May 2017

The Third Dimension of Financialization:

Electronification, Intraday Institutional Trading, and Commodity Market Quality

by

Vikas Raman **Michel A. Robe**° **Pradeep K. Yadav**

° Vikas **Raman** is at the Warwick Business School, Coventry CV4 7AL (United Kingdom). Tel: (+44) 24 761 50438. Email: vikas.raman@wbs.ac.uk. Michel A. **Robe (corresponding author)** is at the U.S. Commodity Futures Trading Commission (CFTC) and at the Department of Finance, Kogod School of Business at American University, 4400 Massachusetts Avenue NW, Washington, DC 20016. Tel: (+1) 202-885-1880. Email: mrobe@american.edu. Pradeep K. **Yadav** is at the Division of Finance, University of Oklahoma, 307 West Brooks Street, Norman, OK 73019. Tel: (+1) 405-325-5591. Email: pyadav@ou.edu. We thank Jim Moser, Wei Xiong, Hank Bessembinder, Andrei Kirilenko, Albert Menkveld, P.K. Jain, Scott Irwin, Kelley Anderson, Jim Overdahl, Craig Pirrong, Phil Garcia, Talis Putnins, Ajeyo Banerjee, Eleni Gousgounis, Esen Onur, Scott Mixon, Casey Petroff, seminar participants at the CFTC, Virginia Tech, the University of Illinois at Urbana-Champaign, George Mason University, Université Paris Dauphine, the University of Technology Sydney, and participants at IPAM's "Workshop III: Commodity Markets and their Financialization" (UCLA), Institut Louis Bachelier's 1st Summer School on Commodity Derivatives Markets (Florence, Italy), and the 12th Energy and Commodity Finance Conference (ESSEC Business School, Paris) for helpful comments and suggestions. Any errors and omissions are the authors' sole responsibility.

The research presented in this paper was co-authored by Michel Robe, who performed work on this paper in his official capacity as a part-time consulting senior economist at the CFTC; and, Vikas Raman and Pradeep Yadav, who performed work as CFTC contractors under CFTC OCE contracts CFCE-10-CO-0237 and CFOCE-13-0064. The Office of the Chief Economist and CFTC economists produce original research on a broad range of topics relevant to the CFTC's mandate to regulate commodity future markets, commodity options markets, and the expanded mandate to regulate the swaps markets pursuant to the Dodd-Frank Wall Street Reform and Consumer Protection Act. These papers are often presented at conferences and many of these papers are later published by peer-reviewed and other scholarly outlets. The analyses and conclusions expressed in this paper are those of the authors and do not reflect the views of other members of the Office of Chief Economist, other Commission staff, or the Commission itself.

The Third Dimension of Financialization:

Electronification, Intraday Institutional Trading, and Commodity Market Quality

Abstract

We provide the first detailed empirical evidence on the financialization of intraday trading activity in the world's largest commodity market and show that this development had a first-order positive impact on market liquidity and pricing efficiency. We use a unique, confidential regulatory dataset to show that the electronification of U.S. crude oil futures trading in 2006 brought about a massive growth in intraday activity by "non-commercial" institutional financial traders. We exploit differences in the post-electronification growth rates of institutional financial trading in crude oil futures contracts of different maturities to tease out the effect of financialization on key metrics of commodity market quality. We show that increased institutional financial trading reduces the variance of futures pricing errors, narrows bid-ask spreads, and improves market depth. Our inferences are robust to differences in the nature and volume of non-financial trading. Finally, we provide novel evidence of notable differences between the contributions of fast (automated) *vs*. other (non-fast) institutional financial traders to different market quality attributes.

JEL Classification: G10, G12, G13, G23, Q49

Keywords: Financialization, Commodities, Institutional Trading, Intraday activity, Pricing efficiency, Liquidity.

1. **Introduction**

In the early 2000s, institutional financial entities, driven purely by "non-commercial" financial motives, started assuming a sharply greater role in commodity markets. This development has been dubbed the "financialization" of commodities (UNCTAD, 2011; Cheng and Xiong, 2014). It comprises three main dimensions, corresponding to the arrival of three distinct kinds of new commodity market participants trading across multiple commodities: first, commodity index traders ("CIT"), known as "massive passives;" second, managed money traders (hedge funds) that are active in multiple asset classes; and third, institutional financial intraday traders (including algorithmic traders).

While the financialization of commodities has spawned much academic research, its focus to date has been on the first two dimensions of financialization mentioned above (i.e., the positions held overnight and the longer-term trading strategies of CITs and hedge funds) and their effects on select aspects of the daily, weekly, monthly, or quarterly distributions of commodity returns: price levels (e.g., Irwin and Sanders, 2012; Sockin and Xiong, 2015), risk premia (e.g., Acharya, Lochstoer, and Ramadorai, 2013; Singleton, 2014; Hamilton and Wu, 2014), realized volatility (e.g., Brunetti, Büyükşahin, and Harris, 2017; Kim, 2015), and co-movements between markets (e.g., Tang and Xiong, 2012; Büyükşahin and Robe, 2014; Başak and Pavlova, 2016).[1] This paper addresses the third dimension of financialization: the massive growth in *intraday* trading, often across multiple commodities, by institutional financial traders who have no commercial interest in the underlying physical commodity.

Prior research shows that the financialization of commodity markets' "buy-side" transformed commodities from a type of asset whose price is driven by physical consumption and supply considerations into a class of financial assets valued in terms of their interactions with other classes of financial assets. Crucially, it links "the changing face of participants in commodity futures markets over the past ten years to changes in commodity futures price dynamics" (Cheng, Kirilenko, and Xiong, 2015, p. 1735). This development, together with

[1] Other contributions include, among others, Bessembinder, Carrion, Tuttle, and Venkataraman (2016); Brunetti and Reiffen (2014); Bruno, Büyükşahin, and Robe (2017); Etula (2013); Hamilton (2009); Hong and Yogo (2012); Kilian and Murphy (2014); Knittel and Pindyck (2016); Korniotis (2009); Sanders, Irwin, and Merrin (2010); and Stoll and Whaley (2010). See Cheng and Xiong (2014) for a detailed literature review.

the electronification of commodity futures markets, paved the road for the third dimension of financialization that is the subject of our paper. This "intraday financialization" reflects the sharply greater role of institutional financial traders in providing liquidity and their active trading on short-term information (e.g., information in the order flow). It includes within its ambit the financialization of commodity markets' "sell-side," in the sense of Hasbrouck and Saar (2013).[2] However, despite its size and importance, it has hitherto received surprisingly little attention in the academic literature due to a dearth of publicly available high-frequency information identifying the makeup of intraday commodity trading activity.

Our paper utilizes a comprehensive, non-public, trader-level dataset from the market regulator (the U.S. Commodity Futures Trading Commission or CFTC) to provide the first quantitative evidence on this intraday dimension of financialization, and to investigate its impact on commodity market quality. Specifically, we test hypotheses regarding its effects on bid-ask spreads, depth, and the absolute magnitude of customers' demand imbalances (i.e., the difference between customer buys and sells).[3] We also test hypotheses about the impact of financialization on commodity pricing efficiency at intraday horizons by examining the variance of futures "pricing errors," i.e., deviations of market prices from informationally efficient "fundamental" values. Overall, our results indicate that institutional financial trading has a significantly beneficial impact on each of these four measures of market quality.

Our findings are based on the world's largest commodity market—the New York Mercantile Exchange's (NYMEX) West Texas Intermediate (WTI) light sweet crude oil futures market. This market underwent a major structural change on September 5th, 2006, when the NYMEX first allowed electronic trading on the Globex platform alongside face-to-face trading in the NYMEX pits. Before electronification, the NYMEX's WTI futures trading was physically confined to the pits during business hours. Pit trading was intermediated largely by "Locals," i.e., by individual traders functioning as scalpers (Silber, 1984) and

---

[2] Unless otherwise indicated, our use of the term "financialization" in the rest of this paper relates to this third intraday financialization dimension: the growth in *intraday* trading/positions of institutional financial traders.

[3] These three market liquidity measures present the double advantage of widespread use and of computability with trade data. Access to order-book data would be necessary to compute other useful market quality measures, such as the availability of a two-sided market and the order-book depth or dispersion.

acting as voluntary providers of immediacy and liquidity in the market (Manaster and Mann, 1996). Importantly, Globex trading brings about a transformative easing of access for traders without physical access to the pits, enabling them to trade remotely, and thereby compete with Locals in supplying liquidity (through limit orders to buy or sell) or otherwise (e.g, through short-horizon trading on information in the order flow). Consistent with evidence on structural reforms at the NASDAQ (Barclay *et al*., 1999) and the London Stock Exchange (Naik and Yadav, 2003) allowing public traders to compete with traditional market makers in supplying liquidity, and in line with evidence on the benefits of electronification in equity markets (e.g., Jain, 2005), we document that electronification results in significantly higher commodity pricing efficiency and significantly lower trading costs.

That said, our paper's focus is specifically on the financialization that resulted from electronification, not on the electronification *per se*. We identify institutional financial traders using our regulatory data, and we document several facts that characterize the financialization of intraday crude oil futures trading following the NYMEX's electronification. First, many of the institutional financial traders that start trading WTI futures on the Globex platform are new to the NYMEX. In total, more than four hundred new institutional financial traders enter the WTI market in the six months immediately following electronification—a rate of entry that is almost three times what it was in the first eight months of 2006. Second, the fraction of all Globex WTI trades involving an institutional financial trader on either side grows to almost 60 percent of the total volume—a figure double what it used to be in the WTI pits. Third, the institutional financial traders entering the WTI market after September 5th, 2006 engage in much shorter-horizon strategies compared to their predecessors in the pits before electronification. Finally, these new entrants are three times more likely to also trade other commodity futures (beside crude oil) than are their counterparts in the WTI pits. These new financial intermediaries' cross-market footprints echo the simultaneous presence in multiple commodity markets characteristic of the longer-horizon, buy-side institutions that started the financialization of commodities at the beginning of the last decade—namely, commodity index traders (Tang and Xiong, 2012; Cheng, Kirilenko, and Xiong, 2015) and managed money traders (Büyükşahin and Robe, 2014).

Electronification enhances market quality through three main channels: it improves pre- and post-trade market transparency (Boehmer, Saar, and Yu, 2005), trims fixed operating and order-processing costs (Jain, 2005), and increases competitive efficiency by removing or reducing barriers to entry into liquidity provision services (Barclay *et al*., 1999; Naik and Yadav, 2003), thereby attracting new traders, e.g., institutional financial traders in the case of commodity markets. What is relevant from our perspective is that, while the first and second channels arguably impact all futures contract maturities similarly, not all contract maturities can expect the same amount of interest from institutional financial traders. In particular, because the two nearest-month futures and the three nearest December futures (commonly used for associated calendar spread positions) correspond to the maturities most commonly held overnight or for longer periods by commercial crude oil traders—producers, refiners, wholesalers, etc.—both before (Neuberger, 1999; Ederington and Lee, 2002) and after (Büyükşahin, Haigh, Harris, Overdahl, and Robe, 2015) electronification, financialization should manifest mainly in these contract maturities. Consistent with this intuition, we find that the entry of new intraday-focused institutional financial traders after electronification does take place chiefly in those specific maturities, which we loosely label "short-term" even though they also include the associated December contracts.

Our empirical design exploits the fact that, post-electronification, financialization is largely concentrated in these "short-term" contracts. We exploit the resulting large post-electronification differences across the crude oil futures term structure to identify the effect of financialization on market quality. Specifically, we use electronification as an instrument for the relative financialization of short-term contracts (w.r.t long-term contracts) in two-stage regressions in order to tie the relative improvements in market liquidity and pricing efficiency for short-term contracts to their relatively greater rate of financialization.We document that a one-standard deviation increase in the percentage difference in the rate of financialization (between short-term and long-term contracts) widens the percentage differences (between short-term and long-term contracts) in the magnitude of pricing errors by 0.43 standard deviations; in bid-ask spreads, by 0.84 standard deviations; in market depth, by 1.07 standard deviations; and in customer trade imbalances, by 0.60 standard deviations.

Clearly, while the entry of institutional financial traders into the crude-oil market is exogenous, their choice of which contract maturities to trade could potentially be based on the order-flow of external "customers," i.e., of non-financial traders. Hence, there is arguably a possibility that the financialization-related improvements in market quality observed by us arise because the nature of these customers changes after electronification, or simply because institutional financial traders are attracted more to contracts with greater customer trading volume. We accordingly control in multiple ways for potentially confounding influences of post-electronification differences in overall trading volume, in customer volume, and in the nature of customers. First, after incorporating linear regression-based controls for overall and customer trading volumes, the influence of financialization on liquidity and pricing efficiency remains robustly significant. Second, when we stratify the regressions based on terciles of cross-maturity differences in customer volume, we find very similar financialization-related market quality improvements across terciles. Even in the lowest tercile (consisting only of days when customer trading volume is actually lower in contracts in which financialization is on average greater), we observe that financialization similarly improves each of our market quality metrics. Third, we use the granularity of our regulatory data to identify exchange customers who traded WTI futures in the pits prior to electronification and who continue to trade (now electronically, on Globex) after September 5^{th}, 2006. We find that the spreads paid by such "continuing customers" are also reduced by financialization—consistent with the inference that financialization-related improvements in liquidity post-electronification are not driven by any changes in the nature of customers. Overall, irrespective of differences in the nature and volume of non-financial trading, institutional financial trading continues to be the driver for market quality improvement.

We establish the robustness of our conclusions also in two other ways. First, as an alternative to using the NYMEX's introduction of *e*-trading as an instrument to extract the component of institutional trading that is exogenous to market conditions, we use instead lagged values of our financialization index as the main instrument for the first-stage regressions. Our results are once more qualitatively similar: an increase in financialization improves both pricing efficiency and market liquidity. Second, we carry out a vector autoregression (VAR) analysis in order to further examine the endogenous relation between the participation of institutional financial traders and market quality. To do so, we use information from the same regulatory dataset but from a later, non-overlapping time period in which no structural market change takes place. Using data from April 2007 to May 2008, we again show that increases in institutional financial trading contemporaneously narrow bid-ask spreads, curtail customer trade imbalances, and cut the variance of pricing errors.

Having established that financialization improves liquidity and pricing efficiency, we then provide novel evidence of differences between the respective roles of fast (automated) and of other, non-fast institutional financial traders. We modify our two-stage procedure and use a narrow measure of financialization that excludes the trading activity of fast algorithmic traders while retaining their trading activity as a control variable. Importantly, we find that non-fast institutional financial trading activity significantly improves each of our metrics of liquidity: it reduces bid-ask spreads, increases market depth, and reduces the imbalances between customer buys and customer sells. At the same time, we show that it is fast (automated) institutional financial trading that significantly reduces the variance of pricing errors. Fast algorithmic trading also contributes to reducing spreads and trade imbalances, but we find no evidence that it contributes to market depth.[4] These results support the view that liquidity improvements are driven by the flow of institutional risk capital into intraday voluntary liquidity provision rather than just the activities of fast automated traders *per se*.

Section 2 motivates our empirical hypotheses. Section 3 discusses our rich regulatory dataset and our measures of intraday market quality. Section 4 documents electronification's huge impact on the latter and the oil market's intraday financialization *post*-electronification. Sections 5 analyzes financialization's impact on market quality. Section 6 shows that, in the causal link from financialization to market quality improvements, fast (automated) and other (non-fast) institutional financial traders play separate and important roles for different attributes of market quality. Section 7 concludes and outlines avenues for further research.

---

[4] Our evidence relating specifically to fast algorithmic traders complements findings in Brogaard, Hendershott, and Riordan (2014, equities) and Chaboud, Chiquoine, Hjalmarsson, and Vega (2014, currencies) for pricing efficiency, and in Hendershott, Jones, and Menkveld (2011, equities) for spreads. Jones (2013) and Menkveld (2016) provide thorough reviews of the extant literature on high frequency trading.

2. **Research Questions**

2.1. Intraday Pricing Efficiency

Our first research question is whether financialization improves *intraday* pricing efficiency, and in particular, the variance of "pricing errors," i.e., the deviations of observed market prices from information-efficient random-walk or "fundamental" values—as in Hasbrouck (1993), Boehmer and Kelly (2009), or Fotak, Raman, and Yadav (2014).

Prior research asks whether buy-side financialization can drive prices away from their fundamental values. On the theory side, Singleton (2014) and Sockin and Xiong (2015) argue that, amid a globalization of the world's economic activity, commodity market participants face severely heightened informational frictions (regarding physical supply, demand, and inventories) and that these frictions, and the associated financial speculation, may cause the magnitude of pricing errors to increase for extended periods.[5] Similarly, there exist several empirical studies on whether trading activities related to commodity index derivatives or other commodity-linked financial products have deleterious effects on prices at daily or longer horizons.[6] The focus of all those papers, however, is on pricing errors that may persist for long periods of time—days, weeks, or months. Thus, while those papers make important contributions to the literature, their relevance to the present paper is relatively limited given that our focus is entirely intraday. Indeed, ours is the first study of institutional financial day traders' impact on the *intraday* efficiency of commodity prices.

In the same vein, there exists extensive empirical evidence from equity markets suggesting that institutional investors are more informed relative to other investors. However, that evidence largely focuses on institutional *investors* (typically, investors who own shares and who engage in fundamental research on earnings and other news and announcements) rather than on institutional *traders*—who are the focus of the present paper.[7] As such, that

[5] See also Goldstein and Yang (2016) and other recent theoretical papers cited therein.
[6] See, e.g., Hamilton and Wu (2015), Henderson, Pearson, and Wang (2015), and Irwin and Sanders (2012).
[7] For example, Boehmer and Kelly (2009) find a positive relation between institutional shareholdings and the relative informational efficiency of stock prices. Badrinath, Kale, and Noe (1995) find that returns of stocks with

prior work does not deal with intraday-focused institutional traders engaged primarily in short-horizon liquidity provision and trading on the order flow. For such traders, the literature on institutional investors with daily (or quarterly) horizons may be informative but is not necessarily conclusive.

More directly relevant to the present paper is the extant research on fast or automated traders showing that, on average, such traders—who likely are institutional—improve price discovery in equity markets (e.g. Brogaard, Hendershott, and Riordan, 2014) and pricing efficiency in currency markets (e.g., Chaboud, Chiquoine, Hjalmarsson, and Vega, 2014). For intraday-focused institutional traders, one can argue, after Hendershott, Lidvan, and Schürhoff (2015), that institutions should be better informed because of superior access to information (in terms of gathering and processing skills) and better financial and analytical resources. Thus, increased intraday trading by institutional financial traders in commodity markets should reduce informational imperfections and pricing errors at intraday horizons. At the same time, though, we know from De Long, Shleifer, Summers, and Waldman (1990) and the related later literature that short-horizon investors could have adverse effects on pricing efficiency because of "short-termism" (reluctance to arbitrage pricing inefficiencies as the latter may last beyond the arbitrageurs' trading horizon, causing pricing errors to persist).

Irrespective of which of these two effects dominates, the financialization of intraday trading should clearly increase the amount of capital available for financial traders to fulfill more continually the risk-sharing role of futures markets (i.e., the capacity to absorb the other side of the hedging-related futures positions taken by commercially-motivated or "commercial" traders). From this perspective, the financialization of commodity markets should also reduce the magnitude of pricing errors by making risk-sharing more efficient.

In short, it is an empirical question whether institutional financial trading increases pricing efficiency. In view of the above, our first hypothesis is:

H1: Financialization lowers the variance of intraday pricing errors.

---

high institutional ownership leading those with low institutional ownership. Chordia, Roll, and Subrahmanyam (2011) find that institutional trading leads to an overall increase in information-based trading. Campbell, Ramadorai, and Schwartz (2009) find institutions arbitraging stock mispricings around earnings announcements.

Finally, given extant findings that high frequency trading improves price discovery in other financial markets, and given that HFTs may be organized as institutional traders, we test for the beneficial effects on the variance of pricing errors of increases in (i) overall institutional financial trading, as well as (ii) a narrow measure of financialization that only considers non-automated traders (i.e., that subtracts from overall institutional financial trading all observations related to fast machine traders).

2.2. Intraday Liquidity

Our second research question is whether financialization—with the resultant flow of institutional risk capital into intraday commodity futures trading—improves market liquidity as manifested in bid-ask spreads, depth, and imbalances between customer buys and customer sells. Ours is the first paper to shed light on this question.

The reasons to expect a beneficial impact of financialization on intraday liquidity arise from factors similar to those cited by Hendershott, Lidvan, and Schürhoff (2015, pp. 249-250) for institutional traders to be relatively more informed. First, insofar as institutional financial traders have more financial resources than individual traders do, their market entry should significantly increase the access to, and the overall availability of, capital available for liquidity provision—thus increasing depth and reducing customer trade imbalances. Second, insofar as institutional financial traders have greater direct access to information and greater resources for processing that information, they are better able at estimating short-term price changes based on information and liquidity flows and have a greater ability to effectively manage their inventories and control risks. Consequently, they can take greater position risks in individual liquidity-provision trades and can supply liquidity at lower costs. This should cut spreads and increase depth. Third, an increase in institutional intraday trading increases competition among liquidity providers, potentially leading to more aggressive pricing and participation, again reducing spreads and customer trade imbalances.

In addition, to the extent that institutional financial traders are better informed than other market participants at intraday horizons, financialization should increase the extent of information-based trading. The theoretical models of Boulatov and George (2008, 2013) and

Goettler, Parlour, and Rajan (2009) predict that informed agents gravitate towards supplying (rather than taking) liquidity, which is consistent with evidence from Kaniel and Liu (2006). When the (more informed) institutional financial traders gravitate toward supplying (rather than demanding) liquidity, they should be able to do so at lower cost since they need to make a relatively lower provision for adverse selection losses to more informed traders (Glosten and Harris, 1988). This competitive advantage in liquidity provision should also mean that the presence of (the relatively more informed) institutional financial traders in the market should, at the margin, lead to greater depth and lower trade imbalances.

Overall, in view of the above, our second set of hypotheses, for both our measures of financialization, are:

H2: Financialization reduces bid-ask spreads.

H3: Financialization increases market depth.

H4: Financialization reduces the absolute magnitude of customer trade imbalances.

As Section 2.1 noted for pricing efficiency, there is evidence (e.g., Hendershott, Jones, and Menkveld, 2011) that, on average, algorithmic trading improves intraday liquidity in equity markets. Thus, given that algorithmic traders may be organized as institutional traders, we also undertake tests that identify the beneficial impact on market liquidity of two alternative measures of financialization: (i) an overall measure that includes fast algorithmic traders, and (ii) a narrower measure that excludes them.

3. Data: Measuring Institutional Financial Trading and Market Quality

For the purposes of this paper, we were granted access to non-public regulatory data from January 2006 to May 2008 for the world's largest commodity market—the NYMEX's WTI light sweet crude oil futures market. The NYMEX introduced electronic trading of WTI futures (alongside face-to-face pit trading) on September 5th, 2006. Our data originate with the market regulator, the U.S. Commodity Futures Trading Commission (CFTC).

3.1. Data

The CFTC collects data on every WTI futures transaction at the NYMEX, and for every trading account in that market. Each futures trade is recorded twice in the dataset, once for the buyer and once for the seller. The buyer and the seller are each identified only by an identity code. Those anonymizing codes are assigned by the CFTC to each trading account so as to conceal the actual identities of market participants. Hence, while the data to which we had access provides a complete WTI trading history for every trader in our sample, each trader's true identity remains confidential and unknown to us.

The CFTC dataset includes details such as the commodity and delivery month; the quantity traded; the trade type (outrights, spreads, trades at settlement,...), price, and direction (i.e., whether the transaction was a buy or sell); and the transaction date and time. For electronic trades on Globex, the latter is the time stamp assigned to a trade when both sides were matched. For open outcry trades in the pits, it is the imputed trade time stamp. For our analysis, we use pit trades time-stamped during business hours (*pre*-electronification) and Globex trades time-stamped between 9AM-2:30PM (*post*-electronification).[8]

The dataset classifies the traders on each side of a given transaction using one of four customer type indicators ("CTI"). The three main categories, comprising over 95 percent of all trades, are Locals (CTI-1 or *individual* exchange members trading for accounts they own or control), *institutional* exchange members trading for accounts they own or control (CTI-2), and non-member customers of the exchange or external traders (CTI-4). The rest, about four percent of all trades in our sample, are classified as CTI-3 (individual member trading on behalf of another member); such trades are largely not relevant for this paper.

In our analysis, we aggregate the account-level data across multiple contracts and by CTI trader category. Each CTI category comprises dozens to thousands of trading accounts,

---

[8] Pits used to be open from 10AM—2:30 PM prior to January 31st, 2007. Starting on February 1st, 2007, pit business hours were increased to 9AM—10:30 PM. We exclude from the sample the Friday immediately after Thanksgiving as well as the entire week from Christmas to New Year (starting the last full trading day before Christmas and ending the first trading day after New Year). Before aggregating the data, we carry out a number of quality checks; for example, we exclude transactions whose reported prices are clearly erroneous.

so the information we provide respects the CFTC's confidentiality statutes by not allowing the reader to identify any individual trader's position(s), trade secrets, or trading strategies.

3.2. Institutional Financial Trading

The trader category of primary interest to us is CTI-2, which captures the participation of institutional traders whose trading activity is large enough to warrant corporate exchange membership for their proprietary trading desks. Such membership allows a firm to obtain preferential fees and other benefits on its proprietary futures trading, and it is particularly useful for short-horizon trading. CTI-2 traders include banks, hedge funds, commodity pool operators, futures commission merchants, commodity trading advisors, foreign and domestic broker/dealers, introducing brokers, proprietary trading firms, and other eligible entities. We use CTI-2 traders' share of the trading volume to compute our financialization proxy.

3.3. Measures of Market Quality

We investigate several measures of market quality: (a) the volatility of pricing errors, i.e., of deviations of prices from their "fundamental" values; (b) bid-ask spreads; (c) depth; and (d) the absolute magnitude of customer trade imbalances. On any given day, futures with up to 84 different maturities are traded. We start by computing market quality variables for each contract maturity in five-minute non-overlapping intervals. Then, we compute daily volume-weighted averages of the five-minute figures during business hours.

We estimate the volatility of pricing errors using Hasbrouck's (1993) widely-used approach. The logarithm of the observed transaction price, p_t , is expressed as the sum of the logarithm of the efficient price, m_t , and the pricing error, s_t, as follows:

$$p_t = m_t + s_t$$

The pricing error is a measure of how efficiently the transaction price tracks the (unobserved) fundamental price represented by an information-efficient "random walk price." Since the pricing error is a zero-mean process, its absolute magnitude is a good measure of its volatility. We follow Hasbrouck (1993) and Boehmer and Kelly (2009) and estimate a lower bound of the volatility of the pricing error, σ_s, using a VAR system comprising four variables: Δp_t, trade sign indicator (estimated using Lee and Ready's (1991) "tick test"), signed trading volume, and signed square root of the trading volume. We compute σ_s on every trading day for each contract maturity for which at least 50 trades take place. In our tables, the variable called "*PE_Proportion*" is the daily ratio of the variance of pricing errors (*PE*), estimated as in Hasbrouck (1993), to the volatility of intraday (log) transaction prices.

We estimate daily bid-ask spreads to approximate the cost of transacting for exchange customers. In the absence of order-book information, we estimate bid and asked prices for each contract in each 5-minute interval after classifying trades as buyer- *vs*. seller-initiated using the Lee and Ready "tick-test."[9] In our tables, the variable called "*Spread*" is the daily volume-weighted average of these 5-minute bid-ask spreads.

We calculate the inverse measure of depth as in Amihud (2002). In our tables, the variable called "*Amihud*" is the daily volume-weighted average of the ratio of absolute return to volume calculated in 5-minute non-overlapping intervals throughout the trading day.

We compute returns tick by tick. We then calculate daily volatility of returns using five-minute non-overlapping intervals throughout the trading day.

Finally, we measure daily customer trade imbalances, reported in our tables as the variable "*AbsOIB*", as the daily volume-weighted average of the ratio of five-minute absolute trade imbalances (buyer-initiated *minus* seller-initiated trades) to trading volume.

4. <u>The Impact of Electronification</u>

Section 4.1 documents changes in market quality measures around electronification. Section 4.2 documents the financialization of intraday activity following electronification by showing the relative contributions to total market activity of individual *vs*. institutional financial traders. It provides novel empirical evidence of entry by new institutional financial

[9] Raman, Robe, and Yadav (2016) verify the tick test's accuracy using data from a time period (post-2009) when "aggressive" traders start being identified by a flag in the CFTC's non-public intraday dataset. For WTI futures, those authors find that the tick-test successfully identifies the (actual) aggressive trader in more than 75% of the cases—similar to the 73% figure found by Theissen (2001) using Frankfurt Stock Exchange data.

traders (Section 4.2.1) and of a resulting change in the nature of financial intermediaries and intraday trading by identifying major differences between these new entrants and other types of traders (size and short-term focus, Section 4.2.2; cross-market presence, Section 4.2.3). Section 4.3 shows that this intraday financialization subsequent to electronification affects short-term more than longer-term contracts.

4.1. Market Quality Metrics

Effective September 5, 2006, the NYMEX introduced electronic trading on Globex in parallel with face-to-face trading in the pits intermediated largely by "Locals." Given that this market reform significantly increased the ease of access for traders without physical access to the trading pits, and correspondingly increased competition in liquidity provision services, one should expect a marked improvement in each of our market quality measures. Table 1 and Figure 1, which present respectively statistical and visual analyses of changes in our market quality measures (defined in Section 3.3 above) surrounding the electronification of WTI futures, show that such is indeed the case.

The sample period for the univariate tests in Table 1 runs from January 3rd, 2006 to March 31st, 2007. *Pre-Electronification* in Table 1 refers to the period from January 3rd, 2006 to September 1st, 2006. *Post-Electronification* refers to the period from September 6th, 2006 to March 31st, 2007. Figure 1 relates to WTI sweet crude oil futures trading in the pits during the *Pre-Electronification* period, and on the Globex platform *Post-Electronification*.

The t-tests in Table 1 provide statistical evidence of a massive improvement in market quality after electronification. Panels A to D in Figure 1 provide strong visual confirmation of our t-tests. Estimated bid-ask spreads drop from an average of 37 basis points to just 3 basis points, a drop of more than 90 percent. Absolute customer trade imbalances drop by about 40 percent, from about 24 percent to about 13 percent. The ratio of the variance of pricing errors to the variance of log transaction prices falls from about 59 percent to about 4 percent, i.e., by more than 90 percent. Each of these changes is statistically highly significant (p-value < 0.001). The Amihud measure of depth also improves substantially, although the change is not statistically significant.

4.2. Electronification and the Financialization of Intraday Activity

4.2.1. Institutional Financial Trading Activity

Following electronification, one also expects an increase in institutional financial traders' contribution to WTI futures market activity. This is exactly what we find. The results are in Table 1 and in Figure 2, describing the nature and respective extents of participation by Locals and by institutional financial traders before *vs*. after September 5, 2006. In Table 1 and in Figure 2, *FIN* is the proportion of trading volume involving the participation of institutional financial traders (traders classified as CTI-2 traders in the CFTC database). It is our proxy for the extent of financialization.

Figure 2 provides visual, trading-activity-based evidence of the WTI futures market's financialization by aggregating the CFTC's account-level intraday information for the CTI-1, CTI-2, and CTI-4 trader categories. Prior to electronification, in line with Manaster and Mann (1996), Locals (CTI-1) dominated pit trading: in the first eight months of 2006, Locals were involved on at least one side of approximately 80 percent of all transactions. In contrast, CTI-2 traders were involved in only about 30 percent of all WTI pit trades in the same period.

In the six months immediately following electronification, we find that over 400 new institutional financial traders enter the WTI market—a rate of entry that is almost three times what it was in the first eight months of 2006. As a result of this inflow of new traders, Figure 2 shows that, within a few months of electronification, the fraction of all Globex WTI futures trades involving an institutional financial trader is almost 60 percent of the total volume—double what the fraction used to be in the WTI pits.[10] Since the overall trading volume also grew substantially in the same period, institutional financial traders captured a bigger slice of a growing WTI pie. The t-tests reported in Table 1 confirm this visual evidence. They show that the average proportion of trading activity involving institutional financial traders almost doubles, from 29.6 percent *pre*-electronification to 55.0 percent *post*-electronification.[11]

[10] Meanwhile, the proportion of trades with Locals falls to approximately half of its *pre*-electronification value.

[11] The significant increase in the proportion of financial institutional trading after the onset of electronic trading echoes the massive growth of the overnight WTI futures positions held by hedge funds and other financial traders during the same period (Büyükşahin *et al*., 2015).

4.2.2. *Characteristics of the Institutional Financial Trader Group*

Because electronification allows for new kinds of institutional financial trading (automated order placement and execution, competition with locals with respect to liquidity provision, etc.), one expects institutional financial traders' trading patterns to differ before and after electronification. To confirm this intuition, Table 2 shows average hourly trading volumes, trading frequencies, and closing ratios for Locals (CTI-1), institutional financial traders (CTI-2), and customers (CTI-4) from January 3rd, 2006, to March 31st, 2007.

Consistent with the expected differences between institutional and individual traders, CTI-2s in the *post*-electronification period trade more than twice as much as Locals do. Most notably, comparing Panels A and B in Table 2 shows that the median value of CTI-2 traders' absolute closing ratio—the average ratio of those traders' ending-of-hour inventory to hourly trading volume—declined sharply from 83 percent *pre*-electronification to only 8 percent *post*-electronification. This finding indicates that the institutional financial traders that enter the WTI futures market after September 5th, 2006 are focused on much shorter horizon strategies (similar to Locals' strategies) compared to the institutional financial traders that had been active in the pits prior to electronification.

4.2.3. *Institutional Financial Traders' Cross-Market Presence*

In contrast to the specialized non-commercial traders that used to populate commodity futures markets in prior decades, a characteristic of the buy-side institutions that started the financialization of commodities fifteen years ago is their simultaneous presence in multiple commodity markets (Tang and Xiong, 2012) and also equity markets (Büyükşahin and Robe, 2014; Cheng, Kirilenko, and Xiong, 2015). If the phenomenon we describe truly amounts to intraday financialization, then one would expect the new institutional day traders in the WTI futures space—unlike their pit counterparts—to be simultaneously active in other markets.

Verifying this conjecture requires intraday data from financial or from non-energy commodity markets, in which individual traders have the same IDs as in the WTI crude oil futures markets. For the period of our study, we are aware of only two such markets: the gold and silver futures marketplaces of the NYMEX's COMEX division.

The COMEX introduced electronic gold and silver futures trading on December 4th, 2006—three months after the NYMEX's energy futures started trading electronically. We use CFTC pit and electronic audit trail data for both of these metals' futures markets, which are available for the last three quarters of 2007. Using the IDs of individual traders from all three futures markets, we identify "common" traders, i.e., traders active in more than one of these markets. For each day in our 2007-Q2 to 2007-Q4 sample, we then compute the proportion of the total WTI crude oil futures trading volume (either in the pits or on Globex) that either involves a "common" Local (CTI-1) or involves a "common" institutional trader (CTI-2).

Table 3 summarizes our analysis of cross-market activity following electronification. It highlights two novel empirical facts. First, "common" institutional financial traders who trade WTI futures on Globex (and who are almost all new to the WTI crude oil market—see Section 4.3.2 below) account for three times as much of the electronic platform's median daily volume as their institutional pit-trading counterparts do of the median daily pit volume. Second, "common" institutional financial traders are involved in several orders of magnitude more trades than are Locals in the WTI pits (almost none of whom trade metals). A similar analysis of gold futures yields similar results. Put differently, Locals really are "local" to the market in which they operate. In all, both empirical regularities clearly suggest that, after electronification, the nature of financial intermediaries and institutional day traders active in commodity futures markets changed drastically, and that intraday trading became dominated by financial traders focused on the very short term and active across multiple markets, rather than traders focused on a single commodity.

4.3. Institutional Financial Trading: Short-term *vs.* Long-term Futures Contracts

Sections 4.1 and 4.2 show, respectively, that the introduction of electronic trading dramatically improved market quality in the crude oil futures market (as it earlier did in the equity markets—see, e.g., Barclay *et al.* (1999) and Jain (2005)) and that it also triggered financialization, i.e., a massive growth in institutional intraday financial trading activity. To isolate the impact of financialization, which is the primary focus of this paper, we turn to differences in the participation of institutional financial traders in different segments of the crude oil futures term structure.

4.3.1. Intuition

With a view to teasing out the impact of financialization from the overall impact of electronification, we note, as discussed earlier in the introduction, that electronic trading can improve market quality *via* three main channels. First, it reduces information asymmetries by improving *pre*- and *post*-trade market transparency. Second, it curbs operating and order processing costs. Finally, it drastically cuts the costs of entry into providing liquidity services. It enables all exchange members, irrespective of their physical location, to exploit deviations from fundamental values and to provide liquidity, thereby significantly increasing competition: the open and transparent electronic market, where all traders have an equal opportunity to voluntarily provide and demand liquidity, attracts new traders—particularly institutional financial traders.

Of these three channels, the first and second should impact different futures contracts similarly, regardless of maturity. Both short-term and long-term contracts should therefore similarly benefit from the improvements in transparency and the reduction of fixed ordering and trading costs.

In contrast, not all contract maturities are expected to experience the same amount of interest from institutional financial traders. First, institutional financial traders have shorter trading horizons than other traders. Intuitively, they should thus trade more in short-term than in long-term contracts (Ederington and Lee, 2002). Second, the two front contract months and the nearest three December contracts (because of related calendar spreads) account for the preponderance of the intraday directional and calendar spread trading in the WTI futures market. Notably, both before (Neuberger, 1999) and after (Büyükşahin *et al.*, 2015) electronification, positions in these five contracts are the most commonly held overnight or for longer periods by producers, refiners, and wholesalers, i.e., by key demanders of WTI futures market liquidity. Hence, with electronification's attracting new financial traders intent on competing to provide liquidity to such users, one would expect financialization to be more pronounced for those five contract maturities.

4.3.2. Evidence

To verify this conjecture, we compute the participation rates of institutional financial traders separately for two groups of futures: short-term *vs*. long-term contracts. Given that approximately half of the total WTI futures trading volume involves calendar spreads in our sample period, we select the "short-term contracts" bin to comprise the two front months (precisely, contracts with 62 days or less to expiration) and the three December contracts with which these two nearest-dated contracts are most often paired for spread trades.[12] Our "long-term contracts" bin consists of the trading activity in the remaining 79 contracts (on any given day) with more than 62 days to expiration.

Figure 3, Panel A plots the evolution of institutional financial traders' participation in short-term and long-term contracts. As predicted, Panel A shows a much stronger rate of financialization for short-term contracts relative to long-term contracts.

Figure 3, Panel B plots the number of new financial institutional traders entering the crude oil futures market in short-term and in long-term contracts. In line with the increased CTI-2 participation rates following electronification discussed in Section 4.2.1 above, Panel B shows a significantly greater number of new institutional financial traders entering the trading of short-term rather than long-term contracts after September 5th, 2006. Overall, the bottom line is that the introduction of electronic trading encouraged an influx of new financial institutional traders, albeit largely in the short-term contracts.

Table 4 presents a more formal comparison of the *pre*- and *post*-electronification differences between the extents of financialization in short-term *vs*. long-term futures. The fraction of the total trading volume in short-term contracts involving institutional financial traders (denoted *FIN_Short-Term*) increases from 28.1 percent for the first eight months of 2006 to 41.4 percent for the six months following electronification. This increase of almost

[12] In our sample period, crack spreads account for about 3.7% of all transactions and 1.8% of the WTI futures trading volume. Calendar spreads account for 22.2% of the futures trade count and 50.1% of the trading volume.

45 percent is highly statistically significant (p-value < 0.001). During the same period, the equivalent measure for long-term contracts (denoted *FIN_Long-Term*) does not change significantly, remaining at around 36-37 percent of the total trading volume at such maturities both *pre*- and *post*-electronification. Consequently, the percentage difference in the contribution of institutional financial trading to the short-dated *vs*. long-dated trading volume, denoted $\Delta FIN = (FIN\_Short\text{-}Term – FIN\_Long\text{-}Term)/FIN\_Short\text{-}Term$, increases from *minus* 30.4 percent pre-electronification to *plus* 9.5 percent after the electronification of the futures market. This event-related increase is statistically significant at the 1 percent level.

In sum, the participation rates of institutional financial traders (financialization) in short- and long-term contracts change differentially as a consequence of electronification, an exogenous exchange-mandated intervention. In the next Section, we exploit these differences in the extent of financialization along the futures term structure to formally test, in an econometrically rigorous framework, for the impact of financialization on market quality. Essentially, even though the market quality metrics for all contracts improve post-electronification, what we test empirically is whether the market quality improvements *post*-electronification are greater for contracts with a greater entry of new institutional financial traders, after controlling for any other factors that could be relevant.

5. Financialization and Market Quality

We saw in Section 4.1 that our market quality metrics improve significantly overall *post*-electronification. We also saw that financialization, in response to electronification, is significantly greater in short-term contracts than in long-term contracts on the same (WTI) commodity. In this Section, we seek to identify the effect of financialization on crude oil futures market quality by exploiting the observed variation in the intensity of financialization for short-term and long-term contracts following the (exogenous) exchange-mandated electronification of crude oil futures. Our contention is that the *average* improvement in market quality variables across all maturities is the average effect of electronification (whether due to improved transparency, lower operating and processing costs, or increased competition amid financialization), but the *relatively* larger improvements observed for short-term (*vs*. long-term) contracts are due to their relatively greater financialization.

Section 5.1 analyzes differences, *pre*- and *post*-electronification, in our market quality metrics for short-dated and long-dated futures contracts. It is a simple event study conducted around the introduction of electronic trading. Section 5.2 carries outs two-stage regressions to establish causality between financialization and improvements in market quality. Section 5.3 discusses the validity of this empirical strategy and shows that our conclusions are qualitatively robust to using alternative methodologies, including a VAR model examining the endogenous relationship between institutional financial trading and market quality using data between April 2007 and March 2008—when electronic trading had become entrenched.

5.1. Descriptive Analysis—Event Study

We start with an event study on a sample comprising all transaction records for WTI futures on NYMEX from January 3rd, 2006 to March 31st, 2007. We split the period between an eight-month period before and a seven-month period after the onset of electronic trading.

We employ the market quality measures discussed in Sections 3.3 and 4.1. We compute daily averages separately for two groups of contracts: short-term and long-term. Table 5 presents the *pre*- and *post*-electronification values of our market quality variables for short-term and long-term contracts separately, as well as the average percentage differences (Δ) between the daily values of these short- and long-term estimates.

Panels A to D of Figure 4 plot the evolution of these percentage differences (trade-volume weighted for short- *vs*. long-term contracts). For all four measures, the improvement after electronification benefited short-term futures more than long-term futures.

First, in Table 5, the *pre*-electronification average ratio of the volatility of pricing errors to the volatility of log transaction prices is 28 percent higher for long-term contracts than for short-term contracts. The difference is 132 percent *post*-electronification. That is, while both long- and short-term contracts have lower pricing errors *post*-electronification, the pricing errors of short-term contracts improve five times more than those of long-term contracts (a relative improvement that is highly statistically significant with a p-value<0.001).

Second, the *pre*-electronification average bid-ask spread is about 28 percent wider for long-term contracts than for short-term contracts. The difference, *post*-electronification, more than decuples—to 304 percent. Again, while both long- and short-term contracts are more liquid *post*-electronification, the liquidity of short-term contracts improves significantly more than that of long-term contracts (p-value<0.001).

Third, the *pre*-electronification absolute magnitude of customer trade imbalances for long-term contracts is on average about 144 percent larger than that for short-term contracts. The same variable in the post-electronification period increases significantly to 175 percent. Here also both long- and short-term contracts display a *post*-electronification improvement (lower customer order imbalances), but again the improvement is significantly greater for short-term contracts than for long-term contracts (p-value<<0.001).

Finally, similar to the depth findings for the WTI market as a whole (see Section 4.1), our t-tests suggest that the average depth for short-term contracts does not change statistically significantly after electronification. We find, however, a statistically significant relative improvement of depth for short-term *vs*. long-term contracts (*p*-value<0.001).

Overall, as captured by our key market quality metrics, electronification benefits short-term contracts significantly more than it does long-term contracts. Meanwhile, as seen in Section 4.3.2, institutional financial traders' contribution to the total volume increases significantly in short-term contracts while staying (statistically) the same in long-term ones.

Together, these results are consistent with our contention that the *average* market quality improvement across all contracts is the effect of electronification, while the relatively greater improvement for short-term contracts is due to their relatively greater financialization. *Prima facie*, notwithstanding the lack of relevant controls (such as changes in relative trading volume and volatility), it appears that financialization improves market quality. The next two sub-Sections examine this conjecture more rigorously.

5.2. Two-Stage Regression Analysis

The NYMEX's introduction of electronic trading removed barriers to trading crude oil futures and facilitated market participation by financial institutional traders. We have documented a massive increase in financial institutional trader activity *post*-electronification. Under the maintained assumption that the NYMEX's decision to "go electronic" was exogenous with respect to pre-existing crude oil derivatives market conditions, we use the advent of WTI futures market electronification as an instrument to tackle the endogeneity issues between market quality and trading activity of financial institutional traders.

Our goal is to identify the impact on market quality of the financialization that followed electronification—not of electronification *per se*. In order to tease out the former, we exploit the exogenous increase due to electronification in the *relative* participation of financial institutional traders in short-term (*vs*. long-term) contracts. To be precise, we use the electronification of the NYMEX WTI crude-oil futures markets as an instrument for the *relative* participation of financial institutional traders in short-term (*vs*. long-term) contracts in that market, as follows:

First Stage: $\Delta FIN_t = \alpha_1 + \beta_1 Electronification + \gamma_1 C_t + \theta_t$

Second Stage: $\Delta M_t = \alpha_2 + \beta_2 \Delta FIN_t + \gamma_2 C_t + \gamma_3 X_t + \epsilon_t$

where ΔFIN_t is the percentage difference between the rates of participation of institutional financial traders in short- *vs*. long-term contracts, i.e., Δ*FIN = (FIN_Short-Term – FIN_Long-Term*) / *FIN_Short-Term*; ΔM_t is the relative difference between the value taken for short- *vs*. long-term contracts by a given market quality measure (bid-ask spreads, depth, etc.); $Electronification$ is a dummy set equal to 1 after September 5th, 2006 (the NYMEX's electronification date) and to 0 prior to that day; C_t are exogenous control dummies; and X_t is a set of control variables including trading volume and volatility. The coefficient β_2 is our estimate of the (causal) effect of financialization on market quality.

5.2.1. First Stage

The first stage regresses the relative difference between financial institutions' rates of participation in trades of short-term *vs*. long-term futures, ΔFIN_t, on the $Electronification$ dummy. We control for differences in trading patterns on: (i) prompt-futures expiration days;

(ii) days when the U.S. Department of Energy's Energy Information Administration (EIA) releases its weekly reports on petroleum inventories; (iii) the day just prior to an EIA news-release day; (iv) the five business days each month when commodity index traders that follow the GSCI indexing methodology roll their nearby-futures positions; (v) possible transitory anomalies in the month when electronification started; and (vi) day-of-the-week effects.

Table 6 summarizes the first-stage results. Consistent with the univariate analyses and the graphical evidence presented in Section 4.3.2, we find a statistically and economically significant link between $Electronification$ and the difference in institutional financial traders' participation in short- *vs*. long-term contracts. Before electronification, institutional financial traders participated more in long-term than in short-term crude oil futures contracts, as indicated by the intercept of -0.30. The $Electronification$ dummy's coefficient β_1 = 0.41 implies that, *post*-electronification, the *relative* participation of financial traders in short-term contracts increased by 41 percentage points. Importantly, the $Electronification$ dummy alone explains more than 30 percent of the variation in ΔFIN, indicating that it is a strong instrument for the relative change in the proportion of institutional financial traders.

5.2.2. Second Stage

In the second stage, we regress our market quality measures (precisely, the percentage differences in depth, spreads, customer imbalances, and pricing error volatility for short-term *vs*. long-term contracts) on ΔFIN (instrumented from the first stage) and the binary controls from the first stage. Panel B in Table 6 shows the results from the second stage. Following Breusch-Godfrey serial correlation tests, all models include two lags of the dependent variables. We estimate standard errors using the Newey-West method with two lags.

For each and every market quality metric, Panel B shows that ΔFIN consistently has a negative and statistically highly significant coefficient (p-value < 0.001). To interpret this result, recall that we are analyzing the relation between the percentage difference (for short- *vs*. long-term contracts) in a given market-quality variable and the corresponding percentage difference in the extent of intraday financialization. In this context, our results mean that an increase in the percentage (or relative) difference in participation of institutional financial traders in short- *vs*. long-term contracts causally influences the percentage (or proportional) difference in that market quality variable in short- *vs*. long-term contracts.

In robustness checks (summarized as "Model B" in Panel B, Table 6), we include in the second stage two variables measuring the percentage differences in (i) crude oil return volatilities and (ii) trading volumes between short- and long-term contracts. The results are robust: when short-term contracts experience more financialization than long-term contracts do, the bid-ask spreads, Amihud inverse measure of depth, customer imbalances, and pricing errors all drop substantially more for short-term contracts than for long-term contracts.

Let us consider each of the market quality variables separately. For spreads, the -4.36 coefficient (Model A, Table 6) means that a one-unit increase in the percentage difference in financialization (with institutional financial trading increasing more in short- than in long-term contracts) decreases the percentage differences in bid-ask spreads (with bid-ask spreads decreasing more for short- than for long-term contracts) by 4.36 units. The standard deviation for the percentage difference in bid-ask spreads is 186 percent; thus, a one-standard deviation increase in the percentage difference in financialization widens the percentage differences in bid-ask spreads by 0.84 standard deviations, or 104 percent of its mean value. Model B in Table 6 shows that, as should be expected, the percentage difference in spreads is positively related to the percentage difference in volatilities between short-term and long-term contracts and negatively related to the percentage difference in trading volumes.

Similar to the bid-ask spread results, we find a consistently negative and statistically significant relation between the difference in financialization intensity and the difference in Amihud inverse depth ratios or customer trade imbalances. A one-standard deviation increase in the percentage difference in financialization widens the percentage difference in Amihud ratios by 1.07 standard deviations (or 38 percent of the mean value) and in the absolute magnitudes of customer trade imbalances, by 0.60 standard deviations (or 19 percent of the mean value).

Last, but not least, a one-unit increase in the percentage difference in financialization between short- and long-term contracts, after controlling for all the relevant variables, further widens the percentage difference in pricing error volatility by 0.92 units in Model A (and by

0.64 units in Model B[13]). A one-standard deviation increase in the percentage difference in the rate of financialization widens the percentage differences in pricing error volatility by 0.43 standard deviations or 74 percent of its mean value. In other words, Table 6 shows that financialization significantly improves intraday pricing efficiency.[14]

5.3. Controlling for Changes in "Customers"

The two-stage approach in Section 5.2 is designed to identify a causal relationship from financialization to market quality. While the entry of institutional financial traders into the crude-oil market is exogenous, however, their choice of which contract maturities to trade could be based on the order-flow of external "customers", i.e., of non-financial traders. In this sub-Section, we accordingly carry out additional analyses to control carefully, in multiple ways, for potentially confounding influences on our inferences of changes in customer trading volume and for the possibility that improvements in market quality might be observed because the nature of customers changes after electronification.

5.3.1. Controlling for Post-Electronification Changes in Customer Volume

In Section 5.2 above, we already showed that the impact of financialization on all of our market quality measures remains economically and statistically significant even after controlling (Model B, Panel B of Table 6) for differences (in short- *vs*. long-term contracts) in the *post*-electronification growth rates of the overall trading volume. We now show that the effect of institutional financial traders remains significant even after taking into account cross-maturity differences in *customer* trading (Δ*Customer Volume*). We do so in two ways.

[13] In our analysis of the volatility of pricing errors, we follow Boehmer and Kelly (2009) in including the standard deviation of transaction *prices* as control while modeling the volatility of the pricing error. Accordingly, we employ the percentage difference in the volatility of transaction *prices* between short-term and long-term controls while modeling the percentage difference in pricing error volatilities.

[14] Our two-stage analyses focus on Intitutional Financial ("CTI-2") traders to the exclusion of Locals ("CTI-1" traders). One might expect that a two-stage regression analysis using the volume share of CTI-1s (rather than that of CTI-2s) could produce "mirror" results. In that case, it could be argued (albeit facetiously) that it is the crowding out of CTI-1 traders and of their trading practices in the futures pits (rather than the competition from institutional financial traders) that led to the *post*-electronification increase in market quality. However, this possibility is unlikely since CTI-1 trading volume (as opposed to the CTI-1 *share* of the total volume) actually *increased* following electronification—which indicates that it is indeed greater competition from CTI-2s, rather than the decline of CTI-1s, that drove market quality improvements.

First, we introduce Δ*Customer_Volume* in the second-stage regressions as an additional control. Table 7 shows that the contributions of increased institutional financial trading to all market quality improvements are economically and statistically significant even after controlling for differences along the futures term structure in the *post*-electronification growth rates of *non-financial* (customers') activity. While the regression results suggest that relatively greater changes in customer activity in near-dated (*vs*. long-dated) contracts do help explain part of the spread improvements, we find no empirical evidence that they improve our other measures of market quality.

Second, to account for possibly non-linear effects of Δ*Customer_Volume* on the relation between institutional financial trading and market quality, we run the same second-stage regressions but stratified by Δ*Customer Volume* (Tercile 1, 2, and 3 corresponding to the bottom third, medium, and highest values of Δ*Customer Volume*). Table 8 summarizes the results of this additional analysis, focusing for brevity on the Δ*FIN* coefficients. It shows similarly significantly beneficial effects of financialization on market quality, irrespective of the level of Δ*Customer_Volume*. Even in the lowest tercile (which consists solely of days when customer trading is actually more intense in long-term than in short-term contracts), we find that financialization improves each of our market quality metrics.[15] These results further strengthen our argument that, economically and statistically, the main driver of change—for all our quality metrics—is the extent of institutional financial trading.

5.3.2. Two-Stage Regression Analysis – "Continuing" Customers

We next look at the effect of the exogenous entry of institutional financial traders on the spreads paid by customers who *already* traded WTI futures in the pits prior to electronification and who continue to trade (now electronically, on the Globex platform) after electronification. In other words, we examine the effect of the entry of institutional financial traders in short-term *vs*. long-term contacts while keeping the nature of the customers and their demand for liquidity, the same before and after electronification.

[15] We obtain similar results if, rather than tercile regressions, we run the analysis separately for negative and positive values of Δ*Customer_Volume.*

The general methodology is identical to the one described Section 5.2, except that we limit our analysis to bid-ask spreads (given that spreads are the only market measure that can be estimated separately for "continuing" customers). As shown in Table 9, the results of this additional analysis are consistent with our previous results: specifically, an increase in ΔFIN significantly reduces (by 4.43 percent on average across all six specifications) the spread paid by "continuing" customers.

5.4. Other Robustness Tests

5.4.1. Two-Stage Regression Analysis—Lagged Identification

Our next robustness check relies on a different instrument to extract the component of institutional trading that is exogenous to market conditions. In all of our two-stage analyses so far, we have used the NYMEX's introduction of electronic trading as our main instrument. Here, inspired by Muravyev (2016), we adopt an alternative instrumental variables approach predicated on the day-to-day persistence of the degree of financialization and we use lagged values (in addition to a set of exogenous variables) to predict future levels of that share.

To be precise, we use in the first stage a one-day lag of ΔFIN together with dummy variables for prompt-contract expiration days, EIA information days, the initial month of electronic trading, and GSCI roll days. As Panel A of Table 10 shows, these variables combine to form a strong instrument: they explain just over 25% of the variation in ΔFIN. Moreover, ΔFIN is statistically significantly persistent (with a coefficient of 0.50), higher on EIA announcement days, and lower on contract expiration days.

In the second stage, we use ΔFIN (now instrumented from this alternative first stage) as an explanatory variable for our market quality variables. The results for the second-stage regressions are presented in Panel B of Table 10. As in Panel B of Table 6, we find strong evidence that financialization improves both liquidity and intraday pricing efficiency.

5.4.2. VAR Analysis

Finally, we further examine the endogenous relation between participation by financial institutions and intraday market quality through a vector autoregression (VAR) analysis. We rely on the same 2006—2008 CFTC dataset of intraday transactions but restrict the sample period from April 1st, 2007, to May 31st, 2008. This choice of sample period rules out any overlap with the two-stage regression sample (which ends on March 31st, 2007). It also allows us to test whether the results obtained for the six months immediately following the onset of electronic trading persist even in more mature market conditions.

As before, we compute percentage differences (for short- $vs.$ long-term contracts) in the financialization rates (ΔFIN), bid-ask spreads ($\Delta Spread$), depth ($\Delta Amihud\ Measure$), and absolute customer trade imbalances (ΔABS_{OIB}). We proceed analogously for the daily ratio of the variance of pricing errors (PE) to the volatility of intraday (log) transaction prices ($\Delta PE\_Proportion$). As well, we compute the percentage differences in realized return volatilities for short-term $vs.$ long-term futures contracts ($\Delta Return\_Volatility$).[16]

We propose a 6-variable VAR model of the roles of volatility and financialization in explaining the behavior of our four liquidity and pricing efficiency variables in 2007–2008. Hameed, Kang, and Viswanathan (2010) note the need for, yet also the difficulty in justifying, a specific ordering of a similar set of variables. We follow their approach, which consists of ordering the variables in a logical manner and then verifying robustness to alternative orderings.

Specifically, in order to test whether the intensity of institutional financial trading (our proxy for the extent of commodity market financialization) impacts market quality, we order ΔFIN and $\Delta Return\_Volatility$ before the four market quality variables. This ordering implies that shocks to volatility or to institutional financial traders' positions result in instantaneous adjustments in liquidity and pricing efficiency, whereas changes in market quality impact volatility and institutional trading activity with a lag.

We obtain qualitatively similar results independent of whether $\Delta Return\_Volatility$ or ΔFIN is ordered first $vs.$ second of the VAR variables. Likewise, we obtain qualitatively similar results with different orderings of the market quality variables. For tractability, we therefore focus our discussion below on a single specification. Reflecting our focus on the

[16] Augmented Dickey-Fuller (ADF) tests show that the percentage difference of all the variables in our SVARs are stationary. We select the number of lags for the ADF tests according to the Akaike information criteria.

effect of financialization on market quality, we discuss results when ΔFIN is placed first with the following ordering: ΔFIN, $\Delta Return\_Volatility$, $\Delta Spread$, $\Delta Amihud\ Measure$, ΔABS_{OIB}, and $\Delta PE\_Proportion$.

Formally, for the data series $\{y_t\}$ consisting of the vector y_t of our six variables of interest, we consider the following reduced-form representation of the VAR model:

$$A(L)y_t = \varepsilon_t,$$

where $A(L)$ is a matrix of polynomial in the lag operator L, $\{I - A_1L^1 - A_2L^2 - \ldots A_pL^p\}$, y_t is a $(6\ x\ 1)$ data vector, and ε_t is a vector of orthogonalized reduced-form disturbances. Specifically, for our six-variable VAR, we impose the standard Cholesky decomposition of the variance-covariance matrix (i.e., a lower triangular matrix with ones on the diagonal, and a diagonal matrix) to fit a just-identified model. With our ordering restrictions, we assume that the extent of financialization is not contemporaneously affected by market volatility or market quality. Likewise, we posit that market volatility is contemporaneously affected by the extent of financialization but not by various aspects of market quality. We also assume that all of our measures of liquidity and pricing efficiency are contemporaneously affected by the rate of financialization and by market volatility, but affect the latter two with a lag.

Panels A to D of Figure 5 present the impulse response functions (IRFs) showing the effect of a one-standard deviation shock to ΔFIN on market quality measures: $\Delta Spread$, $\Delta Amihud\ Measure$, ΔABS_{OIB}, and $\Delta PE\_Proportion$. Consistent with the results of our earlier event-study and regression analyses, Panel A shows that an increase in ΔFIN results in a negative and significant effect on (i.e., an improvement in) $\Delta Spread$ on day t (contemperaneously) and on day $t+1$. That is, an increase in the relative financialization of short-term contracts leads to a decrease in their relative bid-ask spreads. While the effect of ΔFIN on $\Delta Amihud$ is statistically insignificant (Panel B), we find a negative and significant effect on ΔABS_{OIB} (Panel C) and on pricing errors, $\Delta PE_{Proportion}$ (Panel D). More specifically, a one-standard deviation increase in ΔFIN leads to a 0.19 and 0.15 standard-deviation decreases in contemperaneous ΔABS_{OIB} and $\Delta PE_{Proportion}$, respectively, and leads to a further 0.13 standard deviation-decrease in $\Delta PE\_Proportion$ on day *t+1.* In sum, the VAR results are in line with the results of our other univariate and mutivariate analyses.

6. Are the Financialization Results Driven by Fast Automated Traders?

For equities, Hendershott, Jones, and Menkveld (2011) show that algorithmic trading improves several intraday market liquidity metrics. In a similar vein, we know that high frequency trading improves intraday price discovery for equities (Brogaard, Hendershott, and Riordan, 2014) and pricing efficiency for currencies (Chaboud *et al*. 2014).

For commodities, Section 5 establishes empirically that financialization, as measured through intraday institutional financial trading, improves both liquidity and pricing efficiency metrics. A natural question, then, is whether some of our results are driven wholly or in part by the rise of high-speed algorithmic trading, given that such algorithmic traders could be institutional traders. In this Section, we therefore investigate the effects of participation by these two components of intraday institutional financial trading (fast institutional financial traders and of non-fast institutional financial traders) on pricing efficiency and liquidity.

Following Raman, Robe, and Yadav (2016), whose analysis of "fast" and "slow" traders is based on CFTC non-public intraday data of the kind we use in the present paper, we identify fast automated institutional traders ("FLP" for short) as those CTI-2 traders who trade more than 990 times a day (3 times per minute, every minute) and carry less than 5% of their daily trading volume overnight (making them largely intraday traders). Therefore, intraday financial institutional trading as studied in the previous Sections is split into two new measures: (i) *FIN_Non_FLP,* which we calculate after removing all fast automated intraday institutional traders from our set of institutional financial traders; and (ii) *FIN_FLP*, the component of financialization that is due to the onset of institutional fast machine trading. Analogous to our preceeding analyses, we use the difference between short-term and long-term contracts for both of these two measures of financialization.

For the revised two-stage regression analysis, we only apply the first stage procedure (see Section 5.2.1) to the non-automated component of financialization (i.e., excluding fast automated CTI-2 traders). We then run the second stage using the same specification as in Section 5.2.2, but using the instrumented series of non-automated financialization as well as the actual level of fast machine-based financialization. Using predicted values for both financialization variables would introduce unacceptable levels of multicollinearity between them.

Table 11 presents the results from the second-stage of this analysis. It is clear that, for non-fast financial institutional traders, the liquidity results in the columns corresponding to spreads, depth, and absolute customer trade imbalances in Table 11 are qualitatively similar to those corresponding to all institutional financial traders as reported respectively in Panel B of Table 6. For each liquidity metric: (a) ΔFIN_Non_FLP has a negative and statistically highly significant coefficient (p-value<0.001); (b) the R-squared of the Table 11 regression is even higher than the R-squared of the corresponding Model B regressions in Panel B of Table 6; and (c) the magnitude of the coefficient for ΔFIN_Non_FLP in Table 11 is significantly higher—about double in every case—relative to the corresponding Model B coefficient in Panel B of Table 6. The impact of non-automated institutional financial trading in Table 11 appears to be at least as strong as the impact of overall institutional financial trading in Table 6. It is also clearly robust to all the specifications and controls we have utilized.

Table 11 also shows that fast/machine institutional traders share some, but not all, of the credit for liquidity improvements: their trading contributes to the narrowing of bid-ask spreads (highly significant) and curtailing of customer trade imbalances (though statistical significance is weak). Their activity's impact on depth, however, is statistically insignificant.

Interestingly, the respective roles of fast machine traders and of other institutional financial traders are reversed in the case of pricing efficiency. In Table 6, financialization as a whole brings about an economically and statistically significant reduction in the variance of pricing errors. Table 11 indicates that, statistically speaking, the improvement in pricing efficiency may be attributed solely to the growth of fast financial institutional traders.

In sum, our results on financialization's beneficial impact on intraday market quality do not come about just because of high-speed machine traders. To wit, a financialization measure based only on non-automated institutional financial trading leads to a significant reduction in bid-ask spreads, a significant increase in depth, and a significant reduction in the absolute magnitude of customer trade imbalances. Our results therefore provide the first evidence that different components of intraday financialization (fast/machine *vs*. slow/human institutional financial trading) contribute differently to different aspects of market quality.

7. Conclusions

On September 5th, 2006, the NYMEX introduced electronic trading to its energy futures marketplace, including the world's largest commodity market: that for WTI light sweet crude oil futures. We document that this structural change sharply increased intraday trading by institutional financial traders, i.e., electronification led to the crude oil market's *intraday* financialization.

We use this event to document the effect of intraday financialization on key measures of market quality: the volatility of intraday pricing errors as well as bid-ask spreads, depth, and the absolute magnitude of customer trade imbalances. Specifically, exploiting variations in the extent of financialization across the futures term structure after electronification, we are able to tie economically and statistically significant improvements in all these market quality proxies to financialization. Our inferences are robust to differences in the nature and volume of non-financial trading. Importantly, we also show that these results are not due solely to the growth of fast machine trading that is made possible by electronification. While the activity of fast algorithms has the biggest impact on intraday pricing efficiency, non-automated institutional financial traders have an economically and statistically beneficial impact on market liquidity (bid-ask spreads, depth, and customer buy-sell imbalances) that is robust to different specifications and controls. *Post*-event, a VAR analysis of the endogenous relation between institutional financial trading and market quality metrics provides strong additional evidence that greater participation by institutional financial traders brings about significant improvements in pricing efficiency and in market liquidity.

Overall, we add significantly to the financialization literature by providing the first detailed empirical evidence on the financialization of intraday trading activity in the world's largest commodity market and by showing that this development had a first-order positive impact on market liquidity and pricing efficiency. We also add to the large literature on the impact of institutional trading. In particular, we are first to investigate the impact of the short (intraday) horizon of both fast and non-fast institutional financial traders and show that they both contribute to intraday market quality (albeit in different ways). While these findings pertain to commodity markets, they are directly relevant to all electronic order-driven markets where liquidity provision is voluntary. Indeed, insofar as most equity and other financial markets are now organized as electronic order-driven markets with voluntary liquidity provision, our results on the beneficial impact of the flow of institutional risk capital into liquidity provision and short-horizon trading are potentially of wide applicability.

Our results point to several avenues for future research. First, given that liquidity provision in U.S. commodity futures markets is entirely voluntary, and given the significant increase that we document in the extent and influence of institutional financial trading, two important questions are: first, whether, in periods of stress, institutional financial traders make markets more or less fragile; and second, whether the financialization of commodity markets affects their resilience to exogenous shocks. Answering those questions would have implications for financial stability and the importance of systemic risk in the presence of electronic trading.

Second, we provide empirical evidence that financialization has changed the nature of financial intermediaries in the world's largest commodity futures markets. In particular, we show that, unlike their predecessors in the pits, the new institutional financial traders on the electronic platform are generally active in other commodity markets. Plausibly, they are likely also active in other asset markets beside commodities. These observations point to the possibility of novel, fascinating new analyses of commonality in liquidity that could be made possible by utilizing granular, comprehensive intraday regulatory data.

References

Acharya, Viral V., Lars A. Lochstoer, and Tarun Ramadorai (2013). "Limits to Arbitrage and Hedging: Evidence from Commodity Markets." *Journal of Financial Economics* 109 (2), pp. 441–65.

Amihud, Yakov (2002). "Illiquidity and Stock Returns: Cross-Section and Time Series Effects." *Journal of Financial Markets* 5, pp. 31–56.

Badrinath, S.J, Jayant R. Kale, and Thomas H. Noe (1995). "Of Shepherds, Sheep, and the Cross-Autocorrelations in Equity Returns." *Review of Financial Studies* 8 (2), pp. 401–30.

Barclay, Michael J., William G. Christie, Jeffrey H. Harris, Eugene Kandel, and Paul H. Schultz. (1999). "The Effects of Market Reform on the Trading Costs and Depths of Nasdaq Stocks." *Journal of Finance* 54 (1), pp. 1–34.

Başak, Süleyman and Anna Pavlova (2016). "A Model of Financialization of Commodities." *Journal of Finance* 71 (4), pp. 1511–1556.

Bessembinder, Hendrik, Allen Carrion, Laura A. Tuttle, and Kumar Venkataraman (2016). "Liquidity, Resiliency and Market Quality around Predictable Trades: Theory and Evidence." *Journal of Financial Economics* 121 (1), pp. 142–166.

Boehmer, Ekkehart and Erik K. Kelly (2009). "Institutional Investors and the Informational Efficiency of Prices." *Review of Financial Studies* 22 (9), pp. 3563–3594.

Boehmer, Ekkehart, Gideon Saar, and Lei Yu (2005). "Lifting the Veil: An Analysis of Pre-Trade Transparency at the NYSE." *Journal of Finance* 60 (2), pp. 783–815.

Boulatov, Alex and Thomas J. George (2008). "Securities Trading when Liquidity Providers are Informed. " Working paper, University of Houston.

Boulatov, Alex and Thomas J. George (2013). "Hidden and Displayed Liquidity in Securities Markets with Informed Liquidity Providers." *Review of Financial Studies* 26 (8), pp. 2096–2137.

Brogaard, Jonathan, Terrence Hendershott and Ryan Riordan (2014). "High Frequency Trading and Price Discovery." *Review of Financial Studies* 27 (8), pp. 2267–2306.

Brunetti, Celso and David Reiffen (2014). "Commodity Index Trading and Hedging Costs." *Journal of Financial Markets* 21 (6), pp. 153–180.

Brunetti, Celso, Bahattin Büyükşahin, and Jeffrey H. Harris (2017). "Speculators, Prices and Market Volatility." *Journal of Financial and Quantitative Analysis*, forthcoming.

Bruno, Valentina, Bahattin Büyükşahin, and Michel A. Robe (2017). "The Financialization of Food?" *American Journal of Agricultural Economics* 99(1), pp. 243–264.

Büyükşahin, Bahattin and Michel A. Robe (2014). "Speculators, Fundamentals and Cross-Market Linkages." *Journal of International Money and Finance* 42(C), pp. 38–70.

Büyükşahin, Bahattin, Michael S. Haigh, Jeffrey H. Harris, James A. Overdahl and Michel A. Robe (2015). "Fundamentals, Trading Activity and Derivative Pricing." Working Paper, U.S. Commodity Futures Trading Commission, May.

Campbell, John Y., Tarun Ramadorai, and Allie Schwartz (2009). "Caught on Tape: Institutional Trading, Stock Returns, and Earnings Announcements." *Journal of Financial Economics* 92 (1), pp. 66–91.

Chaboud, Alain P., Benjamin Chiquoine, Erik Hjalmarsson, and Clara Vega (2014). "Rise of the Machines: Algorithmic Trading in the Foreign Exchange Market." *Journal of Finance* 69 (5), pp. 2045–2084.

Cheng, Ing-Haw and Wei Xiong (2014). "Financialization of Commodity Markets." *Annual Review of Financial Economics* 6, pp. 419–441.

Cheng, Ing-Haw, Andrei Kirilenko, and Wei Xiong (2015). "Convective Risk Flows in Commodity Futures Markets." *Review of Finance* 19 (5), pp. 1733–1781.

Chordia, Tarun, Richard Roll, and Avanidhar Subrahmanyam (2011). "Recent Trends in Trading Activity and Market Quality." *Journal of Financial Economics* 101 (2), pp. 243–263.

DeLong, J. Bradford, Andrei Shleifer, Lawrence Summers, and Robert Waldman (1990). "Noise Trader Risk in Financial Markets." *Journal of Political Economy* 98, pp. 703–738.

Ederington, Louis H. and Jae Ha Lee, 2002. "Who Trades Futures and How: Evidence from the Heating Oil Futures Market," *Journal of Business* 75 (2), pp. 353–73.

Etula, Erkko (2013). "Broker-Dealer Risk Appetite and Commodity Returns." *Journal of Financial Econometrics*, 11 (3), pp. 486–521.

Fotak, Veljko, Vikas Raman and Pradeep K. Yadav (2014). "Fails-to-Deliver, Short Selling, and Market Quality" *Journal of Financial Economics* 114 (3), pp. 493–516.

Goettler, Ronald L., Christine Parlour, and Uday Rajan (2009) "Informed Traders and Limit Order Markets." *Journal of Financial Economics* 93 (1), pp. 67–87.

Glosten, Lawrence R. and Lawrence E. Harris (1988). "Estimating the Components of the Bid-Ask Spread." *Journal of Financial Economics* 21 (1), pp. 123–142.

Goldstein, Itay and Liyan Yang (2016). "Commodity Financialization: Risk Sharing and Price Discovery in Commodity Futures Markets." Working paper, Wharton School, February.

Hameed, Allaudeen, Wenjin Kang, and S. Viswanathan (2010). "Stock Market Declines and Liquidity." *Journal of Finance* 65 (1), pp. 257-293.

Hamilton, James D. (2009). "Causes and Consequences of the Oil Shock of 2007–08." NBER Working Paper No. 15002, May.

Hamilton, James D. and J. Cynthia Wu (2014). "Risk Premia in Crude Oil Futures Prices." *Journal of International Money and Finance* 42(C), pp. 9–37.

Hamilton, James D. and J. Cynthia Wu (2015). "Effects of Index-Fund Investing on Commodity Futures Prices." *International Economic Review*, 56 (1), pp. 187–205.

Hasbrouck, Joel (1993). "Assessing the Quality of a Security Market: A New Approach to Transaction-Cost Measurement." *Review of Financial Studies* 6 (1), pp. 191–212.

Hasbrouck, Joel and Gideon Saar (2013). "Low-Latency Trading." *Journal of Financial Markets* 16 (3), pp. 646–679.

Hendershott, Terrence, Charles M. Jones and Albert J. Menkveld (2011). "Does Algorithmic Trading Improve Liquidity?" *Journal of Finance*, 66 (1), pp. 1–33.

Hendershott, Terrence, Dmitry Livdan, and Norman Schürhoff (2015). "Are Institutions Informed about News?" *Journal of Financial Economics* 117 (2), pp. 249–287.

Henderson, Brian J., Neil D. Pearson, and Li Wang (2015). "New Evidence on the Financialization of Commodity Markets." *Review of Financial Studies* 28 (5), pp. 1285–1311.

Hong, Harrison and Motohiro Yogo (2012). "What Does Futures Market Interest Tell Us about the Macroeconomy and Asset Prices?" *Journal of Financial Economics*, 105 (3), pp. 473–90.

Irwin, Scott H. and Dwight R. Sanders (2012). "Testing the Masters Hypothesis in Commodity Futures Markets." *Energy Economics* 34 (1), pp. 256–69.

Jain, Pankaj J. (2005). "Financial Market Design and the Equity Premium: Electronic versus Floor Trading." *Journal of Finance*, 60 (6), pp. 2955–2985.

Jones, Charles M. (2013). "What Do We Know About High-Frequency Trading?" Columbia Business School Research Paper No. 13-11, March.

Kaniel, Ron and Hong Liu. (2006) "What Orders do Informed Traders Use?" *Journal of Business* 79 (4), pp. 1867–1913.

Kilian, Lutz and Dan Murphy (2014). "The Role of Inventories and Speculative Trading in the Global Market for Crude Oil." *Journal of Applied Econometrics*, 29 (3), pp. 454–478.

Kim, Abby (2015). "Does Futures Speculation Destabilize Commodity Markets?" *Journal of Futures Markets* 35 (8): 696–714.

Knittel, Christopher R. and Robert S. Pindyck (2016). "The Simple Economics of Commodity Price Speculation." *American Economic Journal: Macroeconomics* 8 (2), pp. 85–110.

Korniotis, George M. (2009). "Does Speculation Affect Spot Price Levels? The Case of Metals with and without Futures Markets." Working Paper No. 2009-29, Board of Governors of the Federal Reserve System, May.

Lee, Charles M.C. and Mark K. Ready (1991). "Inferring Trade Direction from Intraday Data." *Journal of Finance* 46 (2), pp. 733–46.

Manaster, Steven and Steven C. Mann (1996). "Life in the Pits: Competitive Market Making and Inventory Control." *Review of Financial Studies*, 9 (3), pp. 953–75.

Menkveld, Albert J. (2016). "The Economics of High-Frequency Trading: Taking Stock." *Annual Review of Financial Economics*, 8, pp. 1–24.

Muravyev, Dimitriy, 2016. "Order Flow and Expected Option Returns." *Journal of Finance* 71 (2), pp. 673–708.

Naik, Narayan and Pradeep K. Yadav (2003). "Trading Costs of Public Investors with Obligatory and Voluntary Market-making: Evidence from Market Reforms." Working Paper, London Business School.

Neuberger, Anthony (1999). "Hedging Long-Term Exposures with Multiple Short-Term Futures Contracts." *Review of Financial Studies*, 12 (3), pp. 429–59.

Raman, Vikas, Michel A. Robe, and Pradeep K. Yadav (2016). "Liquidity Provision under Stress: The Fast, the Slow, and the Dead." Working Paper, U.S. Commodity Futures Trading Commission, August.

Sanders, Dwight R., Scott H. Irwin, and Robert P. Merrin (2010). "The Adequacy of Speculation in Agricultural Futures Markets: Too Much of a Good Thing?" *Applied Economic Perspectives and Policy* 32 (1), pp. 77–94.

Silber, William L. (1984). "Marketmaker Behavior in an Auction Market: An Analysis of Scalpers in Futures Markets." *Journal of Finance* 39 (4), pp. 937-953.

Singleton, Kenneth J. (2014). "Investor Flows and the 2008 Boom/Bust in Oil Prices." *Management Science* 60 (2), pp. 300–318.

Sockin, Michael and Wei Xiong (2015). "Informational Frictions and Commodity Markets." *Journal of Finance* 70 (5), pp. 2063–2098.

Stoll, Hans R. and Robert E. Whaley (2010). "Commodity Index Investing and Commodity Futures Prices." *Journal of Applied Finance* 2010 (1), pp. 7–46.

Tang, Ke and Wei Xiong (2012). "Index Investing and the Financialization of Commodities." *Financial Analysts Journal* 68 (6), pp. 54–74.

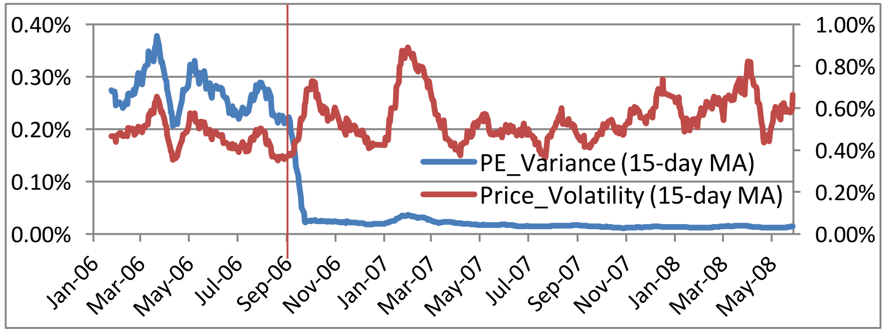
Theissen, Erik (2001). "A Test of the Accuracy of the Lee/Ready Trade Classification Algorithm." *Journal of International Financial Markets, Institutions and Money*, 11 (2), pp. 147–165.

UNCTAD (2011). "Price Formation in Financialized Commodity Markets: The Role of Information." Study prepared by the secretariat of the United Nations Conference on Trade and Development (UNCTAD), June.

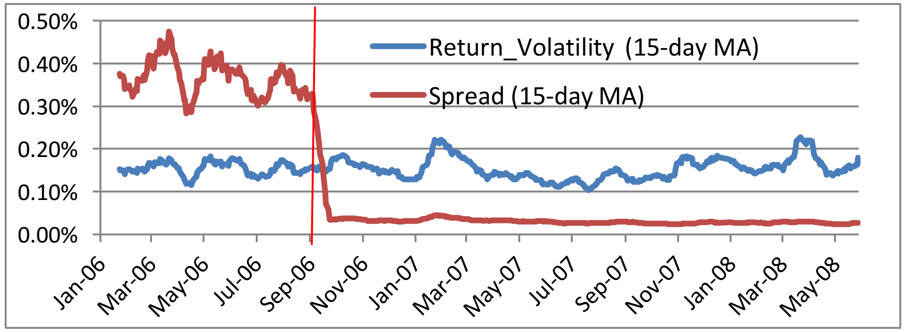
Figure 1: Market Quality Measures, 2006–2008

Figure 1 depicts the evolution of 15-day moving averages for various market quality measures at the New York Mercantile Exchange's (NYMEX) West Texas Intermediate sweet crude oil (WTI) futures market between 2006 and 2008. The underlying measures are computed using pit data for the *pre*-electronification period (January 3rd, 2006, to September 1st, 2006) and Globex data for the *post*-electronification period (September 5th, 2006, to May 31st, 2008). In **Panel A**, *PE_Variance* is the daily average pricing error variance, estimated as in Hasbrouck (1993). *Price_Volatility* is the daily average of 5-minute volatility of intraday (log) prices for each futures maturity. In **Panel B**, *Spread* is the daily average of 5-minute Bid-Ask spreads, where bid and asked prices are estimated for each contract maturity in each interval (5 minutes) after classifying trades as buyer- *vs*. seller-initiated using the Lee and Ready (1991) tick test. *Volatility* is the daily average 5-minute (300 seconds) average return volatility. In **Panel C**, *Amihud* is an inverse measure of depth (Amihud, 2002) equal to the daily average of the ratio of absolute return to volume, calculated in 5-minute non-overlapping intervals throughout the trading day. In **Panel D**, *AbsOIB* is the daily average of 5-minute customer trade imbalances (where customers are the traders classified as CTI-4 traders in the CFTC database) calculated as the ratio of 5-minute absolute trade imbalances (buyer- *minus* seller-initiated trades) to trading volume. All the measures are estimated for each contract maturity and then volume-weight-averaged across all 84 futures contract maturities using trades time-stamped during business hours. Source: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

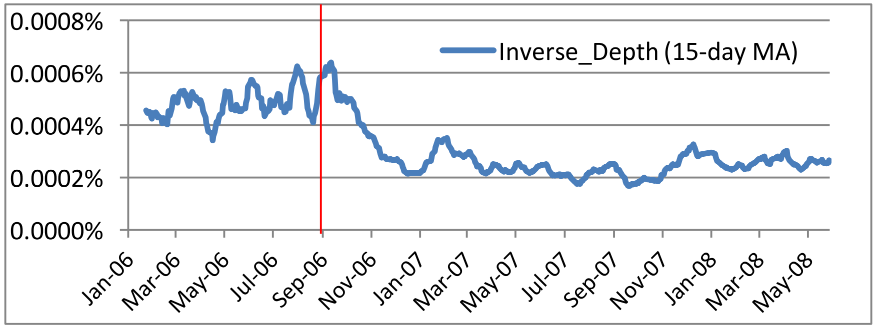
Panel A: Pricing Errors (*PE_Variance* and *Price_Volatility*)



Panel B: *Spread* and *Volatility*



Panel C: Inverse Depth (*Amihud Ratio*)



Panel D: Customer Demand Imbalances (*AbsOIB*)

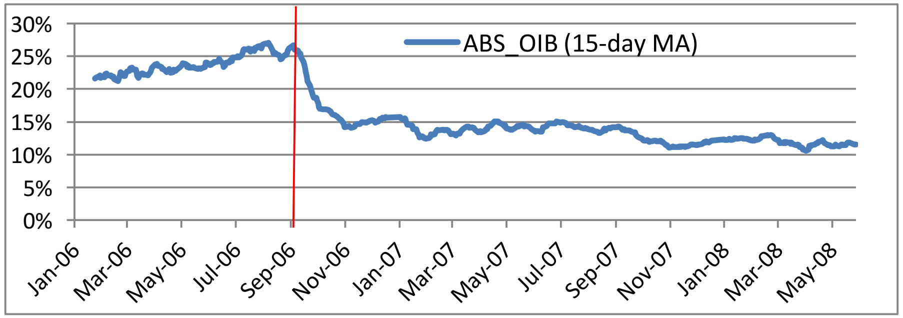


Figure 2: Trading Volume – Share of Locals *vs.* Institutional Financial Traders, 2006 – 2008

Figure 2 compares the respective evolutions between 2006 and 2008 of the fractions of the total trading volume involving institutional financial traders (dashed line) and Locals (solid line) in the NYMEX's WTI sweet crude oil futures market. Volume shares are based on pit data for the *pre*-electronification period (January 3rd, 2006, to September 1st, 2006) and on Globex data for the *post*-electronification period (September 5th, 2006, to May 31st, 2008). *FIN* is the proportion of trades involving the participation of one or two institutional financial traders (traders classified as CTI-2 traders in the CFTC database) in either or both legs of a trade. *Local* is the proportion of the total trading volume involving the participation of one or two "Locals" (i.e., traders classified as CTI-1 traders in the CFTC database) in one or both legs of a trade. Figure 2 plots moving averages of these daily volume shares based on trades time-stamped during business hours. Source: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

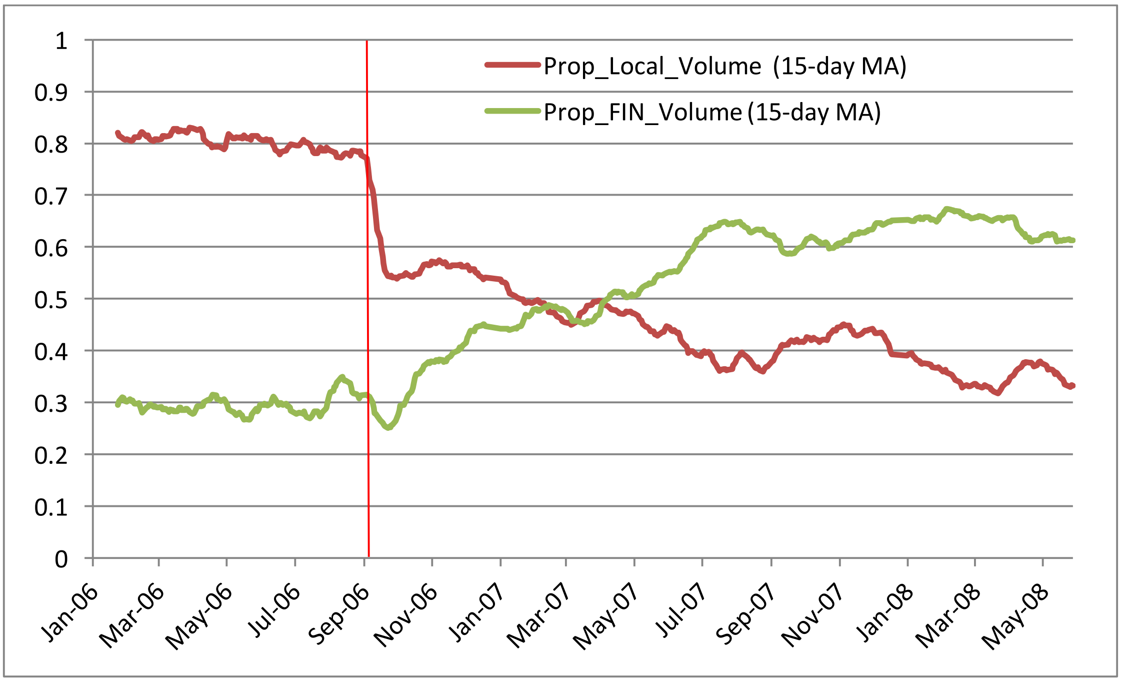
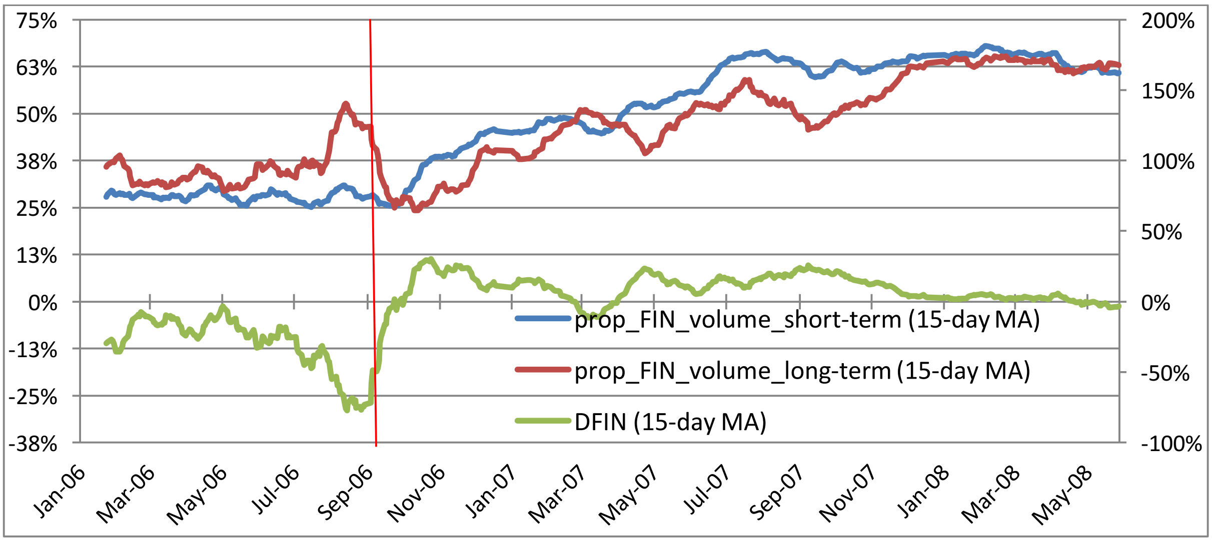


Figure 3: Institutional Financial Trading Activity: Short-Term *vs.* Long-Term contracts

Figure 3 compares the evolution of institutional financial trading activity in short-term *vs*. long-term WTI sweet crude oil futures contracts on the NYMEX. **Panel A** compares the proportions of the total trading volume involving institutional financial traders in short-term *vs*. long-term WTI futures; **Panel B** compares the monthly number of new institutional financial traders (i.e., arrivals) in short-term *vs*. long-term WTI futures. The analysis is conducted on pit data for the *pre*-electronification period (January 3rd, 2006, to September 1st, 2006) and Globex data for the *post*-electronification period (September 5th, 2006, to May 31st, 2008). In **Panel A**, *FIN* is the proportion of the trading volume involving one or more institutional financial traders (traders classified as CTI-2 traders in the CFTC database): *FIN_Short-Term* is the daily, trading volume-weighted average of *FIN* across short-term contracts (contracts with up to 62 days to expiration); *FIN_Long-Term* is the daily, volume weighted average of *FIN* for long-term contracts (contracts with more than 62 days left to expiration). Δ*FIN* or *DFIN* is the daily percentage difference between the short- and long-term proportions: *(FIN_Short-Term – FIN_Long-Term*)/ *FIN_Short-Term*. The vertical line in Panel A identifies the date of the introduction of electronic trading – September 5th, 2006. Source: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

Panel A: Financial trading volume in short-term *vs*. long-term crude oil contracts



Panel B: Entry of new institutional financial traders in short-term *vs*. long-term WTI crude oil futures

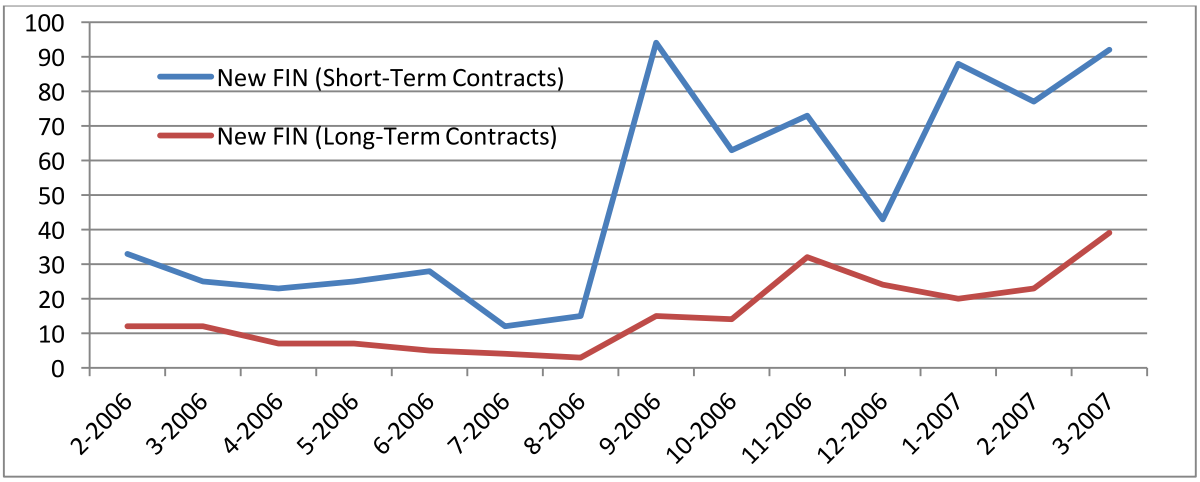
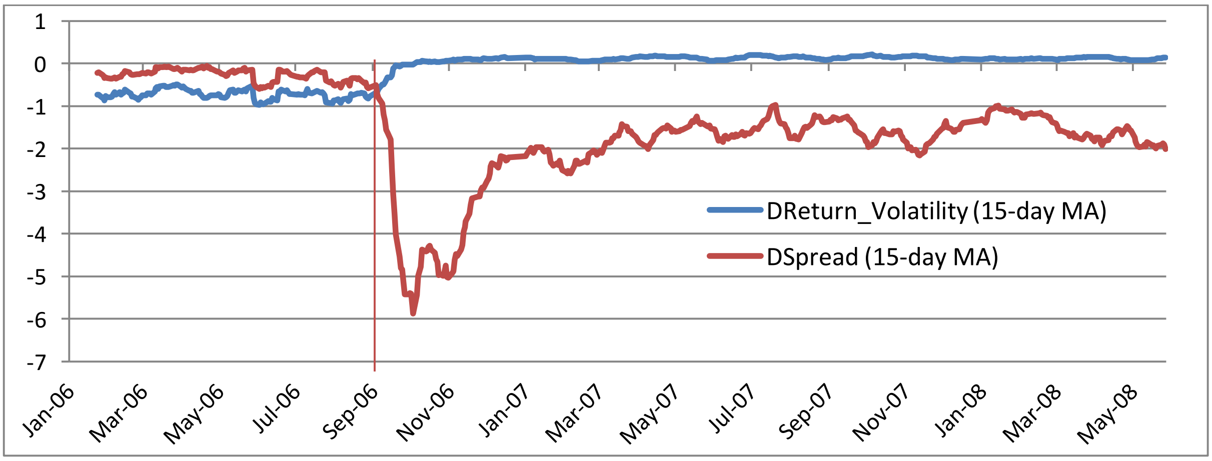


Figure 4: Institutional Financial Trading Activity and Market Quality measures:

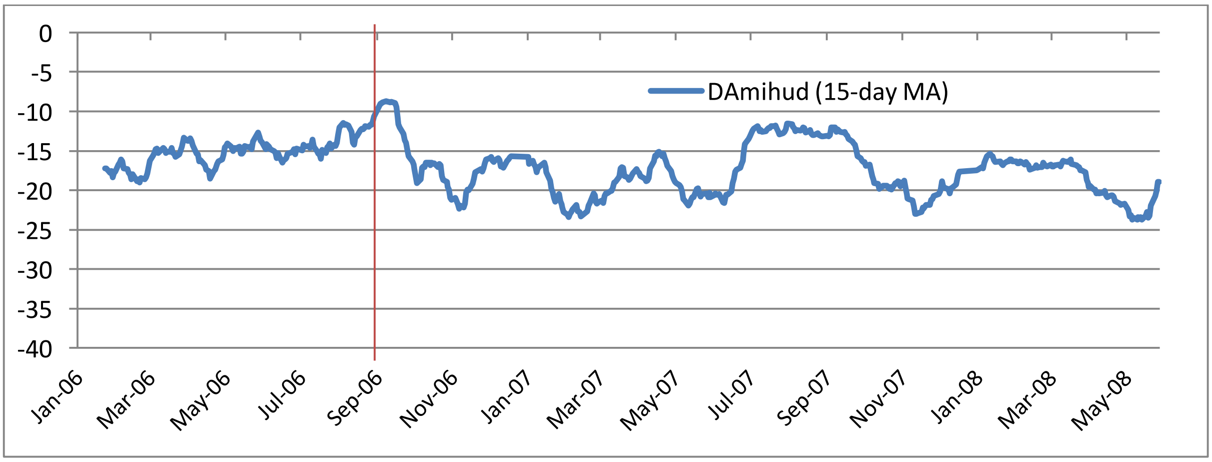
Short-Term *vs.* Long-Term contracts

Figure 4 compares the evolution of various market quality measures in short-term (up to 62 days to expiration) *vs*. longer-term (more than 62 days until expiration) crude oil futures contracts. The analysis is conducted for NYMEX WTI sweet crude oil futures trading during business hours in the NYMEX pits for the *pre*-electronification period (January 3rd, 2006, to September 1st, 2006) and on the Globex platform for the *post*-electronification period (September 5th, 2006 to May 31st, 2008). In each Panel, we plot the daily percentage difference (denoted Δ*)* between the *Short-Term* and *Long-Term* values of the relevant variable(s). In **Panel A**, *Spread* refers to the daily average of 5-minute Bid-Ask spreads obtained using bid and asked prices estimated for each contract maturity in each interval (5 minutes) after classifying trades as buyer- *vs*. seller-initiated using the Lee and Ready (1991) tick test; *Volatility* or *Std_Return_300* refers to the 5-minute (300 seconds) average return volatility. In **Panel B**, *Amihud* refers to an inverse measure of depth (Amihud, 2002) equal to the daily average of the ratio of absolute return to volume calculated in 5-minute non-overlapping intervals throughout the trading day. In **Panel C**, *AbsOIB* refers to the daily average of 5-minute customer (traders classified as CTI 4 traders in the CFTC database) trade imbalances calculated as the ratio of 5-minute absolute trade imbalances (buyer-initiated *minus* seller-initiated trades) to trading volume. In **Panel D**, *PE_Proportion* is the daily ratio of *PE_Variance* and *Price_Volatility*. In **Panel E**, *PE_Variance* refers to the daily pricing error variance, estimated as in Hasbrouck (1993), while *Price_Volatility* refers to the daily average of 5-minute volatility of intraday (log) transaction prices for each contract maturity in each time interval. The dark vertical line in each plot identifies the date of the introduction of electronic trading – September 5th, 2006. Sources: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

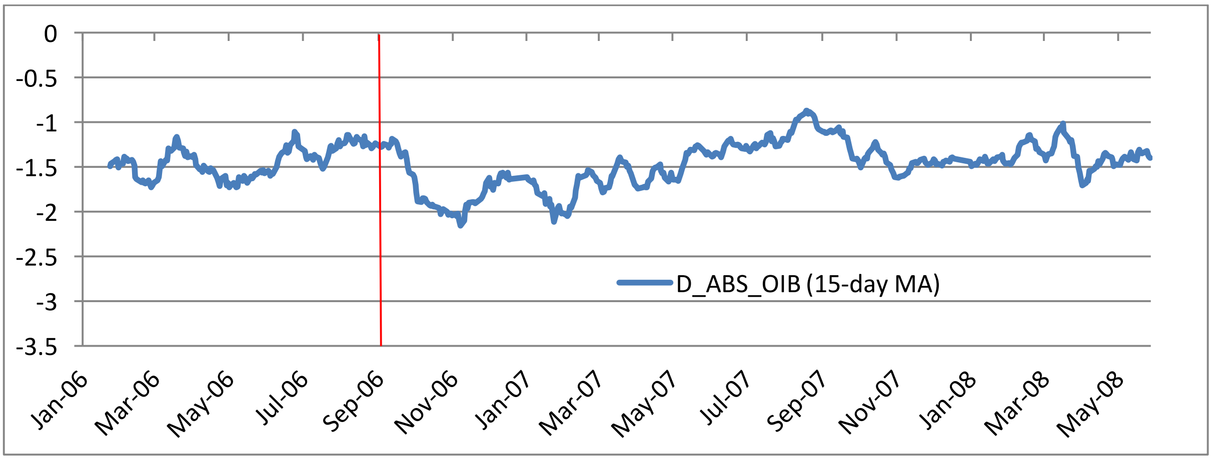
Panel A: Δ*Spread* and Δ*Volatility*



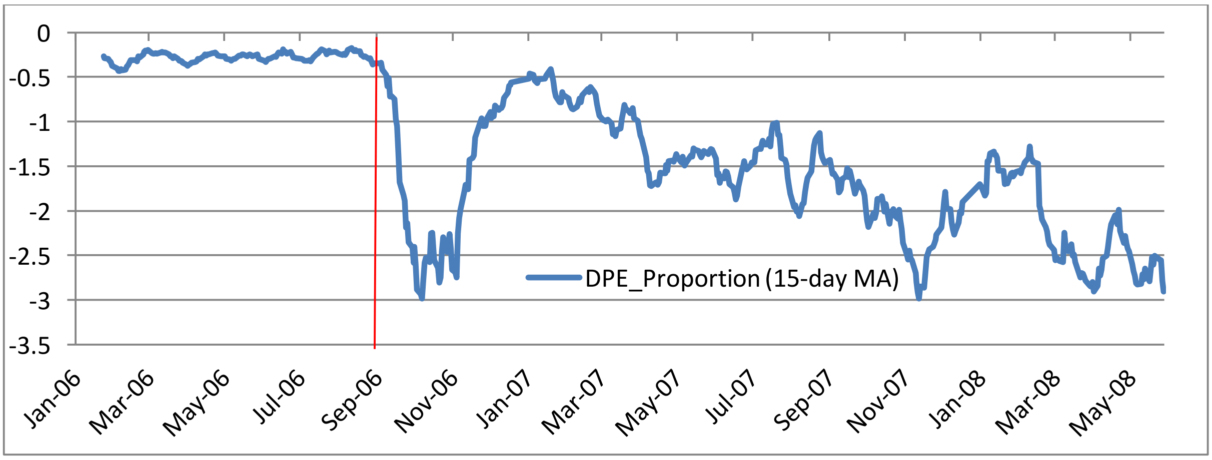
Panel B: Δ*Amihud* (inverse depth)



Panel C: Δ*AbsOIB*



Panel D: Δ*PE_Proportion*



Panel E: Δ*PE_Variance* and Δ*Price_Volatility*

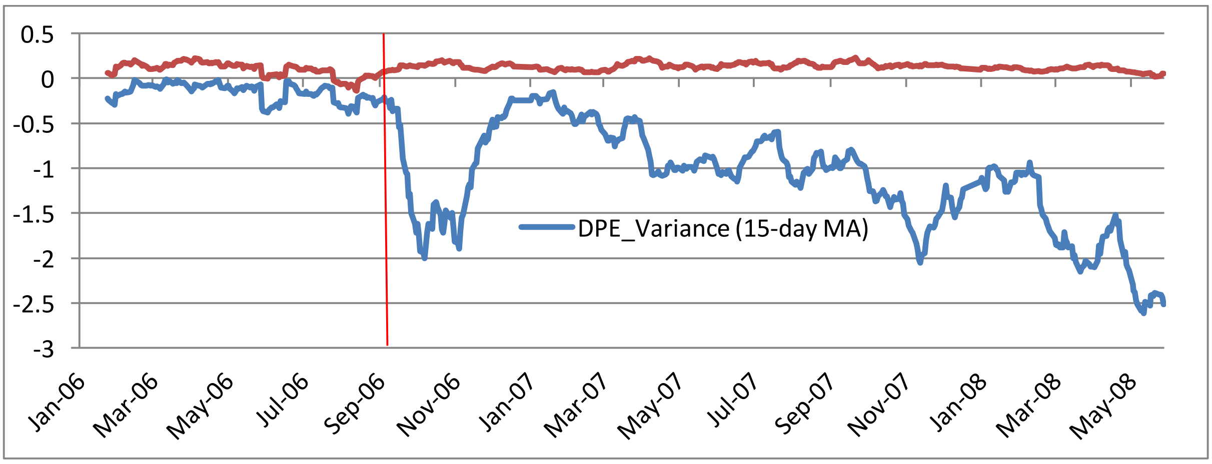
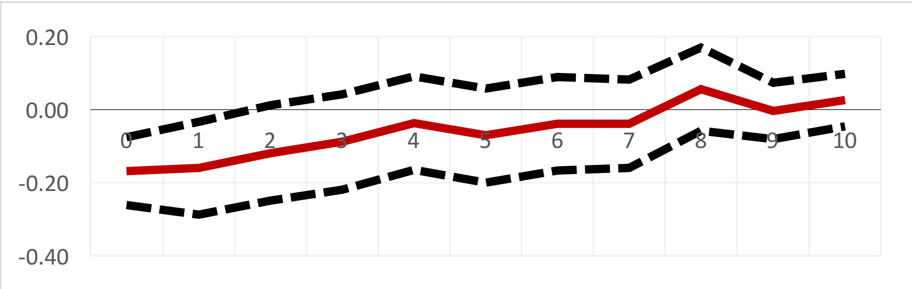


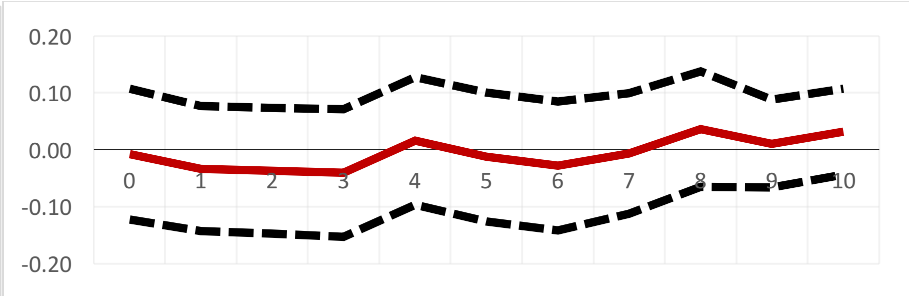
Figure 5: Effect of Institutional Financial Traders – Impulse Response Functions

Figure 5 provides graphs of orthogonalized impulse response functions (red lines) with 10% confidence bands (dotted lines). Each Panel depicts the impact on measures of market quality and pricing efficiency, up to 10 days out, of a one-standard deviation shock to Δ***FIN***, the difference between the daily average trading volume shares of institutional financial traders in short-term *vs*. long-term WTI sweet crude oil futures contracts. The analysis is conducted using Globex data from April 1st, 2007, to May 31st, 2008. Δ***Spread*** (**Panel A**), Δ***Amihud*** (depth, **Panel B)**, Δ***AbsOIB*** (customer trade imbalances, **Panel C**), and Δ***PE_Proportion*** (Pricing errors, Panel D). Impulse response functions are obtained for a VAR system consisting of 5 lags of Δ*FIN*, Δ*Spread, ΔAmihud, and ΔAbsOIB and ΔPE_Proportion.*

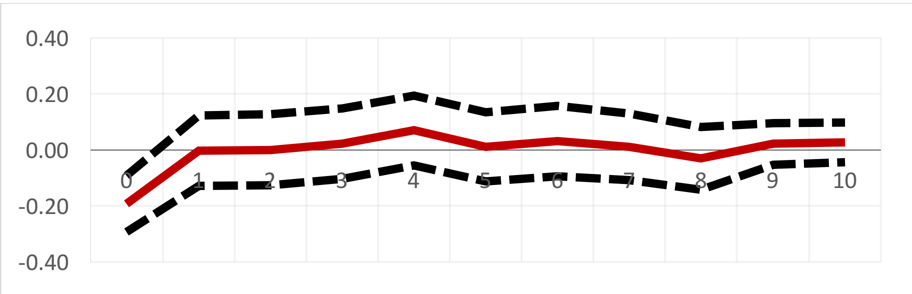
Panel A: Effect of Δ*FIN* on Δ*Spread*



Panel B: Effect of Δ*FIN* on Δ*Amihud*



Panel C: Effect of Δ*FIN* on Δ*ABSOIB*



Panel D: Effect of Δ*FIN* on Δ *PE_Proportion*

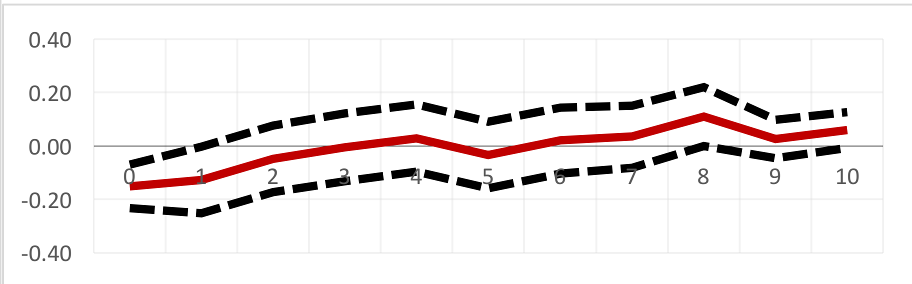


Table 1: Impact of Electronification on Institutional Financial Trading and Market Quality

Table 1 presents an analysis of institutional financial traders' participation and measures of market quality surrounding the introduction of electronic trading in WTI sweet crude-oil futures by the NYMEX on September 5th, 2006. The sample period is January 3rd, 2006, to March 31st, 2007. *Pre-Electronification* refers to the period from January 3rd, 2006, to September 1st, 2006; *Post-Electronification* refers to the period from September 5th, 2006, to March 31st, 2007. The analysis is conducted on pit trading data for the *Pre-Electronification* period and on Globex data for the *Post-Electronification* period. ***FIN*** is the proportion of the total trading volume during business hours involving the participation of institutional financial traders (traders classified as CTI-2 traders in the CFTC database). ***Spread*** is the daily average of 5-minute Bid-Ask spreads obtained using bid and asked prices estimated for each contract maturity in each interval (5 minutes), after classifying trades as buyer- *vs*. seller-initiated using the Lee and Ready (1991) tick-test. ***Amihud,*** an inverse measure of depth (Amihud, 2002), is the daily average of the ratio of absolute return to volume calculated in 5-minute non-overlapping intervals throughout the trading day. ***AbsOIB*** is the daily average of 5-minute customer (traders classified as CTI-4 traders in the CFTC database) trade imbalances calculated as the ratio of five-minute absolute trade imbalances (buyer-initiated *minus* seller-initiated trades) to trading volume. ***PE_Proportion*** is the daily ratio of the pricing error variance, estimated as in Hasbrouck (1993), to the volatility of intraday (log) transaction prices. All the variables are estimated for each contract maturity and daily volume-weighted averages of these figures are then computed and employed in the regressions. Two-tailed *p-values* are also reported. <u>Source</u>: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

	Pre-Electronification	Post-Electronification	Difference	Pct. Difference	p-value
FIN	29.64%	55.01%	25.37%	85.59%	<.001
Spread	0.37%	0.03%	-0.34%	-91.94%	<.001
Amihud	4.90	2.66	-2.24	-45.76%	0.604
AbsOIB	23.85%	13.48%	-10.37%	-43.48%	<.001
PE_Proportion	58.87%	3.73%	-55.14%	-93.66%	<.001

Table 2: Trader Descriptions

Table 2 describes key attributes of three kinds of traders in the NYMEX's WTI sweet crude-oil futures market in 2006–2007. The summary statistics in **Panel A** are based on pit data during the *pre*-electronification period (January 3rd, 2006, to September 1st, 2006); in **Panel B,** the information is based on Globex data from the *post*-electronification period (September 5th, 2006, to March 31st, 2007). *Locals, Financial Institutions* ("*Fin. Inst.*") and *Customers* refer to traders classified respectively as CTI-1, 2 and 4 in the CFTC database. *Abs. Closing Ratio* refers to the average ratio of a trader's ending-of-hour inventory to that trader's hourly trading volume during business hours. Similarly, *Trading Volume* and *Number of Trades* are also hourly averages of a trader's activity. Cross-sectional mean and median are also presented. Source: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

Panel A: Pits, *Pre*-electronification (January 3rd, 2006 to September 1st, 2006)

Traders	Trading Volume		Number of Trades		Abs. Closing Ratio	
	Mean	Median	Mean	Median	Mean	Median
Locals	258	85	14	8	22%	3%
Fin. Inst.	269	81	6	3	57%	83%
Customers	87	10	4	2	75%	100%

Panel B: Globex, *Post*-electronification (September 5th, 2006 to March 31st, 2007)

Traders	Trading Volume		Number of Trades		Abs. Closing Ratio	
	Mean	Median	Mean	Median	Mean	Median
Locals	115	36	30	13	32%	12%
Fin. Inst.	298	50	114	19	38%	8%
Customers	77	10	23	4	60%	100%

Table 3: Locals and Institutional Financial Traders – Electronic *vs*. Pit Cross-Market Traders

Table 3 tabulates the average proportion of the pits or electronic (i.e., Globex) daily futures trading volume that involves a "Local" or a "Financial Institution" active not only in the NYMEX WTI crude oil futures market but also in both gold and silver COMEX futures (left columns) or only in gold COMEX futures (right columns). Panel A computes those proportions for the WTI futures market; Panel B, for the gold futures market. The sample period is March 27th through December 31st, 2007. All proportions are computed across all contract maturities. ***Source***: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

	Common to Crude Oil, Gold, and Silver			**Common to Crude Oil and Gold**		
	Institutions (Electronic)	***Institutions (Pits)***	***Locals (Pits)***	***Institutions (Electronic)***	***Institutions (Pits)***	***Locals (Pits)***
A. Crude Oil Futures						
Mean	21.6%	10.4%	0.0%	23.8%	10.5%	0.2%
Median	21.8%	7.4%	0.0%	24.1%	7.5%	0.1%
Std Dev.	3.4%	8.8%	0.0%	3.8%	8.8%	0.1%
B. Gold Futures						
Mean	20.2%	1.4%	0.0%	22.4%	1.5%	0.2%
Median	19.6%	0.1%	0.0%	22.0%	0.2%	0.0%
Std Dev.	5.9%	3.6%	0.3%	5.9%	3.6%	0.6%

Table 4: Effect of Electronification on Institutional Financial Trading – Short-Term *vs*. Long-Term

Table 4 presents a univariate analysis of institutional financial traders' participation surrounding the introduction of WTI futures electronic trading by the NYMEX on September 5th, 2006. The sample period is January 3rd, 2006, to March 31st, 2007. *Pre-Electronification* refers to the period from January 3rd, 2006, to September 1st, 2006. *Post-Electronification* refers to the period from September 5th, 2006 to March 31st, 2007. The analysis is conducted using pit data in the *Pre-Electronification* period and Globex data in the *Post-Electronification* period. ***FIN*** is the proportion of the futures trading volume during business hours that involves the participation of institutional financial traders (traders classified as CTI-2 traders in the CFTC database). All the variables are estimated for each contract maturity, with daily volume-weighted averages computed separately for (i) *Short-Term* (contracts with up to 62 days to expiration) and (ii) *Long-Term* (contracts with more than 62 days to expiration) futures. ***FIN_Short-Term*** is the daily, volume-weighted average of *FIN* in *Short-Term* contracts. ***FIN_Long-Term*** is the daily, volume-weighted average of *FIN* in *Long –Term* contracts. Δ***FIN*** is the daily percentage difference in the two: Δ*FIN = (FIN_Short-Term – FIN_Long-Term*)/*FIN_Short-Term*. Two-tailed *p-values* are reported in the last column. Source: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

	Pre-Electronification	Post-Electronification	Difference	p-value
FIN_Short-Term	28.10%	41.42%	13.32%	<.001
FIN_Long-Term	36.27%	37.48%	1.21%	0.312
Δ*FIN*	-30.42%	9.54%	39.96%	<.001

Table 5: Effect of Electronification on Market Quality – Short-Term vs. Long-Term

Table 5 presents univariate analyses of key measures of market quality surrounding the introduction of WTI futures electronic trading by the NYMEX on September 5th, 2006. The sample period is January 3rd, 2006, to March 31st, 2007. *Pre-Electronification* refers to the period from January 3rd, 2006, to September 1st, 2006; *Post-Electronification* refers to the period from September 5th, 2006, to March 31st, 2007. The analysis is conducted using pit data in the *Pre-Electronification* period and Globex data in the *Post-Electronification* period. ***Spread*** is the daily average of 5-minute Bid-Ask spreads obtained using bid and asked prices estimated for each contract maturity in each interval (5 minutes), after classifying trades as buyer- *vs*. seller-initiated using the Lee and Ready (1991) tick-test. ***Amihud**,* an inverse measure of depth (Amihud, 2002), is the daily average of the ratio of absolute return to volume calculated in 5-minute non-overlapping intervals throughout the trading day. ***AbsOIB*** is the daily average of 5-minute customer (traders classified as CTI-4 traders in the CFTC database) trade imbalances calculated as the ratio of 5-minute absolute trade imbalances (buyer-initiated *minus* seller-initiated trades) to trading volume. ***PE_Proportion*** is the daily ratio of the pricing error variance, estimated as in Hasbrouck (1993), to the volatility of intraday (log) transaction prices. All the variables are estimated for each contract maturity with volume weighted averages computed separately for (i) *Short-Term* (contract maturities with less than 62 days to expiration) and (ii) *Long-Term* (contract maturities with greater than or equal to 62 days to expiration) futures. For example, *Spread_Short-Term* is the daily, trading-volume-weighted average of *Spread* across *Short-Term* contracts. *Spread_Long-Term* is the daily, volume weighted average of *Spread* across *Long –Term* contracts. Δ***Spread*** is the daily percentage difference between the two: *(Spread_Short-Term – Spread_Long-Term*)/ *Spread_Short-Term*. The other market quality variables are defined analogously. Two tailed *p-values* are reported in the last column. <u>*Source*</u>: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

	Pre-Electronification	**Post-Electronification**	**Difference**	***p-value***
Spread_Short-Term	0.35%	0.03%	-0.32%	<.001
Spread_Long-Term	0.41%	0.10%	-0.31%	<.001
Δ*Spread*	-28%	-304%	-276%	<.001
Amihud_Short-Term	1.04	1.07	0.03	0.604
Amihud_Long-Term	15.00	20.00	5.00	<.001
Δ*Amihud*	-14.87	-18.43	-3.56	<.001
AbsOIB_Short-Term	17.09%	12.36%	-4.73%	<.001
AbsOIB_Long-Term	40.85%	33.19%	-7.66%	<.001
Δ*AbsOIB*	-143.74%	-175.26%	-31.52%	<.001
PE_Proportion_Short-Term	55.35%	4.12%	-51.23%	<.001
PE_Proportion_Long-Term	69.61%	8.90%	-60.71%	<.001
Δ*PE_Proportion*	-27.73%	-132.27%	-104.54%	<.001

Table 6: Institutional Financial Traders and Market Quality – Two-stage Regression Analysis

Table 6 presents the results of a two-stage regression analysis of the impact of institutional financial trading on market quality. Results from the first stage are presented in **Panel A**; the second-stage results are presented in **Panel B**. The analyses are conducted using NYMEX pits data for the *pre*-electronification period (January 3rd, 2006, to September 1st, 2006) and Globex data for the *post*-electronification period (September 5th, 2006, to March 31st, 2007). ***FIN*** is the proportion of the total futures trading volume involving the participation of financial traders (traders classified as CTI-2 traders in the CFTC database). ***Electronification*** is a dummy variable that equals 1 in the *post*-electronification period and 0 otherwise. ***EIA_Inventory*** is a dummy variable that equals 1 on the day (usually Wednesday, otherwise Thursday) when the U.S. Department of Energy's Energy Information Administration (EIA) releases its weekly report on crude oil stock levels and 0 otherwise. ***Lead_Inventory*** is a dummy variable that equals 1 on the day preceding the EIA announcement day and 0 otherwise. ***GSCI Roll*** is a dummy variable that equals 1 on the five business days when the monthly GSCI roll takes place and 0 otherwise. ***Contract_Exp_Day*** is a dummy variable that equals 1 on the day of the prompt contract's expiration and 0 otherwise. ***September_2006*** is a dummy variable that equals 1 in the calendar month when electronification took place and 0 otherwise. ***Day of the Week*** are three dummy variables set equal to 1 for Monday, Tuesday, or Friday and 0 otherwise. ***Volatility*** is the daily volume-weighted average of the 5-minute volatility of (mid-quote) returns estimated for each contract in each maturity interval. ***Volume*** is the daily volume-weighted average of 5-minute trading volume estimated for each contract in each maturity interval. ***Price_Volatility*** is the daily volume-weighted average of 5-minute volatility of intraday (log) transaction for each contract in each maturity interval. ***Amihud**,* an inverse measure of depth (Amihud, 2002), is the daily average of the ratio of absolute return to volume calculated in 5-minute non-overlapping intervals throughout the trading day. ***AbsOIB*** is the daily average of 5-minute customer (traders classified as CTI 4 traders in the CFTC database) trade imbalances calculated as the ratio of five-minute absolute trade imbalances (buyer-initiated minus seller-initiated trades) to trading volume. AbsOIB_Short-Term is the daily, volume weighted average of AbsOIB across short-term contracts (up to 62 days to expiration). ***PE_Variance*** is the average daily pricing error variance, estimated as in Hasbrouck (1993). ***Spread*** is the daily volume-weighted average of 5-minute Bid-Ask spreads obtained using bid and asked prices estimated for each contract maturity in each interval (5 minutes), after classifying trades as buyer- *vs*. seller-initiated using the Lee and Ready (1991) tick-test. **∆*Spread*** is the daily percentage difference between *Spread_Short-Term* and *Spread Long-Term. Spread_Short-Term* is the daily volume-weighted average of *Spread* for short-term contracts (up to 62 days to expiration). *Spread_Long-Term* is the daily, volume weighted average of *Spread* for long-term contracts (more than 62 days to expiration). ***∆FIN, ∆PE_Variance, ∆Amihud, ∆AbsOIB, ∆Volatility, ∆Price_Volatility, and ∆Volume*** are defined analogously. ∆*FIN* is the ***dependent variable*** in the first stage and is instrumented by variables from the relevant Model in Panel A (i.e., Model 2 or 3), in the second stage. Two-tailed *p-values,* obtained using Newey-West standard errors with 5 lags, are also reported.

Panel A: First Stage

Parameter	Model 1		Model 2		Model 3	
Intercept	-0.30	<.001	-0.33	<.001	-0.33	<.001
Electronification	0.40	<.001	0.40	<.001	0.41	<.001
EIA_Inventory			0.07	0.212	0.07	0.206
Lead_Inventory			0.01	0.886	0.01	0.871
GSCI_Roll			0.07	0.088	0.07	0.085
Contract_Exp_Day			-0.08	0.318	-0.08	0.325
September_2006					-0.07	0.336
Day of the Week			YES		YES	
N	299		299		299	
Adj RSq	30.65%		31.06%		31.04%	

Panel B: Second Stage

Parameter	ΔSpread				ΔAmihud				ΔAbsOIB				ΔPE_Variance			
	Model A		Model B		Model A		Model B		Model A		Model B		Model A		Model B	
Intercept	-1.06	<.001	0.91	0.089	-9.01	<.001	9.15	0.010	-1.30	<.001	-1.16	<.001	-0.65	<.001	0.42	0.338
ΔFIN	**-4.36**	**<.001**	**-3.89**	**<.001**	**-17.42**	**<.001**	**-11.76**	**<.001**	**-0.85**	**<.001**	**-0.81**	**<.001**	**-0.92**	**<.001**	**-0.64**	<.001
ΔVolume			-2.42	<.001			-22.03	<.001			-0.17	0.682			-1.30	0.019
ΔVolatility	0.83	<.001	0.80	<.001	5.95	<.001	5.63	<.001	0.07	0.263	0.06	0.299				
ΔPrice Volatility													1.29	<.001	1.27	<.001
EIA_Inventory	0.28	0.132	0.28	0.129	0.32	0.689	0.27	0.732	-0.17	0.056	-0.17	0.056	0.01	0.908	0.01	0.896
Lead_Inventory	0.02	0.901	0.03	0.824	-0.71	0.397	-0.58	0.461	-0.13	0.138	-0.13	0.146	0.21	0.086	0.21	0.078
GSCI_Roll	0.53	<.001	0.49	<.001	-0.26	0.711	-0.78	0.247	0.18	0.004	0.18	0.005	0.24	0.001	0.22	0.001
Contract_Exp_Day	-0.08	0.689	-0.11	0.513	-2.78	0.011	-2.94	0.014	-0.03	0.758	-0.21	0.088	-0.18	0.144	-0.19	0.129
September_2006	-1.10	0.041	-0.94	0.079	2.63	0.096	4.61	0.008	0.27	0.047	0.28	0.045	-0.53	0.034	-0.43	0.115
Dependent Lags	2		2		2		2		2		2		2		2	
Day of the Week	YES		YES		YES		YES		YES		YES		YES		YES	
N	299		299		299		299		299		299		299		299	
Adj RSq	75.25%		75.81%		39.04%		44.45%		18.72%		18.48%		37.60%		38.49%	

Table 7: Institutional Financial Traders and Customer Volume

Table 7 presents the results of the second-stage of a two-stage analysis of the effect of institutional financial trading on market quality while controlling for customer trading.The analyses are conducted using NYMEX pits data for the *pre*-electronification period (January 3rd, 2006 to September 1st, 2006) and Globex data for the *post*-electronification period (September 5th, 2006 to March 31st, 2007). *Customer_Volume* is the daily, volume-weighted average of the proportion of 5-minute trading volume involving customers (traders classified as CTI-4 in the CFTC database) on at least one side of a trade. ∆***Customer_Volume*** is the percentage difference between *Customer_Volume_Short-Term* and *Customer Volume Long-Term*. *Customer_Volume_Short-Term* is the daily, volume-weighted average of *Customer_Volume* for short-term contracts (up to 62 days to expiration). *Customer_Volume_Long-Term* is the daily, volume weighted average of *Customer_Volume* for long-term contracts (more than 62 days to expiration). ∆***FIN***, ∆***Price_Volatility,*** ∆***Spread,*** ∆***Amihud,*** ∆***AbsOIB,*** ∆***Volume, EIA_Inventory***, ***Lead_Inventory***, ***GSCI_Roll***, ***Contract_Exp_Day***, ***September_2006,*** and ***Day of the Week*** are defined in Table 6. ∆***FIN*** is instrumented by the exogenous variables from Model 3 in Table 6, Panel A. Two-tailed *p-values* are also reported.

Parameter	**∆Spread**		**∆Amihud**		**∆AbsOIB**		**∆PE_Variance**	
Intercept	0.89	0.088	7.97	0.024	-0.85	0.009	0.37	0.397
∆***FIN***	**-3.89**	**<.001**	**-11.34**	**<.001**	**-0.94**	**<.001**	**-0.61**	**0.003**
∆*Volume*	0.80	<.001	-5.38	0.022	-0.52	0.183	-1.23	0.025
∆*Customer Volume*	-2.40	<.001	5.67	<.001	1.54	<.001	-0.33	0.244
∆*Volatility*	-0.11	0.823	-20.81	<.001	0.05	0.368		
∆*Price Volatility*							1.26	<.001
EIA_Inventory	0.28	0.129	0.07	0.928	-0.11	0.163	0.00	0.971
Lead_Inventory	0.03	0.835	-0.66	0.406	-0.10	0.208	0.21	0.086
GSCI_Roll	0.49	0.001	-0.62	0.366	0.13	0.031	0.23	0.001
Contract_Exp_Day	-0.11	0.543	-2.53	0.033	-0.33	0.005	-0.16	0.195
September_2006	-0.94	0.080	4.76	0.007	0.25	0.084	-0.42	0.115
Dependent Lags	2		2		2		2	
Day of the Week	YES		YES		YES		YES	
N	299		299		299		299	
Adj RSq	76.80%		45.35%		30.01%		38.52%	

Table 8: Institutional Financial Traders and Customer Volume Terciles

Table 8 presents the results of the second-stage of a two-stage analysis of the effect of institutional financial trading on market quality for different terciles of customer trading intensity. We use NYMEX pits data for the *pre*-electronification period (January 3rd, 2006 to September 1st, 2006) and Globex data for the *post*-electronification period (September 5th, 2006 to March 31st, 2007). *Customer_Volume* is the daily, volume-weighted average of the proportion of 5-minute trading volume involving customers (traders classified as CTI-4 in the CFTC database) on at least one side of a trade. **Δ*FIN***, **Δ*Price_Volatility,* Δ*Spread,* Δ*Amihud,* Δ*AbsOIB,* Δ*Volume,* Δ*Customer_Volume,* *EIA_Inventory***, ***Lead_Inventory***, ***GSCI_Roll***, ***Contract_Exp_Day***, and ***Day of the Week*** are defined in Table 7. ***Tercile Average*** is the average of **Δ*Customer_Volume*** in the corresponding tercile. **Δ*FIN*** is instrumented by the exogenous variables from Model 2 in Table 6, Panel A. The second-stage analyses are conducted as in Tables 6 and 7 but data are first sorted by tercile. Only the regression coefficients for **Δ*FIN*** are reported for brevity.Two-tailed *p-values* are also reported.

ΔCustomer Volume Tercile	**Tercile Average**	**ΔSpread**		**ΔAmihud**		**ΔAbsOIB**		**ΔPE_Variance**	
Δ*Customer Volume - Low*	-12.97%	-6.65	<.001	-14.15	0.001	-1.49	0.001	-0.61	0.006
Δ*Customer Volume - Moderate*	0.64%	-5.69	<.001	-11.81	0.001	-0.56	0.048	-0.91	0.008
Δ*Customer Volume - High*	13.18%	-7.22	<.001	-17.80	<.001	-0.95	0.058	-0.89	0.063

Table 9: Effect of Institutional Financial Traders on Spreads for Continuing Customers

Table 9 presents regression analyses of the effect of the percentage difference between Δ***FIN*** (the daily trading volume shares of institutional financial traders in short-term *vs*. long-term contracts) on the percentage difference between the Bid-Ask spreads for short-term *vs*. long-term contracts paid by continuing customers—traders classified as "CTI-4" in the CFTC database who trade WTI futures in the pits before electronification and who continue to do so on the electronic (Globex) platform after electronification of the crude oil market. The analysis is conducted on WTI crude-oil futures trading in the NYMEX pits in the *pre*-electronification period (January 3rd, 2006, to September 1st, 2006) and on the Globex platform in the *post*-electronification period (September 5th, 2006, to March 31st, 2007). ***FIN*** is the proportion of the trading volume involving the participation of financial traders (traders classified as CTI 2 traders in the CFTC database). ***Volatility*** is the daily volume-weighted average of the 5-minute volatility of (mid-quote) returns estimated for each contract in each maturity interval. ***Volume*** is the daily volume-weighted average of 5-minute trading volume estimated for each contract in each maturity interval. ***Spread*** is the daily volume-weighted average of 5-minute Bid-Ask spreads obtained using bid and asked prices estimated for each contract maturity in each interval (5 minutes), after classifying trades as buyer- *vs*. seller-initiated using the Lee and Ready (1991) tick-test – it is calculated only for continuing customers. *Spread_Short-Term* is the daily volume-weighted average of *Spread* for short-term contracts (up to 62 days to expiration). *Spread_Long-Term* is the daily, volume weighted average of *Spread* for long-term contracts (more than 62 days to expiration). Δ***Spread*** is the daily percentage difference between the two: *(Spread_Short-Term – Spread Long-Term)/ Spread Short-Term, and is the* ***dependent variable*** *in the analysis.* Δ***FIN,*** Δ***Volatility*** and Δ***Volume*** are defined analogously. Δ***FIN*** is instrumented by the exogenous variables from Model 2 & 3 in Table 6, Panel A. ***EIA_Inventory*** is a dummy variable equal to 1 during EIA announcement days. ***Lead_Inventory*** is a dummy variable set equal to 1 during the days prior to the EIA announcements. ***GSCI_Roll*** is a dummy variable equal to 1 on the five business days when a GSCI roll takes place. ***Contract_Exp_Day*** is a dummy variable equal to 1 on the day of the prompt contract's expiration. ***September_2006*** is a dummy variable equal to 1 in the calendar month when electronification took place and 0 otherwise. ***Day of the Week*** are three dummy variables set equal to 1 for Monday, Tuesday, or Friday. Two-tailed *p-values,* obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Intercept	-1.22	<.001	2.09	0.006	-1.21	<.001	1.93	0.006	1.85	0.011	2.00	0.007
Δ*FIN*	-5.09	<.001	-4.31	<.001	-5.02	<.001	-3.59	<.001	-4.31	<.001	-4.30	<.001
Δ*Volume*			-4.11	<.001			-3.57	<.001	-3.82	<.001	-4.01	<.001
Δ*Volatility*	0.94	<.001	0.87	0.001	0.93	<.001	0.88	0.001	0.88	0.001	0.88	0.001
EIA_Inventory	0.24	0.192	0.24	0.192	0.24	0.194	0.19	0.282	0.22	0.236	0.22	0.235
Lead_Inventory	0.03	0.897	0.05	0.808	0.02	0.905	0.04	0.823	0.04	0.849	0.04	0.843
GSCI_Roll	0.41	0.005	0.35	0.013	0.42	0.005	0.19	0.276	0.38	0.009	0.37	0.008
Contract_Exp_Day	-0.58	0.169	-0.62	0.112	-0.56	0.172	-0.41	0.278	-0.57	0.143	-0.58	0.142
September,2006					-0.51	0.222	0.53	0.339	-0.22	0.599		
Dependent-variable Lags	2		2		2		2		2		2	
Day of the Week	YES		YES		YES		YES		YES		YES	
N	299		299		299		299		299		299	
Adj RSq	59.43%		61.67%		59.73%		62.83%		61.66%		75.69%	

Table 10: Effect of Institutional Financial Traders on Market Quality – Lag Identification

Table 10 presents the results of a two-stage analysis in which 1-day lagged values of the intensity of financialization are used as an instrument for the first-stage regression in **Panel A**; the second-stage regression results are presented in **Panel B**. The analyses are conducted using NYMEX pits data for the *pre*-electronification period (January 3rd, 2006 to September 1st, 2006) and Globex data for the *post*-electronification period (September 5th, 2006 to March 31st, 2007). *FIN* is the proportion of trading volume involving the participation of financial traders (traders classified as "CTI-2" traders in the CFTC database). ***ΔFIN*** is the percentage difference between the daily trading volume shares of institutional financial traders in short-term (less than 62 days to expiration) *vs*. long-term (62 or more days to expiration) WTI sweet crude oil futures contracts. ***ΔFIN*** is the ***dependent variable*** *in Panel A*. ***ΔFIN_Lag*** is the 1-day lag of ***ΔFIN***. ***ΔPrice_Volatility, ΔSpread, ΔAmihud, ΔAbsOIB, ΔVolume, ΔCustomer_Volume***, ***EIA_Inventory***, ***Lead_Inventory***, ***GSCI_Roll***, ***Contract_Exp_Day*** and ***Day of the Week*** are defined as in Table 6. ***ΔFIN*** is instrumented by variables from the first-stage regression in Panel A. Two-tailed *p-values* are also reported.

Panel A: First Stage

Parameter	Model 3	
Intercept	-0.11	0.012
ΔFIN_Lag1	0.50	<.001
EIA_Inventory	0.10	0.083
Lead_Inventory	0.06	0.299
GSCI_Roll	0.02	0.590
Contract_Exp_Day	-0.20	0.022
September_2006	0.11	0.131
Day of the Week	YES	
N	299	
Adj RSq	25.26%	

Panel B: Second Stage

Parameter	**ΔSpread**		**ΔAmihud**		**ΔAbsOIB**		**ΔPE_Variance**	
Intercept	2.83	<.001	14.91	<.001	-0.37	0.202	0.65	0.087
ΔFIN	**-1.32**	**0.002**	**-5.39**	**<.001**	**-0.58**	**<.001**	**-0.54**	**<.001**
Δ*Volume*	-4.26	<.001	-28.32	<.001	-1.08	0.003	-1.55	0.003
Δ*Customer Volume*	-0.38	0.479	-7.09	0.002	1.36	<.001	-0.48	0.088
Δ*Volatility*	0.37	0.024	4.24	<.001	-0.06	0.254		
Δ*Price Volatility*							1.27	<.001
EIA_Inventory	0.19	0.317	-0.06	0.939	-0.12	0.132	0.00	0.985
Lead_Inventory	0.01	0.945	-0.67	0.399	-0.10	0.206	0.21	0.090
GSCI_Roll	0.29	0.035	-0.91	0.151	0.11	0.063	0.23	0.001
Contract_Exp_Day	0.06	0.799	-2.35	0.102	-0.32	0.012	-0.15	0.259
September_2006	-0.85	0.118	4.11	0.022	0.21	0.166	-0.45	0.086
Dependent-variable Lags	2		2		2		2	
Day of the Week	YES		YES		YES		YES	
N	299		299		299		299	
Adj RSq	72.20%		42.29%		28.61%		38.63%	

Table 11: Effect of Non-Fast and Fast Institutional Financial Traders on Market Quality

Table 11 presents regression analyses of the effect of the percentage difference in the trading volume shares of Non-Fast institutional financial traders in short-term *vs*. long-term contracts on the percentage differences between various market quality measures for short-term *vs*. long-term contracts. The analyses are conducted on WTI sweet crude oil futures trading in the NYMEX pit for the *pre*-electronification period (January 3rd, 2006, to September 1st, 2006) and on the electronic (Globex) platform for the post-electronification period (September 5th, 2006, to March 31st, 2007). ***FIN*** is the proportion of trading volume involving the participation of financial traders (traders classified as CTI-2 traders in the CFTC database). ***FIN_Non_FLP*** is the daily weighted average trading-volume share of Non-Fast financial traders, i.e., of institutional financial traders who trade less than 990 times a day (as in Raman, Robe, and Yadav, 2016). ***FIN_FLP*** is the daily weighted average trading-volume share of Fast financial traders, i.e., institutional financial traders who more than 990 times a day (as in Raman, Robe, and Yadav, 2016). **Δ*FIN_Non-FLP*** is instrumented by variables from the first-stage regressions (analogous to Model 3 in Table 6). **Δ*FIN*, Δ*Price_Volatility*, Δ*Spread*, Δ*Amihu* , Δ*AbsOIB*, Δ*Volume*, Δ*Customer_Volume*, *EIA_Inventory***, ***Lead_Inventory***, ***GSCI_Roll***, ***Contract_Exp_Day*, *September_2006***, and ***Day of the Week*** are defined as in Table 6. Two-tailed p-values, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	**ΔSpread**		**ΔAmihud**		**ΔAbsOIB**		**ΔPE_Variance**	
Intercept	0.06	0.923	4.52	0.279	-1.17	<.001	0.40	0.425
ΔFIN_Non_FLP	**-6.24**	**<.001**	**-28.21**	**<.001**	**-1.75**	**<.001**	0.10	0.842
ΔFIN_FLP	**-1.24**	**<.001**	**1.73**	**0.085**	-0.16	0.107	**-0.69**	**0.002**
ΔVolume	-2.72	<.001	-24.68	<.001	-0.57	0.132	-1.01	0.048
ΔCustomer Volume	-0.45	0.333	-5.84	0.014	1.50	<.001	-0.43	0.104
ΔVolatility	0.65	<.001	5.35	<.001	0.03	0.595		
ΔPrice Volatility							1.25	<.001
EIA_Inventory	0.53	0.010	1.68	0.056	-0.03	0.746	-0.04	0.750
Lead_Inventory	0.07	0.655	-0.56	0.482	-0.09	0.261	0.22	0.070
GSCI_Roll	0.98	<.0001	2.00	0.042	0.27	<.001	0.18	0.041
Contract_Exp_Day	-0.43	0.054	-4.51	0.001	-0.42	<.001	-0.08	0.555
September_2006	-0.55	0.321	3.92	0.030	0.34	0.034	-0.14	0.666
Dependent Lags	2		2		2		2	
Day of the Week	YES		YES		YES		YES	
N	299		299		299		300	
Adj RSq	76.66%		45.10%		30.21%		42.27%	