Limit orders and price discovery: Evidence from agricultural futures markets

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Objectives

We analyze limit order messages and assess their contribution to price discovery in CME agricultural futures markets using order-level data.

- Porviding detailed descriptive analyses about limit order activities, including submissions, executions, revisions, and deletions.
- Calculating the latency of limit order activities.
- Assessing how trades and limit orders contribute to the price discovery.

Introduction

CME futures markets transitioned into order-driven electronic trading in the 21st century. This deeply changed the nature of commodity trading which is now characterized by massive quote updates and a high quote-to-trade ratio. The speed at which limit orders are submitted, canceled, and revised, has become a concern for market participants. Moreover, electronic trading allows traders using both market and limit orders to reveal information, conditional upon their strategies and market conditions (Kaniel and Liu, 2006). By placing limit orders, informed traders may reveal their information and may contribute to price discovery. In this study, we analyze limit order activities and how they contribute to the price discovery in agricultural futures markets.

Institutional details

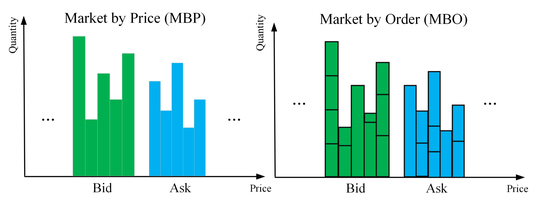
We focus on CME corn, soybean, and wheat futures markets from Jan 7, 2019 to June 26, 2020.

- Market prices are quoted in U.S. cents/bushel, with tick size of 0.25 cents/bushel. The contract size is 5,000 bushels.
- There are two continuous (day and night) trading sessions preceded by two pre-open sessions.
- We consider all orders submitted during the continuous trading sessions.

Data

We use the CME Market by Order (MBO) data for front-month futures.

- Limit order messages are classified into submission, revision, execution, and deletion.
- Each limit order is assigned a unique order ID.
- Complex orders, such as FAK, are decomposed as corresponding limit orders and trades.
- All data are timestamped to nanosecond with a unique message number for sorting events.
- We only focus on revisions and deletions initiated by traders instead of ones generated by system.
- Implied liquidity is also considered in this study to represent the comprehensive market liquidity.



Limit order activity

- Order revisions or deletions represent how traders respond to new information. One of the major reasons limit orders get revised is to increase the likelihood of execution. Moreover, a limit order may be deleted with partial or no execution.
- We explore whether revised orders are more likely to be executed and whether most limit orders are deleted without executions.

	Corn			Soybean			Wheat		
	Total	*BBO*	*Non-BBO*	*Total*	*BBO*	*Non-BBO*	*Total*	*BBO*	*Non-BBO*
Panel A: Executions after revisions.									
Mean	41.94%	48.73%	33.11%	37.33%	43.36%	31.45%	41.87%	66.12%	25.34%
Std. Dev	7.38%	10.41%	7.67%	7.27%	10.77%	6.62%	6.86%	8.73%	6.91%
Min.	18.72%	15.37%	13.56%	11.53%	9.59%	13.67%	23.56%	41.66%	9.14%
Median	42.51%	49.25%	32.75%	37.89%	43.26%	31.84%	42.31%	67.93%	24.10%
Max.	62.10%	73.67%	50.72%	56.44%	67.88%	54.75%	60.50%	82.45%	48.06%
Diff.		*t*-stat.	23.30***		*t*-stat.	18.17***		*t*-stat.	70.63***
Panel B:Executions before deletions									
Mean	8.34%	11.42%	2.37%	4.33%	5.67%	1.44%	4.36%	6.34%	1.32%
Std. Dev	1.39%	1.99%	0.66%	0.79%	1.07%	0.33%	0.91%	1.11%	0.45%
Min.	4.99%	6.50%	1.21%	1.77%	2.09%	0.66%	1.70%	2.56%	0.35%
Median	8.32%	11.38%	2.33%	4.43%	5.76%	1.41%	4.34%	6.36%	1.26%
Max.	12.70%	17.67%	8.46%	6.47%	8.85%	2.73%	6.93%	9.17%	3.16%
Diff.		*t*-stat.	83.30***		*t*-stat.	72.67***		*t*-stat.	81.14***

Limit order latency

- The latency is defined as the time difference between order execution, revision, or deletion, and its submission.

	Corn			Soybean			Wheat		
	Total	*BBO*	*Non-BBO*	*Total*	*BBO*	*Non-BBO*	*Total*	*BBO*	*Non-BBO*
Panel A: Execution latency–submission to the 1st execution.									
Mean	506.51s	155.68s	3369.26s	293.74s	94.92s	1860.00s	326.93s	99.24s	1959.42s
Std. Dev	3154.06s	1042.88s	8547.12s	2197.17s	765.88s	5955.93s	2352.48s	776.64s	6152.50s
Min.	–	–	–	–	–	–	–	–	–
P25	0.81s	0.50s	62.94s	0.20s	0.08s	25.11s	0.31s	0.12s	28.41s
Median	11.53s	7.93s	330.88s	5.46s	3.76s	125.60s	7.54s	5.10s	133.53s
Panel B: Deletion latency–submission to deletion.									
Mean	935.67s	149.75s	2468.55s	446.88s	83.96s	1235.38s	598.70s	117.37s	1324.76s
Std. Dev	4818.60s	1243.50s	7869.94s	3077.50s	850.16s	5250.69s	3598.60s	1013.00s	5482.64s
Min.	238.42ns	238.42ns	0.16μs	–	238.42ns	–	–	–	–
P25	0.09s	0.02s	1.86s	0.02s	4.87ms	1.39s	0.10s	0.01s	1.77s
Median	4.33s	1.71s	38.87s	2.00s	0.87s	16.75s	4.74s	1.65s	21.91s
Panel C: Revision latency–submission to the 1st revision.									
Mean	711.39s	131.59s	1585.32s	343.88s	74.41s	680.49s	413.79s	101.62s	633.26s
Std. Dev	3778.42s	1135.67s	5707.96s	2425.09s	804.31s	3495.02s	2672.37s	904.20s	3386.88s
Min.	238.42ns	238.42ns	0.15μs	238.42ns	238.42ns	2.86μs	238.42ns	238.42ns	4.29μs
P25	0.19s	5.92ms	5.02s	0.01s	2.45ms	1.07s	0.81s	0.51s	1.00s
Median	8.29s	2.03s	52.55s	2.92s	0.60s	11.09s	8.01s	6.06s	9.90s

Price discovery

- We use event-time data to assess the price discovery, which can precisely measure the influence of each event on midpoint price.
- Following Brogaard, Hendershott, and Riordan (2019), we employ a structural VAR model

$$\boldsymbol{A}\boldsymbol{y}_t = \sum_{i=1}^{p} \boldsymbol{B}_i \boldsymbol{y}_{t-i} + \boldsymbol{\epsilon}_t,$$

where

$$\boldsymbol{A} = \begin{bmatrix} 1 & \boldsymbol{C} \\ \boldsymbol{0}_{8\times 1} & \boldsymbol{I}_{8\times 8} \end{bmatrix}_{9\times 9},$$

$$\boldsymbol{C} = \begin{bmatrix} 0 & -a_{13} & -a_{14} & 0 & 0 & -a_{17} & 0 & 0 \end{bmatrix}.$$

Variable	Description
r_t	Midpoint log returns
$Trades^{change}$	Trades that deplete full liquidity at best-bid-offer and move the mid-quote price.
$Submit^{improve}$	Limit order placements that change the best bid and offer prices.
$Cancel^{worsen}$	Limit order cancellations that change the best bid and offer prices.
$Trades^{same}$	Trades that do not deplete full liquidity at best-bid-offer and do not move the midpoint price.
$Submit^{BBO}$	Limit orders adding liquidity at the current best bid and offer prices.
$Cancel^{BBO}$	Limit orders reducing liquidity at the current best bid and offer prices.
$Submit^{Non-BBO}$	Limit orders adding liquidity below (above) the current best (offer) price.
$Cancel^{Non-BBO}$	Limit orders reducing liquidity below (above) the current best (offer) price.

- The midpoint return is affected by aggressive limit orders that change the midpoint price and aggressive trades contemporaneously.
- We calculate cumulative impulse response functions of each variable to the midpoint returns up to 150 events as permanent price impacts as well as information shares.

Permanent price impacts

	Corn (bps.)				Soybean (bps.)				Wheat (bps.)			
	Mean	Std.	Med	% sig.	Mean	Std.	Med	% sig.	Mean	Std.	Med	% sig.
Panel A: Day trading session.												
$Trades^{change}$	3.23	1.39	3.08	100.00%	2.12	0.64	2.00	100.00%	8.23	2.46	8.09	99.73%
$Trades^{same}$	0.71	0.37	0.64	100.00%	0.59	0.23	0.53	100.00%	1.99	0.85	1.95	99.46%
$Submit^{improve}$	2.14	1.00	1.99	99.46%	1.66	0.64	1.58	100.00%	5.29	2.55	4.93	98.92%
$Submit^{BBO}$	0.13	0.13	0.09	98.92%	0.23	0.15	0.19	100.00%	1.15	0.67	1.01	100.00%
$Submit^{Non-BBO}$	-0.02	0.01	-0.01	56.18%	-0.01	0.01	-0.01	53.23%	-0.05	0.03	-0.04	25.81%
$Cancel^{worsen}$	4.14	2.65	3.73	89.25%	2.61	1.09	2.42	98.39%	7.52	3.21	6.94	97.58%
$Cancel^{BBO}$	0.03	0.05	0.01	16.94%	0.08	0.09	0.05	43.01%	0.56	0.38	0.48	79.03%
$Cancel^{Non-BBO}$	0.06	0.06	0.04	87.63%	0.08	0.06	0.08	53.23%	0.25	0.13	0.22	80.11%

Information shares

	Corn (%)			Soybean (%)			Wheat (%)		
	Mean	Std.	Med	Mean	Std.	Med	Mean	Std.	Med
Panel A: Day trading session.									
$Trades^{change}$	31.68	17.23	29.71	29.13	12.29	27.48	42.62	15.18	41.80
$Trades^{same}$	1.91	2.02	1.14	2.31	1.55	1.94	2.81	2.03	2.31
$Submit^{improve}$	14.88	10.57	12.10	18.24	10.54	16.36	18.08	10.73	16.36
$Submit^{BBO}$	0.09	0.14	0.03	0.41	0.49	0.25	0.99	1.00	0.71
$Submit^{Non-BBO}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$Cancel^{worsen}$	43.95	22.74	44.63	40.47	15.76	39.49	34.19	14.94	33.22
$Cancel^{BBO}$	0.01	0.02	0.00	0.07	0.14	0.01	0.24	0.28	0.15
$Cancel^{Non-BBO}$	0.02	0.03	0.00	0.06	0.07	0.04	0.05	0.05	0.03
Limit total vs. Trades (p-value)	<0.001			<0.001			<0.001		
Improve vs. Worsen (p-value)	<0.001			<0.001			<0.001		

Concluding remarks

- Around 75%-79% of the limit orders submitted are finally deleted, which contrasts with a much smaller proportion of these orders getting executed (25%-28%) or revised (7%-8%).
- Latency of limit orders is low, with half of the limit orders being deleted, revised or executed within 5 to 12 seconds after their placement across markets.
- Aggressive limit orders jointly contribute more to the price discovery than trades, while non-aggressive trades and limit orders play a marginal role.

References

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