December 2016

Liquidity Provision Under Stress: The Fast, the Slow, and the Dead

(Evidence from Crude Oil Futures, 2006-2009)

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Abstract

We investigate the reliability and the consistency of liquidity provision by fast liquidity providers ("FLPs") in periods of market stress. We draw on a comprehensive, non-public, account-level intraday dataset of trading activity in crude oil futures (the world's largest commodity market), where liquidity provision has always been entirely voluntary. That market was transformed in 2006 by the onset of electronic trading, with liquidity provision since dominated by machines trading at ultra-high speeds. We ask if these FLPs significantly reduce their participation or liquidity provision amid liquidity shocks or in information-rich periods (characterized by persistently high volatility or elevated information asymmetry). Using market stress episodes from January 2006 to June 2009, we compare FLPs' trading with the contemporaneous behaviors of the (now "Dead") Locals in the trading pits and of the ("Slow") *e*-Locals in the electronic market. Compared to slower liquidity providers, we find that FLPs withdraw more (and provide less liquidity to customers) during high-volatility and other information-rich periods but are less sensitive to liquidity shocks. In contrast, FLP-to-customer spreads are not substantially affected by high volatility *per se* but go up significantly in response to high informational asymmetries.

Keywords: Trading speed, Voluntary liquidity provision, Volatility, Information, Stress
JEL classification: G10, G14, G18

1. Introduction

Following the development of electronic trading platforms and innovations in trading technology, an important new economic agent has emerged and increasingly dominated trading in financial markets. We label them "fast liquidity providers." These "FLPs" are machine traders that act voluntarily in a proprietary capacity and exploit a speed-related competitive advantage in capturing information from the order flow to harvest bid-offer spread revenues through their net liquidity supply (Biais, Declerck, and Moinas, 2016). FLP profits are driven by buying and selling financial instruments at ultra-high speed, typically without human trade-by-trade interaction or premeditated directional bets, by participating on both sides of the book, and by turning over inventory with extremely short horizons – thereby generating a relatively high amount of trading volume with minimal capital investment.

FLPs nowadays collectively account for over half of the trading volume at major U.S. financial markets. In the futures space, in particular, they have displaced the erstwhile "Locals" – the human traders who used to manually provide liquidity, face-to-face, in the trading pits. On electronic futures exchanges, FLPs compete with "*e*-Locals" and other types of slow traders to provide "predictable immediacy" (Demsetz, 1968) by standing ready and waiting to trade with incoming buy and sell orders demanding immediate execution.

A number of recent empirical studies document that FLP activity generally improves overall market liquidity.[1] The vast majority of today's electronic order matching markets (e.g., U.S. futures markets), however, do not entrust designated any "market-maker" with an affirmative obligation to provide liquidity; in this context, two important—yet thus far unanswered—questions are whether FLP liquidity provision is impacted negatively by episodes

[1] For equities, see Menkveld (2013) and cited references therein. For futures, see Raman, Robe, and Yadav (2014).

of market stress, and whether the reliability and the consistency of FLP liquidity provision in stressful periods differ materially from those of other voluntary liquidity providers. The present paper deals with those questions. We think of "stress" in terms of large and persistent liquidity shocks, volatility, or informational asymmetries. We provide evidence that FLPs pull back during high-volatility episodes and during other information-rich periods but, in contrast, are not very sensitive to liquidity shocks. At the same time, we document that these patterns broadly do not hold for human liquidity providers.

The present paper provides answers to both of these questions. We show that FLPs pull back during high-volatility episodes and during other information-rich periods but, in contrast, are not very sensitive to liquidity shocks. We find that the opposite pattern broadly holds for slower liquidity providers. We complement our analysis of these participation rates and intensity of liquidity provision by investigating FLPs' spreads in their trades with customers. We find that realized spreads do not go up due to high volatility *per se* but increase significantly during episodes characterized by high informational asymmetries.

Our findings are based on the analysis, between January 2006 and June 2009, of a comprehensive, non-public, account-level intraday dataset of trading activity at the world's largest commodity market: the New York Mercantile Exchange's (NYMEX) West Texas Intermediate (WTI) sweet crude oil futures market. U.S. futures markets in general, and the WTI futures market in particular, provide an ideal laboratory for our investigation. Firstly, they have always functioned through voluntary liquidity providers, free from affirmative obligations. In contrast, equity markets have switched from affirmative obligations to voluntary provision of liquidity – making it difficult to cleanly benchmark FLPs' impact on liquidity provision in equity

markets.[2] Secondly, the WTI market was transformed by the onset of electronic trading on September 5th, 2006. It has since become dominated by FLPs. By analyzing data from the 2006-2007 period, we can compare the impact of various kinds of stress on liquidity provision in environments where there are no FLPs (namely, prior to electronification) *versus* in settings where FLPs compete with slower voluntary market makers providing liquidity either electronically (like FLPs do) or face-to-face in trading pits. Thirdly, the WTI market in 2008–2009 experienced two episodes of extraordinarily severe stress that were clearly exogenous to the trading activities of automated crude oil traders (ATs) in general and FLPs in particular: the failure of Lehman Brothers in September 2008 and an unprecedented petroleum storage-capacity shortfall at the WTI crude oil futures delivery point in Cushing, Oklahoma during the Winter of 2009. The second event was associated with a major informational disadvantage for machine traders, compared to their human counterparts. As such, we exploit this exogenous shock to carry out an econometric analysis of FLPs' liquidity provision in the presence of unexpected information asymmetries.

Crucially, the data to which we were granted access allow us to model the behaviors of individual traders before aggregating their trades for the empirical analysis. We can therefore compare FLP behavior with the respective trading patterns of the erstwhile Locals in trading pits (the "Dead") and of "*e*-Locals" on the electronic platform (the "Slow"). We analyze behaviors before, amid, and after the onset of electronic ("*e*-") trading in 2006 and the Cushing crisis. In all

[2] While today's equity markets are almost all organized as order-matching markets with voluntary liquidity provision, such was not the case earlier. Liquidity providers in traditional dealer-based equity markets, like the specialists on the New York Stock Exchange and the competing market makers on NASDAQ or in London, used to have affirmative obligations to always stand ready to supply liquidity and to maintain orderly markets. In spite of the increasing ability of public traders to contribute to liquidity supply, and of the deregulation that has taken place over the past two decades, market-making affirmative obligations in the main U.S. equity markets have not entirely disappeared, though the ambit and effective impact of these affirmative obligations have significantly declined. Anand and Venkataraman (2016), for example, analyze the effect of market making obligations on the reliability of liquidity provision in an environment where both endogenous (voluntary) and designated market makers coexist.

cases, we ask whether FLPs significantly reduce their participation and liquidity provision (overall and to customers) in response to information shocks (e.g., in periods of large and persistent volatility), liquidity shocks (e.g., in periods of large and persistent customer demand imbalances and during roll periods), or elevated information asymmetry (e.g., around preannounced releases of market-moving news and during the Cushing storage crisis).

Our results provide empirical evidence on the impact of anonymity (Benveniste, Marcus and Wilhelm, "BMW" 1992) and trader speed (Aït-Sahalia and Saglam, 2014) on liquidity provision under stress. We find little difference between the contemporaneous behaviors of Locals (trading face-to-face in the Pits) *vs. e*-Locals (who do so anonymously on the electronic platform), suggesting that anonymity is not what makes FLP behavior special. Rather, we find that FLPs withdraw more than do human liquidity providers during high-volatility and during information-rich periods. Our empirical finding that FLPs substantially scale back their liquidity provision in response to elevated volatility complements theoretical predictions (Aït-Sahalia and Saglam, 2014) that, insofar as high-frequency traders (HFTs) have no competitive advantage regarding fundamental information and rely on speed to capture tiny spreads, HFTs will be at an informational disadvantage (and are therefore likely to pull back more) during such episodes.

The remainder of the paper is organized as follows. Section 2 places our contribution within the extant finance literature. Section 3 describes the data. Section 4 presents our empirical results. Section 5 summarizes the paper and offers concluding remarks.

2. Contribution.

Almost all prior empirical studies examining the impact of FLP activity on market quality

do so only under normal or average market conditions[3] rather than during stressful periods, however defined.[4] Furthermore, extant studies do not tell us how FLPs differ from other liquidity providers with respect to trading behaviors. It is therefore important to empirically test, *with benchmarks as precisely controlled as possible*, whether FLPs' contribution to liquidity supply is as reliable and stable as that of other voluntary liquidity providers during times of market stress. In this paper, we investigate the impact of stressful periods on FLP behavior, and benchmark FLP behavior against the concurrent trading patterns of Locals and *e*-Locals.

We are able to cleanly examine the effect of anonymity on the fragility of liquidity provision, thereby shedding light on the Benveniste, Marcus and Wilhelm (1992) (hereafter "BMW") hypothesis that, in an environment where traders are not anonymous, longstanding relationships between market participants can mitigate the effects of asymmetric information. BMW argue that, if a particular broker/trader is identified as having traded on private information, then that broker/trader will face long-term "sanctions" whose costs will outweigh the benefits of concealing the private information. Consequently, floor traders/market-makers should in theory be able to separate informed and uninformed traders more efficiently than their counterparts in an electronic exchange, and the resulting separating equilibrium should dominate

[3] See Menkveld (2016) for a thorough review. Hendershott and Riordan (2013) find that high frequency traders play a positive role in price efficiency through their marketable orders. Hasbrouck and Saar (2013) find that low-latency activity improves traditional market quality measures such as short-term volatility, spreads, and displayed depth in the limit order book. Brogaard, Hendershott, and Riordan (2014) also find that high-frequency traders generally provide liquidity and correct mispricing of securities. Hendershott, Jones, and Menkveld (2011) find that the introduction of auto-quote on the NYSE improves liquidity and enhances the informativeness of quotes. Raman, Robe, and Yadav (2014) establish empirically that the big increase in trading by financial institutions that followed the 2006 introduction of electronic trading at the NYMEX led to higher market quality and pricing efficiency.

[4] Recent exceptions include Raman, Robe, and Yadav (2015) and Jain, Jain, and McInish (2016). Another exception is Brogaard, Hendershott, and Riordan (2014). They conclude, using 2008-2009 data on trades executed against liquidity on the NASDAQ exchange (excluding trades executed on other stock markets), that HFTs do not reduce their liquidity supply on high-volatility days. Their data, unlike ours, do not identify each trader individually, so their results rely on an artificial "aggregate" HFT – see also Carrion (2013) and Chordia (2013). A further advantage of our dataset is that it allows us to compare liquidity provision at the trader level in electronic (after 2006) *vs*. non-electronic (2006) market environments.

the pooling equilibrium obtained in anonymous electronic exchanges.[5] Since FLPs and *e*-Locals operate in an anonymous trading environment, they should both have greater sensitivity to perceived informational asymmetries than would Locals in the traditional floor/pit trading environment – where reputational considerations would have been likely relevant. Hence, the BMW framework predicts that voluntary FLPs and *e*-Locals would both be more likely than the face-to-face Locals to exit the market and reduce their contribution to overall liquidity during periods of information-related market stress, while there should be no differences between trader types in the handling of pure liquidity shocks. Our results, spanning several different time periods and different ways of measuring stress, consistently show that the liquidity provision behavior of *e*-Locals is not significantly different from that of Locals, whereas the behavior of FLPs is consistently different. Hence, our results are not consistent with an impact of anonymity, and do not support BMW.

We are able to also examine the effect of speed on the fragility of liquidity provision. Aït-Sahalia and Saglam (2014, hereafter "AS") propose a model of dynamic trading where a strategic FLP exploits its speed advantage to receive an imperfect signal about the future order flow and to increase its profits as a market maker. The model predicts that high volatility would lead the FLP to reduce its provision of liquidity. Intuitively, FLPs provide liquidity through limit orders just one or two ticks away from the current price but, insofar as they have no informational advantage regarding fundamental factors, they risk losses outside their tolerance limit in periods of high volatility; hence, they choose instead to withdraw from market

[5] Franke and Hess (2000), using data from two European exchanges (DTB and LIFFE), show that in periods of low information intensity, the insight into the order book of the electronic trading system provides more valuable information than floor trading, but in periods of high information intensity, this is not the case. Similarly, Easley, Prado and O'Hara (2011) show that order flow "toxicity" peaked around the 2010 "flash crash" event in U.S. equity markets. Zigrand, Cliff, and Hendershott (2011) argue that high-frequency traders rely on automated risk management algorithms to mitigate the disadvantage arising from the fact that they have no way of knowing the information level of their counterparties: these risk management algorithms tend to limit high-frequency trader participation and liquidity provision at the first hint of a spike in informed trading.

participation and liquidity provision at such times. Put differently, FLPs are the prototypical 'short-horizon' traders in De Long, Shleifer, Summers and Waldmann (1990)—bearing position risks only when they expect to profitably offload their positions within their trading horizon. The trading advantage of FLPs stems from their ability to trade in and out of positions faster than other traders (Javanovic and Menkveld, 2010); and this agility is hindered when capital is locked-up in a single position. Therefore, the lower the chances of profitable inventory rebalancing in a short period of time, the greater the reluctance to take a position. Under the maintained hypothesis that FLPs' sole advantage over other types of liquidity providers comes from their higher trading speeds, our results are consistent with the AS predictions.

3. Data

The data we employ comprise all intraday transaction records for WTI sweet crude oil futures and options-on-futures at the New York Mercantile Exchange (NYMEX) from January 3rd, 2006 to June 30th, 2009. The CFTC provided these confidential data for the purpose of the present study.

The raw CFTC data include details such as the commodity traded and delivery month, the quantity, the price, the date, and the time of the transaction, and buyer and seller identity codes. These codes conceal the actual identities of the market participants while enabling the analysis of a trader's activity in different contracts over time. In any event, we aggregate the account-level data across dozens, hundreds, or thousands of accounts in order to protect the confidentiality of individual traders' underlying position(s) and trade secrets or trading strategies.

Importantly, these data classify traders into one of four customer types via a Customer Type Indicator (CTI), which ranges from 1 to 4 as follows:

- CTI 1 traders are the individual members of the exchange, also known as "Locals";
- CTI 2 traders are the institutional members of the exchange;
- CTI 3 traders are exchange member traders trading on behalf of other member traders;
- CTI 4 are customers of the exchange or external traders.

The era of electronic trading of WTI futures on the Globex platform starts September 5th, 2006. Prior to that day, there was no electronic trading during Pit hours. Until January 31st, 2007, Pit trading used to take place between 10am and 2:30pm (EST); starting February 1st, 2007, Pit hours were extended to 9am-2.30pm. In our Globex sample, WTI futures trade around the clock except between 5:15pm-6pm. Even on the Globex platform, most of the WTI futures trades (~90%) in our sample take place between 9am-2.30pm. In order to ensure proper comparisons between the *pre*- and *post*-electronic periods, we therefore restrict the analysis of Globex (*Pit*) trading to the activity taking place in the hours between 9am—2.30pm (*Pit business hours*).[6] Figure 1 shows the evolution of trading volume on different NYMEX platforms between January 2006 and December 2007. Electronic trading develops rapidly and dominates after March 2007.

Our final samples use data from January 3rd, 2006 to March 31st, 2007 for the intraday analyses and from April 1st, 2008 to June 30th, 2009 for the daily analyses. Figure 2 displays the Hasbrouck (1995, 2002) information shares of the electronic and Pit WTI futures trading venues after electronification. The graph shows that much, but not all, of the price discovery takes place on Globex during our intraday sample period (October 2006—March 2007).

3.1 Identification of Fast Liquidity Providers (FLP)

[6] For similar reasons we also remove from our sample the Friday following a Thanksgiving holiday, all days starting with the last full business day before Christmas till the first business day after New Year, and trading days that coincide with the Martin Luther King holiday. Data regarding a prompt contract are excluded on its last trading day.

All of the trading in our pre-electronic sample happens in the Pits: there are therefore no FLPs prior to September 5th, 2006. We identify FLPs in the electronic sample on a monthly rolling basis, using two criteria. First, by definition, FLPs are fast traders. We set the minimum speed requirement for inclusion in the FLP group at an average of 6 trades or more per minute during trading hours, every day when the trader is active in at least one month prior to the month when the trader is being classified as an FLP.[7] This level of speed entails trading more than 2,000 times a day. Second, we require that (in that same prior month) FLPs' end-of-day positions be tiny compared to their daily trading volume. In line with prior literature (e.g., Kirilenko, Kyle, Samadi, and Tuzun, 2014), we set that cutoff at 5 percent.

Based on these criteria, we identify 16 FLPs for our intraday analyses in the six-month period from October 2006 to March 2007 and 87 FLPs for the daily analyses in the one-year period from July 2008 to June 2009. Those FLPs make up less than one percent of all trading accounts but between 30 percent (Fall 2006) and 50% (2008-2009) of the overall trading volume in the world's most active commodity futures market. FLPs' average trade size is less than the average market trade size. Consistent with our selection criteria, FLPs carry little of their daily trading overnight: their Mean Closing Ratio (End-of-Day Inventory/Total Trading) is ~ 0.00%.

3.2 Identification of Locals and e-*Locals*

As do Manaster and Mann (1996), we identify Locals as CTI 1 traders in the Pits. There are close to one thousand Locals in our pit sample (January 2006 till March 2007): we focus on the several hundred Locals who trade more than 25 times a day. As is the case for FLPs, Locals'

[7] Using prior-month behavior for FLP classification is meant to rule out possible endogeneity issues. For this reason, our analysis of FLP liquidity provision starts in October, rather than in September, of 2006.

mean trade size is less than the average market trade size and they tend to go-home 'flat' (their Mean Closing Ratio is also ~ 0.00%).

All of the CTI 1 traders in the pit sample trade less than 450 times a day. On Globex (after electronification), we therefore define "*e*-Locals" as CTI 1 traders who likewise trade less than 450 times a day. This cutoff guarantees that there is a big difference between the respective trading speeds of (*e*-)Locals and FLPs.[8]

3.3 Trader Participation and Liquidity Provision

For each voluntary liquidity provider category—FLP or (*e*-)Local—we define market participation as the proportion of all trades in which those traders in the aggregate are involved on the buy-side or on the sell-side of the transaction. For the intraday analyses (2006—2007), we calculate participation rates every minute as volume-weighted averages across all 84 futures contract maturities. For the 2008—2009 analyses, figures are aggregated daily. Similarly, we compute servicing of customers as the proportion of all trades in which a given type of voluntary liquidity provider is involved on the buy-side or on the sell-side of the transaction and a customer (traders classified as CTI 4 in CFTC data) is on the other side. We compute each group's overall liquidity provision in terms of their proportion of passive trades (a proxy for posting standing limit orders), and the group's aggregate liquidity provision to customers as the proportion of all their passive trades where a customer is the "aggressor." Table 1 provides summary statistics.

3.5 Realized spreads

We calculate the realized spreads, for customers trading with various kinds of liquidity providers (FLPs, Locals, or *e*-Locals), as the forward-looking difference (in the following five

[8] A recent analysis of 2012 CME futures order-book data suggests that the fastest humans trade at most 60 times an hour, which amounts to 330 trades in our case (Fishe, Haynes, and Onur, 2015).

minutes) between the average buy prices paid by customers to liquidity providers and sell prices received by the same customers from those liquidity providers. For the 2008—2009 analyses, we aggregate these five-minute figures daily on a volume-weighted basis.

3.5 Market Variable Definitions

Finally, as we do for our trader participation and liquidity provision variables, we calculate all market variables (returns, volatility of returns, bid-ask spreads, customer demand imbalances) as volume-weighted averages. We first compute all of our market variables in 1-minute intervals for each contract maturity, then we compute volume-weighted average figures across all 84 futures contract maturities. In the regression analyses, we use as independent variables the moving averages (for the last 60 minutes) of these one-minute variables.

Volume, Returns, Volatility of Returns, and Bid-Ask spreads are calculated as done in the prior literature. We also use Customer Demand Imbalances (denoted CDI and calculated as the absolute difference between CTI4 or Customer Buy *minus* CTI4 or Customer Sell Volumes) to indicate the direction and magnitude of the liquidity demanded by customers of the exchange.

Table 1 provides descriptive statistics of the market variables in the time periods for which we use them in intraday analyses (January to June 2006 in the pits; October 2006 to March 2007 on Globex. Table 1 yields the following observations. The volatility of returns is not substantially different between the two sub-samples, allowing for valid comparisons of intraday market participation and liquidity provision before and after the onset of electronic trading. As Figure 3 also shows, realized spreads are higher *pre*-electronification: clearly, Pit trading was more profitable for liquidity providers than electronic trading is for FLPs.

Table 2 provides descriptive statistics of voluntary market-making activity in the time periods that we analyze intraday (January to June 2006 in the pits; October 2006 to March 2007

on Globex) and daily (July 2008 to June 2009 on Globex). As expected, volume (daily) is much higher in the 2008—2009 sample than in 2006—2007.

4. Intraday Analyses of the Impact of Stress on Liquidity Provisions

Intuitively, one would expect market makers to be reluctant to trade and provide liquidity during crashes. To wit, floor traders on the NYSE and dealers in NASDAQ both closed shop on "Black Monday" (October 19th, 1987). Yet, FLPs may have an inherent disadvantage in dealing with some fundamental information arrivals (Aït-Sahalia and Saglam, 2014). Because their goal to maximize their trading with minimal capital investment, they may therefore be extremely sensitive to even fairly minor deviations from "normal" market conditions. Put differently, it might not take a market-wide crash for FLPs to pull back: relatively small intraday perturbations have the potential to instigate an FLP withdrawal.

To test this conjecture, this Section examines the trading and market making of FLPs when intraday market conditions deviate from their sample mean by more than two standard deviations for at least 60 minutes. Crucially, we benchmark FLPs' participation and liquidity provision against those by *e*-Locals on Globex during the same period of time (October 2006 to March 2007) as well as with that of Locals in the Pits—both when competing with electronic traders after electronification (October 2006 to March 2007) and preceding the WTI futures market's electronification in the first half of 2006 (January to June).

4.1 Overview of the methodology

In all our univariate and multivariate intraday analyses, we examine how the behavior of FLPs and (*e*-)Locals is affected by different market conditions. We consider participation (the proportion of trades in which an intermediary group is involved on at least one side of the

transaction) and liquidity provision (the proportion of trades in which an intermediary group is passive); in both cases, we look at overall activity and at trading with customers.

The greater the proportion of trading volume for which market makers are passive traders providing liquidity, the better the contribution to liquidity provision. In this context, one can proceed in two ways.

First, extant work uses the textbook perspective on liquidity provision: a trader is deemed to be supplying liquidity when s/he is posting a standing limit order and demanding liquidity when s/he is "picking" an existing limit order through a market order or a marketable limit order. However, this perspective is not the only perspective that should be taken to liquidity provision. Market makers supplying liquidity engage in active inventory management, and have to occasionally demand liquidity to rebalance their inventory. With FLPs, this ratio can be much higher – up to 40% *vs*. 15 to 20% historically (Sofianos, 1995) in conventional dealer markets.

A second way to measure the extent of liquidity provision by a market maker is to estimate the extent to which "customer order flow" finds FLP counterparties to consummate their trades. Our data allows us to measure the extent to which FLPs offset customer order-flow, and we use this as a second measure of liquidity provision by a market maker.

4.2 Marking activity in different market conditions: Univariate analysis

This subsection provides the results of univariate intraday analyses of the respective behaviors, in different market conditions, of FLPs and (*e*-)Locals in various sample periods. Precisely, Table 3 provides a picture of these three types of voluntary liquidity providers in normal market conditions and during periods of market stress. The latter are defined in terms of either high volatility or high customer demand imbalances – where "high" is defined in terms of being two standard deviations away from the mean for the past 60 minutes. When volatility or

customer demand imbalance is greater than two standard deviations, it means that the average of the one-minute return volatility or the average of the one-minute order imbalances over the past one hour has been abnormally high. All variables are standardized by quarter prior to running T-tests;[9] in all cases, the univariate analyses omit the first 30 minutes of the trading day.

Panel A of Table 3 provides strong and statistically significant conclusions. First, when volatility is persistently high, FLPs reduce their participation substantially. They also service significantly fewer customer trades, their overall liquidity provision in terms of posting standing limit orders falls significantly, and their liquidity provision to customers also falls significantly. Second, when customer demand imbalances are persistently high, the FLP univariate results are in the same (negative) direction but both economically and statistically weaker. That is, the extent of participation and the liquidity provision by FLPs are affected, both in general or specifically to customers, but to a lesser extent than amid high-volatility episodes. This finding is consistent with the intuition that *customer* demand imbalances are liquidity shocks that do not contain much information regarding future returns.

Overall, the univariate analyses in Panel A indicate that FLPs tend to withdraw and to provide less liquidity in episodes of market stress, most notably when volatility is high. Insofar as there is, to date, no extant empirical analysis of purely voluntary liquidity provision in periods of market stress, one might be tempted to conclude that Panel A in Table 3 is representative of all voluntary market-makers' behavior during stressful periods. Panel B *(C)* of Table 3, however, summarizes a corresponding analysis of the contemporaneous behaviors of *e*-Locals (*Locals*) alongside the FLPs on Globex (*in the Pits*) – and, for both Locals and *e*-Locals, these results differ from the FLP results reported in Panel A.

[9] FLPs are involved in between a quarter and a third of all trades in the last quarter of 2006, and in approximately one half of all trades starting in January 2007. For this reason, we standardize variables separately for each quarter.

First, when the volatility of returns is persistently and significantly high, neither the liquidity provision by *e*-Locals alongside FLPs (Panel B, October 2006 to March 2007) nor that by Locals side-by-side in the Pits (Panel C, same period) is statistically significantly reduced.[10] Panel D of Table 3, which summarizes similar univariate analyses of Locals' behavior from January to June 2006, shows that the Pit Locals' trading activity and liquidity provision were similarly impervious to high intraday volatility even before the NYMEX futures market's electronification and the emergence of FLPs.

Second, in another contrast to the high-volatility results, we find that persistently high customer demand imbalances have differential impacts on Locals (Panel C) *vs*. *e*-Locals (Panel B) *vs*. FLPs (Panel A). While FLPs and Locals exhibit a statistically significant negative reaction to those liquidity shocks (in terms of participation and liquidity provision), *e*-Locals do not. Again, Panel D in Table 3 shows that the behavior of Locals in the Pits is qualitatively similar before and after electronification.

There are several possible reasons why the high-volatility results differ for (*e*-)Locals and FLPs. First, compared to fast liquidity providers, it may be that Locals are better informed about price and liquidity schedules because human interaction in the Pits provides more intelligence than what is available through anonymous trading in the electronic market. This explanation is unlikely, however, given that *e*-Locals behave similarly to Locals even though the former do not have access to such intelligence.[11] Second, (*e*-)Locals could be less averse to taking positions during stressful periods because they have longer trading horizons than FLPs. Third, and most interestingly, our findings are in line with the theoretical view that increased return volatility is

[10] To the contrary, e-Locals *increase* both their overall participation and liquidity provision (though the increase is statistically insignificant in their interactions with customers).

[11] In additional robustness checks, we find similar results for Locals who are active both in the Pits and on the Globex platform – see "overlap Locals", Panel E of Table 2.

associated with the arrival of new information that FLPs, but not human traders, are at a disadvantage to process—leading FLPs to pull back (Aït-Sahalia and Saglam, 2014).

4.3 Marking activity in different market conditions: Multivariate analysis

This sub-Section revisits the univariate results of Section 4.2 by regressing our measures of FLP or (*e*-)Local participation and liquidity provision on the extreme events already discussed (persistently high intraday volatility or customer demand imbalances), as well as on 1-minute lagged values of the market condition variables and on dummy variables that capture exogenous changes in the liquidity or information environment. All of these variables (save dummies) are standardized as in the univariate analyses.

Specifically, our regressions control for: the 30 minutes right after the beginning or right before the end of a given platform's main business hours; dummies for three windows before (30 minutes), during (5 minutes), and after (30 minutes) market-moving announcements – for WTI futures, we focus on the Energy Information Administration's (EIA) weekly report on petroleum inventories, which are released at either 10:30AM on Wednesdays (most weeks) or 11AM on Thursdays (some weeks); day-of-the-week dummies; and, days when those commodity index traders ("CITs") following the GSCI indexing methodology roll over their near-dated positions (between the 5th and 9th business days of the month). Singleton (2014) and Sockin and Xiong (2015) argue that, in theory, the trading volume during the GSCI roll could reveal (or be perceived to contain) new information about fundamental market conditions; accordingly, we use two separate dummies: one for the first day of the GSCI roll (when that information would first percolate) and another for the next four days (when any changes to the usual environment would instead stem from the need to accommodate unusually large customer demand imbalances).

Overall, the multivariate results in Table 4 confirm that FLPs significantly reduce their participation (Models 1 to 4) and contribution to liquidity provision (Models 5 to 8) when the magnitude or the rate of new information arrival are elevated (as captured by periods of persistently high volatility of returns) but that FLPs are less sensitive to liquidity shocks (as captured by persistently high customer demand imbalances or "CDI"). Specifically, the "Volatility-High" regression coefficients in all of our models are negative and strongly statistically significant whereas the "CDI-High" regression coefficients are much smaller in magnitude and are statistically significant only in the case of overall participation (what is more, FLP trading with – and FLP liquidity provision to – customers are either insignificantly or barely significantly affected by extreme CDIs).

The corresponding results for Locals in the Pits are in Table 5 (contemporaneously with FLPs, October 2006 to March 2007) and Table 6 (prior to FLPs' arrival, January to June 2006). First, as in the univariate analysis, both Table 5 (*post*-electronification) and Table 6 (*pre*-electronification) show that Locals neither pull back from the market nor reduce their provision of liquidity (overall and to customers) in periods of high volatility. In contrast, while the results are mixed with respect to the propensity to trade, Locals' liquidity provision is significantly and negatively impacted by high absolute customer demand imbalances.

A natural question is whether the difference observed between FLPs and Locals is due to anonymity, or to some other FLP-specific characteristic. Table 7 helps answer this question.

First, Table 7 directly compares with FLPs another group of traders who benefit from anonymity on the electronic platform: *e*-Locals. For the sharpest possible comparison, Table 7 (similar to Panel E of Table 2) looks at how the *differences* between the two groups intraday rates of participation and liquidity provision are impacted by stressful events. Consistent with the

results for Locals in the Pits (Tables 5 and 6) and with the univariate analyses (Panels C and D in Table 2), Table 7 shows that FLPs withdraw from the market more than do *e*-Locals both amid information shocks (persistently high volatility) and—to some extent—also amid liquidity shocks (persistently large customer demand imbalances), with a much bigger difference in the case of information-related shocks (high volatility) and statistically insignificant differences between the two types of traders in terms of liquidity provision in the case of liquidity shocks.

Unlike FLPs, of course, *e*-Locals are human and thus could also trade in the pits. To rule out the possibility that the difference between e-Local and FLP trading patterns is driven by information gleaned through human interaction the trading Pits, we revisit the behavior of Locals whose activities "overlap" electronic and human markets, by limiting the analysis only to CTI 1 traders who are active concurrently in the Pits and also on Globex between October 2006 and March 2007. More than half of all Locals in our Pit sample fall in that category. In unreported results, for this subset of Locals, we again find (similar to the above results for all Locals) no impact of high return volatility on either participation or liquidity provision, and only an impact on participation in the case of high absolute customer demand imbalances.

5. Daily Analyses of the Impact of Major Exogenous Shocks on Liquidity Provision

A natural question is whether our central finding in Section 4—the significant decrease in FLP participation and liquidity provision rates in periods of elevated intraday return volatility—is echoed by their response to a major, multi-week change in the informational environment. In Section 5.1, we argue that the Winter 2009 storage glut crisis in Cushing, OK, constitutes an ideal such episode. In section 5.2, we use the Cushing crisis to show that FLPs indeed pull back in situations where they have an informational disadvantage.

5.1 The Cushing storage crisis

The NYMEX's WTI futures contracts are commodity-settled. Their delivery point is located in Cushing, a small Oklahoma town that is a major cog in the U.S. oil infrastructure. Pipelines running through the town connect the main landlocked North-American oil fields to the Gulf of Mexico and points beyond, while Cushing's storage tanks have the capacity to hold tens of millions of barrels of crude oil.

Due to a massive growth in North-American crude oil output brought about by the fracking revolution and due to infrastructure bottlenecks hindering the shipment of crude from Cushing to the Gulf of Mexico, exceptionally large amounts of oil were stored in Cushing by late Fall 2008 and Winter 2009. As a result, a shortage of storage capacity developed. Büyükşahin, Lee, Moser, and Robe (2013) document that these conditions brought about "a change in price dynamics for WTI crude" and a partial decoupling of the WTI benchmark from other crude oil benchmarks. Crucially for our purposes, these authors document that the price dynamics changes were due solely to local inventory conditions—and, as a result, that the changes affected WTI only and not "seaborne crudes like Brent (that could) easily be transported to meet worldwide demand (or, given weak energy demand, could be stockpiled cheaply on floating storage)."

5.2 FLP and e-Local liquidity provision during the Cushing crisis

The Cushing crisis involved large levels of informational asymmetries regarding physical crude oil market fundamentals in general and the state of petroleum inventories in particular (Büyükşahin *et al*., 2013). Intuitively, FLPs should be less adept than human traders at processing this type of environment. That is, the crisis gave human traders an informational advantage over machines, in that adapting trading strategies to uncertainty regarding changing

inventory conditions at Cushing required site-specific knowledge that became known to the public only at discrete (weekly) intervals.

The Cushing crisis is clearly exogenous to the trading activities of automated traders in general and FLPs in particular. We therefore exploit it to carry out a regression analysis of FLP liquidity provision under extreme informational stress. To this end, we analyze one year of daily data from July 1st, 2008 to June 30th, 2009.

As a first pass approach, we start our analysis by simply dividing the 2008—2009 time period. We define a *Cushing_crisis* dummy that takes the value 1 from December 17th, 2008 to February 17th, 2009 and 0 otherwise. The cutoffs are based on extreme crude oil inventory levels during that period, with the slope of the term structure of WTI futures prices exceeding its 2002-2012 mean by more than two standard deviations (Robe and Wallen, 2016). Because the Cushing crisis came on the heels of the global market upheavals that ensued from Lehman Brothers' demise, we need to control for possible changes in the crude oil futures trading environment caused by Lehman's failure. To that effect, we use a *Lehman_Crisis_Long* dummy variable that takes the value 1 from September 15th, 2008 (Lehman bankruptcy) to January 15th, 2009—and 0 otherwise. We select the end date based on the level of the TED spread, which exceeded its 2002-2012 mean by more than two standard deviations during that four-month period.

The results of our daily dummy regressions are summarized in Table 8. For both the FLP rates of participation and liquidity provision (whether overall or with customers), the signs of the Lehman and Cushing crisis dummies are negative in all models: clearly, fast liquidity providers pull back during both crises. During the Lehman crisis, FLP results are statistically significant (at the 5 percent level) only for liquidity provision – not for participation. In contrast, FLP trading and liquidity provision both fall dramatically in the case of the Cushing crisis: the magnitude of

FLPs' pullback is two to four times as large as it is amid the Lehman crisis, and the statistical significance is very strong (almost all *p*-values are less than 0.0001).

As a second pass approach, we replace the Lehman and Cushing crisis dummies by two continuous variables designed to capture each crisis episode: respectively, the VIX for Lehman Brothers and the absolute value of the WTI futures term structure slope (denoted *Slope*) to capture the Cushing crisis. Using these alternative specifications, we obtain qualitatively similar (and therefore unreported) results as with the dummy regressions: FLP participation and liquidity provision are statistically significantly depressed by storage-related informational asymmetries in the physical space (captured by the *Slope* variable) but much less so by the economy-wide stress that characterized the Lehman episode (captured by the *VIX*).

We carry out a third analysis of FLP liquidity provision in the presence of unusually high asymmetric information, by comparing FLPs' behavior with that of human liquidity providers. To do so, we note that, by 2008, most of the trading activity in the futures pits had died out, but most of the option trading activity still took place in the Pits. We therefore use, as benchmarks for FLP behavior, futures trading by hundreds of *e*-Locals on Globex (Table 9) as well as options trading by hundreds of Locals in the Pits (Table 10). Tables 9 and 10 show that, during the Cushing crisis, FLPs pulled back much more than Locals did. Insofar as (*e*-)Locals are better at handling fundamental information, these results confirm that FLPs pull back in situations where they have an informational disadvantage.

6. Spreads

Sections 4 and 5 analyze the impact of information and liquidity shocks on the extent to which various kinds of voluntary market makers participate in trading and liquidity provision. Liquidity providers facing stress, however, can react not only by pulling back from trading but

also by changing the prices at which they agree to trade. In this Section, we therefore look at the impact of market stress on customers' realized spreads, conditional on trading with FLPs or *e*-Locals. Similar to our modeling approach for participation rates, we carry out intraday analyses of the impact stemming from elevated volatility or customer demand imbalances (Tables 11 and 12) and daily analyses of the effects of large exogenous shocks represented by the Lehman and Cushing crises (Tables 13 and 14).

Intuitively, spreads should increase during periods of high volatility. Table 11, though, shows that (statistically speaking) customers' realized spreads when trading with FLPs increase significantly in periods of high customer demand imbalances but are unchanged during periods of high volatility. In other words, while FLPs pull back due to volatility (see Sections 4.2 and 4.3), conditional on trading, spreads do not increase.

Importantly, there is no statistically significant difference between the behaviors of FLPs and *e*-Locals in this regard. Table 12 summarizes the results of an intraday analysis, during the same period (October 2006 to March 2007), of the difference between the patterns exhibited by realized customer spreads with FLP *vs*. *e*-Local in response to market stress. While Table 7 showed that FLPs pull back significantly more than *e*-Locals in response to extreme volatility, we find no statistically significant difference between the responses of customers' realized spreads with either type of intermediary (who do not withdraw) in response to extreme volatility or customer demand imbalances.

Tables 13 and 14 round out our analysis by summarizing daily analyses of the impact of the Cushing crises on customers' realized spreads. Table 13 shows that spreads rose during that major fundamental-information event, as should be expected, with the impact of the information-rich Cushing crisis on spreads being two to three times as large as that of the Lehman crisis (as

captured by the Cushing dummy coefficient of regression). This finding echoes the results for FLP participation rates in Section 5. Table 14, in turn, shows that the Cushing crisis' impact on FLP spreads were significantly larger than on *e*-Local spreads, again in line with the evidence for FLP *vs*. *e*-Local participation rates during the Cushing crisis (in contrast, the average customer spreads of the FLPs who do not withdraw in the high-uncertainty Lehman period do increase, but not differently from those of *e*-Locals).

In robustness checks, we replace the Lehman and Cushing crisis dummies by two continuous variables that capture each episode: respectively, the VIX and the absolute value of the WTI futures term structure slope (denoted *Slope*). Using these alternative specifications, we obtain similar (and therefore unreported) results in Table 14—with the spread difference statistically significantly boosted by the *Slope* (the variable that captures storage-related informational asymmetries in the physical space) but not by the *VIX*.

7. Concluding Remarks

The liquidity and pricing efficiency of financial markets is critically dependent on the market makers who provide liquidity in these markets. With the move to electronic trading, and changes in trading technology, the nature of the market-makers supplying liquidity has changed significantly. Traders in electronic markets trade anonymously and face potentially greater information asymmetries than in markets with floor or pit traders. Electronic markets also allow market makers to have considerably shorter trading horizons. In these contexts, we aim to empirically investigate the impact of information and liquidity shocks on *the reliability and the consistency* with which financial markets now provide transactional liquidity services.

Our empirical analysis is based on trader-level intraday data from U.S. futures markets. Market making in these markets has always been voluntary. Earlier, trading was in futures pits

and Locals were the voluntary market makers. Now, trading is electronic, and the new fast liquidity providers continue to be voluntary. Markets where market-making is voluntary are also more susceptible to issues of reliability and stability in liquidity provision. Hence, these markets provide an ideal laboratory for our investigation.

We find strong evidence that, in contrast both to Locals trading face-to-face in the futures and options pits and to *e*-Locals trading futures anonymously on the same electronic platform, FLPs reduce their participation and liquidity provision in periods of high and persistent volatility (a proxy for informationally-rich environments). The difference between FLPs and (*e*-)Locals is less significant in the case of responses to customer demand imbalances (a proxy for liquidity shocks). Analyses of FLP and (*e*-)Local's participation and liquidity provision amid episodes of extreme market stress in 2008–2009 provide further support that FLPs do not withdraw just due to volatility but, especially, pull back in situations where they face informational disadvantages.

Our findings highlight avenues for further research. In particular, they are consistent with the intuition that FLPs withdraw when the risks arising from fundamental volatility exceed the benefits that FLPs can get from using speed to tease out information in the order flow. One should expect, as a nuance, that FLPs whose business model is predicated more on positioning revenues (from information in the order flow) would withdraw more at times of stress than FLPs that rely more on spread revenues (from passive supply of liquidity and earning of spread). In that spirit, we are currently carrying out a cross-sectional investigation of the links between FLP horizon, passiveness, and sensitivity to market volatility. Second, our findings in the present paper focus on FLPs and human traders – to the exclusion of other machine traders. A natural question is the difference between FLPs, on which we focus, and other algorithmic traders who do not trade as frequently. We investigate those differences in a companion project.

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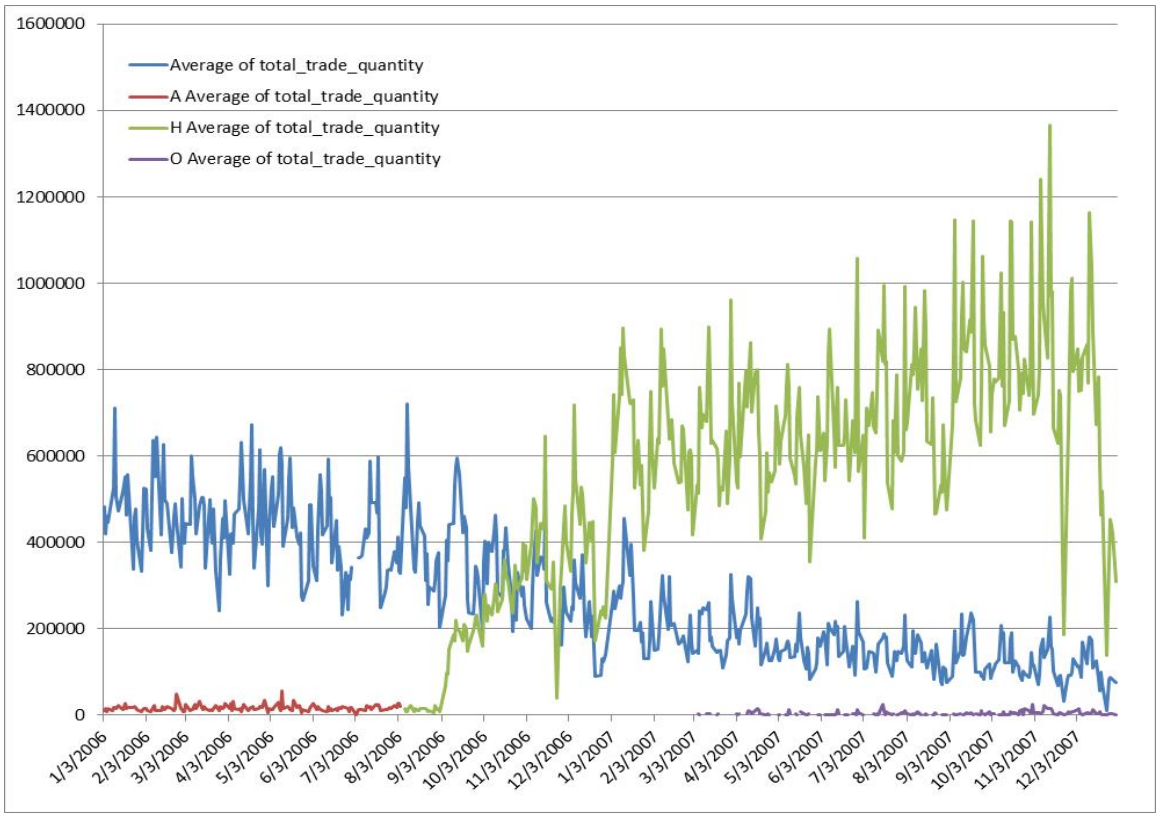
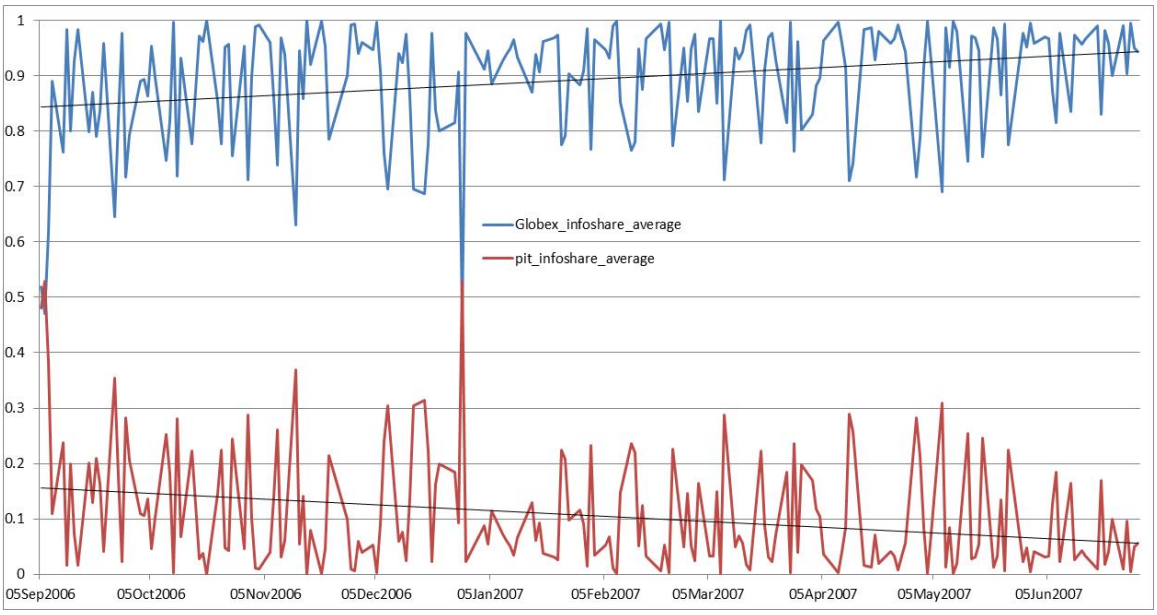
Figure 1: Globex *vs.* Pit Trading Volumes, January 2006 to December 2007



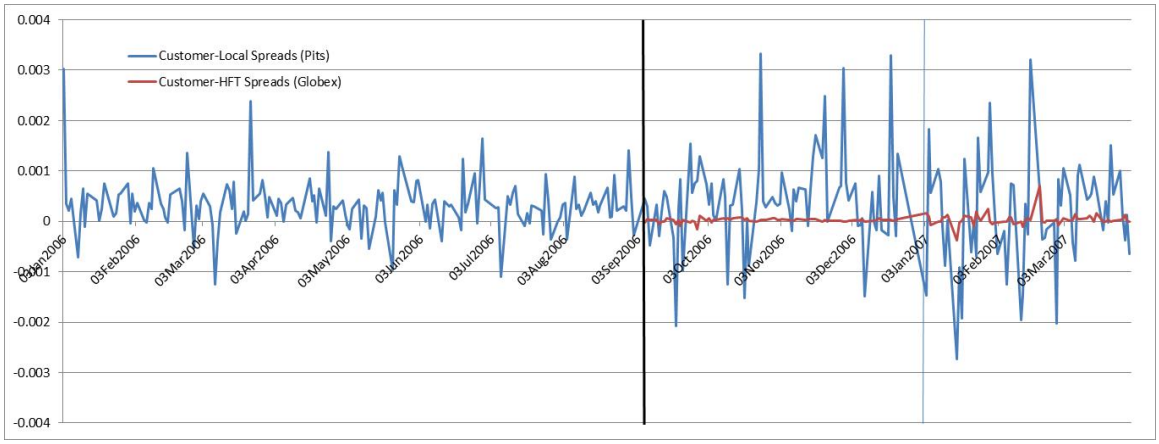
Notes: Figure 1 plots total trading volumes by platform for the NYMEX WTI sweet crude oil futures (all maturities). In green is Globex (H). In blue are the pits. Electronic trades outside of business hours are depicted, until September 1st, 2006, in red (January to July, 2006) or in green (August 2006). Sample period: January 3rd, 2006 to December 31st, 2007.

Figure 2: Globex vs. Pit Information Shares, September 2006 to June 2007



Notes: Figure 2 plots the Hasbrouck (1995, 2002) information shares of the electronic and Pit platforms, estimated through a vector error correction model (VECM) for the bivariate NYMEX floor and electronic (Globex) WTI futures price innovations. Sample period: September 5th, 2006 to June 30th, 2007.

Figure 3: Realized Spreads, January 2006 to March 2007



Notes: Figure 3 plots the daily average realized spreads for trades between customers (traders classified as CTI-4) and two kinds of liquidity providers (FLPs on Globex, Locals in the Pits). We calculate the realized spreads intraday as the forward-looking difference (in the following five minutes) between the average buy prices paid by customers to liquidity providers and sell prices received by the same customers from those liquidity providers, and then plot the average of those intraday figures for each trading day. All figures are volume-weighted averages across all (84) futures contract maturities, over the course of a given day.

Table 1: Sample Description – Market Variables

This table presents summary statistics on market variables for several data periods in the WTI crude-oil futures market. Abs CDI (Absolute Customer Demand Imbalance) is the absolute value of the difference between CTI 4 (Customers) Buy and Sell trading volume. Returns, Volatility, Volume, (Bid-Ask) Spread and Abs CDI are calculated as 60 minute moving averages of 1 minute estimations and are volume weighted averages across all 84 futures contract maturities.

Panel A: January to June, 2006 - Pits

	Mean	Median	Std. Dev.	P10	P90
Volume	818	633	836	169	1598
Return	0.00%	0.00%	0.20%	-0.20%	0.20%
Volatility	0.18%	0.13%	0.17%	0.03%	0.39%
Spread	0.38%	0.29%	0.30%	0.10%	0.78%
Abs CDI	42.15	21.34	81.86	2.39	96.79

Panel B: October, 2006 to March, 2007 – Globex

	Mean	Median	Std. Dev.	P10	P90
Volume	749	543	749	114	1598
Return	0.00%	0.00%	0.08%	-0.09%	0.09%
Volatility	0.06%	0.05%	0.05%	0.01%	0.12%
Spread	0.04%	0.03%	0.04%	0.01%	0.06%
Abs CDI	38.67	21.01	59.98	2.55	89.81

Table 2: Sample Description – Trader Activity

This table presents summary statistics on voluntary liquidity provider (Locals, *e*-Locals, FLPs) activity for several data periods in the WTI crude-oil futures market. *FLPs* are traders who trade more than 2,000 times a day and carry less than 5% of their daily trading volume overnight. *Locals* are traders who are categorized under CTI (Customer Type Indicator) 1 category and trade in the Pits. e-*Locals* are traders who are categorized under CTI 1 category and trade on the electronic platform (Globex). *Customers* are traders who are categorized under CTI 4 category. All variables are calculated over 1-minute intervals as volume weighted averages across all 84 futures contract maturities. *Prop. FLP Volume* is the proportion of trading volume with FLP participation. *Prop. FLP-Customer Volume is the proportion of Customer* volume where *FLPs* trade against *Customers*. *Prop. FLP Passive Volume* is the proportion of trading volume where *FLPs* trade passively. *Prop. FLP-Customer Passive Volume* is the proportion of Customer volume where *FLPs* provide liquidity to *Customers.* Variables for *e-Locals* and *Locals* are analogously defined.

Panel A: January to June, 2006 - Pits

	Mean	Median	Std. Dev.	P10	P90
Prop. Local Volume	83.97%	91.73%	19.58%	55.24%	100.00%
Prop. Local-Customer Volume	77.47%	87.65%	25.84%	36.34%	100.00%
Prop. Local Passive Volume	52.66%	52.82%	19.37%	27.43%	77.49%
Prop. Local-Customer Passive Volume	40.71%	40.17%	23.47%	9.59%	71.84%

Panel B: October, 2006 to March, 2007 - Pits

	Mean	Median	Std. Dev.	P10	P90
Prop. Local Volume	80.59%	99.30%	29.03%	29.33%	100.00%
Prop. Local-Customer Volume	39.68%	33.33%	34.14%	0.00%	94.34%
Prop. Local Passive Volume	49.85%	50.00%	30.57%	6.17%	100.00%
Prop. Local-Customer Passive Volume	38.80%	36.76%	33.20%	0.00%	99.72%

Panel C: October, 2006 to March, 2007 - Globex

	Mean	Median	Std. Dev.	P10	P90
Prop. FLP Volume	28.71%	27.25%	16.90%	7.69%	51.67%
Prop. FLP-Customer Volume	20.19%	17.40%	14.96%	3.48%	40.56%
Prop. FLP Passive Volume	17.17%	15.83%	10.76%	4.49%	31.23%
Prop. FLP-Customer Passive Volume	11.45%	9.39%	9.56%	1.65%	23.53%
Prop. e-Local Volume	24.77%	21.90%	16.89%	16.89%	47.72%
Prop. e-Local-Customer Volume	15.49%	11.28%	15.07%	15.07%	35.36%
Prop. e-Local Passive Volume	12.86%	10.31%	11.00%	11.00%	27.05%
Prop. e-Local-Customer Passive Volume	7.48%	4.63%	9.16%	9.16%	18.18%

Panel D: July 2008 to June 2009 - Globex

	Mean	Median	Std. Dev.	P10	P90
Prop. FLP Volume	57.55%	57.83%	3.60%	52.92%	61.96%
Prop. FLP-Customer Volume	42.60%	42.96%	3.34%	38.45%	46.66%
Prop. FLP Passive Volume	35.93%	36.02%	2.54%	32.72%	38.96%
Prop. FLP-Customer Passive Volume	22.53%	22.57%	1.81%	20.31%	24.62%
Prop. e-Local Volume	12.80%	12.85%	2.06%	9.86%	15.40%
Prop. e-Local-Customer Volume	7.67%	7.75%	1.29%	5.82%	9.30%
Prop. e-Local Passive Volume	6.53%	6.54%	1.03%	5.22%	7.82%
Prop. e-Local-Customer Passive Volume	3.83%	3.87%	0.63%	3.01%	4.67%

Table 3: Trading and Voluntary Liquidity Provision by Market Conditions – Univariate Analysis

This table presents univariate intraday analyses of trading activity and liquidity provision by fast liquidity providers' (*FLPs*, Panel A), *Locals* in the Pits (Panel B), and e-*Locals* on Globex (Panel C) between October 2006 to March 2007 as well as *Locals* in the Pits in the first half of 2006 (January to June 2006, Panel D). Each Panel compares regular periods with periods of market stress, i.e., when market conditions (*Customer Demand Imbalances* in the top sub-panel*, Volatility* in the bottom one) are abnormally high (greater than 2 standard deviations from the mean) for prolonged periods of time (60 minutes). For example, *Volatility-High* is when 1-min *Volatility* (and/or *CD Imbalance*) over the past 1 hour has been greater than twice its standard deviation over the sample period. *FLPs* are traders who trade more than 2,000 times a day and carry less than 5% of their daily trading volume overnight. *Customers* are traders who are classified under the CTI (Customer Type Indicator) 4 category in the dataset. *Prop. FLP Volume* is the proportion of trading volume with FLP participation. *Prop. FLP-Customer Volume is the proportion of Customer* volume where *FLPs* trade against *Customers*. *Prop. FLP Passive Volume* is the proportion of trading volume where *FLPs* trade passively. *Prop. FLP-Customer Passive Volume* is the proportion of Customer volume where *FLPs* provide liquidity to *Customers.* Variables for *e-Locals* and *Locals* are analogously defined. All variables are standardize by quarter (either Fall 2006 or Winter 2007). Two tailed *p-values* are also reported.

Panel A: Stress and FLP Trading and Liquidity Provision *(Electronic, October 2006-March 2007)*

	N	Volume	Prop. FLP Volume	Prop. FLP-Customer Volume	Prop. FLP Passive Volume	Prop. FLP-Customer Passive Volume
Abs CDI - Regular	32846	-0.008	0.005	0.004	0.003	0.002
Abs CDI - High	1610	0.166	-0.103	-0.075	-0.062	-0.041
Difference		0.174	-0.108	-0.078	-0.065	-0.043
p-value		<.0001	<.0001	0.002	0.011	0.092
Volatility - Regular	33356	-0.005	0.011	0.009	0.010	0.008
Volatility - High	1100	0.139	-0.329	-0.287	-0.300	-0.228
Difference		0.143	-0.340	-0.297	-0.310	-0.236
p-value		<.0001	<.0001	<.0001	<.0001	<.0001

Panel B: Stress and Locals Trading and Liquidity Provision (Pits, October 2006-March 2007)

	N	Volume	Prop. Local Volume	Prop. Local-Customer Volume	Prop. Local Passive Volume	Prop. Local-Customer Passive Volume
Abs CDI - Regular	27812	-0.004	0.000	-0.001	0.003	0.000
Abs CDI - High	1195	0.087	-0.002	0.028	-0.062	-0.009
Difference		0.090	-0.002	0.029	-0.065	-0.010
p-value		0.002	0.955	0.346	0.029	0.756
Volatility - Regular	27727	0.003	0.000	0.000	-0.001	-0.002
Volatility - High	1280	-0.072	-0.008	0.010	0.017	0.040
Difference		-0.075	-0.009	0.010	0.018	0.042
p-value		0.009	0.758	0.730	0.530	0.161

Panel C: Stress and Locals Trading and Liquidity Provision (Pits, January-June 2006)

	N	Volume	Prop. Local Volume	Prop. Local-Customer Volume	Prop. Local Passive Volume	Prop. Local-Customer Passive Volume
Abs CDI - Regular	28224	-0.006	-0.001	-0.001	0.000	-0.001
Abs CDI - High	972	0.185	0.036	0.039	-0.002	0.020
Difference		0.191	0.037	0.041	-0.002	0.021
p-value		<.0001	0.257	0.213	0.950	0.524
Volatility - Regular	27677	0.008	-0.001	-0.001	-0.001	-0.001
Volatility - High	1519	-0.147	0.027	0.021	0.017	0.011
Difference		-0.155	0.028	0.022	0.018	0.012
p-value		<.0001	0.286	0.408	0.494	0.665

Panel D: Stress and e-Local's Trading and Liquidity Provision (Electronic, October 2006-March 2007)

	N	Volume	Prop. e-Local Volume	Prop. e-Local-Customer Volume	Prop. e-Local Passive Volume	Prop. e-Local-Customer Passive Volume
Abs CDI - Regular	32846	-0.008	-0.003	-0.003	-0.002	-0.001
Abs CDI - High	1610	0.166	0.062	0.059	0.032	0.028
Difference		0.174	0.065	0.061	0.033	0.029
p-value		<.0001	0.011	0.016	0.191	0.251
Volatility - Regular	33356	-0.005	-0.002	-0.002	-0.002	-0.001
Volatility - High	1100	0.139	0.075	0.059	0.067	0.034
Difference		0.143	0.078	0.061	0.069	0.035
p-value		<.0001	0.011	0.048	0.024	0.258

Table 4: FLP Trading Activity and Market Conditions – Q4, 2006 to Q1, 2007

This table presents an analysis of "Fast Liquidity Providers" (*FLP*) trading during periods of market stress. *FLPs* are defined as traders who make more than 2,000 trades a day and carry less than 5% of their daily trading volume overnight. The analysis is conducted on WTI crude-oil futures trading on the Globex platform in the time period from October 2006 through March 2007. *Dummy_Q1_2007* is a dummy variable equal to 1 during the first quarter of 2007 and 0 otherwise. *Volatility* is the 1-minute volatility of returns. *Abs CDI* is the absolute value of customer (traders classified as CTI 4 traders in the CFTC database) demand imbalance over a 1-minute interval. *Volatility-High* (*Abs CDI - High*) is a dummy variable equal to 1 when the 1-minute *Volatility* (*Abs CDI*) over the past 1 hour has been greater than twice its standard deviation over the sample period. *Open* (*Close*) is a dummy variable equal to 1 during the first (last) 30 minutes of trading. *EIA Pre-Event* is a dummy variable equal to 1 during the 30 minutes before a weekly EIA announcement. *EIA Event* is a dummy variable equal to 1 in the 5 minutes following a weekly EIA announcement. *EIA Post-Event* is a dummy variable equal to 1 between 5 and 35 minutes after a weekly EIA announcement. *First GSCI Roll* is a dummy variable equal to 1 on the first day of the monthly GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2nd and 4th day after a GSCI roll. *Day of the Week* are dummy variables for the first 4 days of the week. *Lags* indicate the number of lags of the dependent variable included in the regression. *Prop. FLP Volume* is the proportion of trading volume with FLP participation. *Prop. FLP-Customer Volume is the proportion of Customer* volume where *FLPs* trade against *Customers*. *Prop. FLP Passive Volume* is the proportion of trading volume where *FLPs* trade passively. *Prop. FLP-Customer Passive Volume* is the proportion of Customer volume where *FLPs* provide liquidity to *Customers.* Two tailed *p-values*, obtained using Newey-West standard errors with 5 lags, are also reported.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Parameter	Proportion of HFT Volume		Proportion of HFT-to-Customer Volume		Proportion of HFT Liquidity Provision		Proportion of HFT-to-Customer Liquidity Provision	
Intercept	19.45%	11.72%	13.27%	9.34%	12.29%	8.03%	8.34%	6.52%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Dummy_Q1_2007	19.01%	11.05%	14.19%	9.54%	10.03%	6.32%	6.41%	4.81%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Volatility		-0.03%		-0.03%		0.01%		0.05%
		0.775		0.804		0.958		0.629
Abs CDI		0.04%		-0.12%		0.01%		-0.11%
		0.544		0.045		0.756		0.003
Return		-0.09%		-0.06%		-0.09%		-0.04%
		0.161		0.297		0.063		0.323
Volatility- High	-4.30%	-2.84%	-3.68%	-2.67%	-2.72%	-1.86%	-2.02%	-1.56%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Abs CDI - High	-0.84%	-0.76%	-0.53%	-0.50%	-0.25%	-0.31%	-0.19%	-0.18%
	0.024	0.011	0.108	0.078	0.293	0.120	0.371	0.361
Open		-0.95%		-0.34%		-0.43%		0.17%
		0.002		0.241		0.049		0.443
Close		-1.19%		-1.19%		-0.79%		-0.75%
		<.0001		<.0001		<.0001		<.0001
EIA Pre-Event		-1.33%		-0.84%		-1.03%		-0.57%
		0.001		0.032		0.000		0.035
EIA Event		1.12%		0.66%		0.16%		-0.18%
		0.199		0.455		0.774		0.736
EIA Post-Event		0.05%		-0.19%		-0.11%		-0.29%
		0.871		0.510		0.587		0.125
First GSCI Roll		-0.11%		0.28%		-0.16%		0.13%
		0.725		0.364		0.459		0.523
GSCI_Roll_Days2to4		0.21%		0.29%		0.17%		0.15%
		0.202		0.071		0.142		0.182
Day of the Week		Yes		Yes		Yes		Yes
Lags		3 Lags		3 Lags		3 Lags		3 Lags
N	37997	37997	37997	37997	37997	37997	37997	37997
Adj RSq	32.05%	38.17%	22.71%	26.56%	22.03%	27.31%	11.36%	13.80%

Table 5: Locals' Trading Activity and Market Conditions – Q4, 2006 to Q1, 2007

This table presents an analysis of trading by "Locals" during periods of market stress. *Locals* are defined as Pit traders who trade more than 25 trades a day and are categorized under CTI (Customer Type Indicator) 1 category. The analysis is conducted on WTI crude-oil futures trading in the Pits over the period September 2006 to March 2007. *Dummy_Q1_2007* is a dummy variable equal to 1 during the first quarter of 2007 and 0 otherwise. *Volatility* is the 1-minute volatility of returns. *Abs CDI* is the absolute value of customer (traders classified as CTI 4 traders in the CFTC database) demand imbalances over a 1-minute interval. *Volatility-High* (*Abs CDI - High*) is a dummy variable set equal to 1 when the 1-minute *Volatility* (*Abs CDI*) over the past 1 hour has been greater than twice its standard deviation over the sample period. *Open* (*Close*) is a dummy variable equal to 1 during the first (last) 30 minutes of trading. *EIA Pre-Event* is a dummy variable equal to 1 during the 30 minutes before a weekly EIA announcement. *EIA Event* is a dummy variable equal to 1 during the 5 minutes after a weekly EIA announcement. *EIA Post-Event* is a dummy variable equal to 1 between 5 and 35 minutes after a weekly EIA announcement. *First GSCI Roll* is a dummy variable equal to 1 on the first day of a monthly GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2^{nd} and 4^{th} day after a GSCI roll. *Day of the Week* are dummy variables for the first 4 days of the week. *Lags* indicate the number of lags of the dependent variable included in the regression. *Prop. Local Volume* is the proportion of trading volume involving Locals' participation. *Prop. Local-Customer Volume* is the proportion of customer (CTI 4) trading volume involving Locals' participation. *Prop. Local Passive Volume* is the proportion of trading volume for which Locals trade passively. *Prop. Local-Customer Passive Volume* is the proportion of customer trading volume for which Locals are the passive traders. Two tailed *p-values*, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Proportion of Local Volume		Proportion of Local-to-Customer Volume		Proportion of Local Liquidity Provision		Proportion of Local-to-Customer Liquidity Provision	
Intercept	80.58%	71.08%	74.38%	66.32%	50.20%	44.82%	39.20%	36.23%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Dummy_Q1_2007	-0.06%	-0.33%	-0.82%	-1.20%	-0.65%	-0.62%	-0.93%	-0.55%
	0.867	0.306	0.060	0.011	0.069	0.070	0.022	0.225
Volatility		-0.10%		0.09%		-0.27%		0.00%
		0.538		0.691		0.100		0.999
Abs CDI		-0.37%		-0.51%		-0.43%		-0.30%
		0.067		0.047		0.016		0.114
Return		0.07%		-0.04%		0.07%		0.01%
		0.653		0.875		0.660		0.975
Volatility- High	0.45%	-0.95%	1.07%	-0.76%	1.20%	-0.01%	1.73%	0.55%
	0.598	0.262	0.323	0.505	0.150	0.987	0.079	0.610
Abs CDI - High	0.71%	-0.70%	1.79%	0.29%	-1.21%	-2.13%	0.10%	-0.85%
	0.434	0.428	0.115	0.814	0.202	0.022	0.924	0.459
Open		-4.14%		-4.21%		-4.64%		-2.08%
		<.0001		<.0001		<.0001		0.003
Close		-5.89%		-6.52%		-4.20%		-3.08%
		<.0001		<.0001		<.0001		<.0001
EIA Pre-Event		-1.85%		-0.03%		-2.07%		-1.02%
		0.079		0.986		0.049		0.428
EIA Event		3.25%		6.34%		-0.73%		1.95%
		0.110		0.016		0.753		0.493
EIA Post-Event		1.68%		2.48%		1.83%		1.49%
		0.020		0.011		0.017		0.125
First GSCI Roll		0.38%		-0.21%		-0.08%		-1.66%
		0.603		0.850		0.916		0.082
GSCI_Roll_Days2to4		-0.18%		-0.96%		-0.73%		-1.28%
		0.647		0.093		0.080		0.016
Day of the Week		Yes		Yes		Yes		Yes
Lags		3 Lags		3 Lags		3 Lags		3 Lags
N	32519	32519	32519	32519	32519	32519	32519	32519
Adj RSq	-0.01%		0.01%	1.40%	0.01%	1.11%	0.02%	0.57%

Table 6 – Locals' Trading Activity and Market Conditions – Q1 and Q2, 2006

This table presents an analysis of trading by "Locals" during periods of market stress. *Locals* are defined as Pit traders who make more than 25 trades a day and are categorized under CTI (Customer Type Indicator) 1 category. The analysis is conducted on WTI crude-oil futures trading in the Pits over the time period from January to June 2006. *Volatility* is the 1-minute volatility of returns. *Abs CDI* is the absolute value of customer (traders classified as CTI 4 traders in the CFTC database) trade imbalance over a 1-minute interval. *Volatility-High* (*Abs CDI - High*) is a dummy variable equal to 1 when the 1-minute *Volatility* (*Abs CDI*) over the past 1 hour has been greater than twice its standard deviation over the sample period. *Open* (*Close*) is a dummy variable equal to 1 during the first (last) 30 minutes of trading. *EIA Pre-Event* is a dummy variable equal to 1 during the 30 minutes before a weekly EIA announcement. *EIA Event* is a dummy variable equal to 1 during the 5 minutes after a weekly EIA announcement. *EIA Post-Event* is a dummy variable equal to 1 between 5 and 35 minutes after a weekly EIA announcement. *First GSCI Roll* is a dummy variable equal to 1 on the first day of the monthly GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2nd and 4th day after a GSCI roll. *Day of the Week* are dummy variables for the first 4 days of the week. *Lags* indicate the number of lags of the dependent variable included in the regression. *Prop. Local Volume* is the proportion of trading volume involving Locals' participation. *Prop. Local-Customer Volume* is the proportion of customer (CTI 4) trading volume involving Locals' participation. *Prop. Local Passive Volume* is the proportion of trading volume for which Locals trade passively. *Prop. Local-Customer Passive Volume* is the proportion of customer trading volume for which Locals are the passive traders. Two tailed *p-values*, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Prop. Local Volume		Prop. Local-Customer Volume		Prop. Local Passive Volume		Prop. Local-Customer Passive Volume	
Intercept	85.06%	70.79%	78.66%	69.23%	53.62%	46.11%	41.10%	37.39%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Volatility		0.03%		-0.07%		-0.10%		0.14%
		0.828		0.692		0.422		0.367
Abs CDI		-0.10%		-0.16%		-0.11%		-0.04%
		0.462		0.332		0.280		0.707
Return		0.07%		0.04%		0.03%		0.00%
		0.536		0.796		0.807		0.983
Volatility- High	0.17%	0.40%	0.45%	0.77%	-0.10%	0.35%	0.42%	0.33%
	0.719	0.432	0.483	0.264	0.835	0.478	0.455	0.593
Abs CDI - High	-5.96%	-4.46%	-5.71%	-4.79%	-3.72%	-3.04%	-1.87%	-1.74%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.020	0.026
Open	-0.90%	0.20%	-0.63%	0.31%	-1.69%	-0.81%	0.35%	0.94%
	0.012	0.571	0.175	0.526	<.0001	0.020	0.376	0.028
Close	-4.77%	-3.91%	-6.20%	-5.45%	-4.28%	-3.59%	-2.60%	-2.31%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
EIA Pre-Event		-2.35%		-2.63%		-2.09%		-1.71%
		0.002		0.006		0.002		0.030
EIA Event		3.74%		4.79%		2.30%		4.36%
		<.0001		0.001		0.072		0.005
EIA Post-Event		2.28%		2.10%		1.62%		0.94%
		<.0001		0.001		0.000		0.094
First GSCI Roll		-1.51%		-1.55%		-1.25%		-1.01%
		0.002		0.018		0.008		0.078
GSCI_Roll_Days2to4		-1.71%		-1.82%		-1.68%		-1.19%
		<.0001		<.0001		<.0001		0.000
Day of the Week		Yes		Yes		Yes		Yes
Lags		3 Lags		3 Lags		3 Lags		3 Lags
N	32594	32594	32594	32594	32594	32594	32594	32594
Adj RSq	0.82%	2.22%	0.66%	1.36%	0.63%	1.60%	0.12%	0.43%

Table 7: FLPs *vs*. *e*-Locals and Market Conditions – Q4, 2006 to Q1, 2007

This table presents an analysis of difference between "Fast Liquidity Providers" (*FLP*) and "*e*-Locals" Globex trading during periods of market stress. *FLPs* are defined as traders who make more than 2,000 trades a day and carry less than 5% of their daily trading volume overnight. *E-Locals* are defined as traders who make more than 25 trades a day on Globex and are categorized under CTI (Customer Type Indicator) 1 category. The analysis is conducted on WTI crude-oil futures trading on Globex over the time-period from October 2006 to March 2007. *Dummy_Q1_2007* is a dummy variable equal to 1 during the first quarter of 2007 and 0 otherwise. *Volatility* is the 1-minute volatility of returns. *Abs CDI* is the absolute value of customer (traders classified as CTI 4 traders in the CFTC database) trade imbalance over a 1-minute interval. *Volatility-High* (*Abs CDI - High*) is a dummy variable equal to 1 when the 1-minute *Volatility* (*Abs CDI*) over the past 1 hour has been greater than twice its standard deviation over the sample period. *Open* (*Close*) is a dummy variable equal 1 during the first (last) 30 minutes of trading. *EIA Pre-Event* is a dummy variable equal to 1 during the 30 minutes before a weekly EIA announcement. *EIA Event* is a dummy variable equal to 1 during the 5 minutes after a weekly EIA announcement. *EIA Post-Event* is a dummy variable equal to 1 between 5 and 35 minutes after a weekly EIA announcement. *First GSCI Roll* is a dummy variable equal to 1 on the day of a GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2nd and 4th day after a GSCI roll. *Day of the Week* are dummy variables for the first 4 days of the week. *Lags* indicate the number of lags of the dependent variable included in the regression. *Prop. FLP Volume* is the proportion of trading volume with FLP participation. *Prop. FLP-Customer Volume* is the proportion of *Customer* volume where *FLPs* trade against *Customers*. *Prop. FLP Passive Volume* is the proportion of trading volume where *FLPs* trade passively. *Prop. FLP-Customer Passive Volume* is the proportion of Customer volume where *FLPs* provide liquidity to *Customers. Prop. e-Local Volume* is the proportion of trading volume involving e-Locals' participation. *Prop. e-Local-Customer Volume* is the proportion of customer trading volume involving e-Locals' participation. *Prop. e-Local Passive Volume* is the proportion of trading volume for which E-Locals are the passive traders. *Prop. e-Local-Customer Passive Volume* is the proportion of customer trading volume for which e-Locals are the passive traders. Two tailed *p-values*, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Prop. FLP Volume – Prop. e-Local Volume		Prop. FLP-Customer Volume – Prop. *e*-Local-Customer Volume		Prop. FLP Passive Volume – Prop. *e*-Local Passive Volume		Prop. FLP-Customer Passive Volume – Prop. *e*-Local-Customer Passive Volume	
Intercept	-4.87%	-3.33%	-2.15%	-1.54%	-0.21%	-0.13%	0.92%	6.52%
	<.0001	<.0001	<.0001	<.0001	0.145	0.552	<.0001	<.0001
Dummy_Q1_2007	17.35%	11.12%	13.66%	9.64%	8.81%	6.17%	5.97%	4.80%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Volatility		-0.07%		-0.12%		-0.15%		-0.04%
		0.571		0.322		0.086		0.450
Abs CDI		0.10%		-0.06%		0.10%		-0.11%
		0.267		0.557		0.110		0.003
Return		-0.13%		-0.10%		-0.10%		-0.02%
		0.189		0.297		0.156		0.570
Volatility- High	-5.63%	-3.79%	-4.65%	-3.35%	-3.47%	-2.36%	-2.33%	-1.52%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Abs CDI - High	-2.03%	-1.44%	-1.56%	-1.16%	-0.62%	-0.51%	-0.45%	-0.18%
	0.001	0.006	0.007	0.026	0.118	0.148	0.165	0.350
Open	5.70%	3.62%	4.04%	2.56%	3.36%	2.33%	2.64%	0.19%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.385
Close	-0.84%	-0.61%	-1.34%	-1.02%	-0.33%	-0.30%	-0.69%	-0.74%
	0.048	0.086	0.001	0.003	0.218	0.206	0.002	<.0001
EIA Pre-Event		-0.24%		-0.43%		-0.61%		-0.56%
		0.729		0.534		0.186		0.040
EIA Event		3.31%		3.40%		1.52%		-0.09%
		0.016		0.006		0.084		0.859
EIA Post-Event		0.14%		-0.30%		-0.17%		-0.28%
		0.789		0.541		0.614		0.141
First GSCI Roll		-0.05%		-0.14%		-0.32%		0.12%
		0.925		0.800		0.378		0.564
GSCI_Roll_Days2to4		0.16%		-0.06%		0.17%		0.15%
		0.584		0.841		0.364		0.192
Day of the Week		Yes		Yes		Yes		Yes
Lags		3 Lags		3 Lags		3 Lags		3 Lags
N	37995	37995	37995	37995	37995	37995	37995	37995
Adj RSq	13.00%	18.26%	9.10%	11.71%	7.93%	11.61%	5.02%	13.80%

Table 8: FLPs' Trading Activity during the Financial Crisis – Q3, 2008 to Q2, 2009

This table presents an analysis of "Fast Liquidity Providers" (*FLP*) trading during the financial crisis of 2008-09. *FLPs* are traders who make more than 2,000 trades a day and carry less than 5% of their daily trading volume overnight. The analysis is conducted on WTI crude-oil futures trading on the Globex platform over the time-period July, 2008 to June, 2009. *Lehman_dummy_long* is a dummy variable that equals 1 from September 15, 2008 to January 15, 2009 and 0 otherwise. Storage issues in Cushing, OK are captured by *Cushing_dummy_AbsStd_PromptSlope,* a dummy variable set equal to 1 from December 17, 2008 to February 17, 2009 and 0 otherwise. *EIA_Inventory* is a dummy variable equal to 1 during EIA announcement days. *Lead_Inventory* is a dummy variable equal to 1 during the days prior to the EIA announcements*. First GSCI Roll* is a dummy variable equal to 1 on the day of a GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2nd and 4th day after a GSCI roll. *Day of the Week* are a set of dummy variable for each day of the week. *Lags* indicate the number of lags of the dependent variable included in the regression. *Prop. FLP Volume* is the proportion of trading volume with FLP participation. *Prop. FLP-Customer Volume* is the proportion of Customer volume where FLPs trade against Customers. *Prop. FLP Passive Volume* is the proportion of trading volume where FLPs trade passively. *Prop. FLP-Customer Passive Volume* is the proportion of Customer volume where FLPs provide liquidity to Customers. Two tailed *p-values*, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Prop. FLP Volume			Prop. FLP-Customer Volume			Prop. FLP Passive Volume			Prop. FLP-Customer Passive Volume		
Intercept	58.12%	58.87%	33.86%	43.30%	44.08%	28.87%	36.49%	37.07%	23.21%	22.87%	23.30%	15.56%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Lehman_dummy_long	-0.64%	-0.59%	-0.34%	-1.05%	-1.03%	-0.70%	-1.00%	-1.00%	-0.65%	-0.62%	-0.61%	-0.43%
	0.294	0.287	0.468	0.064	0.045	0.129	0.016	0.011	0.064	0.040	0.027	0.078
Cushing_dummy_AbsStd_PromptSlope	-2.62%	-2.46%	-1.36%	-2.57%	-2.38%	-1.50%	-1.74%	-1.59%	-0.95%	-1.04%	-0.93%	-0.58%
	0.000	<.0001	0.032	<.0001	<.0001	0.010	0.000	0.001	0.042	0.002	0.007	0.073
EIA_Inventory		0.43%	0.05%		0.21%	-0.23%		0.16%	0.03%		-0.03%	-0.41%
		0.377	0.949		0.643	0.761		0.654	0.963		0.919	0.407
Lead_Inventory		-0.37%	-0.23%		-0.28%	-0.36%		-0.23%	-0.21%		-0.06%	-0.24%
		0.390	0.790		0.496	0.636		0.465	0.744		0.809	0.596
First_GSCI_Roll		-2.39%	-3.04%		-2.95%	-3.49%		-1.81%	-2.17%		-1.59%	-1.88%
		0.003	<.0001		<.0001	<.0001		0.002	<.0001		<.0001	<.0001
GSCI_Roll_Days2to4		-3.50%	-2.45%		-3.29%	-2.46%		-2.40%	-1.72%		-1.72%	-1.28%
		<.0001	<.0001		<.0001	<.0001		<.0001	<.0001		<.0001	<.0001
Day of the Week			Yes			Yes			Yes			Yes
Lags			2 Lags			2 Lags			2 Lags			2 Lags
N	245	245	245	245	245	245	245	245	245	245	245	245
Adj RSq	0.0651	21.34%	31.07%	0.0897	25.17%	30.93%	0.0875	22.93%	29.84%	6.10%	20.86%	26.92%

Table 9: FLPs *vs*. *e*-Locals Trading Activity during the Financial Crisis – Q3, 2008 to Q2, 2009

This table presents an analysis of difference between "Fast Liquidity Providers" (*FLP*) and "*e*-Locals" trading during the financial crisis of 2008-09. *FLPs* are traders who trade more than 2000 trades a day and carry less than 5% of their daily trading volume overnight. *E-Locals* are defined as traders who trade more than 25 trades a day and are categorized under CTI (Customer Type Indicator) 1 category in the Globex (electronic) market. The analysis is conducted on WTI crude-oil futures trading on the Globex platform over the time-period July, 2008 to June, 2009. *Lehman_dummy_long* is a dummy variable that equals 1 from September 15, 2008 to January 15, 2009 and 0 otherwise. Storage issues in Cushing, OK are captured by *Cushing_dummy_AbsStd_PromptSlope,* a dummy variable set equal to 1 from December 17, 2008 to February 17, 2009 and 0 otherwise. *EIA_Inventory* is a dummy variable equal to 1 during EIA announcement days. *Lead_Inventory* is a dummy variable equal to 1 during the days prior to the EIA announcements. *First GSCI Roll* is a dummy variable equal to 1 on the day of a GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2nd and 4th day after a GSCI roll. *Day of the Week* are a set of dummy variable for each day of the week. *Lags* indicate the number of lags of the dependent variable included in the regression. *Prop. FLP Volume* is the proportion of trading volume with FLP participation. *Prop. FLP-Customer Volume* is the proportion of *Customer* volume where FLPs trade against *Customers*. *Prop. FLP Passive Volume* is the proportion of trading volume where FLPs trade passively. *Prop. FLP-Customer Passive Volume* is the proportion of *Customer* volume where FLPs provide liquidity to *Customers*. *Prop. e-Local Volume* is the proportion of trading volume involving e-Locals' participation. *Prop. e-Local-Customer Volume* is the proportion of customer trading volume involving e-Locals' participation. *Prop. e-Local Passive Volume* is the proportion of trading volume for which E-Locals are the passive traders. *Prop. e-Local-Customer Passive Volume* is the proportion of customer trading volume for which e-Locals are the passive traders. Two tailed *p-values*, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Prop. FLP Volume – Prop. e-Local Volume			Prop. FLP-Customer Volume – Prop. *e*-Local-Customer Volume			Prop. FLP Passive Volume – Prop. e-Local Passive Volume			Prop. FLP-Customer Passive Volume – Prop. e-Local-Customer Passive Volume		
Intercept	45.77%	46.43%	18.66%	35.87%	36.58%	20.26%	30.21%	30.73%	16.67%	19.17%	19.56%	12.68%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Lehman_dummy_long	-1.31%	-1.25%	-0.47%	-1.38%	-1.33%	-0.74%	-1.46%	-1.44%	-0.78%	-0.81%	-0.79%	-0.53%
	0.061	0.064	0.327	0.027	0.022	0.126	0.001	0.001	0.034	0.011	0.008	0.050
Cushing_dummy_AbsStd_PromptSlope	-4.30%	-4.23%	-1.63%	-3.55%	-3.43%	-1.84%	-2.51%	-2.41%	-1.25%	-1.49%	-1.42%	-0.88%
	<.0001	<.0001	0.018	<.0001	<.0001	0.004	<.0001	<.0001	0.013	<.0001	0.000	0.016
EIA_Inventory		0.64%	0.82%		0.33%	-0.20%		0.31%	0.52%		0.07%	-0.26%
		0.275	0.334		0.505	0.815		0.419	0.384		0.792	0.616
Lead_Inventory		-1.01%	-0.73%		-0.61%	-0.99%		-0.59%	-0.53%		-0.24%	-0.55%
		0.083	0.458		0.222	0.250		0.112	0.453		0.376	0.249
First_GSCI_Roll		-2.07%	-2.74%		-2.69%	-3.31%		-1.68%	-2.07%		-1.51%	-1.79%
		0.037	<.0001		0.001	<.0001		0.004	<.0001		<.0001	<.0001
GSCI_Roll_Days2to4		-2.68%	-1.47%		-2.86%	-1.93%		-2.00%	-1.25%		-1.52%	-1.11%
		0.001	0.009		<.0001	0.000		<.0001	0.001		<.0001	0.000
Day of the Week			Yes			Yes			Yes			Yes
Lags			2 Lags			2 Lags			2 Lags			2 Lags
N	245	245	245	245	245	245	245	245	245	245	245	245
Adj RSq	12.91%	19.09%	42.21%	12.95%	22.28%	33.37%	15.07%	23.29%	34.88%	10.37%	20.21%	26.80%

Table 10: FLPs *vs.* Locals Trading Activity during the Financial Crisis – Q3, 2008 to Q2, 2009

This table presents an analysis of the difference between "Fast Liquidity Providers" (*FLP*) and Locals trading during the financial crisis of 2008-09. *FLPs* are futures traders who trade more than 2,000 times a day and carry less than 5% of their daily trading volume overnight. *Locals* are defined as traders who trade more than 25 trades a day and are categorized under CTI (Customer Type Indicator) 1 category in the Pits. The analysis is conducted over the time-period July, 2008 to June, 2009 for WTI crude-oil futures trading on the Globex platform (FLPs) and in the option Pits (Locals). *Lehman_dummy_long* is a dummy variable that equals 1 from September 15, 2008 to January 15, 2009 and 0 otherwise. Storage issues in Cushing, OK are captured by *Cushing_dummy_AbsStd_PromptSlope,* a dummy variable set equal to 1 from December 17, 2008 to February 17, 2009 and 0 otherwise. *EIA_Inventory* is a dummy variable equal to 1 during EIA announcement days. *Lead_Inventory* is a dummy variable equal to 1 during the days prior to the EIA announcements*. First GSCI Roll* is a dummy variable equal to 1 on the day of a GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2nd and 4th day after a GSCI roll. *Day of the Week* are dummy variables for each day of the week. *Lags* indicate the number of lags of the dependent variable included in the regression. *Prop. FLP Volume* is the proportion of trading volume with FLP participation. *Prop. FLP-Customer Volume* is the proportion of *Customer* volume where FLPs trade against *Customers*. *Prop. FLP Passive Volume* is the proportion of trading volume where FLPs trade passively. *Prop. FLP-Customer Passive Volume* is the proportion of *Customer* volume where FLPs provide liquidity to *Customers*. *Prop. Local Volume* is the proportion of trading volume involving Locals' participation. *Prop. Local-Customer Volume* is the proportion of customer (CTI 4) trading volume involving Locals' participation. *Prop. Local Passive Volume* is the proportion of trading volume for which Locals trade passively. *Prop. Local-Customer Passive Volume* is the proportion of customer trading volume for which Locals are the passive traders. Two tailed *p-values*, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Prop. FLP Volume – Prop. Local Volume			Prop. FLP-Customer Volume – Prop. Local-Customer Volume			Prop. FLP Passive Volume – Prop. Local Passive Volume			Prop. FLP-Customer Passive Volume – Prop. Local-Customer Passive Volume		
Intercept	-25.53%	-23.99%	-12.58%	-33.86%	-31.87%	-16.41%	-13.27%	-12.38%	-8.41%	-19.08%	-17.90%	-13.02%
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Lehman_dummy_long	3.09%	3.01%	1.67%	3.88%	3.76%	2.00%	3.28%	3.25%	2.48%	4.19%	4.13%	3.15%
	0.024	0.023	0.093	0.028	0.027	0.109	0.001	0.001	0.006	0.001	0.001	0.005
Cushing_dummy_AbsStd_PromptSlope	-4.03%	-3.55%	-2.25%	-4.33%	-3.75%	-2.37%	-2.51%	-2.26%	-1.74%	-2.17%	-1.91%	-1.42%
	0.011	0.006	0.036	0.015	0.011	0.052	0.014	0.028	0.076	0.091	0.187	0.301
EIA_Inventory		-0.03%	2.79%		-1.02%	4.28%		0.65%	2.31%		0.17%	3.53%
		0.983	0.287		0.474	0.222		0.579	0.448		0.905	0.316
Lead_Inventory		-0.31%	1.65%		-0.35%	2.86%		-0.76%	2.19%		-1.56%	0.75%
		0.778	0.482		0.804	0.342		0.446	0.491		0.230	0.839
First_GSCI_Roll		-4.62%	-5.02%		-4.91%	-6.06%		-2.99%	-3.67%		-1.52%	-2.43%
		0.057	0.007		0.092	0.010		0.131	0.056		0.501	0.276
GSCI_Roll_Days2to4		-5.99%	-4.29%		-7.04%	-5.16%		-3.52%	-2.72%		-3.83%	-3.30%
		<.0001	<.0001		<.0001	<.0001		0.001	0.006		0.001	0.004
Day of the Week			Yes			Yes			Yes			Yes
Lags			2 Lags			2 Lags			2 Lags			2 Lags
N	245	245	245	245	245	245	245	245	245	245	245	245
Adj RSq	5.46%	14.32%	24.75%	4.83%	12.69%	23.78%	5.24%	8.40%	9.62%	5.36%	7.68%	7.60%

Table 11: FLPs' Realized Spreads and Market Conditions – Q4, 2006 to Q1, 2007

This table presents an analysis of the impact of market stress on the realized spreads paid by customers while trading with "Fast Liquidity Providers" (*Customer-to-FLP Spreads)*. *FLPs* are traders who trade more than 2,000 times a day and carry less than 5% of their daily trading volume overnight. The analysis is conducted on WTI crude-oil futures trading on the Globex platform over the time-period October 2006 to March 2007. *Dummy_Q1_2007* is a dummy variable equal to 1 during the first quarter of 2007 and 0 otherwise. *Volatility* is the 1-minute volatility of returns. *Abs CDI* is the absolute value of customer (traders classified as CTI 4 traders in the CFTC database) trade imbalance over a 1-minute interval. *Volatility-High* (Abs CDI - High) is a dummy variable equal to 1 when the 1-minute Volatility (Abs CDI) over the past 1 hour has been greater than twice its standard deviation over the sample period. *Open* (*Close*) is a dummy variable equal 1 during the first (last) 30 minutes of trading. *EIA Pre-Event* is a dummy variable equal to 1 during the 30 minutes before a weekly EIA announcement. *EIA Event* is a dummy variable equal to 1 during the 5 minutes after a weekly EIA announcement. *EIA Post-Event* is a dummy variable equal to 1 between 5 and 35 minutes after a weekly EIA announcement. *First GSCI Roll* is a dummy variable equal to 1 on the 1st day of the monthly GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2nd and 4th day after a GSCI roll. *Day of the Week* are dummy variables for each day of the week. *Lags* indicate the number of lags of the dependent variable included in the regression. *Customer-to-FLP Spreads* are calculated every minute as 5-minute forward-looking percentage difference in customer buy and sell prices while trading with FLPs. Two tailed p-values, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Customer-to-HFT Spreads					
Intercept	0.570		0.560	0.530	0.530	0.560
	<.0001		<.0001	<.0001	<.0001	<.0001
Dummy_Q1_2007	-0.200		-0.200	-0.200	-0.200	-0.200
	<.0001		<.0001	<.0001	<.0001	<.0001
Volatility	-0.100		-0.020	-0.023	-0.022	-0.013
	0.456		0.233	0.164	0.187	0.432
Abs CDI	0.260		-0.021	-0.024	-0.019	-0.018
	0.024		0.181	0.125	0.212	0.252
Return			0.010	0.009	0.009	0.007
			0.559	0.599	0.582	0.655
Volatility- High			-0.097	-0.075	-0.073	-0.044
			0.510	0.611	0.624	0.773
Abs CDI - High			0.270	0.280	0.280	0.270
			0.019	0.015	0.014	0.018
Open				0.200	0.190	0.056
				0.027	0.043	0.610
Close				0.180	0.200	0.180
				0.015	0.009	0.016
EIA Pre-Event					0.450	0.420
					<.0001	<.0001
EIA Event					-0.300	-0.300
					0.290	0.291
EIA Post-Event					-0.029	-0.035
					0.767	0.747
First GSCI Roll					-0.200	-0.200
					0.033	0.067
GSCI_Roll_Days2to4					-0.006	0.000
					0.903	0.999
Day of the Week						Yes
Lags						2 Lags
N	37377	37377	37377	37377	37377	37377
Adj RSq	0.20%		0.21%	0.26%	0.39%	0.66%

Table 12: FLPs *vs. e*-Locals Spreads Realized Spreads and Market Conditions – Q4, 2006 to Q1, 2007

This table presents a daily analysis of the impact of market stress on the difference between the realized spreads paid by customers while trading with "Fast Liquidity Providers" (*FLP*) *vs*. with *e*-Locals. The analysis is conducted on WTI crude-oil futures trading in the Pits over the time-period September, 2006 to March, 2007. *Dummy_Q1_2007* is a dummy variable equal to 1 during the first quarter of 2007 and 0 otherwise. *Volatility* is the 1-minute volatility of returns. *Abs CDI* is the absolute value of customer (traders classified as CTI 4 traders in the CFTC database) trade imbalance over a 1-minute interval. *Volatility-High* (*Abs CDI - High*) is a dummy variable equal to 1 when the 1-minute *Volatility* (*Abs CDI*) over the past 1 hour has been greater than twice its standard deviation over the sample period. *Open* (*Close*) is a dummy variable equal 1 during the first (last) 30 minutes of trading. *EIA Pre-Event* is a dummy variable equal to 1 during the 30 minutes before a weekly EIA announcement. *EIA Event* is a dummy variable equal to 1 during the 5 minutes after a weekly EIA announcement. *EIA Post-Event* is a dummy variable equal to 1 between 5 and 35 minutes after a weekly EIA announcement. *First GSCI Roll* is a dummy variable equal to 1 on the day of a GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2nd and 4th day after a GSCI roll. *Day of the Week* are a set of dummy variable for each day of the week. *e-Locals* are defined as traders who trade more than 25 trades a day and are categorized under CTI (Customer Type Indicator) 1 category in the Globex (electronic) market. *Customer-to-FLP Spreads* are calculated every minute as 5-minute forward-looking percentage difference in customer buy and sell prices while trading with FLPs. *Customer-to-e-Local Spreads* are calculated every minute as 5-minute forward-looking percentage difference in customer buy and sell prices while trading with E-Locals. Two tailed p-values, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Customer-to-FLP Spread - Customer-to-E_Local Spreads					
Intercept	0.710	0.680	0.710	0.680	0.710	0.660
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Dummy_Q1_2007	-0.400	-0.400	-0.400	-0.400	-0.400	-0.400
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Volatility			-0.056	-0.062	-0.061	-0.047
			0.087	0.062	0.067	0.143
Abs CDI			-0.085	-0.092	-0.090	-0.087
			0.001	0.000	0.000	0.001
Return			0.028	0.027	0.026	0.022
			0.318	0.337	0.344	0.432
Volatility- High	-0.069	-0.049	-0.040	-0.017	-0.049	-0.100
	0.769	0.834	0.866	0.942	0.839	0.600
Abs CDI - High	0.230	0.230	0.260	0.260	0.250	0.280
	0.203	0.193	0.150	0.143	0.158	0.121
Open		0.210	0.000	0.190	0.180	0.370
		0.279		0.349	0.359	0.092
Close		0.180	0.000	0.240	0.240	0.240
		0.148		0.067	0.060	0.066
EIA Pre-Event					0.170	0.140
					0.406	0.539
EIA Event					-0.200	-0.300
					0.744	0.549
EIA Post-Event					0.040	0.069
					0.800	0.699
First GSCI Roll					-0.400	-0.400
					0.011	0.008
GSCI_Roll_Days2to4					-0.031	0.029
					0.729	0.741
Day of the Week						Yes
Lags						2 Lags
N	37220	37220	37220	37220	37220	37220
Adj RSq	0.19%	0.20%	0.23%	0.25%	0.28%	0.52%

Table 13: FLPs' Realized Spreads during the Financial and Cushing Crises – Q3, 2008 to Q2, 2009

This table presents a daily analysis of the impact of market stress on the realized spreads paid by customers while trading with "Fast Liquidity Providers" (*FLP*) between July 2008 and June 2009. *FLPs* are traders who make more than 2,000 trades a day and carry less than 5% of their daily trading volume overnight. The analysis is conducted on WTI crude-oil futures trading on the Globex platform over the time-period July, 2008 to June, 2009. *Lehman_dummy_long* is a dummy variable that equals 1 from September 15, 2008 to January 15, 2009 and 0 otherwise. Storage issues in Cushing, OK are captured by *Cushing_dummy_AbsStd_PromptSlope,* a dummy variable set equal to 1 from December 17, 2008 to February 17, 2009 and 0 otherwise. *EIA_Inventory* is a dummy variable equal to 1 during EIA announcement days. *Lead_Inventory* is a dummy variable equal to 1 during the days prior to the EIA announcements. *First GSCI Roll* is a dummy variable equal to 1 on the day of a GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2nd and 4th day after a GSCI roll. *VIX_std* is the standardized value of the VIX index. *Std_Abs_Prompt_Slope_Cal* is the standardized value of the absolute near-dated cost-of-carry for WTI crude oil, measured as the percentage difference between the near-month and first-differed crude oil WTI futures prices net of LIBOR. *Day_after_holiday* is a dummy variable equal to one on days after public holidays. *Customers* are traders classified as CTI 4 traders in the CFTC database. Two tailed p-values, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Customer-to-FLP Spreads		
Intercept	0.600	0.530	0.650
	<.0001	<.0001	<.0001
Lehman_dummy_long	0.087	0.220	
	0.537	0.046	
Cushing_dummy_AbsStd_PromptSlope	0.640	0.500	
	0.067	0.014	
EIA_Inventory		-0.059	-0.048
		0.467	0.573
Lead_Inventory		0.094	0.098
		0.249	0.218
First_GSCI_Roll		-0.100	-0.100
		0.512	0.562
GSCI_Roll_Days2to4		-0.200	-0.200
		0.056	0.038
VIX_std			0.160
			0.014
Std_Abs_Prompt_Slope_Cal			0.052
			0.065
Day_after_holiday		3.560	3.620
		0.011	0.012
N	244	244	244
Adj RSq	0.43%	37.04%	36.02%

Table 14: FLPs *vs*. *e*-Locals Realized Spreads during the Financial and Cushing Crises – Q3, 2008 to Q2, 2009

This table presents a daily analysis of the impact of market stress on the difference between the realized spreads paid by customers while trading with "Fast Liquidity Providers" (*FLP*) *vs*. with *e*-Locals between July 2008 and June 2009. *FLPs* are traders who trade more than 2,000 times a day and carry less than 5% of their daily trading volume overnight. *E-Locals* are defined as traders who trade more than 25 trades a day and are categorized under CTI (Customer Type Indicator) 1 category in the Globex (electronic) market. The analysis is conducted on WTI crude-oil futures trading on the Globex platform over the time period from July 2008 to June 2009. *Lehman_dummy_long* is a dummy variable that equals 1 from September 15, 2008 to January 15, 2009 and 0 otherwise. Storage issues in Cushing, OK are captured by *Cushing_dummy_AbsStd_PromptSlope,* a dummy variable set equal to 1 from December 17, 2008 to February 17, 2009 and 0 otherwise. *EIA_Inventory* is a dummy variable equal to 1 on EIA announcement days. *Lead_Inventory* is a dummy variable equal to 1 during the day prior to the EIA announcement day. *First GSCI Roll* is a dummy variable equal to 1 on the 1st day of the monthly GSCI roll. *GSCI_Roll_Days2to4* is a dummy variable equal to 1 between the 2nd and 4th day after a GSCI roll. *VIX_std* is the standardized value of the VIX index. *Std_Abs_Prompt_Slope_Cal* is the standardized value of the absolute near-dated cost-of-carry for WTI crude oil, measured as the percentage difference between the near-month and first-differed crude oil WTI futures prices net of LIBOR. *Day_after_holiday* is a dummy variable equal to 1 on the first day following a U.S. public holidays. *Customers* are traders classified as CTI 4 traders in the CFTC database. Two tailed p-values, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Customer-to-FLP Spreads – Customer-to-*e*_Local Spreads		
Intercept	0.430	0.470	0.480
	<.0001	<.0001	<.0001
Lehman_dummy_long	-0.100	-0.100	
	0.382	0.471	
Cushing_dummy_AbsStd_PromptSlope	0.620	0.610	
	0.006	0.003	
EIA_Inventory		-0.013	0.003
		0.936	0.985
Lead_Inventory		0.043	0.046
		0.795	0.783
First_GSCI_Roll		-0.500	-0.500
		0.064	0.052
GSCI_Roll_Days2to4		-0.200	-0.200
		0.241	0.176
VIX_std			0.005
			0.950
Std_Abs_Prompt_Slope_Cal			0.098
			0.028
Day_after_holiday		0.530	0.680
		0.450	0.380
N	244	244	244
Adj RSq	0.43%	37.04%	36.02%