Tick size and price discovery: Futures-options evidence

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Objectives

We analyze how tick size constraints affect the price discovery between futures and options in the CME agricultural markets. We find:

- Options are at least as informative as futures.
- Price-improving quotes from options, due to their less constrained tick size compared to futures, enhance new information impounded into prices.

Introduction

Most financial markets feature public limit order books, enhancing transparency in the price discovery process. This process involves incorporating new information into market prices and is influenced by market microstructure characteristics such as the tick size. The tick size establishes the minimum price increments at which traders can post orders and thus defines the market pricing grid. When the tick size exceeds the bid-ask spread required by market conditions (McInish and Wood 1992), the spread becomes constrained to one tick, making the tick size binding (Dyhrberg, Foley, and Svec 2023). Tick size constraints limit informed traders' ability to post price-improving quotes, resulting in less frequent updates of the midpoint price. This paper focuses on the relevance of tick size constraints in price discovery when an asset or its derivatives are traded with different nominal tick sizes across venues.

Institutional details

- We focus on futures and options in CME corn and soybean markets from January 7, 2019, to June 26, 2020.
- Prices are quoted in cents/bushel and the contract size is 5,000 bushels.
- The (nominal) tick size in futures (options) is 0.25 (0.125) cents/bushel.
- They are both traded electronically at Globex and share the same trading schedule.

Data

We use the CME Market Depth (MD) data for front-month futures and corresponding options.

- CME MD data record incremental updates in both trades and quotes.
- All data are timestamped to nanosecond with a unique sequence number for sorting events.
- Options and futures are recorded under the same data protocol, the timestamps are synchronized.
- Futures implied liquidity is considered to represent the comprehensive market liquidity.
- Options do not support implied liquidity and thus all (public) options quotes are trader-initiated.

Options-implied futures price

- Our price discovery analyses focus on put-call pairs instead of individual options.
- We begin with the European put-call pair parity adjusted by the early exercise premium

$$F_t e^{-r(T-t)} + v_t(K,T) = C_t(K,T) - P_t(K,T) + Ke^{-r(T-t)}$$

- Following Muravyev, Pearson, and Broussard (2013), $v_t(K,T)$ can be explained by the error term from the put-call parity

$$\varepsilon_t(K,T) = C_t(K,T) - P_t(K,T) + Ke^{-r(T-t)} - F_t e^{-r(T-t)}$$

and we eventually estimate $v_t(K,T)$ by the average of error term ($\frac{1}{N}\sum_{j=1}^{N}\varepsilon_j$).

- Finally, we get

$$Implied\ Bid = e^{r(T-t)}\left[C_t^{Bid}(K,T) - P_t^{Ask}(K,T) + Ke^{-r(T-t)} - v_t(K,T)\right],$$

$$Implied\ Ask = e^{r(T-t)}\left[C_t^{Ask}(K,T) - P_t^{Bid}(K,T) + Ke^{-r(T-t)} - v_t(K,T)\right].$$

- Our analyses use the midpoint prices instead of trade prices because the midpoint prices can reflect both the quote and trade changes.
- We calculate Hasbrouck (1995)'s information share (IS) and estimate a vector error correction model at 1-second frequency.

$$\Delta p_t^{fut} = \alpha_1\left(p_{t-1}^{fut} - p_{t-1}^{opt}\right) + \sum_{i=1}^{p}\gamma_i \Delta p_{t-i}^{fut} + \sum_{j=1}^{p}\delta_j \Delta p_{t-j}^{opt} + \varepsilon_{1,t}\ ,$$

$$\Delta p_t^{opt} = \alpha_2\left(p_{t-1}^{fut} - p_{t-1}^{opt}\right) + \sum_{k=1}^{p}\phi_i \Delta p_{t-k}^{fut} + \sum_{m=1}^{p}\psi_i \Delta p_{t-m}^{opt} + \varepsilon_{2,t}\ .$$

Price discovery

- We also calculate Putnins (2013)'s information leadership share (ILS) as it is not dependent on relative noise level of the two markets.

	Corn (%)						Soybean (%)					
	ILS			IS			ILS			IS		
	Mean	Std	Med	Mean	Std	Med	Mean	Std	Med	Mean	Std	Med
Panel A: Day trading session.												
Futures	47.58	26.99	51.70	75.19	19.05	80.94	45.93	28.43	46.53	79.50	15.27	83.71
Options	52.42	26.99	48.30	24.81	19.05	19.06	54.07	28.43	53.47	20.50	15.27	16.29
t-stat.	−10.15***						−16.00***					
Obs.	12,823						12,465					
Panel B: Night trading session.												
Futures	43.97	25.07	48.04	77.17	18.22	81.18	40.91	26.19	40.98	79.07	12.64	80.50
Options	56.03	25.07	51.96	22.83	18.22	18.82	59.09	26.19	59.02	20.93	12.64	19.50
t-stat.	−27.22***						−38.73***					
Obs.	12,823						12,465					

Price discovery and price-improving quotes

- The tick size constraint directly affects the availability of price-improving quotes.
- We define our measure as the ratio of the number of options price-improving quotes to the total number of options BBO updates ($\%PriceImprove^{OPT}$), reflecting liquidity providers' ability to enhance best bid/offer prices.
- Identification strategy
  - The submission of price-improving quotes may be endogenous to price discovery due to reverse causality.
  - An exogenous market structure change affecting options trading: the closure of the options floor trading on Mar 16, 2020, due to the COVID-19 pandemic.
  - Floor traders participate in the electronic venue where they compete with high-frequency traders (HFTs), who may favor placing price-improving quotes that prioritize price over speed (Yao and Ye 2018).
  - We use a dummy variable $FloorClose_t$ as an IV, which equals 1 after the floor trading closes, and 0 otherwise.

	Options price improving quotes (%)								
	N	Mean	Std.	Min	P25	Med	P75	Max	t-stat.
Panel A: Day trading session.									
Pre	20,363	5.11	3.72	0.13	3.00	4.20	5.84	50.59	
Post	4,925	6.45	3.86	1.30	3.55	6.05	7.83	40.44	21.95***
Panel B: Night trading session.									
Pre	20,363	10.60	6.33	0.50	6.50	8.82	12.79	65.91	
Post	4,925	17.48	8.58	1.16	11.79	16.57	22.07	61.64	52.93***

First-stage regression

$$\%PriceImprove_{ijt}^{OPT} = \beta \times FloorClose_t + \boldsymbol{Controls} + \lambda_{ij} + \varepsilon_{ijt}$$

	Dependent variable: $\%PriceImprove_{ijt}^{OPT}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$FloorClose_t$	3.848***	4.026***	3.824***	3.635***	3.110***	4.302***
	(0.286)	(0.255)	(0.244)	(0.241)	(0.240)	(0.282)
$Leverage_{it}$				−0.277***		
				(0.018)		
$Omega_{it}$					−0.946***	
					(0.060)	
$StrikeDistance_{it}$						−0.006
						(0.004)
$Volatility_{jt}^{FUT}$			0.592***	0.573***	0.518***	−0.614***
			(0.025)	(0.025)	(0.024)	(0.038)
$VolumeRatio_{it}$		−0.364***	−0.381***	−0.360***	−0.295***	−0.369***
		(0.021)	(0.020)	(0.020)	(0.019)	(0.023)
$TimeMaturity_{it}^{OPT}$	−0.014***	−0.006*	−0.007*	−0.015***	−0.036***	−0.005
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Options × Session FE	Yes	Yes	Yes	Yes	Yes	Yes
Effective F-stat.	180.49	248.67	246.11	227.83	167.20	232.57
N	50,576	50,576	50,576	50,576	50,576	50,576
Adj. R^2	0.561	0.573	0.578	0.584	0.594	0.261

Second-stage regression

$$ILS_{ijt}^{OPT} = \beta \times \%Price\widehat{Improve}_{ijt}^{OPT} + \boldsymbol{Controls} + \lambda_{ij} + \varepsilon_{ijt}$$

	Dependent variable: ILS_{ijt}^{OPT}					
	(1)	(2)	(3)	(4)	(5)	(6)
$\%Price\widehat{Improve}_{ijt}^{OPT}$	1.224***	1.135***	0.872**	1.029***	1.500***	0.994***
	(0.366)	(0.342)	(0.362)	(0.386)	(0.453)	(0.353)
$Leverage_{it}$				0.878***		
				(0.144)		
$Omega_{it}$					3.178***	
					(0.518)	
$StrikeDistance_{it}$						−0.042**
						(0.017)
$Volatility_{jt}^{FUT}$			3.098***	3.068***	2.976***	3.049***
			(0.278)	(0.283)	(0.292)	(0.273)
$VolumeRatio_{it}$		0.699***	0.515***	0.511***	0.467***	0.401**
		(0.164)	(0.175)	(0.175)	(0.170)	(0.176)
$TimeMaturity_{it}^{OPT}$	0.257***	0.240***	0.236***	0.264***	0.338***	0.239***
	(0.022)	(0.020)	(0.020)	(0.022)	(0.030)	(0.020)
Options × Session FE	Yes	Yes	Yes	Yes	Yes	Yes
N	50,576	50,576	50,576	50,576	50,576	50,576
Adj. R^2	0.023	0.030	0.048	0.047	0.033	0.045

- A one-standard-deviation (6.71%) increase in price-improving quotes is expected to increase the options ILS by 8.21%, representing 14.83% of its sample mean.

References

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