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Financialization of Intraday Commodity Trading and Market Quality

by

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

° Vikas **Raman** is with the Department of Accounting and Finance, Lancaster University, Lancaster LA1 4YX (United Kingdom). Email: v.raman@lancaster.ac.uk. Michel A. **Robe** is with the U.S. Commodity Futures Trading Commission (CFTC) and the Department of Finance, Robins School of Business, University of Richmond, 102 UR Drive, Richmond, VA 23173 (USA). Tel: (+1) 804-287-6589. Email: mrobe@richmond.edu. Pradeep K. **Yadav** is at the CFTC and the Division of Finance, Price College of Business, University of Oklahoma, 307 West Brooks Street, Norman, OK 73019 (USA). Email: pyadav@ou.edu. June Harding has our sincere gratitude for her cheerful help with the raw data. We thank Hank Bessembinder, Pat Fishe, Scott Irwin, Jim Moser, Kumar Venkataraman, and Wei Xiong for discussions that substantially improved the paper. We thank Kelley Anderson, Ing-Haw Cheng, Eleni Gousgounis, P.K. Jain, Andrei Kirilenko, Albert Menkveld, Scott Mixon, Esen Onur, Jim Overdahl, Casey Petroff, Craig Pirrong, Tālis Putniņš, Jonathan Wallen, seminar participants at the CFTC, Virginia Tech, George Mason University, Université Paris Dauphine, the University of Illinois, the University of Nebraska, Audencia Business School, the University of Technology Sydney, as well as participants at the Institut Louis Bachelier Summer School on Commodity Derivatives Markets in Florence, Italy; annual symposiums of the World Finance Conference and J.P. Morgan Center for Commodities; a biennial OU—*Review of Financial Studies* Commodities Finance Research Conference; and annual meetings of the Commodity and Energy Markets Association (CEMA) and the PBFEAM for useful comments. Robe gratefully acknowledges the financial support received when he was the Clearing Corporation Foundation Professor in Derivatives Trading at the University of Illinois. Any errors and omissions are the authors' sole responsibility.

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Abstract

We provide the first empirical evidence on what Goldstein and Yang (2022) label the "financialization of intraday trading" in commodity markets. We use regulatory crude oil futures trading data with coded trader identities to identify institutional financial traders. We relate the large increase in their intraday trading to statistically and economically significant improvements in bid-ask spreads, market depth, and short-term price efficiency—after accounting for concomitant changes arising from electronification and for changes in the nature and volume of customer trading. Finally, we find that HFT and non-HFT intraday financial traders are associated differentially with improvement in market quality attributes.

JEL Classification: G10, G23, Q02, G14, G12, G13.

Keywords: Financialization of commodities, Institutional trading, Intraday activity, Market Quality, HFT.

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 waves, corresponding to the arrival of three distinct kinds of new commodity market participants trading across multiple commodities: (1) passive commodity index traders ("CITs"); (2) managed money traders (hedge funds) active in multiple asset classes; and (3) short-horizon institutional financial traders trading intraday and largely going home flat (including high frequency traders, *i.e.*, "HFTs").

While financialization has spawned much academic research, the focus has been on its first two dimensions (*i.e.*, on the positions held overnight and the long-term trading strategies of CITs and hedge funds), and their impacts on various aspects of the daily, weekly, monthly, or quarterly distributions of commodity returns: price levels (e.g., Irwin and Sanders, 2012; Sockin and Xiong, 2015; Brogaard, Ringgenberg, and Sovich, 2019), overshoots and reversals (e.g., Da *et al.*, 2023), risk premia (e.g., Acharya, Lochstoer, and Ramadorai, 2013; Hamilton and Wu, 2014; Baker, 2021), volatility (e.g., Kim, 2015; Brunetti, Büyükşahin, and Harris, 2016; Christoffersen, Lunde, and Olesen, 2019), and co-movements with other markets (e.g., Tang and Xiong, 2012; Büyükşahin and Robe, 2014; Cheng, Kirilenko, and Xiong, 2015; Başak and Pavlova, 2016).[1]

We address instead, for the first time empirically, the phenomenon that Goldstein and Yang (2022) refer to as the "financialization of intraday trading activity" (p. 2630) —*i.e.*, the enormous growth in *intraday* trading, often across unrelated commodities, by financial institutions that have no commercial interest in the underlying physical commodities. These intraday institutional financial traders are "financial speculators" in Goldstein and Yang's (2022) theoretical model, which predicts that their entry should boost pricing efficiency in large commodity markets such as the crude oil market.

[1] Other contributions include, among many 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 review of the early literature.

This financialization of intraday trading can be labeled as the third dimension of the financialization of commodity markets.

Thanks to our access to high-frequency trader-level data with coded identities, we can identify institutional financial traders and we can date the start of this intraday financialization. We show that, after controlling for trading by commodity index traders and other customers of the exchange, intraday financialization is associated with significant improvements in market quality *over and above* any improvements stemming from the electronification at that time.

Prior research shows that the financialization of the "buy-side" of commodity markets transformed commodities from a type of asset whose price is driven by physical consumption and supply considerations into a class of financial assets that are valued also in terms of their interactions with other classes of financial assets. That development, together with the electronification of commodity futures markets, paved the road for the financialization of intraday trading that we focus on. 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 the "sell-side" of commodity markets in the sense of Hasbrouck and Saar (2013).

Despite its importance, intraday financialization has hitherto received surprisingly little attention in the academic literature. This is likely due to a dearth of publicly available high-frequency information on the makeup of intraday commodity trading activity.[2]

Our paper utilizes comprehensive, non-public, trader-level futures trading data from the U.S. commodity derivatives market regulator (the Commodity Futures Trading Commission or CFTC) to provide the first quantitative evidence on this intraday dimension of financialization, and to analyze empirically its impact on commodity market quality. We investigate the world's largest commodity market—the New York Mercantile Exchange's (NYMEX) West Texas Intermediate (WTI) light sweet

[2] For example, Lauter, Prokopczuk, and Trück (2023) aim to relate "financialization" and intraday market quality. However, they focus on the first dimension of financialization, *i.e.*, the massive growth in long-only positions by passive commodity index traders. They do not use any trader-level data, and hence cannot identify intraday trading by financial institutions—which would be necessary to link intraday market quality improvements to the financialization of intraday activity. We discuss this paper further in Section 2.

crude oil futures market. Our analysis covers 2006 to 2008—which, as we document, includes the period when intraday financialization occurred—and yields three main results.

First, consistent with the theoretical model of Goldstein and Yang (2022), we show that increases in intraday financialization are associated with reductions in intraday pricing errors, *i.e*., deviations of futures prices from informationally efficient "fundamental" values. Next, we document that intraday financialization is also associated with improvements in key markers of market liquidity: depth, bid-ask spreads, and the magnitude of buy-sell demand imbalances of external exchange "customers" (*i.e*., of commodity market participants who are *not* financial intermediaries).[3,4] Finally, we investigate heterogeneity among the new market entrants and find that HFT and non-HFT intraday institutional financial traders influence the different market quality metrics differently. Specifically, while HFTs improve pricing efficiency and spreads, improvements in market depth are entirely due to non-HFT traders. Our findings on the price informativeness of intraday financial speculators, their beneficial impact on liquidity, and the different aspects of liquidity that HFT and non-HFT financial traders respectively provide, are each new to the literature, as discussed in greater detail in Section 2.

The WTI market underwent a major structural change on September 5, 2006, when the NYMEX first allowed electronic futures trading on the Globex platform alongside face-to-face trading in its 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 acting as voluntary providers of immediacy and liquidity in the market (Manaster and Mann, 1996). Importantly, Globex trading brought about a transformative easing of access for traders without physical access to the pits, enabling them to trade remotely, and thereby to 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 the earlier evidence from structural changes at the NASDAQ (Barclay *et al*., 1999) and the London Stock

[3] The first two liquidity measures are widely used and can be readily computed with futures trades data. Uniquely in this paper, we use regulatory data that also enable estimation of "customer" focused liquidity measures relating to actual users of exchange services, measures that do not include the positions of financial intermediaries.
[4] Kang, Rouwenhorst, and Tang (2020) employ public aggregate position data from the CFTC to examine liquidity provision by commodity hedgers *vs*. speculators at weekly and monthly horizons. In contrast, we use non-public, high-frequency trader-level data to examine the link between liquidity and intraday institutional financial trading.

Exchange (Naik and Yadav, 2003), and the evidence on the benefits of electronification in equity markets (e.g., Jain, 2005), we expect—and we empirically document—that electronification indeed does result in significantly improved intraday commodity pricing efficiency and trading costs.

That said, our paper is *not about electronification* but about the intraday financialization that we independently show followed as a consequence of electronification. We are able to use our regulatory data to identify institutional financial traders who largely trade intraday, and we document several facts that characterize the financialization of the intraday crude oil futures trading activity following electronification. First, many of the institutional financial traders that start short-horizon trading of WTI futures on the Globex platform are new to the NYMEX. In total, over four hundred new institutional financial traders (including, for the first time, almost two dozen HFTs) enter the WTI market within six months of electronification—a rate of entry that is almost triple what it used to be before electronification. Second, the fraction of all Globex WTI trades involving an institutional financial trader on either side of a trade grows to almost 40 percent of the total trading volume within a few months—more than double what it used to be. Third, both HFT and non-HFT institutional financial traders that enter the WTI market after September 5, 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' intraday cross-market footprints thus echo the simultaneous presence in multiple commodity markets that is characteristic of the two kinds of longer-horizon, buy-side institutions that initially started the financialization of commodities —namely, commodity index traders (Tang and Xiong, 2012; Cheng *et al.*, 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., short-horizon institutional financial traders in the case of commodity markets. What is relevant from our perspective of investigating intraday financialization is that, while the first and second channels arguably impact all futures contract maturities similarly, not all futures maturities can expect the same interest from intermediation- and short-term-information-focused institutional financial traders. In particular, the two most active contracts (nearby and first-deferred futures) and the three nearest-dated December futures contracts (commonly used for calendar spreading with the nearby contracts) correspond to the maturities most held overnight or for longer periods by commercial oil traders—producers, refiners, wholesalers, etc.—both before (Neuberger, 1999; Ederington and Lee, 2002) and after (Büyükşahin *et al*., 2011) electronification. Hence, intraday financialization should logically manifest itself mainly in these contract maturities. Consistent with this intuition, we find that entry by new intraday-focused institutional financial traders after electronification does take place chiefly in those specific maturities, which we loosely label "short-dated" even though they also include the associated December contracts.

We exploit this cross-maturity heterogeneity in intraday financialization (induced by the electronification of futures trading) to examine how it relates to cross-maturity differences in market quality. Specifically, we analyze how the differences between the intraday financialization of short-dated *vs*. long-dated contracts are related to corresponding differences in pricing efficiency and in different measures of market liquidity.

In all of our analyses, we control for cross-maturity differences in the trading by external exchange "customers." The latter group includes commercial hedgers (*i.e*., traders who hold positions in the underlying physical commodity) as well as financial hedgers (traders who take crude oil futures positions to diversify their investment portfolio). Controlling for this customer activity enables us to test the Goldstein and Yang (2022) hypothesis in the specific case of intraday financial speculators—that an increase in the latter's presence, while controlling for the positions of financial hedgers, increases pricing efficiency.

Our results are significant statistically and also economically. A one-standard-deviation increase in the relative intraday financialization of short- contracts *vs*. long-dated contracts is associated with significant improvements in the former's relative pricing efficiency (0.12 standard deviations), bid-ask spreads (0.14 standard deviations), market depth (0.22 standard deviations) and the magnitude of customer trade imbalances (0.15 standard deviations).

Our findings, that intraday financialization is related to improvements in both pricing efficiency and market liquidity, are robust to using alternative methodologies that attempt to assuage concerns of possible reverse causality. First, akin to Boehmer and Wu (2013), we replace cross-maturity differences in intraday financialization with their one- or two-day lagged values in our single-stage regression analyses. Next, inspired by Muravyev (2016), we exploit the day-to-day persistence in cross-maturity intraday financialization differences and we use lagged values of this difference—together with a set of exogenous variables likely to generate fluctuations in intraday institutional financial trading—in a two-stage instrumental variable (IV) regression analysis. Finally, we use the introduction of electronic trading, along with other exogenous variables, as an instrument in an alternative two-stage IV regression.

Irrespective of the methodology used, we find that greater intraday financialization is associated with improved liquidity and greater price efficiency. In fact, the results obtained with IV regressions are even stronger than those obtained with simple OLS regressions. For example, when we use electronification as an instrument, our results indicate that a one standard deviation increase in cross-maturity differences in intraday financialization reduces the cross-maturity percentage differences in bid-ask spreads by 0.82 standard deviations and those in pricing efficiency by 0.24 standard deviations. The qualitative consistency of our findings across many different empirical methodologies makes it unlikely that our results are entirely driven by reverse causality (*i.e.*, market quality affecting intraday financialization).

Finally, having provided evidence consistent with intraday financialization improving market liquidity and pricing efficiency, we then use the special features of our data to also investigate the respective roles of HFT and non-HFT intraday institutional financial traders in improving different aspects of market quality. Importantly, we find that each of these two groups of traders adds value, making qualitatively distinctive contributions to market quality attributes. We relate non-HFT intraday institutional financial traders to significant improvements in market depth and bid-ask spreads, and to reductions in the imbalances between customer buys and sells—but not to enhancing pricing efficiency. On the other hand, HFT activity is related to a significant improvement in pricing efficiency, and also a reduction in spreads and customer trade imbalances—but not to an increase in market depth.

Section 2 presents our contribution to the literature. Section 3 develops our hypotheses. Section 4 discusses our unique dataset and our measures of liquidity and pricing efficiency. Section 5 documents electronification's huge impact on WTI futures market intraday quality, and the financialization of intraday activity *post*-electronification. Sections 6 links intraday financialization and market quality. Section 7 shows that, in that relation, HFT and non-HFT intraday institutional financial traders play important but separate roles for different attributes of market quality. Section 8 concludes and outlines avenues for further research.

2. Contribution to the literature

Our findings on the price informativeness of intraday financial speculators, their beneficial impact on liquidity, and the different aspects of liquidity that HFT and non-HFT financial traders respectively provide, are each new to the literature.

2.1. Financialization

Prior research on the link between financialization and price informativeness largely focuses on the first dimension of financialization, probing theoretically (e.g., Sockin and Xiong, 2015; Başak and Pavlova, 2016) or empirically (e.g., Henderson *et al*., 2015, Brogaard *et al*., 2019; Yan, Irwin, and Sanders, 2022; Da *et al*., 2023) if passive commodity index investments make prices deviate from some "fundamental" level at horizons of days, weeks, or months. Some of those papers also investigate the second dimension of financialization, asking if hedge funds—likely to be financial speculators rather than financial hedgers—impact commodity price dynamics (e.g., Büyükşahin and Harris, 2011; Singleton, 2014; Cheng *et al*., 2015). However, all those studies rely on daily or lower frequency data, and their horizons are long-term. As such, they do not address the collective impact of the large number of institutional financial traders that do not carry positions overnight and, hence, are absent from end-of-day positions data—even though, for commodity futures, daily trading volumes are often three times as large as the open interest.

Several papers do investigate the consequences of financialization using intraday data. They all focus, however, on CITs or commodity note issuers (e.g., Bessembinder *et al*., 2016; Henderson *et al*., 2015; Ready and Ready, 2022). Such traders are uninformed financial hedgers that consume rather than provide liquidity. Hence, one would not expect their trading to improve intraday pricing efficiency or market liquidity. The opposite should be true of the intraday institutional financial traders that we study, who would want to exploit short-term information in the order-flow and be net liquidity providers. We provide empirical evidence in support of this intuition, using a unique WTI crude oil futures dataset.

A recent working paper by Lauter, Prokopczuk, and Trück (2023) also focuses on electronification, financialization, and intraday market quality. In contrast to our paper, that study does not use any trader-level data. Hence, it cannot identify intraday financial traders, let alone relate market quality changes to changes in such trading. Contrary to our paper, but like the papers discussed in the previous paragraph, that study aims to capture the *first* dimension of financialization, *i.e*., the massive growth in long-only positions held by passive index traders. It proxies that development by way of a dummy variable set equal to 0 through 2003 and to 1 afterwards. The January 2004 cutoff predates by almost three years the actual financialization of intraday trading that we study empirically in this paper. Indeed, the timing of market quality improvements found by Lauter *et al*. (2023) in a cross-section of commodity markets broadly coincides with their electronification. Thanks to high-frequency, trader-level data, we are able to document for the first time that the financialization of intraday trading took place following electronification in the Fall of 2006. Furthermore, we establish also for the first time—using models that control for the activity of commodity index traders and other exchange customers—that intraday financialization is associated with significant improvements in market quality *over and above* those stemming from electronification.

2.2. Intraday Market Quality: HFTs vs. Non-HFTs

In addition to our main contribution to the financialization literature as discussed above, we also make an independent contribution to the literature on the market quality impact of HFT intraday financial traders vs. their non-HFT counterparts. The literature on the impact of HFTs and of algorithmic trading on market quality measures is extensive. It includes, e.g., Brogaard, Hendershott, and Riordan (2014, HFTs, equities); Chaboud, Chiquoine, Hjalmarsson, and Vega (2014, algorithmic trading, currencies); Hendershott, Jones, and Menkveld (2011, electronic message traffic, equities); Carrion (2013, HFTs, equities); Hasbrouck and Saar (2013, low-latency message traffic equities); and Coughlan and Orlov (2023, HFTs, futures).[5] In the context of this extensive literature, our contribution is two-fold.

First, we document and contrast the respective market quality impacts of HFT and non-HFT financial traders on two aspects of market quality that have not been addressed thus far in this specific context. One, we are the first to report the impact, whether of HFTs or of non-HFTs, on market depth as measured by the Amihud (2002) measure—the sensitivity of prices to traded volume—and to show that non-HFTs add value by increasing market depth, while HFTs do not impact market depth. Two, we are also the first to report the impact, whether of HFTs or of non-HFTs, on a *customer-focused* liquidity measure: the imbalance between *customer* buys and *customer* sells. Traditional liquidity measures in the literature cover all traders, including financial intermediaries. Our data allow us to distinguish between financial intermediaries and external users of exchange services (*i.e.*, customers) and thus to construct a customer-focused measure of liquidity. We find that HFTs and non-HFTs, whether considered as separate trader sub-categories or collectively, improve *customer-focused* liquidity.

Second, we show that non-HFT financial traders add value incremental to that provided by HFTs with respect to certain market quality attributes even in normal times—for example, market depth, bid-ask spreads, and customer demand-supply imbalances. In this context, our results complement those of Brogaard, Ringennberg, and Rösch (2023) and of Raman, Robe, and Yadav (2023). Those two papers show that human traders complement HFTs and add value in the intermediation ecosystem. While both of those papers focus on unusual situations (open and close of markets in the former, and situations of extreme information-related stress in the latter), our analysis here provides empirical evidence of complementarity even in normal times.

[5] For reviews of the early literature on HFTs, see Jones (2013) and Menkveld (2016).

Overall, our results support the view that, in a market where both HFT and non-HFT intraday institutional financial traders compete and where each group has a substantial share of the total trading activity, market quality improvements are tied to (i) the overall flow of institutional risk capital into intraday voluntary liquidity provision and not just (ii) the activities of HFTs *per se*. While we obtain this novel set of results in the context of a commodity market, there is no reason to suspect that they should not hold in other financial markets as well.

3. **Hypotheses Development**

Our interest is in the relationship between the intraday financialization of commodities—specifically, the arrival of active short-horizon institutional financial traders in commodity futures markets—and intraday futures market quality. This Section discusses reasons why intraday institutional financial trading activity should impact intraday pricing efficiency (Section 3.1) and liquidity metrics (Section 3.2) in these markets.

3.1. Intraday Pricing Efficiency

Our first research question is whether financialization improves intraday commodity 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).

Financial traders in commodity markets can be broadly categorized into financial hedgers and financial speculators. Neither group holds positions in the spot/physical markets. Financial hedgers participate in commodity markets to "improve the efficiency of their broader financial portfolios" (Goldstein and Yang, 2022, p. 2652), and should accordingly be uninformed players in commodity markets (Brunetti and Reiffen, 2014). Commodity index traders ("CIT"), also dubbed the "massive passives", would be a good example of financial hedgers. In contrast, financial speculators trade on information, and should make prices more informative. The institutional intraday financial traders that we study here are a subset within the financial speculators category, those that are motivated by short-horizon information, while having no positions in (or other underlying exposure to) the spot market.

The dimension of financialization associated with financial hedgers has been addressed in prior empirical literature both theoretically (Singleton, 2014; Sockin and Xiong, 2015; Başak and Pavlova, 2016; Baker, 2021) and in numerous empirical studies (e.g., Irwin and Sanders, 2012; Büyükşahin and Robe, 2014; Cheng *et al*., 2015; Hamilton and Wu, 2015; Brogaard *et al*., 2019; and references cited in those papers). The focus of all those papers, however, is on long-term pricing dynamics: cross-market price cointegration, and bubbles or pricing errors that persist for long periods of time (days, weeks, or months).

This long-term focus makes sense, given that CITs trade almost exclusively in just two circumstances: when rolling over (Bessembinder *et al*., 2016) or rebalancing portfolio weights at year end (Yan, Irwin, and Sanders, 2022). At other times, CITs are not part of the typical order flow (Henderson *et al*., 2015; Ready and Ready, 2022). Thus, while papers that study the dimension of financialization linked to CIT activity contribute majorly to the financialization literature, their relevance is limited with respect to pricing at intraday frequencies.

In sharp contrast, the dimension of financialization associated with intraday financial speculators has been largely ignored.[6] On the theory side, one exception is Goldstein and Yang (2022). Their model provides testable hypotheses about the respective impacts of financial speculators and of financial hedgers on pricing efficiency in commodity markets, including at the intraday frequency. On the empirical side, our paper is the first investigation of short-horizon institutional financial traders' impact on the intraday efficiency of commodity prices.

Goldstein and Yang's (2022) theoretical model predicts a "hump-shaped" relation between pricing efficiency and the total presence of financial traders (denoted $\bar{\lambda}$), where pricing efficiency

[6] As noted in the Introduction, several papers use end-of-day data on aggregate hedge fund positions in commodity futures markets to investigate possible links between hedge funds and various dimensions of long-term commodity price dynamics. For example, Büyükşahin and Harris (2011) ask if hedge fund positions Granger-cause crude oil prices; Singleton (2014) asks if hedge fund calendar spread positions impact nearby futures price levels; and Büyükşahin and Robe (2014) and Cheng, Kirilenko, and Xiong (2015) ask if hedge funds boost co-movements between equity and commodity prices. Those studies all use end-of-day positions data. Our question is different: we investigate the financialization of intraday trading due to the arrival of many new institutional financial traders who do not carry positions overnight, and we ask if they improve price informativeness at an intraday frequency.

initially improves with the participation of financial traders and then deteriorates once they become too large. A natural question is what "too large" might mean. These authors argue that "the crude-oil futures market is the world's largest commodity market, and so an influx of financial capital into this market" due to financialization "corresponds to a relatively small value of $\bar{\lambda}$" (p. 2631)—and they accordingly predict a positive relation between intraday financialization and pricing efficiency in the WTI crude oil futures market.

Specifically, a central prediction of their Proposition 2 is that, when the market activity of hedgers is fixed or controlled for, an increase in financial speculators' activity should improve pricing efficiency at the horizon at which the latter operate. Insofar as our intraday institutional financial traders are mostly financial speculators trading on very short-horizon information rather than financial hedgers, we should expect intraday pricing efficiency to improve with their increased presence in the WTI futures market (after duly controlling for the activity of financial hedgers and for other uninformed trading).

Finally, since some (but not all) intraday institutional financial traders are automated high-frequency traders (HFTs), we investigate whether HFTs influence pricing efficiency any differently from non-HFT institutional financial traders. On the one hand, HFTs have a competitive advantage over other traders stemming from the speed with which they can access, process, and trade on information. On the other hand, we know from De Long, Shleifer, Summers, and Waldman (1990), and later literature, that ultra-short horizon HFTs may have adverse effects on pricing efficiency because of their "short-termism" (reluctance to arbitrage pricing inefficiencies if the latter may last beyond the arbitrageurs' trading horizon, causing pricing errors to persist). In sum, it is an empirical question whether the trading activity of HFT financial traders would influence pricing efficiency differently from other financial traders.[7]

[7] Empirically, Hirschey (2021) uses NASDAQ trader-level data to show that HFTs' speed edge "allow(s) them to anticipate and trade ahead of other investors' order flow," a fact that helps rationalize earlier findings that HFTs improve price discovery in equity (e.g., Brogaard, Hendershott, and Riordan, 2014) and foreign exchange (e.g., Chaboud *et al*., 2014) markets. No such evidence exists for commodity markets: the present paper is the first to provide an empirical answer in this context. Additionally, it is also the first also to run, for any financial market, a nuanced horse race between HFT and non-HFT financial traders' contributions to different aspects of pricing efficiency and market liquidity.

3.2. Intraday Liquidity

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

We expect possible impacts of intraday financialization on market liquidity through the prism of three common determinants of liquidity: market competition, inventory costs, and asymmetric information. First, from a competition perspective, an increase in institutional intraday trading increases competition among liquidity providers, potentially leading to more aggressive pricing and participation, thereby reducing spreads and customer trade imbalances. Second, the entry of institutional financial traders should significantly increase the capital available for liquidity provision. As discused in Comerton-Forde *et al.* (2010), relaxing funding constraints of market-makers reduces their risk-aversion, increases their inventory holding capacity, and thereby should unequivocally improve market liquidity.

From an asymmetric information perspective, in contrast, the impact of intraday financialization on liquidity could potentially be ambiguous. Relative to *pre*-financialization liquidity provision by largely individual traders ("Locals"), institutional financial traders could be expected to be able to capture greater information from the order-flow, and invest greater resources for processing that information, thereby being able to better estimate short-term price changes based on information and liquidity flows. On the one hand, 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 earlier 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. This should cut spreads and increase depth. On the other hand, insofar as institutional financial traders use their informational advantage to function as intraday value arbitrageurs, an increase in their presence would mean an increase in the proportion of informed traders in the market. In that case, intraday financialization would increase the costs of liquidity provided by other liquidity providers on account of the increased probability of these other providers' encountering more informed trading, thereby worsening market liquidity. In this context, assessing the overall impact of intraday financial traders on liquidity warrants an empirical examination.

Finally, as with our tests of pricing efficiency, we also examine whether HFT and non-HFT intraday institutional financial traders influence various measures of market liquidity differently. While both types of traders can provide liquidity, their styles of liquidity provision should arguably differ. HFTs are likely to have a competitive informational advantage (relative to non-HFTs) arising from the speed with which they can access and process order-flow and other information. HFTs should thus expect to face smaller adverse selection costs, resulting in their providing liquidity at smaller bid-ask spreads. However, HFTs' inventories typically mean-revert around zero over ultra-short horizons. HFTs also carry lower inventories and have higher inventory turnover. HFT financial traders might be able to provide cheaper liquidity for small orders, but non-HFT institutional financial traders should have an advantage in providing larger quantities of liquidity. Prior research does find some evidence consistent with this. For example, Chordia, Roll, and Subrahmanyam (2011) document that bid-ask spreads and market depth fell in US equity markets over the course of approximately two decades around the turn of the 21st century. Those authors speculate that the increased presence of automated trading may have been an important factor in explaining this trend, but they leave direct examination of the hypothesis for future research. We exploit the unique features of our dataset that allow us to separate HFT from non-HFT institutional financial traders to test if they differentially influence key dimensions of liquidity such as bid-ask spreads and market depth.

4. Data: Measuring Institutional Financial Trading and Market Quality

The NYMEX introduced electronic trading of WTI futures (alongside face-to-face pit trading) on September 5, 2006. For the purposes of this study, we were granted access to non-public, comprehensive, high frequency trader-level data from January 2006 to May 2008 for the world's largest commodity market—the NYMEX's WTI light sweet crude oil futures market. Our data come directly from the market regulator, the CFTC.

4.1. Data

The CFTC collects data on every WTI futures transaction at the NYMEX, and for every trading account in that market. The CFTC dataset includes details such as the commodity and delivery month; the quantity traded; the trade type (outright, spread, trade at settlement, etc.), 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]

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

Importantly from the perspective of this paper, the dataset also 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 CTI-4 category includes, among others, the financial hedgers of Goldstein and Yang (2022). The rest, about four percent of the total 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.

[8] Pits used to be open from 10AM—2:30 PM prior to January 31, 2007. Starting on February 1, 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 several quality checks; for example, we exclude transactions whose reported prices are clearly erroneous.

In our analyses, we aggregate account-level data by CTI trader category across multiple contract maturities. Each CTI category comprises dozens to thousands of trading accounts: as a result, the information that we provide respects the CFTC's confidentiality statutes by not allowing readers to identify an individual trader's positions, trade secrets, or trading strategies.

4.2. CTI-2 Trader Category: 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 active short-horizon trading. CTI-2 traders include banks, hedge funds, commodity pool operators (CPO), futures commission merchants (FCM), commodity trading advisors (CTA), foreign and domestic broker/dealers, introducing brokers (IB), proprietary trading firms, and other eligible entities.

Post-electronification, as discussed in greater detail later in Sections 5.2.2 and 5.2.3: (a) the number of CTI-2 traders and the volume of CTI-2 trading grows enormously, (b) CTI-2 traders trade extensively across multiple markets, and (c) importantly from the perspective of this paper, the trading of the CTI-2 traders' group is overwhelmingly intraday. We accordingly use CTI-2 traders' share of the trading volume to compute our proxy of intraday commodity market financialization.

4.3. Measures of Market Quality

We investigate several measures of market quality: (i) the volatility of pricing errors, *i.e.*, of deviations of intraday prices from their "fundamental" values; (ii) bid-ask spreads; (iii) depth; and (iv) the absolute magnitude of customer trade imbalances. On any given day in our sample, WTI oil futures with up to 84 different maturities are traded. We first compute 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. Following Hasbrouck (1993), Boehmer and Kelly (2009), and numerous authors, we estimate a lower bound of the volatility of the pricing error, σ_s, using a VAR system comprising four variables: $\Delta p_t,$ 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 use the latter for univariate analyses, and the former in regressions that control for volatility.

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 estimates of the 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.

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9 Raman *et al.* (2023) 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.

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

Section 5.1 documents changes in market quality measures around electronification. Section 5.2 documents the financialization of intraday activity following electronification by showing the relative contributions to total market activity of Locals *vs*. institutional financial traders. It provides novel empirical evidence of entry by new institutional financial traders (Section 5.2.1) 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 5.2.2; cross-market presence, Section 5.2.3). Section 5.3 shows that this intraday financialization subsequent to electronification affects short-dated more than long-dated contracts—an empirical fact that we exploit to tease out the relationship between intraday financialization and market quality.

5.1. 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 market access for traders without physical presence in the NYMEX pits, and thus also boosted 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 4.3 above) around 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 3, 2006 to May 31, 2008. *Pre-Electronification* in Table 1 refers to the period from January 3, 2006 to September 1, 2006. *Post-Electronification* refers to the period from September 6, 2006 to May 31, 2008. Figure 1 relates to WTI light 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 show that the 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 change is statistically highly significant (p-value < 0.001). The Amihud measure of depth also improves substantially, although the change is not statistically significant.

5.2. Electronification and the Financialization of Intraday Activity

5.2.1. Institutional Financial Trading Activity

Following electronification, one would also expect an increase in institutional financial traders' contribution to WTI futures trading. 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 the total 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 intraday financialization.

Figure 2 provides visual, trading-activity-based evidence of the WTI futures market's intraday financialization by aggregating the CFTC's account-level intraday information for the CTI-1 and CTI-2 trader categories. Prior to electronification, in line with Manaster and Mann (1996), we find Locals (CTI-1) dominating pit trading: in the first eight months of 2006, Locals account for approximately 80 percent of the total trading volume. In contrast, CTI-2 traders account only for about 15 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 futures market—a rate of entry that is almost three times what it was in the first eight months of 2006.[10] As a result of this inflow, Figure 2 shows that, well within a year of electronification, the fraction of all Globex WTI futures trades involving institutional financial traders climbs to about 40 percent of the total volume—double what the CTI-2 volume share used to be in the WTI pits.[11] The overall trading volume also grows substantially in the same period,

[10] These figures are consistent with Boyd and Kurov (2012), who note a sharp increase in the entry of new traders overall into NYMEX energy futures markets following their electronification in September 2006. That study, however, focuses on the profitability of Locals before and after electronification, and it does not provide information on the activities of financial traders.

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

with institutional financial traders capturing a bigger slice of what is a growing WTI pie. The t-tests reported in Table 1 confirm that the *average* proportion of trading activity involving institutional financial traders almost doubles, from about 16 percent in the eight-month *pre*-electronification period to over 33 percent in the 21-month *post*-electronification period.[12]

5.2.2. Characteristics of the Institutional Financial Trader Group

Because electronification allows for new kinds of trading (automated order placement and execution, competition with locals with respect to liquidity provision and arbitraging, etc.), one expects institutional financial traders' trading patterns to differ after electronification. To confirm this intuition, Table 2 shows the mean and median hourly trading volumes, trading frequencies, and closing ratios for Locals (CTI-1), institutional financial traders (CTI-2), and customers (CTI-4) from January 3, 2006, to March 31, 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 individual traders' ending-of-hour inventory to their hourly trading volume—declines 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 5, 2006 are focused on much shorter horizon intraday strategies (similar to Locals' strategies) compared to the institutional financial traders that had been active in the pits prior to electronification. To wit, with about six trading hours in a day, and with an average of 92% of the positions held at the start of each hour closed by the end of that hour, a relatively minuscule proportion of daily trading volume results in open positions at the end of the day. Put differently, as discussed in Section 4.2, the trading of CTI-2 traders post electronification is largely intraday. Hence CTI-2 traders' share of the trading volume is an excellent proxy for intraday commodity market financialization.

[12] 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).

5.2.3. Institutional Financial Traders' Cross-Market Presence

In contrast to the specialized traders that used to populate futures markets in prior decades, a characteristic of the institutions that started the financialization of commodities two decades ago is their simultaneous presence in multiple commodity markets (Tang and Xiong, 2012) and other asset markets (e.g., hedge funds in Büyükşahin and Robe, 2014; CITs in Cheng *et al*., 2015). If the phenomenon that we describe truly amounts to intraday financialization, then one would expect the new institutional day traders of WTI futures—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 the individual traders (who are anonymized in our regulatory data) have the same IDs as in the WTI crude oil futures markets. In our sample period, the two such markets are the gold and silver futures marketplaces of the NYMEX's COMEX division.

The COMEX introduced electronic gold and silver futures trading on December 4, 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 precious 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 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 this 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 5.3.2 below) account for approximately 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. To summarize, Locals really are "local" to the market in which they operate.

Overall, these two empirical regularities 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 institutional financial traders focused on the very short term and active across multiple markets, rather than traders focused on a single commodity.

5.2. Institutional Financial Trading: Short-dated *vs*. Long-dated Futures Contracts

Section 5.1 shows that the 2006 introduction of electronic trading dramatically improved market quality for WTI crude oil futures, as it earlier had for equities—see, e.g., Barclay *et al*. (1999) and Jain (2005). Section 5.2 shows that electronification also triggered *intraday* financialization, *i.e*., a massive growth in intraday institutional financial trading. To isolate the link between this dimension of financialization and market quality, which is the primary focus of the present paper, we turn to differences in the participation of institutional financial traders in different segments of the WTI futures trading's term structure.

5.3.1. Intuition

With a view to teasing out the impact of intraday 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 proprietary trading and 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 two should impact different futures contracts similarly, regardless of maturity. Short-dated and long-dated 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-dated than in long-dated 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 directional and calendar spread trading activity in the WTI futures market. In the same vein, both before (Neuberger, 1999) and also after (Büyükşahin *et al.*, 2011) electronification, positions in these five contracts are the most commonly held overnight or for longer periods by producers, refiners, and wholesalers, *i.e.*, by the commercial traders that are key demanders of (intraday) WTI futures market liquidity. With electronification's attracting new financial traders intent on competing to provide liquidity to such users, one would expect intraday financialization to be more pronounced for those five contract maturities.

5.3.2. Evidence

To verify this conjecture, we compute the participation rates of institutional financial traders separately for two groups of WTI futures: short-dated *vs*. long-dated contracts. Given that approximately half of the total WTI futures trading volume involves calendar spreads in our sample period, we select the "short-dated 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.[13] Our "long-dated 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' (CTI-2) participation rate ("FIN") in short-dated and long-dated contracts in 2006-2008. As anticipated, Panel A shows a much stronger relative rate of intraday financialization ("DFIN") following electronification for short-dated contracts compared to long-dated contracts. Figure 3, Panel B plots the number of new financial institutional traders entering the WTI crude oil futures market in short-dated and in long-dated futures. In line with the increased CTI-2 participation rates following electronification discussed in Section 5.2.1

[13] 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.

above, Panel B shows a significantly greater number of new institutional financial traders entering the trading of short-dated rather than long-dated contracts after September 5, 2006. Overall, the bottom line is that introducing electronic trading encouraged an influx of new financial institutional traders into the WTI futures market, albeit largely in the short-dated contracts.

Table 4 presents a more formal comparison of the *pre*- and *post*-electronification differences between the extents of intraday financialization in short-dated *vs*. long-dated futures. The fraction of the total trading volume in short-dated contracts involving institutional financial traders (denoted *FIN_Short-Dated*) increases from 15.13 percent for the first eight months of 2006 to 23.6 percent for the six months following electronification. This increase of more than 50 percent is statistically highly significant (p-value < 0.001). During the same period, the equivalent measure for long-dated contracts (denoted *FIN_Long-Dated*) does not change significantly, remaining at around 20 percent of the total trading volume at such maturities both *pre*- and *post*-electronification. Consequently, the percentage difference in the contribution of intraday institutional financial trading to the short-dated *vs*. long-dated trading volume, denoted $\Delta FIN = (FIN\_Short\text{-}Dated - FIN\_Long\text{-}Dated) / FIN\_Short\text{-}Dated$, rises from *minus* 34.05 percent pre-electronification to *plus* 11.72 percent after electronification in the futures market. This event-related increase is statistically significant at the 1 percent level.

In sum, the participation rates of institutional financial traders (*i.e*., the extent of intraday financialization) in short-dated and in long-dated contracts change differentially after 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 for the relation between intraday financialization and 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.

6. Intraday Financialization and Market Quality

We saw in Section 5.1 that our market quality metrics improve significantly overall *post*-electronification. We also saw in Section 5.2.1 and 5.3.2 that intraday financialization, in response to electronification, is significantly greater in short-dated contracts than in long-dated contracts on the same (WTI) commodity. In this Section, we examine how financialization is related to crude oil futures market quality by exploiting the observed variation in the intensity of intraday financialization for short-dated *vs*. long-dated contracts in the aftermath of the exchange-mandated electronification of crude oil futures.

Our contention is that the *average* improvement in market quality variables across all maturities captures the common effect of electronification (whether due to improved transparency, lower operating and processing costs, or increased competition amid intraday financialization), but the *relatively* larger improvement observed for short-dated (*vs*. long-dated) contracts is due to relatively greater financialization. Section 6.1 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 6.2 carries out regressions to establish the relation between intraday financialization and improvements in market quality. Section 6.3 shows that conclusions are qualitatively robust to using alternative methodologies.

6.1. Descriptive Analysis—Event Study

We start with an event study on a sample comprising all transaction records for WTI futures on NYMEX from January 3, 2006 to March 31, 2007. We split the sample 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 4.3 and 5.1. We compute daily averages separately for two groups of contracts: short-dated and long-dated. We compute the *pre*- and *post*-electronification values of our market quality variables for short- and long-dated contracts separately, as well as the percentage differences (Δ) between the daily values of these short- and long-dated estimates.

Panels A to E in Figure 4 plot the evolution of these percentage differences (trade-volume-weighted for short-dated *vs*. long-dated contracts) in 2006-2008. For all market quality metrics, the improvement after electronification clearly benefited short-dated futures relative to long-dated futures. Spreads are shown in Panel A; depth, in Panel B; absolute customer order imbalances, in Panel C; and pricing errors and volatility in Panels D and E (ratio).

Table 5 presents simple *t*-tests of these variables *pre*- vs. *post*-electronification. First, while both long- and short-dated contracts have lower pricing errors *post*-electronification, the errors improve more for short-dated (92.6 percent) than long-dated contracts (87 percent). In relative terms, the average ratio of the volatility of pricing errors to the volatility of log transaction prices is 28 percent higher for long-dated contracts than short-dated contracts *pre*-electronification, with the percentage difference rising to 132 percent *post*-electronification. That relative improvement for short-dated contracts is highly significant ($p < 0.001$), in line with the visual evidence from Panel E in Figure 4.

Second, the *pre*-electronification average bid-ask spread is about 28 percent wider for long-dated than short-dated contracts. The difference, *post*-electronification, is nearly eleven times larger—304 percent. Again, while both long- and short-dated contracts are both more liquid *post*-electronification (75.6 and 91.4 percent drops, respectively), the liquidity of short-dated contracts improves significantly more than that of long-dated contracts (p-value < 0.001).

Third, the *pre*-electronification absolute magnitude of customer trade imbalances for long-dated contracts is on average about 144 percent larger than for short-dated contracts. The same variable *post*-electronification increases significantly to 175 percent. Here also, long- and short-dated contracts both display a *post*-electronification improvement (imbalances lowered by 18.8 and 27.7 percent, respectively), but again the improvement is significantly greater for short-dated contracts than for long-dated contracts (p-value<0.001).

Finally, similar to the depth findings for the WTI market as a whole (see Section 5.1), our *t*-tests find that the average depth for short-dated contracts does not change statistically significantly after electronification. We do find, however, a statistically significant *relative* improvement of depth for short-dated *vs*. long-dated contracts (p-value<0.001) as depth worsens (by 33.3 percent) for long-dated contracts after electronification.

Overall, as captured by our key market quality metrics, electronification benefits short-dated contracts significantly more than it benefits long-dated contracts. Meanwhile, as seen in Section 5.3.2, institutional financial traders' contribution to the total volume increases significantly in short-dated contracts while staying (statistically) the same in long-dated 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-dated 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 intraday financialization improves market quality. The next two sub-Sections examine this conjecture more rigorously.

6.2. Regression Analysis

The NYMEX's introduction of electronic trading removed barriers to trading crude oil futures and facilitated market participation by financial institutional traders. *Post*-electronification, we have documented a significantly greater increase in financial institutional trader activity in short-dated contracts, relative to the same in long-dated contract. We now examine how, following the exchange-mandated electronification of crude oil futures, the observed differences in the intensity of intraday financialization across the term structure is related to difference between measures of market quality in short- *vs*. long-dated contracts. Sub-section 6.2.1 presents our baseline analysis. Sub-Sections 6.2.2 and 6.3 assess robustness.

6.2.1 Baseline Analysis

We regress our market quality measures (precisely, the percentage differences in depth, spreads, customer imbalances, and pricing error volatility for short- *vs*. long-dated contracts) on ΔFIN (*i.e.*, the percentage difference in the intensity of intraday financialization: (*FIN_Short-Dated* – *FIN_Long-Dated*) / *FIN_Short-Term*) and on relevant control variables.

First, we control for differences in trading patterns due to: (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 have to roll their nearby-futures positions following the GSCI indexing methodology; (v) possible transitory anomalies in the month when electronification started; and (vi) day-of-the-week effects. In addition, we control for the percentage differences, between short- and long-dated contracts, in (vii) crude oil return volatilities and (viii) trading volumes.

Importantly, we also control for cross-maturity differences in customer trading across the term structure (Δ*Customer Volume*). As discussed in the *Data* Section, "Customers" are futures traders classified as CTI-4: "external traders or traders who are not members of the exchange." These are typically longer-horizon traders who, unlike CTI-1 (Locals) and CTI-2 traders do not trade frequently enough to justify the costs of exchange membership. The CTI-4 category includes commercial hedgers (traders who hold positions in the underlying physical commodity) as well as financial hedgers (traders investing in the crude-oil market to diversify their investment portfolio, as in Goldstein and Yang (2022)). In this sense, controlling for CTI-4 activity enables us to properly test the Goldstein and Yang (2022) hypothesis that an increase in the presence of financial speculators, while keeping financial hedgers positions constant, increases pricing efficiency.

Table 6 summarizes the results from the regression analysis. 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, Table 6 shows that Δ*FIN* consistently has a negative and statistically highly significant coefficient ($p\text{-value} < 0.001$). To interpret this result, recall that we are analyzing the relation between the percentage difference (for short- *vs*. long-dated 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 the participation of institutional financial traders in short-dated *vs*. long-dated contracts is significantly related to the percentage (or proportional) difference in that market quality variable in short- *vs*. long-dated contracts.

Let us consider each of the market quality variables separately. For spreads, the -0.62 coefficient means that a one-unit increase in the percentage difference in intraday financialization (with intraday institutional financial trading increasing more in short- than in long-dated contracts) is associated with a decrease in the percentage differences in bid-ask spreads (with bid-ask spreads falling more for short- than for long-dated contracts) by 0.62 units. As shown in Appendix 2, the standard deviations for the percentage differences in *FIN* and bid-ask spreads are 42 and 186 percent, respectively; thus, a one-standard deviation increase in the percentage difference in intraday financialization widens the percentage difference in bid-ask spreads by approximately 0.14 standard deviations (to the benefit of short-dated contracts). Table 6 also shows that, as should be expected, the percentage difference in spreads is positively related to the percentage difference in volatilities between short- and long-dated 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. For a one-standard deviation increase in the percentage difference in intraday financialization, we find a widening of the percentage difference in Amihud ratios of 0.22 standard deviations, and in the absolute magnitudes of customer trade imbalances by 0.15 standard deviations.

Last, but not least, for a one-standard deviation (one unit) increase in the percentage difference in intraday financialization between short- and long-dated contracts, we find (after controlling for other relevant variables) an increase of the percentage difference in pricing error volatility by 0.28 units, or by 0.12 standard deviations. In other words, Table 6 suggests that intraday financialization significantly improves intraday pricing efficiency.[14]

Finally, our results suggest that relatively greater changes in customer activity in near-dated

[14] Our analyses focus on Intitutional Financial ("CTI-2") traders to the exclusion of Locals ("CTI-1" traders). One might expect that an 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.

(*vs*. long-dated) contracts do help explain part of the spread improvements. However, we find no evidence that they boost pricing efficiency. More importantly, our results are in line with the predictions of the Goldstein and Yang (2022) model (Proposition 2): an increase in the presence of financial speculators, *while controlling for the activity of financial hedgers*, improves pricing efficiency.[15]

Overall, our results present a coherent story: the short-dated futures experience more intraday financialization than long-dated contracts do, and the bid-ask spreads, Amihud inverse measure of depth, customer imbalances, and pricing errors all drop substantially more for short-dated than for long-dated contracts.

6.2.2 "Continuing" Customers

One could worry that improvements in market quality might be observed because the nature of customers (rather than financial intermediaries) changes after electronification. To examine this possibility, we investigate the relation between intraday institutional financial trading and the spreads that are paid by the subset of 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 revisit the effect of the entry of institutional financial traders in short-dated *vs*. long-dated contracts while controlling for both the nature of the customers and their demand for liquidity.

The general methodology is identical to the one described in Section 6.2.1, except that we limit our analysis to bid-ask spreads (because spreads are the only market quality measure that can be estimated separately for "continuing" customers). The results of the additional analysis are consistent with those of the baseline regressions in Section 6.2.1: thus, for brevity, we do not provide tables with these additional results.

[15] Table 6 presents linear regression results only. To account for possibly non-linear effects of Δ*Customer_Volume* on the relation between intraday institutional financial trading and market quality, we also run the same regressions but now stratified by Δ*Customer Volume* (Terciles 1, 2, and 3 corresponding to the bottom, medium, and highest values of ΔCustomer Volume). We find 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-dated than in short-dated contracts), we find that financialization improves each of our market quality metrics.

6.3. Robustness Tests

Our evidence that the increased presence of institutional financial traders is associated with increased market quality is in-line with the theoretical predictions of Goldstein & Yang (2022), but it might arguably be open to an alternative interpretation that would run as follows. Suppose that, due to some fundamental characteristic, short-dated contracts are more liquid and are also priced more efficiently than long-dated contracts. As such, these short-dated contracts might attract more financial traders than long-dated contracts after electronification, which might explain why we find a positive association between the increased presence of financial traders and market quality improvements. In this Sub-Section, we conduct a series of alternative tests to alleviate possible concerns that our results might be *entirely* driven by such reverse-causality.

6.3.1. Single-Stage Regression Analysis—Lagged Values

First, we use lagged values of our main explanatory variable ΔFIN to reduce the potential contemporaneous impact of variations in market quality on intraday institutional financial trading. Table 7 summarizes the results of single-stage regressions, similar in concept to those of Section 6.2.1 but using ΔFIN lagged by one (Panel A) or two (Panel B) days. As seen from the Table, we continue to find strong evidence that intraday financialization improves both market liquidity and intraday pricing efficiency.

6.3.2. Two-Stage Regression Analysis—Lagged Identification

Next, inspired by Muravyev's (2016) analysis of order flow and option returns, we implement an instrumental variables approach predicated on the day-to-day persistence of the degree of intraday financialization. Namely, we use lagged values of the degree of intraday financialization (plus a set of exogenous variables that are likely to generate fluctuations in intraday institutional financial trading) to predict its future levels.

Precisely, we use a one-day lag of ΔFIN as instrument, in the first stage regression that also includes dummy variables for (a) prompt-contract expiration days, (b) EIA information days, (c) the initial month of electronic trading, and (d) GSCI roll days. As Panel A of Table 8 shows, these variables combine to form a strong predictor: they explain just over 25% of the variation in Δ*FIN*. Moreover, Δ*FIN* is statistically significantly persistent (with a coefficient of 0.50), higher on EIA announcement days, and lower on contract expiration days.

The results for the second-stage regressions are presented in Panel B of Table 8. We again find evidence consistent with the hypothesis that intraday financialization significantly improves both liquidity and intraday pricing efficiency.

6.3.3. Two-Stage Regression Analysis—Electronification as an Instrument

Lastly, 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 WTI futures market's electronification as an instrument in two-stage regressions to examine the relation between market quality and the trading activity of financial institutional traders.

In this approach, our goal is to identify the impact on market quality of the intraday financialization that followed electronification—not the impact 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-dated (*vs*. long-dated) contracts. To be precise, we use the electronification of the NYMEX WTI light sweet crude oil futures market as an instrument for the relative participation of financial institutional traders in short-dated (*vs*. long-dated) contracts in that market, as follows:

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

Second Stage: $$\Delta M_t = \alpha_2 + \beta_2 \widehat{\Delta FIN}_t + \gamma_2 C_t + \gamma_3 X_t + \epsilon_t$$

where ΔFIN_t is (as before) the percentage difference between the rates of participation of institutional financial traders in short- *vs*. long-dated futures; ΔM_t is the percentage difference between the values of a given market quality measure for short- *vs*. long-dated contracts by (bid-ask spreads, depth, etc.); $Electronification$ is a dummy set equal to 1 after September 5th, 2006 (the NYMEX electronification date) and to 0 prior to that day; C_t are exogenous control dummies from Section 6.3.2; $\widehat{\Delta FIN_t}$ represents the fitted values of ΔFIN_t from the first stage estimates; and X_t is a set of control variables including trading volume and volatility.[16]

Panel A of Table 9 summarizes the first-stage results. Consistent with the univariates

and the graphical evidence presented in Section 5.3.2, we find a statistically and economically significant link between $Electronification$ and the difference in institutional financial traders' participation in short- *vs*. long-dated contracts. The institutional financial traders who were active before electronification trade more actively in long-dated than in short-dated crude oil futures, as indicated by the intercept of -0.34. The $Electronification$ dummy's coefficient β_1 = 0.46 implies that, *post*-electronification, the *relative* participation of financial traders in short-dated contracts increased by 46 percentage points. Importantly, the $Electronification$ dummy alone explains almost 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.

The results for the second stage are presented in Panel B of Table 9. Qualitatively, they results are similar to those obtained in Sections 6.2 and 6.3.1 with single-stage regressions. Interestingly, the quantitative results obtained using this instrumental variable approach are even stronger than the ones obtained using simple OLS regressions. A one-standard deviation increase in the percentage difference in the rate of intraday financialization (between short-dated and long-dated contracts) widens the percentage differences (for short- *vs*. long-dated contracts) in the magnitude of pricing errors by 0.24 standard deviations; in bid-ask spreads, by 0.82 standard deviations; in market depth, by 0.74 standard deviations; and in customer trade imbalances, by 0.60 standard deviations. To sum up, we continue to find that intraday financialization improves liquidity and pricing efficiency.

[16] In addition, we control for (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.

7. Electronification, Intraday Financialization, and High-Frequency Trading

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

For commodities, Section 6 establishes empirically that intraday financialization, as measured through relative increases in institutional financial trading, improves both liquidity and pricing efficiency metrics. A natural question, then, is whether some of our results obtain wholly or in part due to the rise of high-frequency algorithmic trading by institutional traders. More broadly, in the light of ongoing academic and policy debates relating to constraining HFTs and boosting the market participation of non-automated liquidity providers,[17] it is important to examine if HFT and non-HFT traders differ in their impact on key aspects market quality, particularly in an environment in which both groups co-exist *and* contribute substantially to trading volumes.

In Section 7.1, we start by documenting that HFT and non-HFT institutional financial traders both make up significant shares of the daily trading during the last quarter of 2006 and the first quarter of 2007. In the NYMEX's WTI futures market, there is obviously no HFT before September 2006, and the relative importance of non-HFT insitutional financial traders wanes after 2007. Our 2006Q4 to 2007Q1 sample therefore provides a unique opportunity to shed light on the above questions. Indeed, Section 7.2 provides empirical evidence—to our knowledge for the first time—of major differences in the respective contributions to pricing efficiency and market liquidity of intraday HFT and non-HFT institutional financial trading.

7.1. Components of Institutional Financial Trading

Inspired by Kirilenko *et al.* (2017) and Raman *et al*. (2023), whose analysis of algorithmic liquidity provision relies on the same type of CFTC non-public intraday data, we identify HFTs as CTI-2 traders who trade more than 990 times a day (3 times per minute, every minute of the trading day)

[17] See, e.g., Budish, Cramton, and Shim (2015), Brolley and Zoican (2023), and references cited therein.

and carry less than 5% of their daily trading volume overnight (making them largely intraday traders). This identification allows us to create two new measures of intraday financial institutional trading: (i) *FIN_Non_HFT,* which we calculate after removing all HFTs from our set of institutional financial traders; and (ii) *FIN_HFT*, the component of intraday financialization that is due to the onset of high-frequency trading. Analogous to our other analyses, we use the difference between short-dated and long-dated contracts for both of these measures of financialization.

Table 10 provides summary information on HFT and non-HFT institutional financial traders, based on Globex data from the *post*-electronification period (September 5, 2006, to March 31, 2007). Predictably, HFTs trade much more, and much more frequently, than non-HFTs. Notably, both groups' median hourly closing ratios (computed using each trader's end-of-hour inventory to that trader's hourly trading volume on the Globex electronic platform during business hours) are massively lower than the corresponding ratio for institutional financial traders *pre*-electronification (1% for HFTs and 15% for non-HFTs in Table 10, *vs*. 83% in Table 2). In other words, Table 10 shows that it is not only the 21 HFT institutional financial traders that begin to trade WTI futures following the market's electronification, but also the more than four hundred other (non-HFT) new institutional financial traders that enter the market for the first time in the same period (Figure 3, Panel B), that behave very differently from their *pre*-electronification counterparts. Finally, Table 10 shows that both the aggregate HFT and non-HFT components of the FIN variable are large and, on average in our two-quarter sample, quite similar in magnitude.

7.2. Differential contributions of HFT and Non-HFT Traders to Market Quality

To compare the contributions of HFT and non-HFT intraday financial traders to market quality, we conduct a regression analysis similar to the one in Section 6.2. Table 11 presents the results from this analysis.

It is clear that HFT institutional financial traders share most, but not all, of the credit for liquidity improvements. Their trading contributes to the narrowing of bid-ask spreads (highly significant, p-value < 0.01) and the curtailing of customer trade imbalances (highly significant, p-value

< 0.01). Their activity's impact on depth, however, is statistically insignificant (*p*-value = 0.500). In contrast, our results show that non-HFT intraday institutional financial traders have a statistically significant impact only on market depth (p-value < 0.01), and not on bid-ask spreads and customer order imabalances.

In the case of pricing efficiency, our results indicate that it is HFT financial traders who appear to be tied to the significant reduction in pricing error variance (highly significant, p-value < 0.01). In Table 6, we saw that intraday financialization as a whole is associated with an economically and statistically significant reduction in the variance of pricing errors. Table 11 indicates that, statistically speaking, the improvement in pricing efficiency is linked solely to the growth of HFT institutional financial traders.

In sum, our results indicate that HFT and non-HFT intraday institutional financial traders perform explementary roles in their positive contributions to the liquidity and pricing efficiency of the crude oil futures market. While HFT traders improve all measures of market quality (bid-ask spreads, order imbalances, and pricing efficiency) except for market depth, non-HFT intraday institutional financial traders appear to improve only market depth. These findings are consistent with HFT financial traders' having a competitive advantage in extracting information form the order flow, and thereby providing cheaper liquidity (lower bid-ask spreads) and improving pricing efficiency (lower pricing error variance). At the same time, non-HFT intraday institutional financial traders improve market depth, as they are less constrained to hold smaller inventories (over very short horizons) than their HFT counterparts are. In that sense, our results provide novel evidence that different components of intraday financialization (HFT *vs*. non-HFT intraday institutional financial traders) contribute differently to different aspects of market quality in a market environment in which *both* types of traders coexist with significant fractions of the total trading volume.

8. <u>Conclusions</u>

The literature on the financialization of commodity markets is now large, and it keeps growing. The focus to date, however, has overwhelming been on the impact of commodity index traders and/or of cross-market traders on pricing dymamics at low frequencies. Despite its potential importance for market quality, what has hitherto received little attention is the phenomenon that Goldstein and Yang (2022) call "financialization of intraday trading activity" (p. 2630). That is the massive growth in *intraday* trading, often across unrelated commodities, by institutional financial traders who have no commercial interest in any underlying physical commodity. Our paper addresses empirically this third dimension of financialization.

We investigate the impact of this intraday financialization on market quality, using high frequency regulatory data that provide anonymized trader-level codes and flag trader categories in a manner that enables identification of institutional financial traders. These data allow us to characterize the institutional features and the timing of intraday financialization. Our sample includes the period most relevant for this investigation—the period around the introduction of electronic trading for crude oil futures in September 2006, a move that triggered the entry of numerous new traders into the intraday trading space. Our analysis provides the first, and only, detailed empirical evidence on the intraday financialization of the world's largest commodity market.

Exploiting differences in the extent of intraday financialization between short-dated and long-dated futures, we are able to document economically and statistically significant relationships between improvements in market quality proxies and the degree of intraday financialization. Specifically, we show that intraday financialization was associated with improvements in bid-ask spreads, market depth, customer demand imbalances, and short-term price efficiency—after controlling for trading by commodity index traders and other customers of the exchange, and *over and above* any improvements resulting from market structure changes associated with electronification.

Our empirical results are robust to different methodologies and differences in the nature and volume of non-financial trading. They unequivocally support Goldstein and Yang's (2022) theoretical prediction that intraday financial traders, as short-horizon "financial speculators" who exploit information in the order flow, should improve pricing efficiency. We also find that they significantly improve market liquidity in multiple ways.

Importantly, we also show that our results are not driven solely by the emergence and growth of high-frequency trading. Non-HFT intraday financial traders separately add value and complement their HFT counterparts. Yes, we document that the activity of HFT financial traders (fast algorithms) has a significant beneficial impact on intraday pricing efficiency, bid-ask spreads, and customer demand-supply imbalances. But, we also find that non-HFT intraday institutional financial traders have an independent economically and statistically beneficial impact on depth, bid-ask spreads, and customer demand-supply imbalances. In particular, unlike HFTs, non-HFT intraday institutional financial traders improve market depth.

We thereby also add significantly to the literature on institutional financial trading, being first to investigate the contemporaneous impact of both HFT and non-HFT institutional financial traders and to show that they both contribute to intraday market quality in different ways. While our findings pertain to commodity markets, they are directly relevant to all electronic order-driven markets where liquidity provision is voluntary. Insofar as most equity and other financial markets are now set up 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 arise. One, in periods of stress, do institutional financial traders make markets more or less fragile? Two, does the financialization of commodity markets affect their resilience to exogenous shocks? Answering these questions would have implications for financial stability and the importance of systemic risk.

Second, we provide empirical evidence that financialization has changed the nature of intermediation in commodity markets. In particular, we show that, unlike their predecessors in the pits, the new institutional financial traders on the electronic platform are often active also in other commodities. They are likely to be active also in other asset markets too. These facts and conjectures point to the need for new research on commonality in liquidity across asset classes, particularly in the context of funding liquidity constraints and associated systemic market risks.

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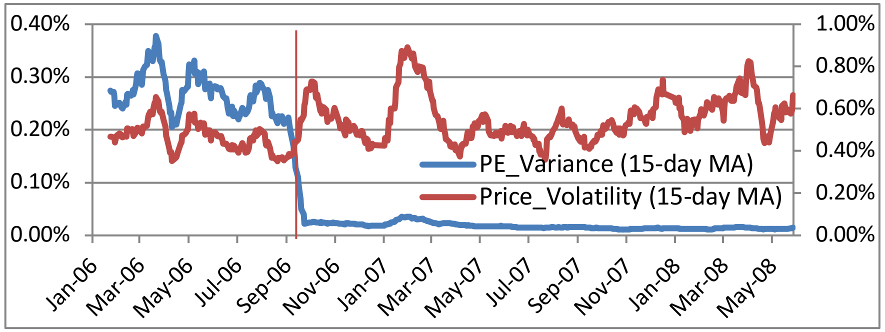
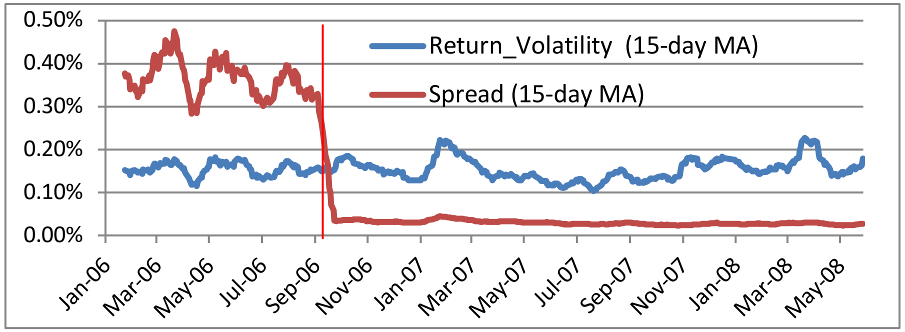
Figure 1: Market Quality Measures, 2006–2008

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). The vertical red lines mark September 5th, 2006. All variables are as defined in Appendix 1. 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.

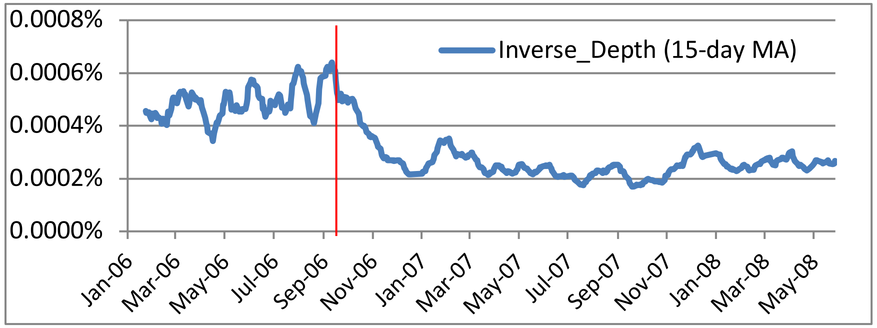
Panel A: Pricing Errors (*PE_Variance* and *Price_Volatility*)



Panel B: *Spread* and *Volatility*



Panel C: Inverse Depth (*Amihud Ratio*)



Panel D: Customer Demand Imbalances (*AbsOIB*)

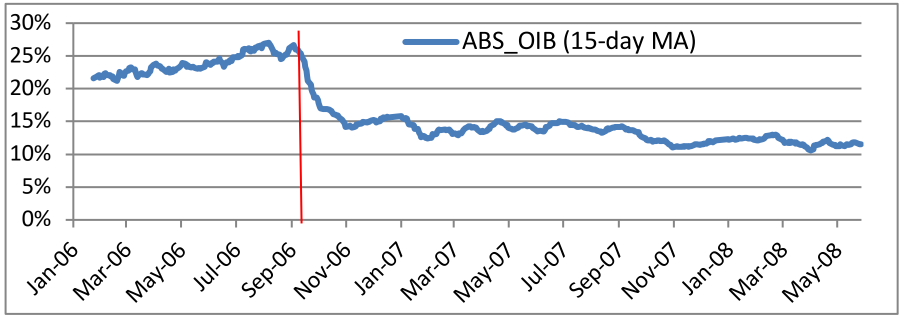


Figure 2: Trading Volume – Share of Locals *vs.* Intraday Institutional Financial Traders, 2006 – 2008

Figure 2 compares the respective evolutions, between 2006 and 2008, of the fractions of the total trading volume involving intraday institutional financial traders (CTI-2, dashed line) and Locals (CTI-1, solid line) in the NYMEX's WTI light sweet crude oil futures market. The vertical red line marks September 5th, 2006 (the day when electronic WTI futures trading started on the Globex platform). 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). All variables are as defined in Appendix 1. 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.

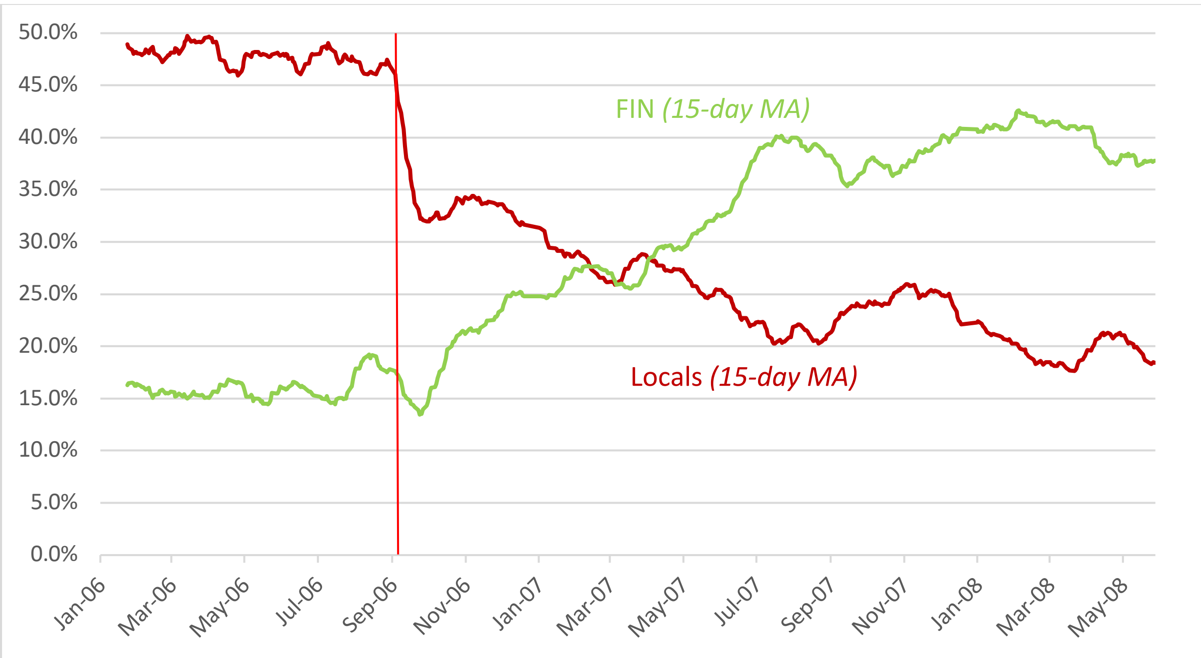
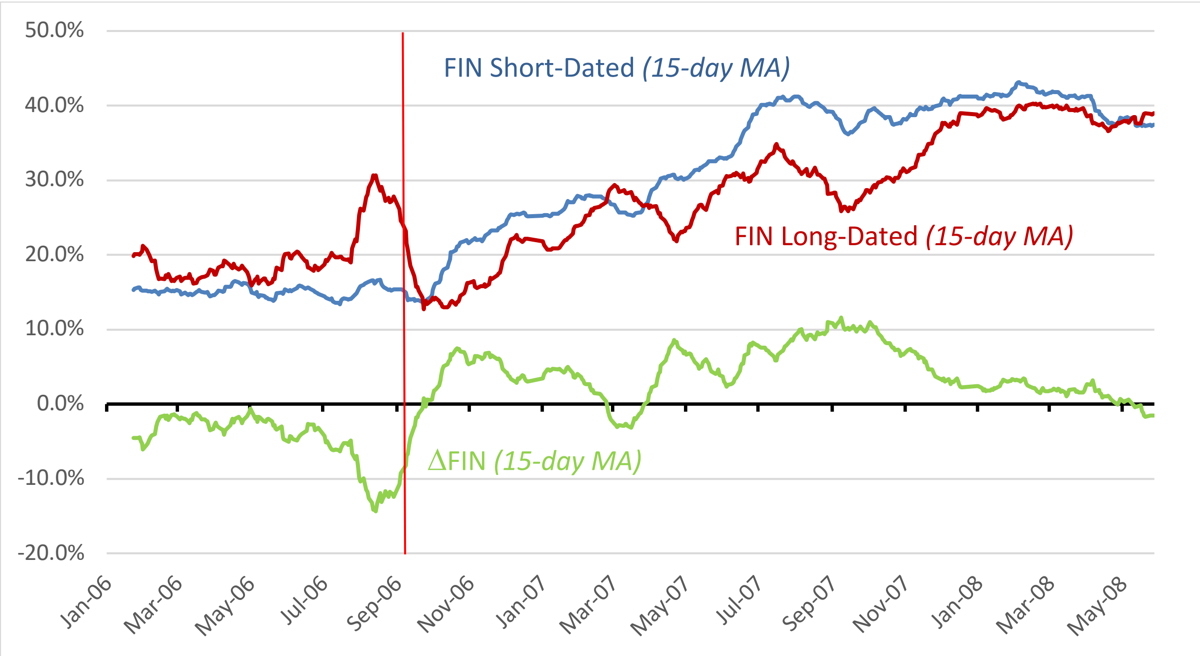


Figure 3: Institutional Financial Trading Activity: Short-dated *vs.* Long-dated contracts, 2006 – 2008

Figure 3 compares the evolution of institutional financial trading in short-dated *vs*. long-dated WTI light sweet crude oil futures contracts on the NYMEX. **Panel A** compares the proportions of the total daily trading volume involving institutional financial traders (FIN) in short-dated *vs*. long-dated WTI futures from January 2006 to May 2008. **Panel B** compares the monthly number of new institutional financial traders (*i.e*., arrivals of CTI-2 traders) in short-dated *vs*. long-dated WTI futures. The analysis uses 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). The vertical line in Panel A identifies the date of the introduction of electronic trading – September 5th, 2006. All variables are defined in Appendix 1. ***Source***: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

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



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

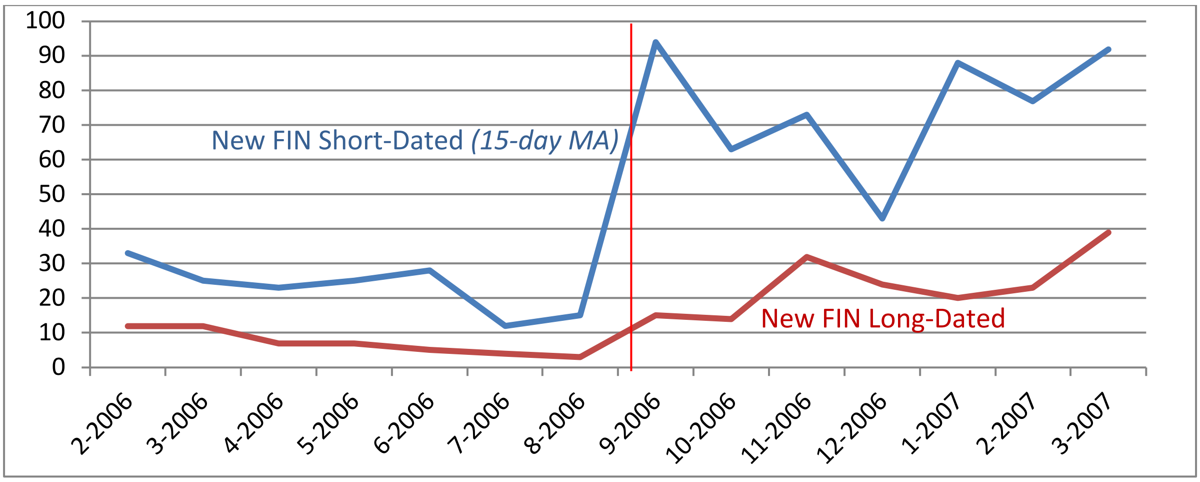
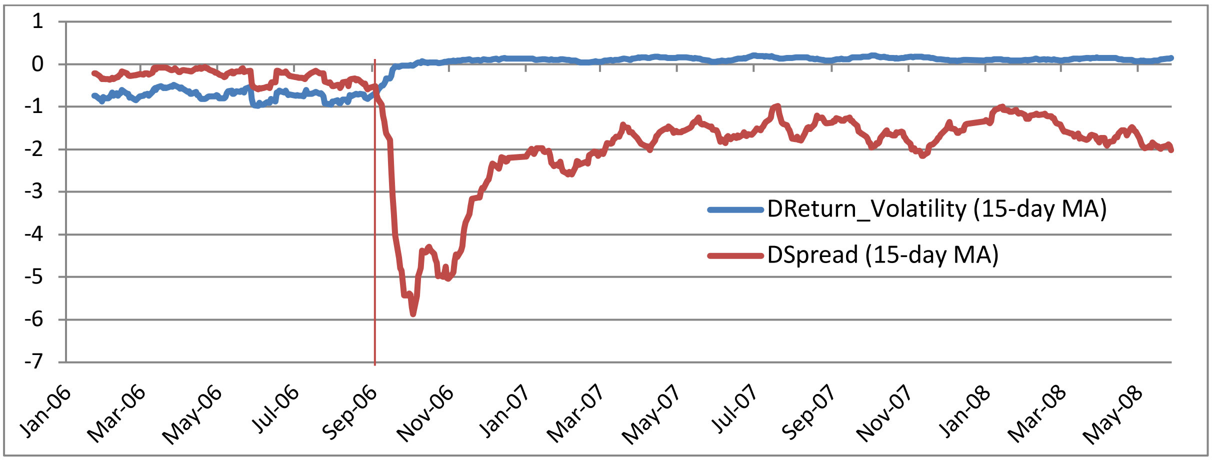


Figure 4: Intraday Institutional Financial Trading Activity and Market Quality measures:

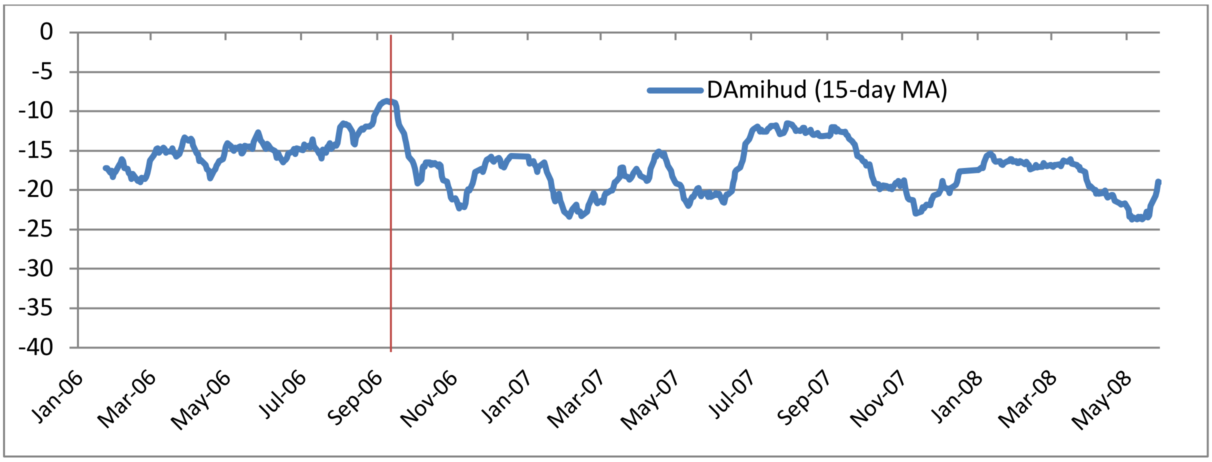
Short-dated *vs.* Long-dated contracts

Figure 4 compares the evolution of various market quality measures in short-dated (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 light 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 values of the relevant variable(s) for short-dated contracts ("*Short-Term*") and long-dated contracts ("*Long-Term*"). The dark vertical line in each plot identifies the date of the introduction of electronic trading – September 5th, 2006. All variables are as defined in Appendix 1. ***Source***: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

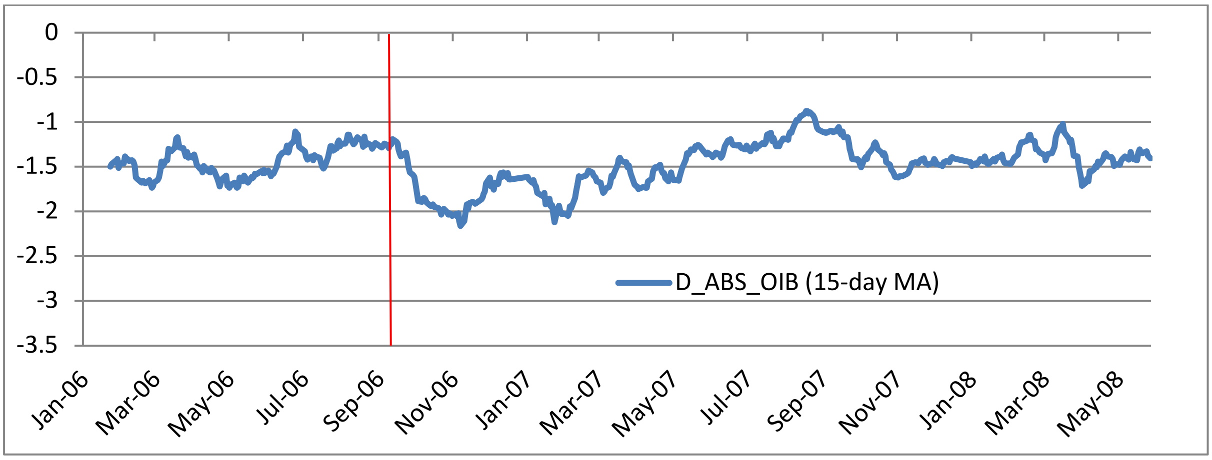
Panel A: Δ*Spread* and Δ*Volatility*



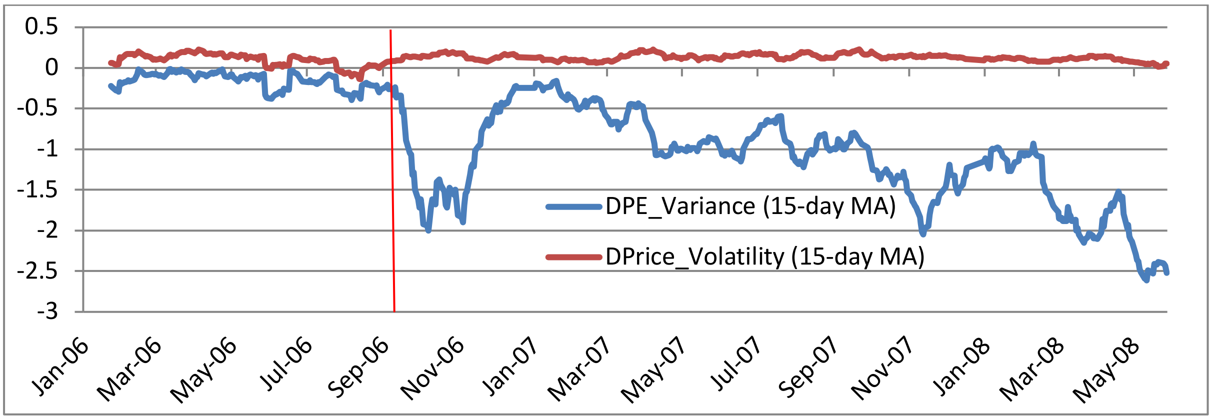
Panel B: Δ*Amihud* (inverse depth)



Panel C: Δ*AbsOIB*



Panel D: Δ*PE_Variance* and Δ*Price_Volatility*



Panel E: Δ*PE_Proportion*

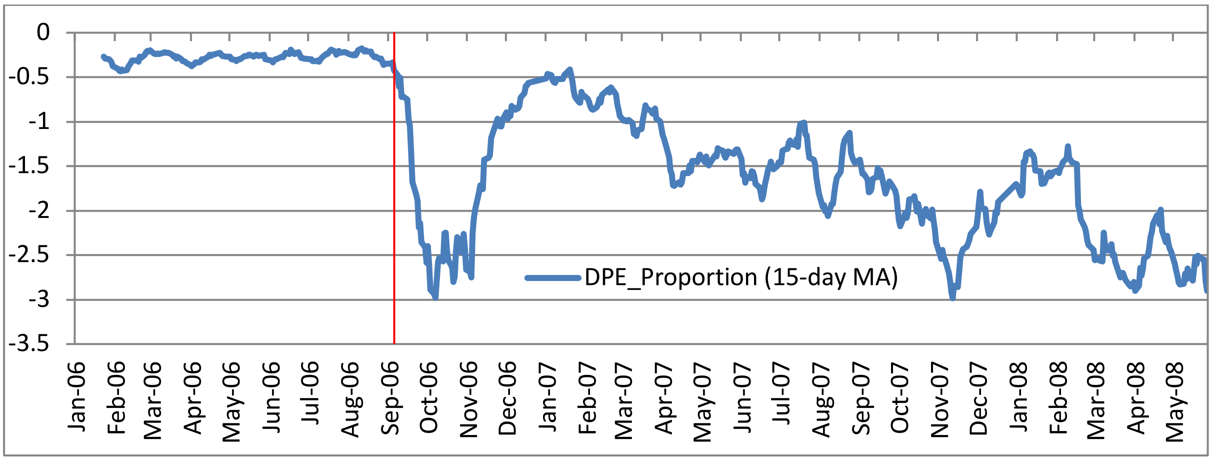


Table 1: Impact of Electronification on Institutional Financial Trading and Market Quality

Table 1 presents an analysis of institutional financial traders' participation and key 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 May 31st, 2008. *Pre-Electronification* refers to the period from January 3rd, 2006, to September 1st, 2006; *Post-Electronification* in this Table refers to the period from September 5th, 2006, to May 31st, 2008. The analysis is conducted on pit trading data for the *Pre-Electronification* period and on Globex data for the *Post-Electronification* period. All variables are as defined in Appendix 1. All variables are first 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. ***Source***: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

	Pre-Electronification	Post-Electronification	Difference	Pct. Difference	p-value
FIN	16.07%	33.10%	17.04%	106.04%	<.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 for a seven-month *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, CTI-2, and CTI-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 Financial Institutional 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 light sweet crude oil futures market but also in gold COMEX futures (right columns) or in both gold and silver COMEX futures (left columns). *Locals and Financial Institutions* ("*Fin. Inst.*") refer to traders classified respectively as CTI-1 and CTI-2 in the regulatory database. Panel A computes those "common futures trader" proportions for the WTI market; Panel B, for the gold 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**		
	Fin. Inst. (Electronic)	***Fin. Inst. (Pits)***	***Locals (Pits)***	***Fin. Inst. (Electronic)***	***Fin. Inst. (Pits)***	***Locals (Pits)***
Panel A: Crude Oil Futures						
Mean	11.2%	5.2%	0.0%	12.5%	5.3%	0.1%
Median	11.3%	3.7%	0.0%	12.6%	3.8%	0.1%
Std Dev.	1.9%	4.4%	0.0%	2.2%	4.4%	0.1%
Panel B: Gold Futures						
Mean	10.5%	0.7%	0.0%	11.7%	0.7%	0.1%
Median	10.1%	0.1%	0.0%	11.5%	0.1%	0.0%
Std Dev.	3.3%	1.8%	0.1%	3.4%	1.8%	0.3%

Table 4: Institutional Financial Trading before and after Electronification – Short- *vs*. Long-dated Futures

Table 4 presents a univariate analysis of institutional financial traders' ("FIN") 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. Two-tailed *p-values* are reported in the last column. All variables are as defined in Appendix 1. ***Source***: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

	Pre-Electronification	Post-Electronification	Difference	p-value
FIN_Short-Dated	15.13%	23.36%	8.23%	<.001
FIN_Long-Dated	20.04%	20.63%	0.59%	0.4403
Δ*FIN*	-34.05%	11.72%	45.77%	<.001

Table 5: Market Quality before and after Electronification – Short-dated *vs*. Long-dated Futures

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. All variables are as defined in Appendix 1. 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**	**Percent Change Pre/Post-Electronification**	***p-value***
Spread_Short-Dated	0.35%	0.03%	-91.4%	<.001
Spread_Long-Dated	0.41%	0.10%	-75.6%	<.001
Δ*Spread*	-28%	-304%		<.001
Amihud_Short-Dated	1.04	1.07	2.9%	0.604
Amihud_Long-Dated	15.00	20.00	33.3%	<.001
Δ*Amihud*	-14.87	-18.43		<.001
AbsOIB_Short-Dated	17.09%	12.36%	-27.7%	<.001
AbsOIB_Long-Dated	40.85%	33.19%	-18.8%	<.001
Δ*AbsOIB*	-143.74%	-175.26%		<.001
PE_Proportion_Short-Dated	55.35%	4.12%	-92.6%	<.001
PE_Proportion_Long-Dated	69.61%	8.90%	-87.2%	<.001
Δ*PE_Proportion*	-27.73%	-132.27%		<.001

Table 6: Institutional Financial Traders and Market Quality

Table 6 presents the results of an analysis of the relation between intraday institutional financial trading (Δ*FIN*) and four markers of market liquidity (Δ*Spread*, Δ*Amihud*, Δ*AbsOIB*) and pricing efficiency (Δ*PE_Variance*). 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). All variables are as defined in Appendix 1. Two-tailed *p-values* are also reported.

Parameter	**ΔSpread**		**ΔAmihud**		**ΔAbsOIB**		**ΔPE_Variance**	
Intercept	2.51	<.001	12.99	<.001	-0.37	0.214	0.50	0.203
ΔFIN	**-0.62**	**<.001**	**-3.11**	**<.001**	**-0.18**	**0.023**	**-0.28**	**<.001**
ΔVolume	-3.71	<.001	-25.86	<.001	-0.96	0.011	-1.31	0.011
ΔCustomer Volume	-0.79	0.085	-0.91	0.301	0.73	<.001	-0.06	0.200
ΔVolatility	0.38	0.021	4.25	<.001	-0.06	0.306		
ΔPrice Volatility							1.31	<.001
EIA_Inventory	0013	0.512	0.27	0.746	-0.158	0.063	-0.03	0.765
Lead_Inventory	0.00	0.986	-0.60	0.450	-0.13	0.142	0.20	0.091
GSCI_Roll	0.27	0.039	-0.86	0.175	0.10	0.127	0.23	<.001
Contract_Exp_Day	0.15	0.517	-2.15	0.010	-0.24	0.051	-0.13	0.279
September_2006	-0.77	0.131	4.46	0.012	0.20	0.168	-0.43	0.104
Dependent Lags	2		2		2		2	
Day of the Week	YES		YES		YES		YES	
N	299		299		299		299	
Adj RSq	72.19%		42.66%		21.82%		38.79%	

Table 7: Institutional Financial Traders and Market Quality – Lagged Values

Table 7 presents the results of two alternative analyses of the relation between intraday institutional financial trading (Δ*FIN*) and four markers of market liquidity (Δ*Spread*, Δ*Amihud*, Δ*AbsOIB*) and pricing efficiency (Δ*PE_Variance*). **Panel A** replaces the contemporaneous value of **Δ*FIN*** by its one-day lagged value **Δ*FIN_L1***, while **Panel B** replaces **Δ*FIN*** by its two-day lagged value **Δ*FIN_L2*,** as an explanatory variable. 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). All variables are as defined in Appendix 1. Two-tailed *p-values* are also reported.

Panel A. (1-day lagged Δ*FIN*)

Parameter	**Δ*Spread***		**Δ*Amihud***		**Δ*AbsOIB***		**Δ*PE_Variance***	
Intercept	2.92	<.001	15.59	<.001	-0.39	0.197	0.69	0.078
Δ*FIN_L1*	**-0.52**	**0.005**	**-2.19**	**0.001**	**-0.23**	**0.002**	**-0.27**	**<.001**
Δ*Volume*	-4.17	<.001	-27.98	<.001	-0.96	0.010	-1.53	0.004
Δ*Customer Volume*	-0.27	0.543	-5.17	0.011	0.84	<.001	-0.39	0.122
Δ*Volatility*	0.35	0.027	4.09	<.001	-0.05	0.299		
Δ*Price Volatility*							1.27	<.001
EIA_Inventory	0.08	0.683	-0.33	0.689	-0.16	0.050	-0.06	0.560
Lead_Inventory	-0.05	0.753	-0.91	0.257	-0.15	0.088	0.18	0.138
GSCI_Roll	0.25	0.061	-1.09	0.087	0.10	0.118	0.22	0.001
Contract_Exp_Day	0.32	0.224	-1.51	0.300	-0.16	0.216	-0.04	0.782
September_2006	-0.82	0.127	3.98	0.026	0.17	0.217	-0.44	0.091
Dependent Lags	2		2		2		2	
Day of the Week	YES		YES		YES		YES	
N	295		295		295		295	
Adj RSq	71.98%		42.46%		22.58%			

Panel B. (2-day lagged ∆*FIN*)

Parameter	***∆Spread***		***∆Amihud***		***∆AbsOIB***		***∆PE_Variance***	
Intercept	2.88	<.001	16.04	<.001	-0.34	0.276	0.71	0.074
∆FIN_L2	**-0.50**	**<.001**	**-1.56**	**0.016**	**-0.17**	**0.013**	**-0.25**	**<.001**
∆*Volume*	-4.16	<.001	-28.63	<.001	-1.02	0.008	-1.57	0.004
∆*Customer Volume*	-0.20	0.672	-4.84	0.017	0.88	<.001	-0.35	0.177
∆*Volatility*	0.33	0.039	3.92	<.001	-0.07	0.212		
∆*Price Volatility*							1.29	<.001
EIA_Inventory	0.11	0.576	-0.17	0.884	-0.14	0.083	-0.05	0.640
Lead_Inventory	-0.00	0.984	-0.67	0.408	-0.13	0.149	0.20	0.089
GSCI_Roll	0.22	0.084	-1.25	0.053	0.08	0.171	0.21	0.002
Contract_Exp_Day	0.20	0.385	-2.04	0.157	-0.22	0.095	-0.10	0.464
September_2006	-0.84	0.104	3.98	0.027	0.17	0.213	-0.46	0.078
Dependent Lags	2		2		2		2	
Day of the Week	YES		YES		YES		YES	
N	295		295		295		295	
Adj RSq	71.92%		41.51%		21.25%			

Table 8: Effect of Institutional Financial Traders on Market Quality – Lag Identification

Table 8 presents the results of a two-stage regression analysis of the impact of intraday institutional financial trading on crude oil market quality, in which one-day lagged values of the relative intensity of financialization in short- *vs*. long-dated WTI futures (Δ***FIN_L1***) is used as an instrument for the first-stage regression in **Panel A**; the second-stage regression results are shown in **Panel B**. Δ*FIN* is the ***dependent variable*** *in Panel A.* We use NYMEX pits data in the *pre*-electronification period (January 3, 2006 to September 1, 2006) and Globex data for the *post*-electronification period (September 5, 2006 to March 31, 2007). All variables are as defined in Appendix 1. Two-tailed *p-values* are also reported.

Panel A: First Stage

Parameter	**Model 1**		**Model 2**		**Model 3**	
Intercept	-0.07	0.002	-0.12	0.019	-0.13	0.013
ΔFIN_Lag1	0.49	<.001	0.50	<.001	0.50	<.001
EIA_Inventory			0.11	0.102	0.10	0.109
Lead_Inventory			0.06	0.359	0.06	0.379
GSCI_Roll			0.04	0.430	0.04	0.437
Contract_Exp_Day			-0.24	0.020	-0.24	0.019
September_2006					0.14	0.105
Day of the Week	YES		YES		YES	
N	297		297		297	
Adj RSq	23.47%		24.54%		24.97%	

Panel B: Second Stage

Parameter	***ΔSpread***		***ΔAmihud***		***ΔAbsOIB***		***ΔPE_Variance***	
Intercept	2.80	<.001	15.07	<.001	-0.45	0.152	0.63	0.108
ΔFIN	**-1.04**	**0.005**	**-4.35**	**<.001**	**-0.46**	**0.001**	**-0.54**	**<.001**
ΔVolume	-4.17	<.001	-27.98	<.001	-0.96	0.010	-1.53	0.004
ΔCustomer Volume	-0.27	0.543	-5.17	0.011	0.84	<.001	-0.39	0.121
ΔVolatility	0.35	0.027	4.09	<.001	-0.05	0.299		
ΔPrice Volatility							1.27	<.001
EIA_Inventory	0.19	0.314	0.14	0.863	-0.11	0.163	-0.01	0.957
Lead_Inventory	0.01	0.944	-0.64	0.419	-0.12	0.161	0.21	0.083
GSCI_Roll	0.29	0.036	-0.92	0.151	0.12	0.075	0.24	<.001
Contract_Exp_Day	0.06	0.794	-2.56	0.077	-0.27	0.038	-0.17	0.216
September_2006	-0.82	0.127	3.98	0.026	0.17	0.217	-0.45	0.083
Dependent-variable Lags	2		2		2		2	
Day of the Week	YES		YES		YES		YES	
N	295		295		295		295	
Adj RSq	71.98%		42.46%		22.58%		38.96%	

Table 9: Institutional Financial Traders and Market Quality – Two-stage Regression Analysis

Table 9 presents the results of a two-stage regression analysis of the impact of intraday institutional financial trading on the WTI light sweet crude oil futures market quality. The electronification of WTI futures trading is used as an instrument for the first-stage regression in **Panel A**; the second-stage results are presented in **Panel B**. Δ***FIN*** is the ***dependent variable*** in the first stage; its predicted value is used in the second stage. All variables are as defined in Appendix 1. 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). 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	**-0.34**	<.001	**-0.37**	<.001	**-0.37**	<.001
Electronification	**0.46**	<.001	**0.46**	<.001	**0.47**	<.001
EIA_Inventory			0.08	0.231	0.08	0.226
Lead_Inventory			0.01	0.903	0.01	0.891
GSCI_Roll			**0.09**	**0.053**	**0.05**	**0.052**
Contract_Exp_Day			-0.09	0.325	-0.10	0.331
September_2006					-0.07	0.454
Day of the Week			YES		YES	
N	299		299		299	
Adj RSq	29.20%		29.68%		29.57%	

Panel B: Second Stage

Parameter	***ΔSpread***		***ΔAmihud***		***ΔAbsOIB***		***ΔPE_Variance***	
Intercept	0.47	0.382	7.29	0.040	-0.85	0.020	0.27	0.557
ΔFIN	**-3.62**	**<.001**	**-10.34**	**<.001**	**-0.73**	**<.001**	**-0.59**	**0.001**
ΔVolume	-1.90	0.003	-19.81	<.001	-0.48	0.266	-1.12	0.048
ΔCustomer Volume	-0.02	0.954	-3.67	0.070	0.99	<.001	-0.26	0.304
ΔVolatility	0.82	<.001	5.63	<.001	0.04	0.435		
ΔPrice Volatility							1.25	<.001
EIA_Inventory	0.29	0.112	0.12	0.885	-0.127	0.135	0.01	0.943
Lead_Inventory	0.03	0.848	-0.63	0.428	-0.12	0.158	0.21	0.081
GSCI_Roll	0.56	<.001	-0.45	0.521	0.14	0.030	0.25	<.001
Contract_Exp_Day	-0.12	0.481	-2.73	0.020	-0.28	0.025	-0.17	0.160
September_2006	-0.92	0.087	4.79	0.007	0.23	0.108	-0.42	0.124
Dependent Lags	2		2		2		2	
Day of the Week	YES		YES		YES		YES	
N	299		299		299		299	
Adj RSq	75.84%		44.72%		23.74%		38.64%	

Table 10: Trader Characteristics—HFT *vs.* non-HFT Institutional Financial Traders

Table 10 describes key attributes of HFT and non-HFT institutional financial traders in the NYMEX's WTI sweet crude-oil futures market in 2006–2007. The information is based on Globex data from the post-electronification period (September 5th, 2006, to March 31st, 2007). ***Non-HFT FIN*** are institutional financial traders who trade less than 990 times a day. ***HFT FIN*** are institutional financial traders who trade more than 990 times a day and go home "flat." ***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. ***Volume share*** is the proportion of all trades involving institutional financial traders on at least one side of the trade. The Table presents cross-sectional means and medians. ***Source***: U.S. Commodity Futures Trading Commission (CFTC) and authors' computations.

Traders	**Trading Volume**		**Number of Trades**		**Abs Closing Ratio**		**Volume Share**	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
HFT FIN_	1,304	772	623	322	8%	1%	29%	30%
Non-HFT FIN	168	42	49	16	42%	15%	26%	26%

	Mean	Median	Standard Deviation
FIN (short-dated futures)	23.4%	24.9%	4.9%
FIN (long-dated futures)	20.6%	21.5%	6.6%
Δ*FIN*	11.7%	11.9%	23.0%
FIN (short-dated, HFT)	10.8%	9.3%	5.6%
FIN (long-dated, HFT)	6.6%	5.0%	6.6%
Δ*FIN (HFT)*	53.6%	46.1%	44.1%
FIN (short-dated, non HFT)	12.5%	11.8%	3.0%
FIN (long-dated, non HFT)	14.0%	13.8%	4.0%
Δ*FIN (non HFT)*	-14.7%	-10.7%	31.2%

Table 11: HFTs, Non-HFT Institutional Financial Traders, and Market Quality

Table 11 presents single-stage regression analyses of the relation between the percentage difference in the trading volume shares of non-HFT (***ΔFIN_Non_HFT***) and HFT (***ΔFIN_HFT***) institutional financial traders in short- *vs*. long-dated WTI futures, on the percentage differences between various market quality measures for short- *vs*. long-dated 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). All variables are as defined in Appendix 1. Two-tailed p-values, obtained using Newey-West standard errors with 5 lags, are also reported.

Parameter	***ΔSpread***		***ΔAmihud***		***ΔAbsOIB***		***ΔPE_Variance***	
Intercept	2.46	<.001	15.22	<.001	-0.48	0.109	0.41	0.291
ΔFIN_Non_HFT	-0.18	0.185	**-2.00**	**0.007**	0.00	0.991	0.02	0.834
ΔFIN_HFT	**-1.53**	**<.001**	-0.66	0.500	**-0.30**	**0.001**	**-0.66**	**0.001**
ΔVolume	-3.54	<.001	-27.81	<.001	-0.76	0.044	-1.06	0.029
ΔCustomer Volume	-0.57	0.193	-7.10	0.002	0.91	<.001	-0.33	0.120
ΔVolatility	0.35	0.035	4.00	<.001	-0.05	0.370		
ΔPrice Volatility							1.25	<.001
EIA_Inventory	0.11	0.568	-0.05	0.957	-0.14	0.079	-0.04	0.730
Lead_Inventory	0.03	0.845	-0.63	0.432	-0.12	0.160	0.22	0.070
GSCI_Roll	0.25	0.047	-0.95	0.152	0.06	0.300	0.19	0.005
Contract_Exp_Day	0.13	0.540	-2.24	0.106	-0.22	0.087	-0.10	0.257
September_2006	-0.26	0.614	4.86	0.008	0.36	0.021	-0.14	0.652
Dependent Lags	2		2		2		2	
Day of the Week	YES		YES		YES		YES	
N	295		295		295		295	
Adj RSq	74.36%		41.78%		22.25%		42.27%	

Appendix 1: Definition of Variables

This Appendix defines the variables used in the paper and explains how they are constructed.

AbsOIB: Daily volume-weighted 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.

Amihud: Daily volume-weighted average of the ratio of absolute return to volume, first calculated for each contract maturity in each 5-minute non-overlapping intervals throughout the trading day.

Contract_Exp_Day: Dummy variable for the day of the prompt contract's expiration.

Customer_Volume: Daily volume-weighted average of the proportion of 5-minute the total trading volume during business hours that involves the participation of customers (traders classified as CTI-4 in the CFTC database).

EIA_Inventory: Dummy variable for the day (usually Wednesday, otherwise Thursday) when the U.S. Department of Energy's (DoE) Energy Information Administration (EIA) releases its weekly report on crude oil storage levels.

Electronification: Dummy variable for the *post*-electronification period, *i.e.*, after September 5th, 2006.

FIN: 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).

FIN_Non_HFT: Proportion of the total trading volume during business hours involving the participation of non-HFT institutional financial traders (traders classified as CTI-2 traders in the CFTC database who trade less than 990 times a day).

FIN_HFT: Proportion of the total trading volume during business hours involving the participation of institutional HFT financial traders (traders classified as CTI-2 traders in the CFTC database and trade more than 990 times a day).

FIN_Short-Dated: Daily, volume-weighted average of FIN in short-dated ("Short-Term") WTI futures contracts (contracts with up to 62 days left to expiration).

FIN_Long-Dated: Daily, volume-weighted average of FIN in long-dated ("Long-Term") WTI futures contracts (contracts with more than 62 days left to expiration).

GSCI Roll: Dummy variable for the five business days when the monthly GSCI roll takes place.

Lead_Inventory: Dummy variable for the day preceding the EIA announcement day.

Local: Proportion of the total trading volume during business hours involving the participation of Locals (traders classified as CTI-1 traders in the CFTC database).

PE_Proportion: Daily ratio of the pricing error variance, estimated as in Hasbrouck (1993), to the volatility of intraday (log) transaction prices. Daily figures are first computed for each contract, and then volume-weighted across contract maturities.

PE_Variance: Daily average pricing error variance, estimated as in Hasbrouck (1993). Daily figures are first computed for each contract, and then volume-weighted across contract maturities.

Price_Volatility: Daily volume-weighted average of 5-minute volatility of intraday (log) transaction for each contract in each maturity interval.

September_2006: Dummy variable for the calendar month when electronification took place (September 2006).

Spread: Daily volume-weighted average of 5-minute bid-ask spreads obtained using bid and asked prices estimated for each contract maturity in 5-minute non-overlapping intervals, after classifying trades as buyer- *vs*. seller-initiated using the Lee and Ready (1991) tick-test.

Volatility: Daily volume-weighted average of the 5-minute volatility of (mid-quote) returns estimated for each contract.

Volume: Daily volume-weighted average of the 5-minute volatility of trading volume estimated for each contract.

***ΔFIN*:** Daily percentage difference between the short- and long-dated proportions: *(FIN_Short-Dated – FIN_Long-Dated) / FIN_Short-Dated*.

ΔFIN_HFT*, *ΔFIN_Non_HFT*, *ΔPE_Variance*, *ΔAmihud*, *ΔAbsOIB*, *ΔVolatility*, *ΔPrice_Volatility*, *ΔVolume*, and *ΔCustomer_Volume are defined analogously to **ΔFIN**.

Appendix 2: Descriptive Statistics for Key Regression Variables

	Mean	**Std. Deviations**
ΔFIN	-0.14	0.42
ΔSpread	-1.51	1.86
ΔAmihud	-16.45	5.84
ΔAbsOIB	-1.58	0.51
ΔPE_Proportion	-0.74	1.02

The Table above presents the respective mean and standard deviation of the main variables used in the intraday regression analyses (Table 6, especially) over the sample period from January 3, 2006 to March 31, 2007: aggregate level of intraday financial institutional trading (dependent variable, first row) and market quality measures (next four rows). All variables are as defined in Appendix 1. Source: CFTC and authors' computations.