Is Pit Closure Costly for Livestock Customers?

Eleni Gousgounis and Esen Onur*

ABSTRACT

This paper evaluates the changes in the execution quality of customer orders in the livestock futures market between 2014 and 2016. The livestock futures market, which had active pit participation prior to the closure of the pits, has recently exhibited unprecedented price fluctuations. A simultaneous increase in the bid ask spread has raised concerns over the liquidity in this market. The focus of our study is to analyze whether liquidity has changed especially for customer orders after the futures pits closed. We find that customers placing aggressive orders in the livestock market face higher execution costs after the pits closed while those customer who were active at the pit prior to its closure, subsequently face higher execution costs in the electronic market.

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*Eleni Gousgounis is an Assistant Professor at The University of Scranton and Esen Onur is an Economist at the U.S. Commodity Futures Trading Commission. The paper was co-authored by Eleni Gousgounis and Esen Onur. While this paper was produced in the authors' official capacity, the analyses and conclusions expressed here are those of the authors and do not necessarily reflect the views of other Commission staff, the Office of the Chief Economist, or the Commission.

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1. Introduction

In July of 2015, the Chicago Mercantile Exchange (CME) closed down most of its pits, getting rid of floor trading in almost all of its markets. While this decision probably made sense from the CME's business perspective, it also caused a lot of discussion on whether the CME was getting rid of a trading design that actually had value for customers and market participants[1]. While the goals of an exchange and its participants are not orthogonal, they are not parallel either. Exchanges naturally want to increase the volume executed on their platforms while participants potentially care more about execution costs. Motivated by this idea, we explore how execution costs have changed for customers at the livestock futures markets traded at the CME after the pits were closed.

Another concern of customers of agricultural futures markets has also been voiced at a recent conference organized jointly by the US Commodity Futures Trading Commission and Kansas State University[2]. The conference, titled "Protecting America's Agricultural Markets," touched upon a number of topics and one of them was the impact of Automated Trading Systems on agricultural derivatives contracts. While farmers in general agreed that automated markets, and the presence of high frequency traders in these markets, reduces bid-ask spreads, they complained that positions of automated traders on these markets lasted just seconds and that was not resulting in the price discovery required by agricultural traders. Part of the concern was related to the fact that bids and offers placed by automated traders were not staying on the limit order book long enough for agricultural traders to be able to take the other side of these orders. As a result, farmers claimed that their transaction costs have increased due to the increased

[1] Polanskek, T. (2015, June 24th). CME traders push regulator to delay futures pit closure by 90 days. Reuters. Retrieved on October 12th 2015 from http://www.reuters.com/article/2015/06/24/cme-group-futures-closure-cftc-idUSL1N0ZA2DS20150624
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[2] https://www.iatp.org/blog/CFTC-goes-to-heartland

presence of automated traders. To analyze the effect of pit closure, and the increased trading with automated trading systems as a result, we turn to livestock futures, which include live cattle, lean hog, and feeder cattle futures[3]. It is well-documented that these contracts have recently experienced high levels of volatility[4]. However, despite the existing evidence of increased volatility (Shang, Mallory, and Garcia - 2016), it is hard to pin point the exact reason for it as the market has seen a number of changes in the past few years[5]. In the mid-December of 2014, CME has changed the settlement procedure in the livestock futures. Prior to that date, settlement was based on the volume weighted calculation of pit transactions only. After that date, settlement price was calculated using pit as well as electronic transactions in the calculation. This has diminished the importance of pit transactions[6]. Following the change in settlement procedure, and in line with the change in almost all of CME's markets, livestock futures pits have closed on July 6th, 2015. Since then, hedgers in these markets have claimed that volatility has increased without much of an explanation, even causing The Wall Street Journal to refer to this market as a "Meat Casino"[7].

This is not the first study to analyze the effect of pit closure on markets. Gousgounis and Onur (2016) analyzes the impact of this change on various markets and provide evidence suggesting that livestock futures have experienced the biggest decline in the ratio of pit trading. Our focus in livestock futures is partially based on this observation, but also on the fact that

[3] Total trading volume in 2015 for live cattle futures was 13,440,934 contracts, for lean hog futures 9,575,882 contracts, and for feeder cattle futures 2,493,051 contracts.
[4] In an open letter to the president and CEO of the CME, the National Cattlemen's Beef Association voice their concerns about increased volatility in the cattle contracts and indicate that this might be due to high frequency trading: http://www.beefusa.org/CMDocs/BeefUSA/Media/NCBAlettertoCMEreHFT.pdf
[5] The cash market has also experienced a number of important changes. For a detailed discussion of these changes, see Schroeder et. al. (2018)
[6] For a detailed description of the effect of settlement procedure changes, see Onur and Reiffen (2016).
7" Welcome to the 'Meat Casino'! The Cattle Futures Market Descends Into Chaos," Wall Street Journal, August 17, 2016: https://www.wsj.com/articles/welcome-to-the-meat-casino-the-cattle-futures-market-descends-into-chaos-1471475438

livestock futures, and especially live cattle futures, has been criticized for its high volatility and unstable market structure within the last few years[8].

This paper adds to the growing literature on livestock futures. In an earlier study, Oellermann and Farris (1985) analyze the life beef cattle market and investigate the lead-lag relationship between changes in futures and cash prices spanning a period from 1966 until 1982. They find tht the futures price led the cash price during the periods they analyzed. In a more recent study, Joseph et al. (2016) analyze a similar question and investigate the lead-lag relationship between the boxed beef price and the live cattle futures price. They also find futures price to lead the fed cattle price and to incorporate information quicker.

Similar to ours, some recent studies make use of higher frequency data to analyze livestock futures. Shang, Mallory, and Garcia (2016) analyze the bid ask spread behavior in the electronic live cattle futures markets and show that the bid ask spread in the live cattle futures widened during the volatiles periods of 2014 and 2015. They also show that adverse selection cost component is small whereas order processing cost is the largest component. Frank and Garcia (2010) use modified Bayesian methodology to analyze the bid ask estimators in live cattle futures markets and find that bid ask spread in this market is negatively correlated with volume and positively correlated with price volatility. Among others, the futures markets analyzed in Gousgounis and Onur (2016) also include livestock futures and their analysis focuses on documenting the changes in various features of the futures markets such as main trading hours, pit traders, and execution costs for the whole market. Couleau et. al (2017) identifies the market structure noise present in live cattle futures market data and finds that the high volatility experienced in this market in 2015 was mainly driven by market fundamentals. Finally, Haynes

[8] See Mulvany 2016, and Meyer 2016.

et. al. (2017) uses the same data set we utilize in our study and analyze the effect of increased algorithmic trading on livestock futures market liquidity and pricing efficiency.

Our paper also contributes to the literature analyzing agricultural markets through the lens of microstructure. In that sense, it is similar to Bryant and Haigh (2004), Frank and Garcia (2011), Shah and Brorsen (2011), Wang et. al (2014), and Aidov and Daigler (2015)[9].

Wang et. al. (2014) use actual bid-ask spreads from the electronically traded corn futures market to study liquidity costs. They find that while the December contract, which is the preferred hedging contract, has the lowest bid-ask spreads, liquidity measured by bid-ask spreads worsens during USDA report release days, when new information is incorporated into the prices. Bryant and Haigh (2004) studies bid-ask spread estimators for open outcry markets and evaluate the impact of change from open outcry to electronic trading on liquidity, measured as bid-ask spreads. They find spreads to generally widen after moving to electronic only trading, and that bid-ask spreads especially widen in periods of high volatility. In a similar study, shah and Brorsen (2011) compare the liquidity cost of trading red winter wheat futures when electronic and open outcry markets co-exist together. Somewhat contradicting the findings of Bryant and Haigh (2004), they find liquidity costs in the electronic market to be lower, but also find that trade sizes are larger in the open outcry market and that large traders also prefer the open outcry market. Aidov and Daigler (2015) use in depth message data from 5 different futures contracts and compare across contracts in interest rates, agriculture, energy, foreign exchange and metals. They find that while the agriculture contract, corn futures, has the smallest amount of messages and least amount of trading in their sample, the dynamics of that market is pretty much similar to the others analyzed in their study.

[9] There are more papers that fall under the heading of microstructure of agricultural markets; these papers are a non-exhaustive sample of that universe.

This study improves the existing literature on three distinct ways. First, it focuses on execution costs specific to customers using a rich transaction level data from the U.S. Commodity Futures Trading Commission (CFTC). The analysis employs a two stage estimation to account for aggressive and passive execution costs and estimate them separately. Second, it measures execution costs of orders, not transactions. This modification is quite important since as markets have become more and more electronic, transaction sizes have shrank all around the world. Orders have been shredded to smaller and smaller pieces to avoid any kind of price impact. In a market where transactions are happening more frequently and in smaller sizes, it is important to measure the true cost of transaction by focusing on orders.

Our main findings indicate that customers placing aggressive orders in the livestock market face higher execution costs after the pit closed. At the same time, customers placing passive orders receive higher compensation for providing liquidity following the pit closure, but the net effect is an decline in execution costs. However, the execution costs for those traders, who were active users of the pit prior to its closure, the execution costs appear to have increased for both aggressive and passive orders.

The rest of the paper is organized as follows. Section 2 describes the data set we use and how it differs from those used in existing literature. Section 3 describes the methodology used for calculating execution costs, and the econometric model utilized. Section 4 describes our empirical findings and the estimates of our model, Section 5 concludes.

2. Data

Our dataset includes transaction data on futures during the time period extending from June 1st 2014 to June 1st 2016. The dataset, constructed using the Transaction Capture Report database of the U.S. Commodity Futures Trading Commission (CFTC), includes detailed transaction information such as the price and quantity of every futures trade and the execution venue (electronic, pit and block trades). The dataset also provides an order identifier, which allows us to bunch trades belonging to the same order. Other useful information in the dataset are indicators for whether a particular trade was part of a trading strategy, and a flag for who initiated the trade (buy side vs. sell side) for electronic transactions. Finally, the dataset identifies counterparties to a transaction and provides information on market participants, such as the identification number for each trader, and the trading role of each customer account, as measured by the customer type indicator (CTI) code. This code allows us to distinguish customer trades from proprietary ones.

Three of the variables described above are key to our analysis and allow us to distinguish our work from existing literature; an order identifier, a code identifying the customer trades, and the aggressor indicator.

An order placed on the book can be fully executed in a high number of transactions and might take several minutes to complete. To be able to capture the true cost of executing an order, one would have to account for all those transactions which are potentially being traded at differing price levels. An order ID allows us to measure that cost with precision.

Additionally, having the ability to distinguish customer trades from proprietary trades is also exceptionally important. Most of the complaints that were voiced after the pit closures were from customers, especially in the livestock futures markets. Most of these customers, who are made up of entities using the futures markets for hedging purposes, cared a lot about the cost of

putting on a sizeable hedge to mitigate the risk in the underlying markets. It is also possible that their orders are more informed than those of proprietary traders and as a result might elicit different transaction costs. Our data allow us to capture all these differences by focusing on customers' orders.

Finally, knowing which side of the transaction initiates the trade, which is also known as the aggressive side, is also pivotal for our analysis. To adopt this transaction-based specification to our order-based analysis, we calculate a volume-weighted measure of aggressiveness for every order from each transaction that is part of that order. This variable is then used to account for the endogenous decisions of customers to place aggressive or passive orders in our analysis.

3. Methodology Description

3.1 Execution Costs

We explore the potential impact of the pit closure on the liquidity of the electronic market, as measured by customer execution costs. Since our dataset allows us to match transactions with their originating orders; we estimate execution costs for the whole order, deviating from the literature, which estimates execution costs using just the aggressive side of each trade. In more detail, we proxy execution costs for electronic orders using the effective half spread, which is estimated as:

$$Effective\ half\ spread = 100 * Di\ * (log(P_{t,0}) - log(P_{t,benchmark})),$$

where log represents the natural logarithm, $P_{t,0}$ is the volume weighted transaction price of each order, and $P_{t,benchmark}$ is the average price of trades occurring in the five minute interval preceding the first trade of each order. The variable Di is a trade direction indicator where Di= 1 for a buy order and Di= - 1 for a sell order. Notably, our data allows us to categorize orders into

passive and aggressive ones. While we are interested in the total effect on the costs of order execution for customers in the electronic market, we also want to explore whether this potential effect is driven by aggressive or passive orders. We expect aggressive (passive) customer orders to have positive (negative) execution costs. To this extent, we label an order as aggressive (passive), if more (less) than fifty percent of that order's traded volume corresponds to trades initiated by the particular customer[10]. It is possible that aggressiveness level of an order might also capture the urgency of the customer to fill her order.

3.2 Estimation Methodology

We model execution costs of customer orders using a two stage regression:

$$y_i = z_i'\gamma + u_i$$

$$c_i = x_i'\beta + \varepsilon_i$$

where the first equation estimates the probability that a customer order i was aggressive($y_i = 1$) or passive($y_i = 0$), where the second equation estimates the execution cost c_i. The errors u_i, ε_i are jointly normal with zero mean and standard deviations 1 and σ respectively, and correlation ρ.

The first stage of the model is a probit regression representing the decision to position each customer order i as aggressive (y_i=1) or passive (y_i=0). The explanatory variables, z_i, include market characteristics, such as realized volatility and volume as well as order characteristics, such as the size of the order. Realized volatility is estimated as the square root of the sum of five minute squared returns during the hour before the order started executing.

[10] There are very few cases in which the aggressive and passive transactions associated with an order are equivalent in volume. In most cases, orders are composed of mostly aggressive trades or mostly passive trades.

Volume is measured as the logarithm of the volume of futures traded during the hour before the order started executing.

The second stage of the model estimates the execution costs of customer orders conditional on the order being aggressive or passive[11]:

$$E[c_i|y_i = 1] = x_i'\beta_a + \rho_a\sigma_a\left[\frac{\varphi(z_i'\gamma)}{\Phi(z_i'\gamma)}\right]$$

$$E[c_i|y_i = 0] = x_i'\beta_p + \rho_p\sigma_p\left[-\frac{\varphi(z_i'\gamma)}{1-\Phi(z_i'\gamma)}\right]$$

where $\varphi(.)$ Denotes the standard normal density function, and $\Phi(.)$ denotes the cumulative standard normal distribution. The second terms in each equation correct for selection bias. They represent nonlinear combinations of the variables used to predict the decision to use an aggressive or a passive order. If $\rho_a\sigma_a$ and $\rho_p\sigma_p$ are equal to zero, the selection of using an aggressive or a passive order should not affect execution costs.

The model is estimated for the effective half spread- The explanatory variables, x_i, include order characteristics (order size, the contract's time to expiration, a dummy indicating whether the order is manual, a dummy indicating whether the order belongs to a strategy), the realized volatility and a dummy indicating whether the order was placed before or after the pit closure. Additional control variable include dummies controlling for the change of the settlement procedure in December 2014, changes in the trading hours, and on whether the order was placed on a Monday or a Friday. The latter two dummies control for the effect of announcements of cash market auction results, which typically occur on Mondays.

[11] The model is estimated twice: first aggressive and then for passive orders.

4. Analysis

4.1 Descriptive statistics

Our objective is to evaluate the potential impact of the pit closure on the execution costs faced by customers in the livestock market. First, we present summary statistics describing the trading behavior of livestock customers before and after the pit closure. We focus our analysis on those customers that were active in the market prior to the announcement of the pit closure (on February 4th 2015) and we follow their behavior until the end of our sample. As expected, some of the customers drop from our sample after the announcement of the pit closure. We separate customers to those who, prior to the pit closure, traded exclusively in the electronic market and those who were using the pit for at least some of their transactions. Table 1 presents the trading patterns of customers in the live cattle futures market. Our summary statistics suggest that the pit customers were executing about 40% of their daily trading volume at the pit. While the number of customers active at the pit was relatively small, those customers appear to be responsible for a substantial trading volume and exhibit substantially higher average trading volume compared to those customers trading exclusively in the electronic market. Moreover, pit users are more likely to trade strategies than the electronic customers. Interestingly, most customers place manual trades irrespective of the trading venue. Also, our dataset provides information on the cti code[12]

[12] The Chicago Mercantile Exchange (CME) specifies the CTI codes as follows:

"CTI 1: Electronic Trading, Open Outcry and Privately Negotiated – Applies to transactions initiated and executed by an individual member for his own account, for an account he controls, or for an account in which he has an ownership or financial interest. However, transactions initiated and executed by a member for the proprietary account of a member firm must be designated as CTI 2 transactions.

CTI 2: Electronic Trading, Open Outcry and Privately Negotiated – Applies to orders entered or trades executed for the proprietary accounts of a member firm.

CTI 3: Electronic Trading – Applies to orders entered by a member or a nonmember terminal operator for the account of another individual member or an account controlled by such other individual member. CTI 3: Open Outcry and Privately Negotiated – Applies to orders that a member executes on behalf of another individual member, or for an account such other member controls or in which such other member has an ownership or financial interest.

CTI 4: Electronic Trading Open Outcry and Privately Negotiated – Applies to all orders and transactions not included in CTI categories 1, 2 or 3. These typically are orders entered by or on behalf of nonmember entities."

of opposing traders. We show that customers who traded exclusively on the electronic platform tend to trade with other customers (cti code=4) about 40% of the time. They also trade with proprietary traders (cti code=2) about 40% of the time. However, this proportion reaches close to 50% after the pit closure. Across all customer transactions, the percentage of trading with traditional market makers (cti code=1) seems to decline after the pits close. Also, as expected, many of the pit users transition to the electronic market in the second half of our sample. Table 2 presents the trading patterns of customers in the lean hog futures market. The trading behavior of customers in this market is similar to the behavior of customers in the live cattle market. One difference is that pit users seem as likely as customers trading exclusively on the electronic platform to place strategy orders. Also, pit users in the lean hog futures market were trading a slightly higher proportion of their volume at the pit (45%) prior to the pit closure announcement, compared with customers in the live cattle futures market. Table 3 presents similar statistics for the customers trading feeder cattle futures. The trading behavior of customers in the feeder cattle futures market mimics that of the customers in the live cattle futures market. However, we should note that the average trading volume for feeder cattle futures customers is smaller than that in the live cattle futures market. Our analysis also suggests a significant jump in trading with proprietary traders. Figure 1 presents the proportion of customer order flow that is executed against trading accounts with a designation of CTI code equal to 2, which proxies for proprietary traders. Trading with proprietary traders appears to have increased at around the time of the pit closure, a trend that is more pronounced in the live cattle market.

To summarize, it seems like customers in the livestock futures market do not appear to place automated trades. This result persists throughout our sample and is irrespective of whether

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Source: CME Group. (2014, April 2). Market Regulation Advisory Notice, Rule 536.D, Retrieved from www.cmegroup.com/rulebook/files/cme-group-ra1401-5.pdf

they use the pit or not. At the same time, customers often trade with proprietary traders and the frequency of such trades seems to have increased after the announcement of the pit closure. Given that automated trading in livestock futures markets is expected to be tied to proprietary traders, we examine the relationship between the proportion of automated trading in the market and the customers' tendency to place aggressive orders. Figure 2 presents the corresponding graphs for each livestock futures contract. Customer aggressiveness measures the average proportion of aggressive electronic orders across customers in a given market, while market automation measures the proportion of automated trades in the market as a whole. We observe that market automation appears to have increased in all livestock markets after the pit closure. Similarly, customer aggressiveness also follows a slight upward trend in the live cattle futures market. This trend is less pronounced in the lean hog futures market and it is nonexistent in the feeder cattle futures market.

These observations suggest that while examining the effect of the pit closure on the execution costs faced by customers, our execution cost analysis should also take into account the changes in the order placement choices of customers: hence we extend our analysis to study aggressive and passive customer orders separately. Figure 3 presents the average effective half spread for aggressive and passive orders separately for each market. The first graph presents the effective half spread for live cattle futures, while the second and third graphs present the effective half spread for lean hog and feeder cattle futures respectively. As expected, aggressive orders exhibit a positive effective half spread while passive orders exhibit on average a negative effective half spread. The effective half spread for aggressive orders seems to have increased after the announcement of the pit closure and the pit closure itself. While the effective half spread for passive orders follows a similar but opposite pattern, it is not clear whether the

magnitude is the same, whether the increased costs of aggressive orders are offset by a higher "benefit" associated with passive orders.

4.2 Multivariate results

In order to properly evaluate the effect of the pit closure on the execution costs faced by customers in the livestock futures market, we first estimate this effect for the aggregate execution costs. Then, we employ the two stage regression to evaluate the effect of the pit closure on aggressive and passive orders separately, while accounting for selection bias, as described in section 3.

Table 4 presents the results of the first stage probit regression. It describes the factors behind the customer choice to place an aggressive vs. a passive order. Large orders appear to be more likely to be aggressive, while trading strategies are more likely to be placed as passive orders. Customers appear to prefer passive orders when volatility increases. Moreover, the higher the volume originating in the same (opposite) side of the market, the higher(lower) the probability of placing aggressive orders. Finally aggressive orders appear to increase as the time of the day progresses. This finding could potentially be explained by the need to complete execution as the closing approaches.

Table 5 presents the results of our second stage regression, which describes the execution costs of customers in the live cattle market, measured by the effective half spread. The first column shows the results for the unconditional effective half spread, while the second and third columns present the results of the respective second stage regressions for aggressive and passive orders. The pit closure dummy takes the value one after the pit closure and zero in the time period before July 6th 2015. The effect of the pit closure on all orders appears to be negative and

significant, indicating that customers trading live cattle futures in the electronic market face lower effective half spread after the pit closure. We then examine this effect on aggressive and passive orders separately. The coefficient is positive significant for aggressive, but negative and significant for passive orders. These findings indicate that customers placing aggressive orders in the electronic market pay a higher effective half spread after the pit closure, while customers with passive orders receive a higher compensation for providing liquidity in the market. Realized volatility is associated with higher effective half spread for both aggressive and passive orders. Effective half spread is also higher (lower) for large manual aggressive (passive) orders. Orders belonging to a strategy (spread dummy) and higher time to expiration exhibit a lower (higher) effective half spread for aggressive (passive) electronic customer orders. Finally, the coefficient of the inverse mills ratios confirm the presence of selection bias and the need to adjust for it.

To better understand the effect of the pit closure on the execution of of live cattle, we separate the effect for those customers that were active users of the pit prior to its shutdown. These customers distributed their order flow between the pit and the electronic market and we would therefore expect to be affected more than non-pit users. We repeat the second stage regression of Table 5, but we also include a dummy that takes the value of one when the order was originated by a pit user and zero otherwise. We also include the interaction between the pit user dummy and the pit closure dummy. The results are presented in Table 6. The signs of the pit closure coefficients remain unchanged. At the same time, the sign of the pit user dummy is negative, while the sign of the interaction is positive across all three models. This indicates that being a pit user is associated with higher execution costs after the pit closure.

We also repeat the second stage regression of Table 5 for live cattle, but this time we include the interaction between order size and the pit closure dummy. Since pit users tend to be

placing larger orders, we would expect order size to be associated with higher execution costs. Indeed, based on the results of Table 7, the interaction of order size and pit closure is positive an significant. This indicates that after the pit closure larger orders are more expensive to execute.

Moreover, we explore whether higher execution costs are a results of trading with proprietary traders. In Table 8, we include as a control variable the proportion of the order that was executed against an order placed by an account with a cti code designation equal to 2, which approximates for proprietary traders. We also include the interaction of this variable with the pit closure. Interestingly, we find that trading with a proprietary trader is generally associated with higher execution costs, but those costs appear to further increase after the pit closure. This result is driven primarily by passive orders.

Tables 9-13 present a similar analysis for the lean hog futures market. Table 9 presents the first stage probit regression for the customer choice of placing aggressive vs. passive orders. The signs are the same with the live cattle market, but the coefficient of the spread dummy is not significant. Table 10 presents the second stage OLS regressions for unconditional execution costs, and execution costs of aggressive and passive orders respectively. Similar to the live cattle market, the effect of the pit closure appear to have an overall negative effect on execution costs, which is primarily driven by passive orders. On the contrary, aggressive orders appear to be more expensive to execute after the pit closure. Based on the results of Table 11, pit users, who were able to execute their electronic orders at a lower effective half spread prior to the pit closure, they face higher execution costs afterwards. According to Table 12, which includes the interaction of order size and pit closure, larger orders after the pit closure are associated with higher execution costs. This finding provides further supports the argument that pit users, that typically place larger orders, tend to face higher execution costs after the shutdown of the pit.

Similar to the analysis on live cattle, Table 13 provides evidence that trading with proprietary traders after the pit closure is associated with higher effective half spread; a result which is driven by passive orders.

Finally, Tables 14-18 repeat the analysis for the feeder cattle contract, the smallest livestock futures contract. Table 14 presents the results of the first stage probit regression for feeder cattle. The signs of all variables are the same with those for live cattle and lean hogs. Tables 15-18 show how the pit closure has affected execution costs. Table 15 shows that, similar to the other two livestock future contracts, the pit closure had an overall negative effect on the effective half spread, but a positive effect for aggressive orders. Nevertheless, as depicted in Table 16, the effective half spread of pit users is higher after the pit closure for both aggressive and passive orders. Additionally, larger orders appear to be most expensive to execute after the pit closure, a result which is driven by aggressive orders. Finally, Table 18 shows that trading with proprietary traders is associated with higher execution costs after the pit closure, especially for passive orders.

5. Conclusion

Closure of pits by the CME in July of 2015 was a significant change for many market participants. In this paper we ask how this change impacted execution costs for customer orders in the livestock futures market. We make use of a rich, regulatory transaction level data and measure the effect of pit closure on execution costs of customer orders, measured by the effective half spread.

When executing a trade, a trader has the choice of using an aggressive order or a passive order, which would affect her execution costs. Our analysis employs a two stage estimation to

account for this choice while estimating execution costs. In addition, we measure execution costs of orders, not transactions. With increased electrification, orders have been shredded to smaller sized transactions and measuring execution costs of just transactions can be quite misleading.

Our results indicate that while the overall execution appear to be lower after the pit closure, customers placing aggressive orders in the livestock market appear to be paying a premium to execute their orders. At the same time, customers who were also active users of the pit face higher execution costs after pits closed, irrespective of their orders being passive or aggressive. After the pit closure, larger orders are also associated with higher execution costs. Finally, trading against proprietary traders, which becomes more prevalent after the pit closure is also associated with higher execution costs.

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Tables

Table 1 shows the customer statistics for Live Cattle Futures.

	Live Cattle (48)			
	Electronic users (exclusively)		Pit users	
	Before the pit closure	After the pit closure	Before the pit closure	After the pit closure
Total volume	9,129,995	6,333,429	3,643,860	2,135,632
Number of customers	20,393	9,069	935	523
Average daily volume	13.13	15.54	57.50	46.72
Average spread volume %	0.23	0.23	0.41	0.47
Average electronic volume %	1	1	0.61	0.98
Average pit volume %	0	0	0.39	0.02
Average manual volume %	0.96	0.96	0.99	0.96
Average volume trading with CTI1 %	0.14	0.08	0.35	0.09
Average volume trading with CTI2 %	0.40	0.48	0.25	0.49
Average volume trading with CTI3%	0.01	0.01	0.03	0.01
Average volume trading with CTI4 %	0.44	0.42	0.36	0.41

Table 2 shows the customer statistics for Lean Hogs Futures.

	Lean Hogs (LN)			
	Electronic users (exclusively)		Pit users	
	Before the pit closure	After the pit closure	Before the pit closure	After the pit closure
Total volume	6,575,867	3,728,728	2,583,876	1,034,104
Number of customers	13,821	5,251	770	351
Average daily volume	13.84	17.82	48.98	45.50
Average spread volume %	0.29	0.30	0.30	0.31
Average electronic volume %	1	1	0.55	0.98
Average pit volume %	0	0	0.45	0.02
Average manual volume %	0.95	0.94	0.98	0.96
Average volume trading with CTI1 %	0.18	0.12	0.34	0.12
Average volume trading with CTI2 %	0.39	0.45	0.22	0.46
Average volume trading with CTI3%	0.02	0.01	0.05	0.01
Average volume trading with CTI4 %	0.41	0.42	0.39	0.41

Table 3 shows the customer statistics for Feeder cattle.

	Feeder Cattle (62)			
	Electronic users (exclusively)		Pit users	
	Before the pit closure	After the pit closure	Before the pit closure	After the pit closure
Total volume	2,114,721	1,316,669	376,453	151,281
Number of customers	13,914	5,563	396	178
Average daily volume	5.74	6.97	18.48	19.26
Average spread volume %	0.17	0.15	0.25	0.27
Average electronic volume %	1	1	0.57	0.99
Average pit volume %	0	0	0.43	0.01
Average manual volume %	0.97	0.96	0.98	0.94
Average volume trading with CTI1 %	0.12	0.08	0.36	0.09
Average volume trading with CTI2 %	0.39	0.49	0.33	0.46
Average volume trading with CTI3%	0.01	0.01	0.02	0.01
Average volume trading with CTI4 %	0.48	0.42	0.28	0.44

Table 4. First Stage Probit Regression – Live cattle futures

Probit			
Parameter	Estimate	Wald Chi-Square	Pr > ChiSq
Intercept	-0.3122	22806.9457	<.0001
Order size	0.1129	61632.4776	<.0001
Spread dummy	-0.2045	110082.089	<.0001
Realized volatility	-3.8296	1217.103	<.0001
Sell side volume	0.1619	39378.2848	<.0001
Buy side volume	-0.1551	36102.7229	<.0001
Time of day	0.0413	44411.7452	<.0001
Number of Observations Used	1,756,1683		

Table 5: Effective half spread – Live cattle futures

Live Cattle (48)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.0852***	0.1026***	-0.1365***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0068***	0.0001	-0.0115***
	<.0001	*0.1866*	*<.0001*
Manual order dummy	-0.0065***	0.0044***	-0.0176***
	<.0001	*<.0001*	*<.0001*
Spread dummy	0.0206***	-0.0085***	0.0417***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0065***	-0.0014***	0.0103***
	<.0001	*<.0001*	*<.0001*
Monday dummy	0.0004***	-0.0009***	0.0011***
	<.0001	*<.0001*	*<.0001*
Friday dummy	0.0004***	0.0002**	0.0002**
	<.0001	*0.0208*	*0.0354*
Trading hours change dummy 1	0.0003***	-0.0001	0.0004*
	0.0091	*0.5620*	*0.0088*
Trading hours change dummy 2	-0.0001*	0.0009***	-0.0011***
	0.0681	*<.0001*	*<.0001*
Settlement change dummy	-0.0015***	0.0003	-0.0029***
	<.0001	*0.1029*	*<.0001*
Pit closure dummy	-0.0007***	0.0014***	-0.0024***
	<.0001	*<.0001*	*<.0001*
Realized volatility	0.1339***	1.3098***	-0.5974***
	<.0001	*<.0001*	*<.0001*
Aggressor dummy	0.3092***		
	<.0001		
Mills ratio aggressive interact	-0.2074***		
	<.0001		
Mills ratio passive interact	0.1123***		
	<.0001		
Mills ratio		*-0.0905****	*0.2039****
		<.0001	*<.0001*
Number of observations	*17,253,067*	*6,374,514*	*10,878,553*
R^2	*0.0339*	*0.0225*	*0.0256*

Table 6: Effective Half Spread with Pit User Interactive Term – Live cattle futures

Live Cattle (48)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.0833***	0.099***	-0.1344**
	<.0001	*<.0001*	*<.0001*
Order size	-0.0066***	0.0000	-0.0109***
	<.0001	*0.4575*	*<.0001*
Manual order dummy	-0.0069***	0.0044***	-0.0182***
	<.0001	*<.0001*	*<.0001*
Spread dummy	0.0202***	-0.0086***	0.0411***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0066***	-0.0011***	0.0102***
	<.0001	*<.0001*	*<.0001*
Monday dummy	0.0003***	-0.0008***	0.0008***
	<.0001	*<.0001*	*<.0001*
Friday dummy	0.0002**	0.0002*	0.0000
	0.0131	*0.0839*	*0.2382*
Trading hours change dummy 1	0.0003**	-0.0001	0.0004**
	0.0117	*0.3840*	*0.0032*
Trading hours change dummy 2	-0.0001	0.0008***	-0.0011***
	0.5191	*<.0001*	*<.0001*
Settlement change dummy	-0.0016***	0.0003*	-0.0031***
	<.0001	*0.0981*	*<.0001*
Pit closure dummy	-0.0015***	0.0006***	-0.0032***
	<.0001	*<.0001*	*<.0001*
Realized volatility	0.1355***	1.289***	-0.5917***
	<.0001	*<.0001*	*<.0001*
Pit user dummy	-0.0012***	0.0002	-0.0029***
	<.0001	*0.2037*	*<.0001*
Pit user settlement interactive term	0.0052***	0.0033***	0.0059***
	<.0001	*<.0001*	*<.0001*
Aggressor dummy	*0.3039****		
	<.0001		
Mills ratio aggressive interact	*-0.2042****		
	<.0001		
Mills ratio passive interact	*0.1103****		
	<.0001		
Mills ratio		*-0.0878****	*0.2014****
		<.0001	*<.0001*
Number of observations	16,045,488	5,908,497	10,136,991
R^2	*0.0336*	*0.0229*	*0.0258*

Table 7: Effective Half Spread with Order Size Interactive Term – Live cattle futures

Live Cattle (48)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.0843***	0.1042***	-0.1360***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0076***	-0.0012***	-0.0118***
	<.0001	*<.0001*	*<.0001*
Manual order dummy	-0.0066***	0.0043***	-0.0176***
	<.0001	*<.0001*	*0.0020*
Spread dummy	0.0206***	-0.0084***	0.0417***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0065***	-0.0015***	0.0103***
	<.0001	*<.0001*	*<.0001*
Monday dummy	0.0004***	-0.0009***	0.0011***
	<.0001	*<.0001*	*<.0001*
Friday dummy	0.0004***	0.0002**	0.0002**
	<.0001	*0.0177*	*0.0346*
Trading hours change dummy 1	0.0002**	-0.0002	0.0003**
	0.0371	*0.2926*	*0.0158*
Trading hours change dummy 2	-0.0002**	0.0009***	-0.0011***
	0.0242	*<.0001*	*<.0001*
Settlement change dummy	-0.0015***	0.0002	-0.0029***
	<.0001	*0.3336*	*<.0001*
Pit closure dummy	-0.0025***	-0.0016***	-0.0032***
	<.0001	*<.0001*	*<.0001*
Realized volatility	0.13303***	1.3091***	-0.5979***
	<.0001	*<.0001*	*<.0001*
Order size settlement interactive term	0.0017***	0.0027***	0.0009***
	<.0001	*<.0001*	*<.0001*
Aggressor dummy	*0.3091****		
	<.0001		
Mills ratio aggressive interact	*-0.2073****		
	<.0001		
Mills ratio passive interact	*0.1123****		
	<.0001		
Mills ratio		*-0.0904****	*0.2039****
		<.0001	*<.0001*
Number of observations	17,253,067	6,374,514	10,878,553
R^2	*0.0339*	*0.0226*	*0.0256*

Table 8: Effective Half Spread with Opposing Side CTI2 Interactive Term – Live cattle futures

Live Cattle (48)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.0872***	0.1045***	-0.1395***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0067***	0.0000	-0.0112***
	<.0001	*0.7421*	*<.0001*
Manual order dummy	-0.0063***	0.0043***	-0.0170***
	<.0001	*<.0001*	*<.0001*
Spread dummy	0.0208***	-0.0086***	0.0420***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0065***	-0.0015***	0.0100***
	<.0001	*<.0001*	*<.0001*
Monday dummy	0.0003***	-0.0009***	0.0010***
	<.0001	*<.0001*	*<.0001*
Friday dummy	0.0003***	0.0002**	0.0002*
	<.0001	*0.0123*	*0.0601*
Trading hours change dummy 1	0.0003**	-0.0001	0.0003**
	0.0120	*0.5946*	*0.0136*
Trading hours change dummy 2	-0.0004**	0.0011***	-0.0014***
	<.0001	*<.0001*	*<.0001*
Settlement change dummy	-0.0015***	0.0002	-0.0031***
	<.0001	*0.1635*	*<.0001*
Pit closure dummy	-0.0017***	-0.0020***	-0.0042***
	<.0001	*<.0001*	*<.0001*
Realized volatility	0.1011***	1.321***	-0.6720***
	<.0001	*<.0001*	*<.0001*
CTI2 perc of opposing volume	0.0058***	-0.0033***	0.0102***
	<.0001	*<.0001*	*<.0001*
CTI2 volume settlement interactive term	0.0011***	-0.0008***	0.0028***
	<.0001	*<.0001*	*<.0001*
Aggressor dummy	*0.3076****		
	<.0001		
Mills ratio aggressive interact	*-0.2067****		
	<.0001		
Mills ratio passive interact	*0.1111****		
	<.0001		
Mills ratio		*-0.0907****	*0.2013****
		<.0001	*<.0001*
Number of observations	*17,253,067*	*6,374,514*	*10,878,553*
R^2	*0.0347*	*0.0228*	*0.0283*

Table 9: First Stage Probit Regression – Lean hog futures

Probit			
Parameter	Estimate	Wald Chi-Square	Pr > ChiSq
Intercept	-0.4736	36090.93	<.0001
Order size	0.068	13240.33	<.0001
Spread dummy	-0.00086	1.2934	0.2554
Realized volatility	-6.4743	3323.09	<.0001
Sell side volume	0.1652	32524.92	<.0001
Buy side volume	-0.1614	31054.23	<.0001
Time of day	0.0461	35960.91	<.0001
Number of observations Used	1,756,1683		

Table 10: Effective half spread – Lean hog futures

Lean Hog (48)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.1876***	0.1469***	-0.1818***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0025***	0.0056***	-0.0086***
	<.0001	*<.0001*	*<.0001*
Manual order dummy	-0.0112***	0.0007***	-0.0270***
	<.0001	*<.0001*	*<.0001*
Spread dummy	-0.0083***	-0.0336***	0.0129***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0012***	-0.0035***	0.0155***
	<.0001	*<.0001*	*<.0001*
Monday dummy	-0.0013***	-0.0017***	-0.0008***
	<.0001	*<.0001*	*<.0001*
Friday dummy	-0.0002**	0.0001	-0.0005**
	0.0263	*0.7456*	*0.0007*
Trading hours change dummy 1	0.0000	-0.0001	-0.0013*
	0.9504	*0.6046*	*<.0001*
Trading hours change dummy 2	-0.0030***	-0.0013***	0.0059***
	<.0001	*<.0001*	*<.0001*
Settlement change dummy	-0.0024***	0.0044	-0.0067***
	<.0001	*<.0001*	*<.0001*
Pit closure dummy	-0.0002*	0.0015***	-0.0023***
	0.0674	*<.0001*	*<.0001*
Realized volatility	1.3361***	2.3821***	0.7025***
	<.0001	*<.0001*	*<.0001*
Aggressor dummy	0.3501***		
	<.0001		
Mills ratio aggressive interact	*-0.1411****		
	<.0001		
Mills ratio passive interact	*0.2619****		
	<.0001		
Mills ratio		*-0.13411****	*0.7025****
		<.0001	*<.0001*
Number of observations	11,390,772	4,545,869	6,844,903
R^2	*0.0378*	*0.0253*	*0.0226*

Table 11: Effective Half Spread with Pit User Interactive Term – Lean hog futures

Lean Hog (48)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.1852***	0.1441***	-0.1818***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0022***	0.0058***	-0.0086***
	<.0001	*<.0001*	*<.0001*
Manual order dummy	-0.0114***	0.0013***	-0.0270***
	<.0001	*<.0001*	*<.0001*
Spread dummy	-0.0081***	-0.0327***	0.0129***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0117***	0.0043***	0.0155***
	<.0001	*<.0001*	*<.0001*
Monday dummy	-0.0014***	-0.0019***	-0.0008***
	<.0001	*<.0001*	*<.0001*
Friday dummy	-0.0004***	0.0000	-0.0005**
	0.0005	*0.9707*	*0.0007*
Trading hours change dummy 1	-0.0004	-0.0003	-0.0013*
	0.5031	*0.3347*	*<.0001*
Trading hours change dummy 2	0.0023***	-0.0024***	0.0059***
	<.0001	*<.0001*	*<.0001*
Settlement change dummy	-0.0024***	0.0046	-0.0067***
	<.0001	*<.0001*	*<.0001*
Pit closure dummy	-0.0014*	-0.0002	-0.0023***
	0.0674	*0.1728*	*<.0001*
Realized volatility	1.2981***	2.2358***	0.7025***
	<.0001	*<.0001*	*<.0001*
Pit user dummy	-0.0045***	-0.0034***	-0.0079***
	<.0001	*<.0001*	*<.0001*
Pit user settlement interactive term	0.0059***	0.0056***	0.0067***
	<.0001	*<.0001*	*<.0001*
Aggressor dummy	0.3473***		
	<.0001		
Mills ratio aggressive interact	*-0.1410****		
	<.0001		
Mills ratio passive interact	*0.2592****		
	<.0001		
Mills ratio		*-0.1311****	*0.2686****
		<.0001	*<.0001*
Number of observations	10,544,180	4,202,604	6,341,576
R^2	*0.0364*	*0.024*	*0.0226*

Table 12: Effective Half Spread with Order Size Interactive Term – Lean hog futures

Lean Hog (LN)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.1869***	0.1483***	-0.1813***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0031***	0.0044***	-0.0090***
	<.0001	*<.0001*	*<.0001*
Manual order dummy	-0.0113***	0.0007***	-0.0271***
	<.0001	*<.0001*	*0.0020*
Spread dummy	-0.0083***	-0.0336***	0.0129***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0115***	0.0035***	0.0156***
	<.0001	*<.0001*	*<.0001*
Monday dummy	-0.0013***	-0.0017***	-0.0008***
	<.0001	*<.0001*	*<.0001*
Friday dummy	-0.0003**	0.0000	-0.0005**
	0.0237	*0.7968*	*0.0006*
Trading hours change dummy 1	0.0000	-0.0002	-0.0013***
	0.9074	*0.5126*	*<.0001*
Trading hours change dummy 2	0.0030***	-0.0014***	0.0059***
	<.0001	*<.0001*	*<.0001*
Settlement change dummy	-0.0025***	0.0043	-0.0067***
	<.0001	*<.0001*	*<.0001*
Pit closure dummy	-0.0014***	-0.0014***	-0.0033***
	<.0001	*<.0001*	*<.0001*
Realized volatility	0.1335***	2.3813***	0.7017***
	<.0001	*<.0001*	*<.0001*
Order size settlement interactive term	0.0013***	0.0028***	0.0010***
	<.0001	*<.0001*	*<.0001*
Aggressor dummy	0.3500***		
	<.0001		
Mills ratio aggressive interact	*-0.1410****		
	<.0001		
Mills ratio passive interact	*0.2618****		
	<.0001		
Mills ratio		*-0.1341****	*0.2686****
		<.0001	*<.0001*
Number of observations	11,390,772	4,545,869	6,844,903
R^2	*0.0379*	*0.0253*	*0.0226*

Table 13: Effective Half Spread with Opposing Side CTI2 Interactive Term – Lean hog futures

Lean Hog (LN)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.1909***	0.1489***	-0.1881***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0024***	0.0055***	-0.0083***
	<.0001	*<.0001*	*<.0001*
Manual order dummy	-0.0109***	0.0006***	-0.0262***
	<.0001	*<.0001*	*<.0001*
Spread dummy	-0.0080***	-0.0337***	0.0137***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0122***	0.0030***	0.0164***
	<.0001	*<.0001*	*<.0001*
Monday dummy	-0.0013***	-0.0017***	-0.0009***
	<.0001	*<.0001*	*<.0001*
Friday dummy	-0.0003**	0.0001	-0.0007***
	0.0015	*0.4979*	*<.0001*
Trading hours change dummy 1	0.0001	-0.0002	-0.0011***
	0.5150	*0.4642*	*<.0001*
Trading hours change dummy 2	0.0029***	-0.0011***	0.0059***
	<.0001	*<.0001*	*<.0001*
Settlement change dummy	-0.0027***	0.0045	-0.0071***
	<.0001	*<.0001*	*<.0001*
Pit closure dummy	-0.0008***	-0.0028***	-0.0045***
	<.0001	*<.0001*	*<.0001*
Realized volatility	0.3189***	2.3877***	0.6586***
	<.0001	*<.0001*	*<.0001*
CTI2 perc of opposing volume	0.0078***	-0.0034***	0.0149***
	<.0001	*<.0001*	*<.0001*
CTI2 volume settlement interactive term	0.0006***	-0.0026***	0.0032***
	0.0005	*<.0001*	*<.0001*
Mills ratio aggressive interact	*-0.1410****		
	<.0001		
Mills ratio passive interact	*0.2618****		
	<.0001		
Mills ratio		*-0.1343****	*0.2686****
		<.0001	*<.0001*
Number of observations	11,390,772	4,545,869	6,844,903
R^2	*0.0385*	*0.0255*	*0.0255*

Table 14: First Stage Probit Regression – Feeder cattle futures

Probit			
Parameter	Estimate	Wald Chi-Square	Pr > ChiSq
Intercept	-0.0734	376.5167	<.0001
Order size	0.1299	9905.6841	<.0001
Spread dummy	-0.4248	115949.177	<.0001
Realized volatility	-3.3944	346.7117	<.0001
Sell side volume	0.1965	22487.0677	<.0001
Buy side volume	-0.1938	21940.8602	<.0001
Time of day	0.0445	13506.7467	<.0001
Number of observations Used	1,756,1683		

Table 15: Effective half spread – Feeder cattle futures

Feeder Cattle (62)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.1775***	0.1612***	-0.2282***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0129***	0.0012***	-0.0199***
	<.0001	*<.0001*	*<.0001*
Manual order dummy	-0.0042***	0.0054***	-0.0135***
	<.0001	*<.0001*	*<.0001*
Spread dummy	0.0751***	0.0164***	0.1060***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0014***	-0.0056***	0.0049***
	<.0001	*<.0001*	*<.0001*
Monday dummy	-0.0022***	-0.0017***	-0.0022***
	<.0001	*<.0001*	*<.0001*
Friday dummy	-0.0009***	-0.0008***	-0.0007***
	<.0001	*0.0009*	*0.0001*
Trading hours change dummy 1	0.0004	0.0018***	-0.0003
	0.1308	*<.0001*	*0.3896*
Trading hours change dummy 2	-0.0003*	0.0025***	0.0029***
	0.08667	*<.0001*	*<.0001*
Settlement change dummy	-0.0007**	0.0019	-0.0028***
	0.0027	*<.0001*	*<.0001*
Pit closure dummy	-0.0011***	0.0012***	-0.0023***
	<.0001	*<.0001*	*<.0001*
Realized volatility	0.7997***	2.9058***	-0.3450***
	<.0001	*<.0001*	*<.0001*
Aggressor dummy	0.5084***		
	<.0001		
Mills ratio aggressive interact	*-0.3039****		
	<.0001		
Mills ratio passive interact	*0.2453****		
	<.0001		
Mills ratio		*-0.1539****	*0.3488****
		<.0001	*<.0001*
Number of observations	4,453,978	1,449,908	3,004,070
R^2	*0.061*	*0.048*	*0.05*

Table 16: Effective Half Spread with Pit User Interactive Term – Feeder cattle futures

Feeder Cattle (62)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.1706***	0.1517***	-0.2197***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0121***	0.0015***	-0.0189***
	<.0001	*<.0001*	*<.0001*
Manual order dummy	-0.0034***	0.0077***	-0.0134***
	<.0001	*<.0001*	*<.0001*
Spread dummy	-0.0734***	0.0158***	0.1038***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0002	-0.0058***	0.0032***
	0.5085	*<.0001*	*<.0001*
Monday dummy	-0.0025***	-0.0024***	-0.0024***
	<.0001	*<.0001*	*<.0001*
Friday dummy	-0.0009***	-0.0007***	-0.0006***
	0.0005	*0.003*	*0.0005*
Trading hours change dummy 1	0.0004*	0.0017***	-0.0001
	0.0744	*<.0001*	*0.649*
Trading hours change dummy 2	-0.0028***	0.0005*	-0.0060***
	<.0001	*0.0588*	*<.0001*
Settlement change dummy	-0.0005**	0.0024	-0.0029***
	0.0162	*<.0001*	*<.0001*
Pit closure dummy	-0.0014*	0.0006**	-0.0028***
	<.0001	*0.0118*	*<.0001*
Realized volatility	0.7119***	2.6619***	-0.3525***
	<.0001	*<.0001*	*<.0001*
Pit user dummy	-0.0009***	-0.0056***	0.0026***
	0.0091	*<.0001*	*<.0001*
Pit user settlement interactive term	-0.0021***	-0.0015*	-0.0015**
	<.0001	*0.065*	*0.0222*
Aggressor dummy	0.3473***		
	<.0001		
Mills ratio aggressive interact	*-0.2923****		
	<.0001		
Mills ratio passive interact	*0.2337****		
	<.0001		
Mills ratio		*-0.1454****	*0.3338****
		<.0001	*<.0001*
Number of observations	3,982,187	1,281,880	2,700,307
R^2	*0.0602*	*0.0464*	*0.0509*

Table 17: Effective Half Spread with Order Size Interactive Term – Feeder cattle futures

Feeder Cattle (62)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.1754***	0.1666***	-0.2288***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0151***	-0.0041***	-0.0193***
	<.0001	*<.0001*	*<.0001*
Manual order dummy	-0.0043***	0.0052***	-0.0134***
	<.0001	*<.0001*	*0.0020*
Spread dummy	0.0750***	0.0164***	0.1060***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0014***	-0.0058***	0.0049***
	<.0001	*<.0001*	*<.0001*
Monday dummy	-0.0022***	-0.0017***	-0.0022***
	<.0001	*<.0001*	*<.0001*
Friday dummy	-0.0009***	-0.0007***	-0.0007***
	<.0001	*0.001*	*0.0001*
Trading hours change dummy 1	0.0003	0.0016	-0.0003
	0.1768	*<.0001*	*0.4062*
Trading hours change dummy 2	-0.0003**	0.0025***	-0.0029***
	0.046	*<.0001*	*<.0001*
Settlement change dummy	-0.0007***	0.0019	-0.0028***
	0.0017	*<.0001*	*<.0001*
Pit closure dummy	-0.0051***	-0.0092***	-0.0011***
	<.0001	*<.0001*	*0.0011*
Realized volatility	0.7984***	2.9047***	-0.3446***
	<.0001	*<.0001*	*<.0001*
Order size settlement interactive term	0.0046***	0.0111***	-0.0014***
	<.0001	*<.0001*	*<.0001*
Aggressor dummy	0.5084***		
	<.0001		
Mills ratio aggressive interact	*-0.3039****		
	<.0001		
Mills ratio passive interact	*0.2454****		
	<.0001		
Mills ratio		*-0.1541****	*0.3488****
		<.0001	*<.0001*
Number of observations	4,453,978	1,449,908	3,004,070
R^2	*0.061*	*0.0048*	*0.05*

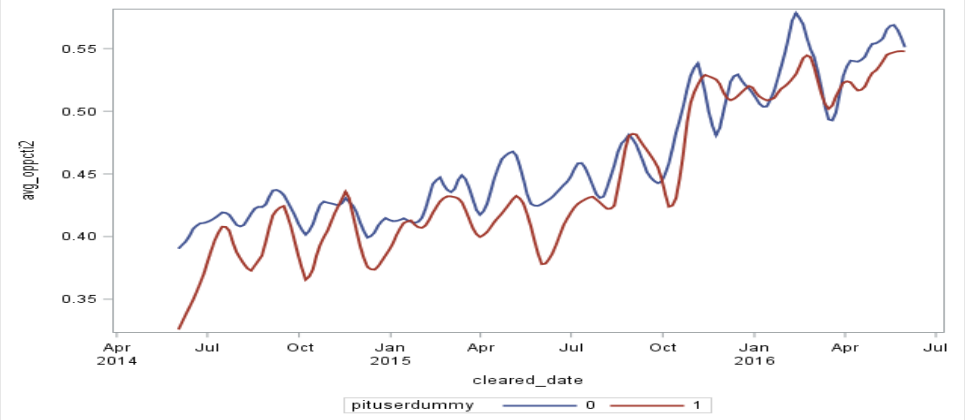
Table 18: Effective Half Spread with Opposing Side CTI2 Interactive Term – Feeder cattle futures

Feeder Cattle (62)			
	Effective half spread		
	All orders	Aggressive orders	Passive orders
Intercept	-0.1804***	0.1613***	-0.2318***
	<.0001	*<.0001*	*<.0001*
Order size	-0.0128***	0.0012***	-0.0196***
	<.0001	*<.0001*	*<.0001*
Manual order dummy	-0.0041***	0.0054***	-0.0131***
	<.0001	*<.0001*	*<.0001*
Spread dummy	0.0759***	0.0163***	0.1070***
	<.0001	*<.0001*	*<.0001*
Years to expiration	0.0023***	-0.0056***	0.0061***
	<.0001	*<.0001*	*<.0001*
Monday dummy	-0.0022***	-0.0017***	-0.0022***
	<.0001	*<.0001*	*<.0001*
Friday dummy	-0.0009***	-0.0008***	-0.0007***
	<.0001	*0.001*	*<.0001*
Trading hours change dummy 1	0.0009***	0.0018	0.0005*
	0.0003	*<.0001*	*0.0922*
Trading hours change dummy 2	-0.0009***	0.0026***	-0.0037***
	<.0001	*<.0001*	*<.0001*
Settlement change dummy	-0.0016***	0.0019***	-0.0039***
	<.0001	*<.0001*	*<.0001*
Pit closure dummy	-0.0033***	0.0016***	-0.0063***
	<.0001	*<.0001*	*<.0001*
Realized volatility	0.7741***	2.9073***	0.3853***
	<.0001	*<.0001*	*<.0001*
CTI2 perc of opposing volume	0.0089***	-0.0001	0.0117***
	<.0001	*0.7065*	*<.0001*
CTI2 volume settlement interactive term	0.0040***	-0.0008**	0.0073***
	0.0005	*0.031*	*<.0001*
Mills ratio aggressive interact	*-0.3035****		
	<.0001		
Mills ratio passive interact	*0.2423****		
	<.0001		
Mills ratio		*-0.1539****	*0.3437****
		<.0001	*<.0001*
Number of observations	4,453,978	1,449,908	3,004,070
R^2	*0.0628*	*0.0481*	*0.0538*

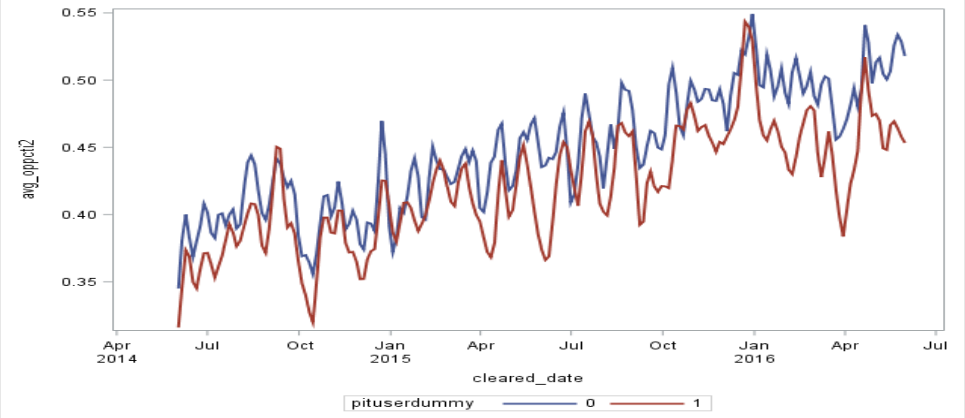
Figures

Figure 1: Percentage of Trading Done With CTI2s by Commodity

Live cattle futures



Lean Hog Futures



Feeder cattle futures

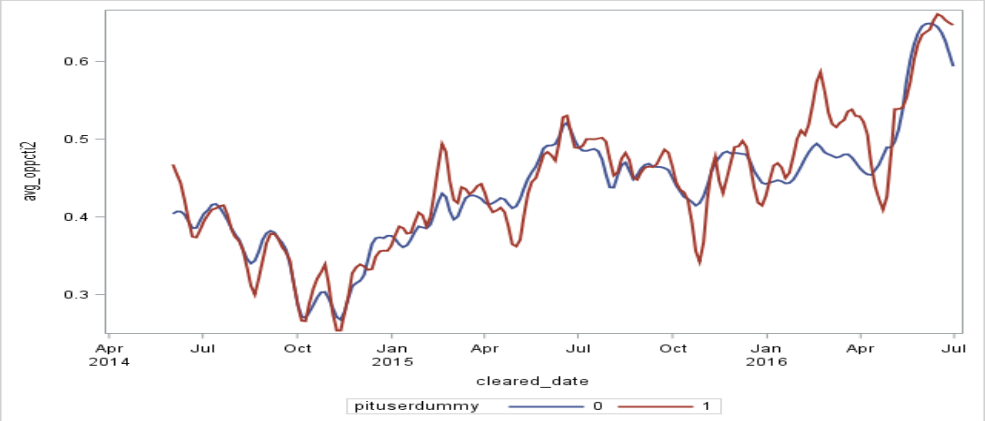


Figure 2: Customer aggressiveness and Market Automation by commodity

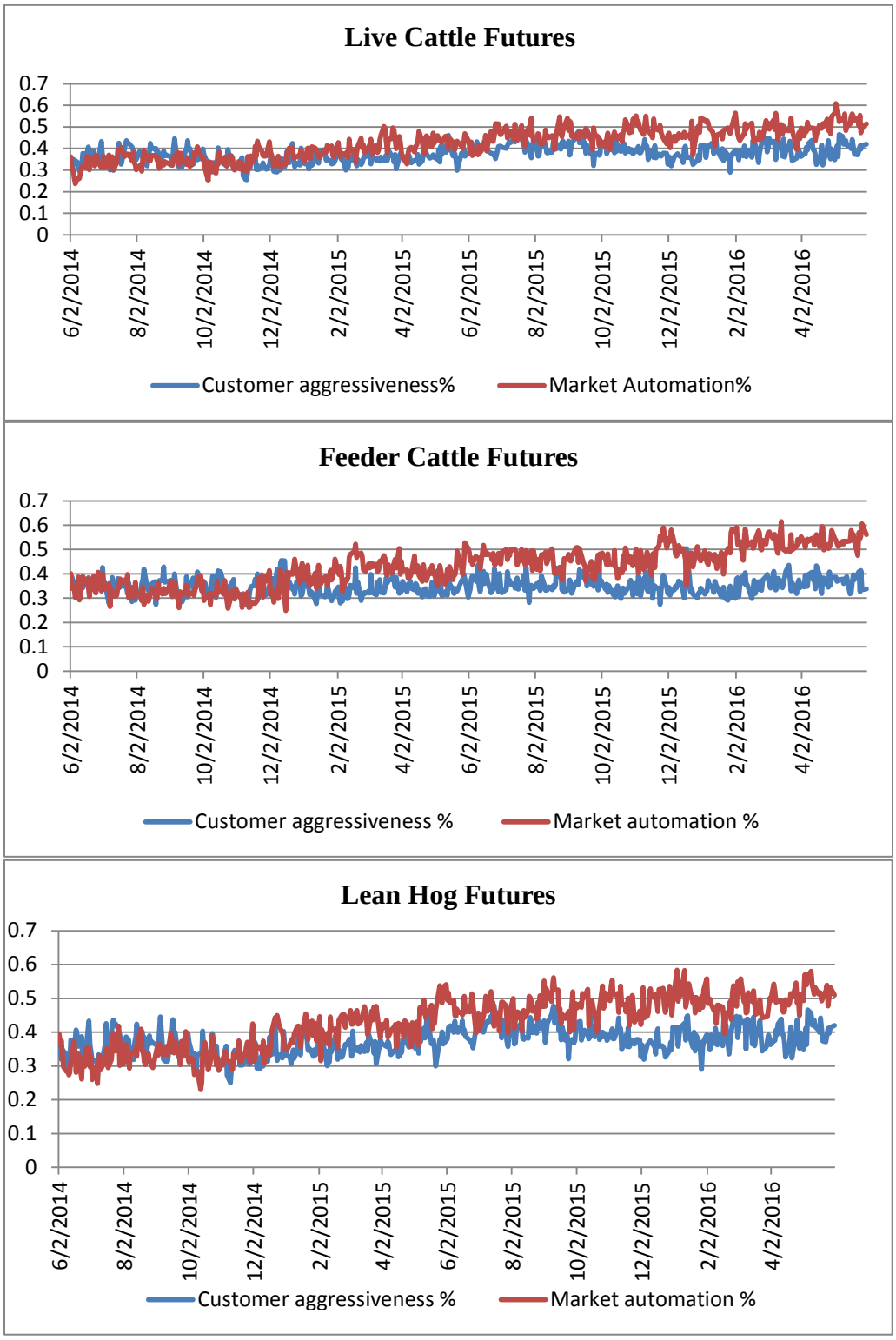


Figure 3: Effective half spread for customer aggressive and passive orders by commodity