 0.05 | 0.29 | 248 | 77 |
| | 2 | 200-400 | 8.70 | 14.23 | -5.52 | 1.63 | -0.39 | 236 | 34 | 0.12 | 0.33 | 46 | 26 |
| | 3 | 400-600 | 14.75 | 4.66 | 10.09 | 0.32 | 2.17 | 494 | 44 | 0.17 | 0.40 | 8 | 7 |
| | 4 | >=600 | 16.01 | -4.91 | 20.92 | -0.31 | -4.26 | 1294 | 20 | 0.12 | 0.40 | 16 | 9 |

## Table 6: Execution costs for crude oil option trading strategies

Table 6 presents the execution costs (effective half spread, temporary impact, price impact) of WTI crude oil option trading strategies by size across all venues before (Panel A) and after the rule change (Panel B). Our sample consists of large orders involving option trading strategies. These orders were placed and executed during the period extending from January 1st 2012 to December 31st 2014. We define large orders as those WTI Crude oil options trades that would meet the post October 2012 minimum block order threshold. Orders are separated by size in four groups.

Panel A: Execution costs for crude oil option trading strategies by order size prior to the rule change

| | | | Before October 15th, 2012 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Spreads | | | | | | | | | | |
| | Order Size Bin | Order Size | Effective Half Spread | Temporary | Permanent | Temporary % | Permanent % | Average trade size by contract | Time to Expiration | Moneyness | Implied volatility | Obs | Number of accounts |
| Electronic | 1 | 0-200 | 2.44 | 0.43 | 2.01 | 0.18 | 0.82 | 57 | 34 | 0.08 | 0.33 | 76 | 37 |
| | 2 | 200-400 | 8.37 | 11.98 | -3.62 | 1.43 | -0.43 | 241 | 25 | 0.09 | 0.33 | 10 | 6 |
| | 3 | 400-600 | | | | | | | | | | | |
| | 4 | >=600 | | | | | | | | | | | |
| Pit | 1 | 0-200 | 7.95 | 6.01 | 1.93 | 0.76 | 0.24 | 74 | 24 | 0.06 | 0.32 | 11655 | 245 |
| | 2 | 200-400 | 6.53 | 4.43 | 2.09 | 0.68 | 0.32 | 232 | 28 | 0.08 | 0.33 | 2357 | 149 |
| | 3 | 400-600 | 6.36 | 4.07 | 2.29 | 0.64 | 0.36 | 463 | 27 | 0.09 | 0.34 | 795 | 85 |
| | 4 | >=600 | 6.83 | 3.71 | 3.12 | 0.54 | 0.46 | 967 | 25 | 0.10 | 0.35 | 418 | 53 |
| Block | 1 | 0-200 | | | | | | | | | | | |
| | 2 | 200-400 | | | | | | | | | | | |
| | 3 | 400-600 | | | | | | | | | | | |
| | 4 | >=600 | | | | | | | | | | | |
| EFRP | 1 | 0-200 | 10.51 | 10.24 | 0.27 | 0.97 | 0.03 | 83 | 29 | 0.06 | 0.32 | 2610 | 176 |
| | 2 | 200-400 | 10.83 | 10.71 | 0.13 | 0.99 | 0.01 | 226 | 33 | 0.08 | 0.33 | 794 | 98 |
| | 3 | 400-600 | 11.59 | 12.79 | -1.19 | 1.10 | -0.10 | 447 | 40 | 0.10 | 0.33 | 202 | 56 |
| | 4 | >=600 | 12.11 | 10.95 | 1.16 | 0.90 | 0.10 | 916 | 37 | 0.12 | 0.34 | 80 | 32 |

Panel B: Execution costs for crude oil option trading strategies by order size after the rule change

| | | | After October 15, 2012 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Spreads | | | | | | | | | | |
| | Order Size Bin | Order Size | Effective Spread | Temporary | Permanent | Temporary % | Permanent % | Average Order size | Time to Expiration | Moneyness | Implied volatility | Obs | Number of accounts |
| Electronic | 1 | 0-200 | 2.91 | 1.14 | 1.77 | 0.39 | 0.61 | 60 | 74 | 0.05 | 0.22 | 16132 | 166 |
| | 2 | 200-400 | 4.12 | 2.83 | 1.28 | 0.69 | 0.31 | 226 | 76 | 0.08 | 0.23 | 409 | 39 |
| | 3 | 400-800 | -0.94 | -2.03 | 1.09 | 2.16 | -1.16 | 452 | 69 | 0.09 | 0.26 | 43 | 15 |
| Pit | 1 | 0-200 | 8.86 | 7.44 | 1.41 | 0.84 | 0.16 | 76 | 34 | 0.04 | 0.24 | 13493 | 307 |
| | 2 | 200-400 | 7.81 | 6.30 | 1.51 | 0.81 | 0.19 | 238 | 39 | 0.06 | 0.24 | 3658 | 199 |
| | 3 | 400-600 | 6.80 | 5.45 | 1.35 | 0.80 | 0.20 | 459 | 42 | 0.07 | 0.24 | 1102 | 122 |
| | 4 | >=600 | 7.31 | 5.78 | 1.53 | 0.79 | 0.21 | 912 | 48 | 0.08 | 0.25 | 589 | 81 |
| Block | 1 | 0-200 | 9.08 | 8.15 | 0.93 | 0.90 | 0.10 | 94 | 50 | 0.04 | 0.23 | 18951 | 477 |
| | 2 | 200-400 | 9.18 | 8.17 | 1.02 | 0.89 | 0.11 | 231 | 57 | 0.06 | 0.23 | 8394 | 361 |
| | 3 | 400-600 | 9.34 | 7.72 | 1.62 | 0.83 | 0.17 | 457 | 64 | 0.07 | 0.24 | 2172 | 221 |
| | 4 | >=600 | 10.08 | 8.62 | 1.47 | 0.85 | 0.15 | 988 | 81 | 0.08 | 0.24 | 1073 | 140 |
| EFRP | 1 | 0-200 | 16.66 | 18.39 | -1.74 | 1.10 | -0.09 | 64 | 18 | 0.04 | 0.31 | 400 | 96 |
| | 2 | 200-400 | 13.98 | 14.18 | -0.20 | 1.01 | -0.01 | 234 | 22 | 0.07 | 0.31 | 119 | 43 |
| | 3 | 400-600 | 16.51 | 16.56 | -0.05 | 1.00 | 0.00 | 478 | 23 | 0.11 | 0.33 | 36 | 20 |
| | 4 | >=600 | 11.72 | 12.90 | -1.17 | 1.10 | -0.09 | 871 | 23 | 0.11 | 0.35 | 15 | 12 |

**Figure 1: The Upstairs WTI options market**

Figure 1 presents the share in the total volume in WTI crude oil options for EFRPs and blocks trades during our the period extending from September 2011 to December 2014.. EFRP and block trading volumes are reported in separate graphs. We also examine option outrights and option trading strategies ("spreads") separately.

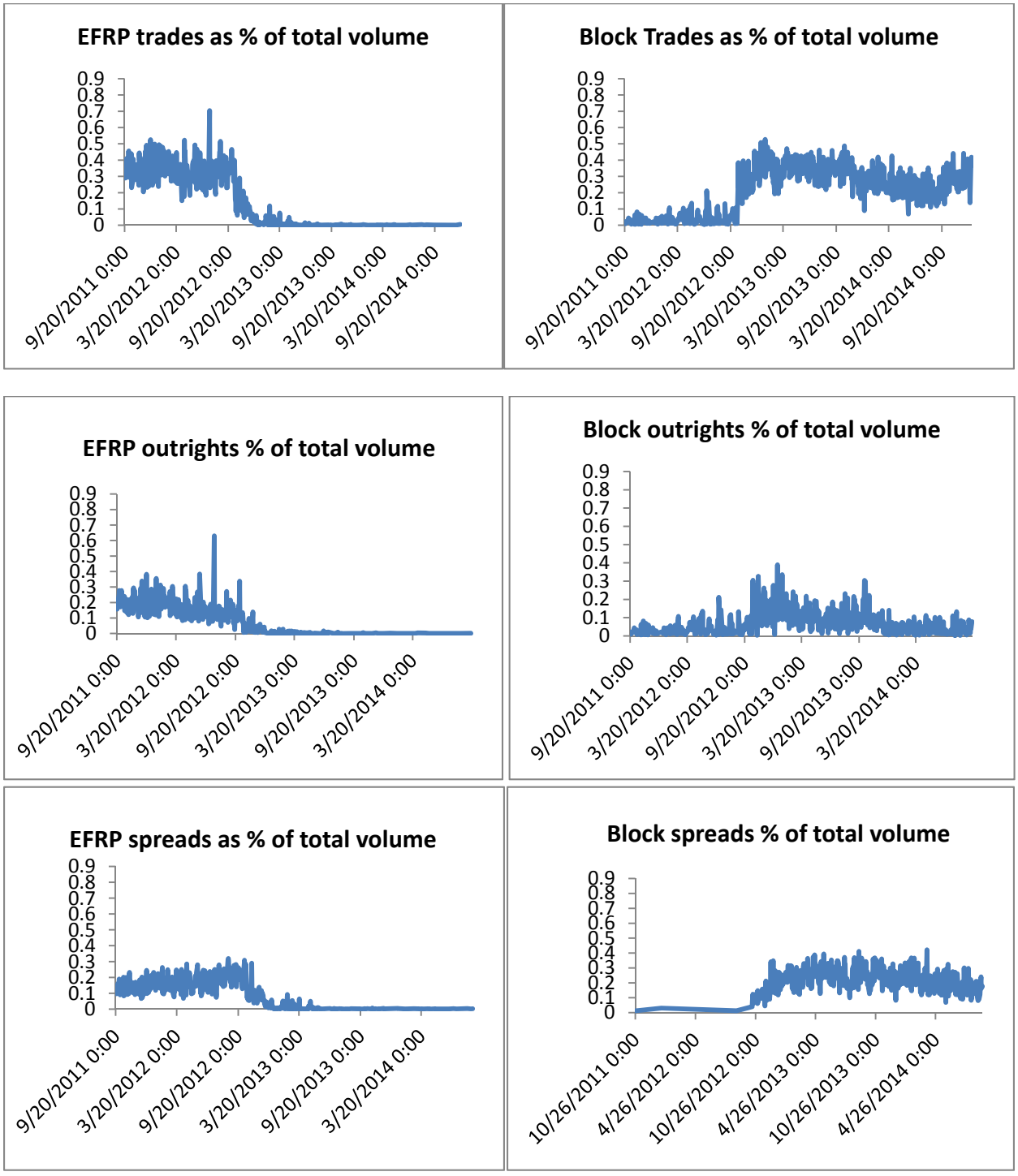

**Figure 2: The WTI Futures market**

Figure 2 exhibits the daily proportion of futures trading in the four venues (the pit, the electronic market, block trades and EFRPs) during the time period extending from September 2011 to December 2014.

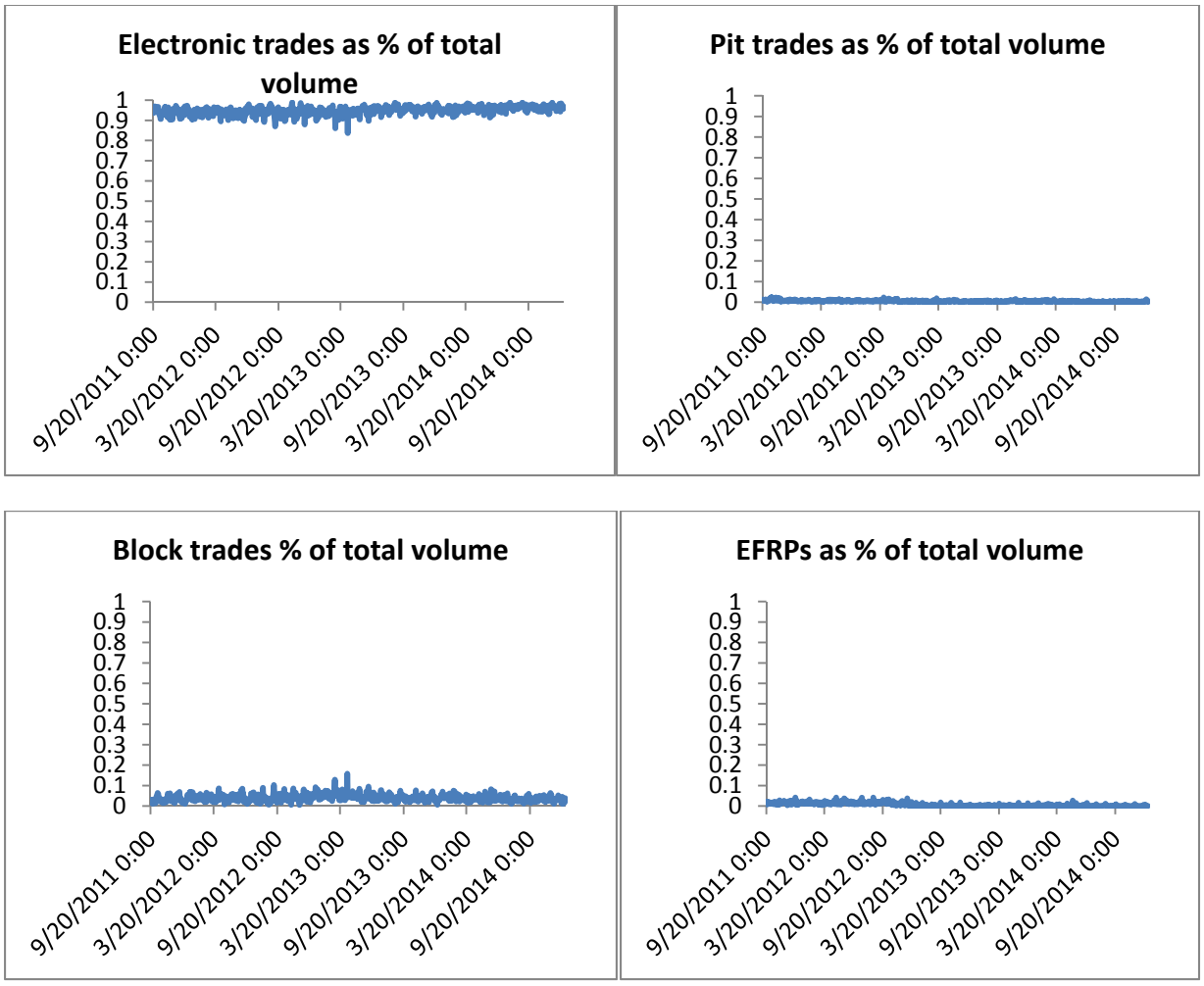

**Figure 3: The downstairs WTI options market**

Figure 3 exhibits the daily proportion of trading in the pit and the electronic market during the time period extending from September 2011 to December 2014. We present trading volume for option outrights and trading strategies separately.