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Lei Yan, Scott H. Irwin, Dwight R. Sanders, and Aaron Smith

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Was Allen Paul Right? Liquidation Bias in Commodity Futures Markets

Lei Yan, Scott H. Irwin, Dwight R. Sanders, and Aaron Smith[†]

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[†] Lei Yan is an Associate Research Scientist, Department of Biostatistics, Yale University. Scott H. Irwin is the Lawrence J. Norton Chair of Agricultural Marketing, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign. Dwight R. Sanders is Professor, Department of Agribusiness Economics, Southern Illinois University Carbondale.

Was Allen Paul Right? Liquidation Bias in Commodity Futures Markets

This paper finds that during the last few days of trading in most commodity futures contracts the nearby futures price increases significantly relative to the prices for deferred contracts. The change in the price spread between nearby and first deferred futures contracts is strongly associated with the change in open interest of the nearby futures contract. We argue that the rise in nearby prices reflects a liquidation premium that buyers receive for bearing the risk of carrying long positions in nearby contracts into the final days of trading. The liquidation bias is consistent with the presence of delivery options in commodity futures markets.

Keywords: commodity, futures, delivery, spread, premium

Introduction

One of the longest-standing controversies in the study of commodity markets is the question of systematic tendencies in futures prices. According to the traditional "normal backwardation" theory of Keynes (1923) and Hicks (1939), hedging demand for futures contracts is net short in aggregate, and as a result, the current futures price has to be set at a discount relative to the expected spot price to entice speculators to take long positions opposite of hedgers. The downward bias of futures prices relative to expected spot prices implies that commodity futures prices, on average, rise over the life of a contract. Consequently, speculators receive a positive expected return for assuming commodity price risk.

A voluminous literature stretching back over 80 years investigates the existence of risk premiums in commodity futures markets. These studies use various approaches, including testing for a positive returns to buying-and-holding long futures positions (e.g., Telser 1958, Gorton and Rouwenhorst 2006), examining the profitability of market participants (e.g., Hartzmark 1987, Moran, Irwin and Garcia 2020), relating risk premiums to systematic risk and hedging pressure (Dusak 1973, Carter, Rausser, and Schmitz 1983), and separating hedging demand from liquidity provision (Kang, Rouwenhorst and Tang 2020). Despite the intensive search, consistent evidence of systematic risk premiums in commodity futures prices is elusive. Upon surveying this literature, Telser (2000, pp. 551) went so far as to state, "It appears on this evidence that normal backwardation as a theory of futures should be respectfully interred."

There is intriguing evidence of a different type of systematic tendency in commodity futures prices. Paul (1986) first documented that nearby commodity futures prices during the last few weeks of trading tend to rise relative to prices for the next maturity, which he referred to as a "liquidation bias." He examined eight agricultural commodities, two softs, and one precious metal for the period 1957-1982. Paul also examined three grain futures markets in the 1920s and 1930s. In most cases, the price of the nearby contract rose between 0.25% and 0.75% relative to the price of the first deferred during the last 15 days of trading. The changes generally were statistically significant, and Paul argued that the magnitudes were also economically significant. Thompson, McNeil, and Eales (1990) performed similar tests on price behavior during the last seven weeks of trading in the sugar and cocoa markets for the period 1978-1986, finding positive changes in the spread between nearby and first deferred prices, but the changes were not statistically significant, likely due to small sample sizes. To the best of our knowledge, the results in these two studies have not been investigated since the papers were published more than 30 years ago.

The purpose of our paper is to revisit the question of liquidation bias in commodity futures markets using data for 27 commodities traded at U.S. exchanges from January 1990 through December 2021. The sample period begins after the end of those used by Paul (1986) and Thompson, McNeil, and Eales (1990), so our tests can be considered out-of-sample tests of liquidation premiums relative to the original studies. We demonstrate that the spread between the nearby and first deferred contract prices (referred to as "the spread" if not specified otherwise) increases by 0.65% over the final 15 trading days leading up to expiration and the increase is strongly statistically significant. This increase in the spread primarily results from the rise in the nearby price relative to the price of the first deferred contract. In contrast, the spread between the first and second deferred contracts remains close to zero until expiration. Importantly, we do not observe a similar increasing pattern in financial futures markets that have cash settlement rather than physical delivery. In sum, the liquidation bias for commodity futures first observed by Paul over 30 years ago is still evident today.

We explore several potential factors that may drive the observed tendency in expiring futures prices. First, we consider who has the right to initiate a delivery and find that the increase in the spread is more evident in markets where delivery is initiated by sellers. Second, we study when a delivery can be initiated by comparing early notice commodities to late notice commodities, where early (late) notice commodities are those whose first notice day of delivery precedes (follows) the last trading day. The results show that the spread increases in both early and late notice markets. Third, we compare the spread changes between markets in contango and backwardation and find that market conditions do not help to explain the increase in spread. Fourth, we explore the role of electronic trading by comparing the spreads between two time periods 1990-2006 and 2007-2021. Not surprisingly, a similar extent of increase in the spread is observed in both periods, suggesting that the increasing pattern in the spread remains after the markets transition to electronic trading. Finally, we link the change in spread to the change in open interest of the nearby contract. The results reveal a significantly negative relationship between change in spread and change in open interest, suggesting that the spread tends to be larger when open interest becomes lower. Collectively, our findings are consistent with the conjecture that the increase in the spread reflects a premium for buyers not to liquidate their positions as the expiration date approaches.

Data and Measurement

We analyze 27 U.S.-based commodity futures markets from 1990 to 2021, including four in energy, five in metals, eight in grains, seven in softs, and three in livestock (Table 1). All these commodify futures are physically settled except lean hogs, which switched to cash settlement in February 1997. We exclude the May and June 2020 WTI crude oil contracts from the analysis because their prices approached or fell below zero during the peak uncertainty of the Covid-19 pandemic. We also exclude contracts that have a trading history of fewer than 60 days (May 2012 pork bellies, June 1990 natural gas, and July 1990 natural gas). In addition to commodity futures, we examine 10 financial futures markets for the same period, including the S&P 500 Index, Dow Jones Industrial Index, Treasury Bill 3-month, Treasury Note 2-year, Treasury Note 3-year, Treasury Note 5-year, Treasury Note 10-year, Treasury Bonds 30-year, U.S. Dollar Index, and U.S. Dollar/Mexican Peso. All these financial futures are cash-settled. For both commodities and financials, we obtain their daily settlement price, trading volume, and open interest data from *Barchart*.

Our analysis of how futures prices behave as the maturity date approaches is conducted within an event study framework. The event window is defined as the last 35 days leading up to contract expiration. In all markets, day 0 is defined as the last day of trading regardless of the particular delivery specifications for a futures market. For example, the last day of trading in grain futures contracts generally is the about the 10th business day of the expiration month. In contrast, the last trading day in most energy futures contracts is around the 20th of the calendar month before the expiration month. Our procedure is to set day 0 to the last trading day, even though this means day 0 may be several weeks apart for the same expiration months in grain and energy futures markets. We define the event window in this manner to focus on price behavior as a function of time-to-maturity rather than calendar time.

We calculate daily price spreads to estimate the change in the nearby futures price relative to the price for the first deferred contract within the last 35 trading days leading up to the nearby contract's expiration. For a given contract, the spread on day t is defined as,

$$Spread_t \ = (\frac{F_t^{T_1}}{F_t^{T_2}} - 1) \times \frac{100}{T_2 - T_1}, \tag{1}$$

where $F_t^{T_1}$ and $F_t^{T_2}$ are the prices of the nearby and first deferred contracts with maturity dates T_1 and T_2, respectively. The subscript t indicates the number of trading days to T_1, which ranges from 35 to 1; $t = 0$ corresponds to the maturity date T_1. According to Equation (1), the spread is expressed as the percentage difference between the nearby and first deferred contract prices, normalized by the time difference in months between the two maturities. To allow cross-contract aggregation, we normalize $Spread_t$ by dividing it by the spread on day 35 so that $Spread_{35}$ equals 100 for all contracts. We calculate the average spreads by forming equally-weighted portfolios of futures contracts.

In event studies, the abnormal return is defined as the raw return minus the expected return derived from a multi-factor model, and this is used to isolate the effects of factors other than the event on asset prices. For instance, Henderson, Pearson and Wang (2015) use a measure of abnormal return to examine the impact of the flows from commodity-linked notes on commodity futures prices. In our case, the influence of non-event factors can be assumed to be differenced out in the calculation of spreads since the prices of the nearby and first deferred contracts are closely linked through storage arbitrage (Pindyck 2001). Our use of spreads for identification aligns with the approach of Yan, Irwin and Sanders (2022) and Irwin, Sanders and Yan (2023), who investigate the impact of index rebalancing and index rolls on futures prices through price spreads. In the presence of a liquidation bias, we expect average spreads to deviate from 100 as the maturity approaches. Otherwise, average spreads should remain relatively unchanged during the 35-day event window.

Empirical Results

We first document the widespread presence of liquidation bias in commodity futures markets. We then examine the variation in liquidation bias across different delivery contexts and market conditions. Finally, we directly associate liquidation bias with fluctuations in open interest.

Prevalence of Liquidation Bias

We examine average spreads between the nearby and first deferred contracts for the 27 commodities over the last 35 trading days before the nearby contract's expiration. For each day t, the spread between the nearby contract and the first deferred contract is normalized by dividing it by the spread on day 35 and then averaged over contracts of all commodities. Error bars indicate 95% confidence intervals. Figure 1 show that the average spreads are stable from days 35 to 15 prior to expiration, which is expected since any factor affecting price levels would similarly impact both the nearby and first deferred prices, resulting in minimal spread change. From day 15, the average spreads start to rise and reach a maximum on day 1 (the day preceding the last trading day). This suggests that the nearby price in commodity futures markets tends to increase relative to the price of the first deferred contract in the last few weeks leading up to expiration. We find that Paul's (1986) liquidation bias, discovered in selected markets over 30 years ago, persists across a broader set of commodities and in more recent years.

To demonstrate that the increasing spread is primarily due to an increase in the price of the nearby contract, we examine the average prices of the nearby and first deferred contracts during the last 35 trading days.[1] Figure 2 indicates that both prices remain nearly constant until day 15, after which the nearby prices increase to a much larger extent than the first deferred prices. As mentioned earlier, while average price changes may stem from economic factors affecting all commodities, the relative change in prices between the nearby and first deferred contracts indicates additional reasons for the rise in the nearby price. As a separate check, we calculate the average spreads between the first and second deferred contract prices during the last 35 days before the nearby contract's maturity. Unlike the increasing pattern in the nearby-first deferred spread, Figure 3 show that the average spreads between the first and second deferred contracts are close to zero from days 35 to 20 and then turn slightly negative up to day 1. Figure 2 and Figure 3 suggest that the increasing spread is mainly driven by an increase in the nearby price. These findings support the hypothesis that if a liquidation bias exists, it would likely be reflected as an increase solely in the nearby contract price.

We investigate whether the increasing spread is consistent across different commodity sectors and maturity months. Figure 4 illustrates the average spreads between the nearby and first

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[1] For each day t, the price of the nearby contract (and similarly, first deferred contract) is normalized by dividing it by its price on day 35 and then averaged over contracts of all commodities.

deferred contract prices for commodities within each sector. The average spreads for grains, livestock, and metals exhibit a similar increasing trend from days 15 to 1, albeit at varying magnitudes. The average spreads for softs begin to rise earlier, around day 30 before expiration. In contrast, the average spreads for energy commodities decline from days 20 to 7, then climb above zero on days 2 and 1. This is likely because deliveries in the energy markets can be initiated by both buyers and sellers, whereas in the other markets, deliveries are initiated by sellers alone. We will examine the relationship between the spread and the initiating party of delivery later.

Figure 5 shows the average spreads between the nearby and first deferred contracts for each maturity month. Not all commodities have the same set of maturity months. For instance, there are twelve maturity months for energy products but only five (March, May, July, September, and December) for most grains. The average spreads exhibit an increasing pattern especially in March, May, July, August, September, and November, although the time when spreads start to rise and the extent varies. Collectively, the nearby price tends to rise relative to the price for the first-deferred contract during the last few weeks of trading across commodity sectors and maturity months, implying that liquidation bias is a widespread phenomenon.

Finally, we examine the average spreads between the nearby and first deferred contracts for the 10 cash settled financial futures during the last 35 days of trading. Figure 6 reveals that, unlike commodity futures, the average spreads for financial futures exhibit little to no variation throughout the 35-day period. This result is consistent with our expectation that the liquidation bias is related to physical delivery, and therefore, exists only in the physically-settled commodity futures markets.

Liquidation Bias and the Initiation of Delivery

We propose that liquidation bias relates to the bargaining power of buyers and sellers during the delivery process. When sellers have the right to initiate delivery, buyers, obligated to take delivery, may seek compensation for carrying long positions nearing the delivery period, manifesting as an appreciation of the nearby contract price. Conversely, in markets where buyers initiate delivery, they may more strongly influence the delivery terms and need to provide incentives to sellers to keep them in the market. In such cases, the nearby contract price is likely to decrease as the maturity date approaches, resulting in a narrower spread.

Of the 27 commodity markets, 23 allow only sellers to initiate delivery, while in 4 markets both buyers and sellers hold this right. These four markets are WTI crude oil, NY Harbor ULSD, RBOB gasoline, and natural gas, which are all energy products traded on the New York Mercantile Exchange. We illustrate the nearby-first deferred spreads for markets with seller versus dual-initiation rights in Figure 7. The average spreads in seller-initiated markets show a marked increase from day 20, while in the four energy markets, spreads begin to fall from day 20, remain negative until day 5, and then approach zero in the final trading days. This pattern aligns with the hypothesis that liquidation bias is more pronounced where sellers control the initiation of delivery. In the energy markets, where delivery can be initiated by either party, the clearing house allocates notices of intention to deliver and notices of intention to accept by matching the sizes of positions when possible. The observed decrease in spread may indicate that buyers can negotiate more favorable delivery terms, which cannot be confirmed without detailed market-specific delivery information. Overall, the results generally support our theory that the liquidation bias serves as a compensation for buyers who wish to avoid taking delivery of the actual commodity.

Liquidation Bias and the Timing of Delivery

The timing of delivery may also influence the liquidation bias. The first notice day, the earliest day on which deliveries are initiated, can occur either before or after the last day of trading. To avoid unexpected delivery obligations, market participants need to close out their positions prior to the first notice day. We expect the liquidation bias to arise earlier when the first notice day falls before the last trading day, as opposed to when it falls after the last trading day.

We divide the 27 commodities into early notice and late notice groups based on whether the first notice day occurs before or after the last trading day. Seven commodities, including WTI crude oil, NY Harbor ULSD, RBOB gasoline, natural gas, sugar #11, lumber, and pork bellies, fall into the late notice category. Figure 8 shows the average spreads between the nearby and first deferred contracts for both early and late notice commodities. For early notice commodities, the average spreads start to increase on day 19 and continue to rise through day 1, suggesting that liquidation bias persists not only until the first notice day but up to the last day of trading. In contrast, the average spreads for late notice commodities fall below zero from day 19 and subsequently shift to above zero in the last few days. This is consistent with our hypothesis that liquidation bias is more prominent when deliveries can be initiated before the contract's expiration. It is noteworthy that four of the seven late notice commodities (WTI crude oil, NY Harbor ULSD, RBOB gasoline, and natural gas) are also the markets where delivery can be initiated by either buyers or sellers. Therefore, it is challenging to disentangle the effects of the timing of delivery from the effects of who initiates delivery.

Liquidation Bias and Electronic Trading

We examine whether liquidation bias varies between pit trading and electronic trading periods. The transition to electronic trading marks one of the most significant changes in commodity futures trading. Electronic trading has greatly reduced the costs of trading and made commodity futures markets more accessible. However, electronic trading may not necessarily diminish the liquidation bias, as delivery processes generally have not changed substantially in the era of electronic trading.

To determine whether the liquidation bias has changed as futures trading moved to electronic platforms, we compute the average spreads for the periods 1990-2006 and 2007-2021, corresponding to the pit trading and electronic trading eras. In both periods shown in Figure 9, the average spreads exhibit an increasing trend during the last ten trading days, although the spreads start to rise earlier and reach a lower peak on day 1 during the electronic trading period. This result suggests that the liquidation bias continues to exist even when futures markets have shifted to electronic trading. While electronic trading allows market participants to better anticipate and manage the risks associated with delivery, the constraints and costs involved in the actual delivery process may still deter participants from holding positions to expiration, thus maintaining the need for a liquidation bias.

Liquidation Bias and Market Conditions

We also account for market conditions in our analysis. A market is considered in contango when the price of the nearby contract is lower than that of the first deferred contract on day 35; conversely, it is in backwardation. In a contango market, the cost of carry–which includes storage costs, insurance, and financing charges associated with holding the commodity until delivery–exceeds the benefit received from holding the physical commodity (known as the convenience yield). We expect the liquidation bias to be more evident in anticipation of higher costs related to delivery.

Figure 10 presents the average spreads between the nearby and first deferred contracts in both contango and backwardation market conditions. As expected, spreads in contango markets start rising on day 20, indicating an early emergence of liquidation bias due to anticipated delivery costs. In contrast, spreads in backwardated markets remain negative through day 10 and rise afterwards, with a similar peak on day 1. This divergence in spread patterns between contango and backwardation conditions could reflect different impacts of storage and holding costs on traders' strategies. In contango markets, the inclination to liquidate positions early is driven by the desire to avoid the escalating costs associated with the nearing delivery. In backwardation markets, the cost incentives are reversed, allowing traders to maintain positions longer in expectation of a convenience yield that outweighs the costs.

Liquidation Bias and Open Interest

Finally, we link the spread to the open interest in the nearby contract. We expect the spread to be negatively correlated with open interest as a higher liquidation premium is needed when fewer contracts are left open in the market. In particular, we estimate a regression of the percentage change in spread on the percentage change in open interest, adjusting for the aforementioned factors that may influence the spread,

$$\Delta \log Spread_{i,t} = \beta_0 + \beta_1 \Delta \log OI_{i,t} + \beta_2 X_{i,t} + \epsilon_{i,t}, \tag{2}$$

where $\Delta \log Spread_{i,t}$ is the daily change in log spread for contract i on day t, $\Delta \log OI_{i,t}$ is the change in log open interest, and t is the number of trading days to expiration. The control variables ($X_{i,t}$) include time to maturity in days, who initiates delivery (sellers only vs. either party), the timing of delivery (early notice vs. late notice), the period of pit or electronic trading era (1990-2006 vs. 2007-2021), market conditions (contango vs. backwardation), commodity sectors, maturity months, and the lagged dependent variable. We estimate the model using a pooled ordinary least square, with standard errors calculated to account for clustering of commodity and maturity month.

Table 2 presents the estimates of the regression model in various specifications. The estimated coefficient for the change in log open interest is negative and statistically significant at the 1% level, when control variables are not included. With a point estimate of -4.2e-4, this implies that a 1% decrease in open interest is associated with a 4.2e-4% increase in the spread. For instance, a 60% reduction in open interest in the last 15 trading days before expiration could result in a 0.378% widening of the spread. This change in open interest notably contributes to the spread increase observed in Figure 1. The inclusion of control variables maintains the negative and significant relationship of the percentage change in open interest, although the magnitude varies a little bit.

The dummy variables for delivery initiation and timing are not concurrently included due to the overlap in market characteristics; markets where delivery can be initiated by either party also feature late notice. When analyzed separately, the findings suggest a greater spread increase in markets where only sellers initiate delivery or when delivery is notified post-maturity, aligning with prior results from Figure 7 and Figure 8. Regarding the period and market condition variables, the coefficients suggest no distinguishable difference in spread changes between the periods 1990-2006 and 2007-2021, nor between contango and backwardation markets.

The addition of the time to maturity variable, which aims to capture potential nonlinear trends in the spread, yields a negative and statistically significant coefficient, indicating that the spread widens as maturity approaches. The positive and significant interaction between time to maturity and percentage change in open interest, alongside the negative coefficient of the percentage change in open interest, intimates that the impact of open interest dwindles as the time to maturity decrease.

Collectively, the regression results support our liquidation bias hypothesis. As delivery approaches and the number of open contracts dwindles, buyers would be increasingly reluctant to maintain long positions due to the heightened risk and cost associated with delivery, prompting them to demand a larger premium. The liquidation bias, as reflected by the spread, is therefore connected to the volume of unsettled positions in commodity futures markets.

Conclusions

We highlight the liquidation bias in commodity futures markets as a compensation for the delivery-related risks borne by buyers, providing crucial insights into market dynamics as futures contracts approach expiration. These findings suggest a need for market participants to consider delivery-related risks in their trading decisions and for policy makers to be aware of the effects of contract specifications on market liquidity and efficiency. The liquidation bias may appear similar to the risk premium in the Keynes-Hicks theory, yet these are distinct concepts. Unlike a conventional risk premium, which exists throughout the life of a futures contract, the liquidation bias is directly tied to the delivery process and emerges only in the days leading up to delivery. The liquidation bias documented in our study is consistent with the presence of delivery options in commodity futures markets. It has long been known that quality, location, and timing flexibility in futures delivery is economically valuable (e.g, Chance and Hemler 1993). The liquidation bias, as reflected by the increase in the nearby contract price relative to the first deferred contract price, could be seen as a manifestation of these underlying delivery options. In future work, we plan to explore the relationship between liquidation bias and delivery options in more detail.

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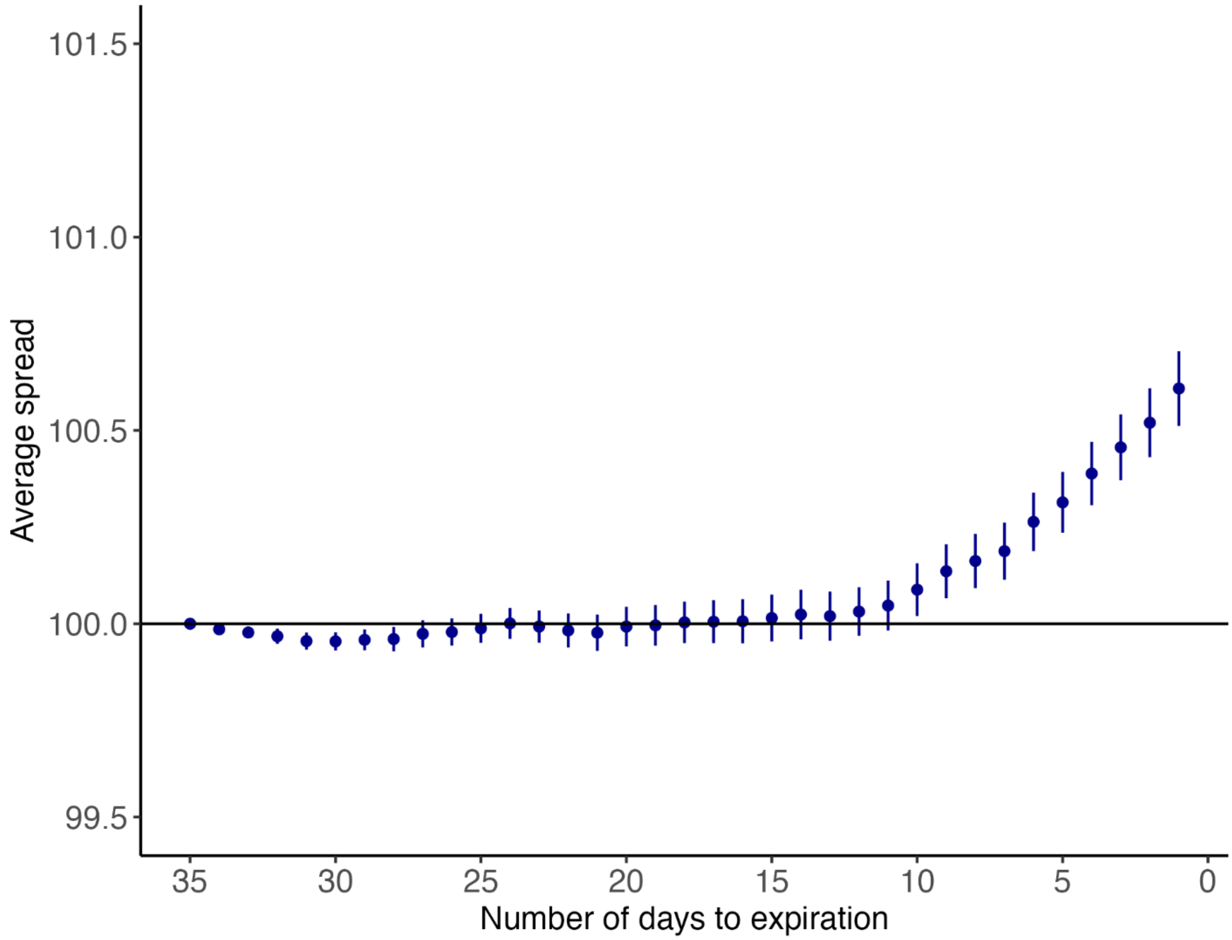

Figure 1. Average spreads between the nearby and first deferred contracts during the last 35 days of trading

Notes: The spread is defined as the ratio of the nearby contract price to the first deferred contract price divided by the number of months between their expirations, with the spread on day 35 normalized to 100. Spreads are then averaged over contracts for all commodities. The sample consists of 27 physically settled commodity futures for 1990-2021. Error bars indicate 95% confidence intervals.

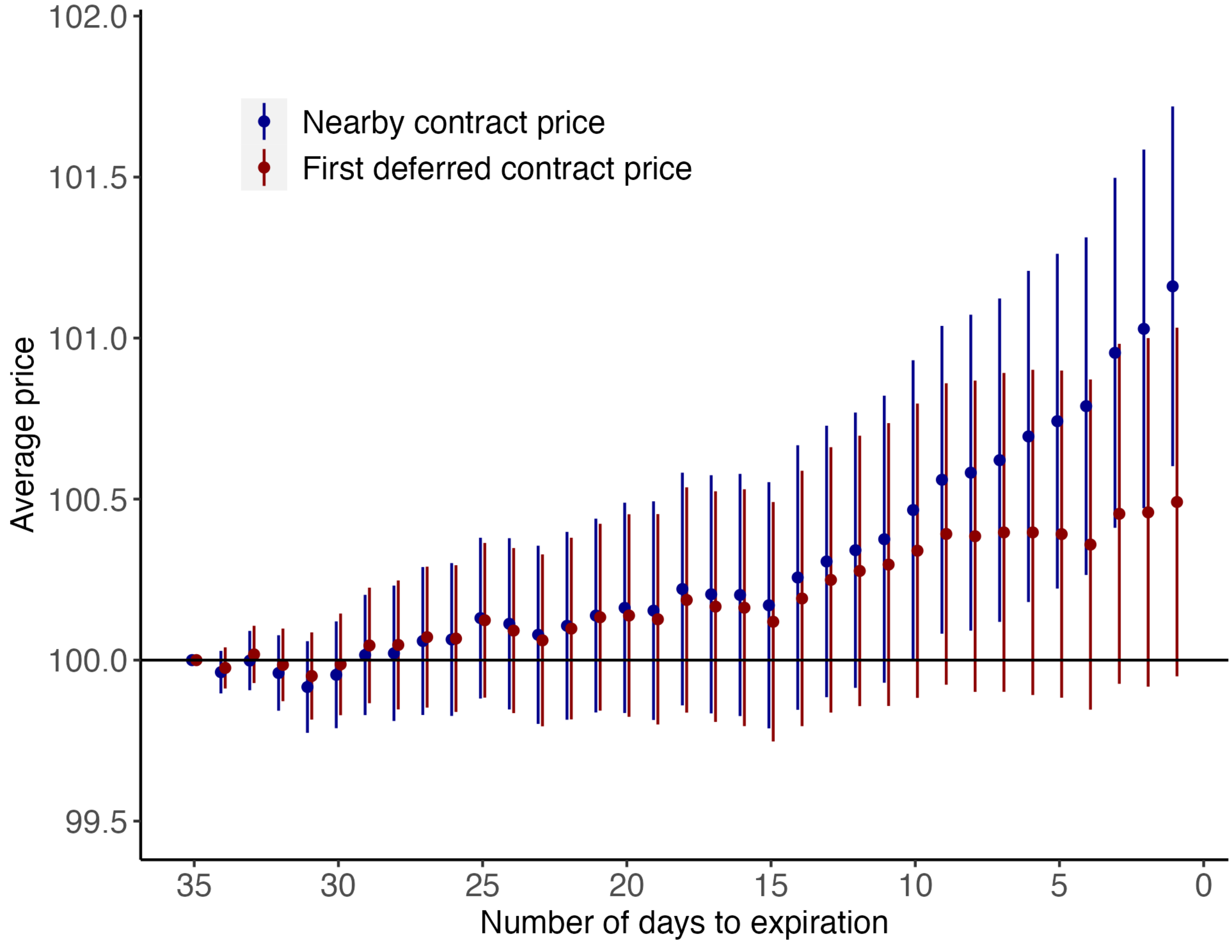

Figure 2. Average prices of the nearby and first deferred contracts during the last 35 days of trading

Notes: Daily prices of the nearby and first deferred contracts are normalized by dividing by their prices on day 35, respectively, and then averaged over contracts for all commodities. Error bars indicate 95% confidence intervals. The sample consists of 27 commodities for 1990-2021.

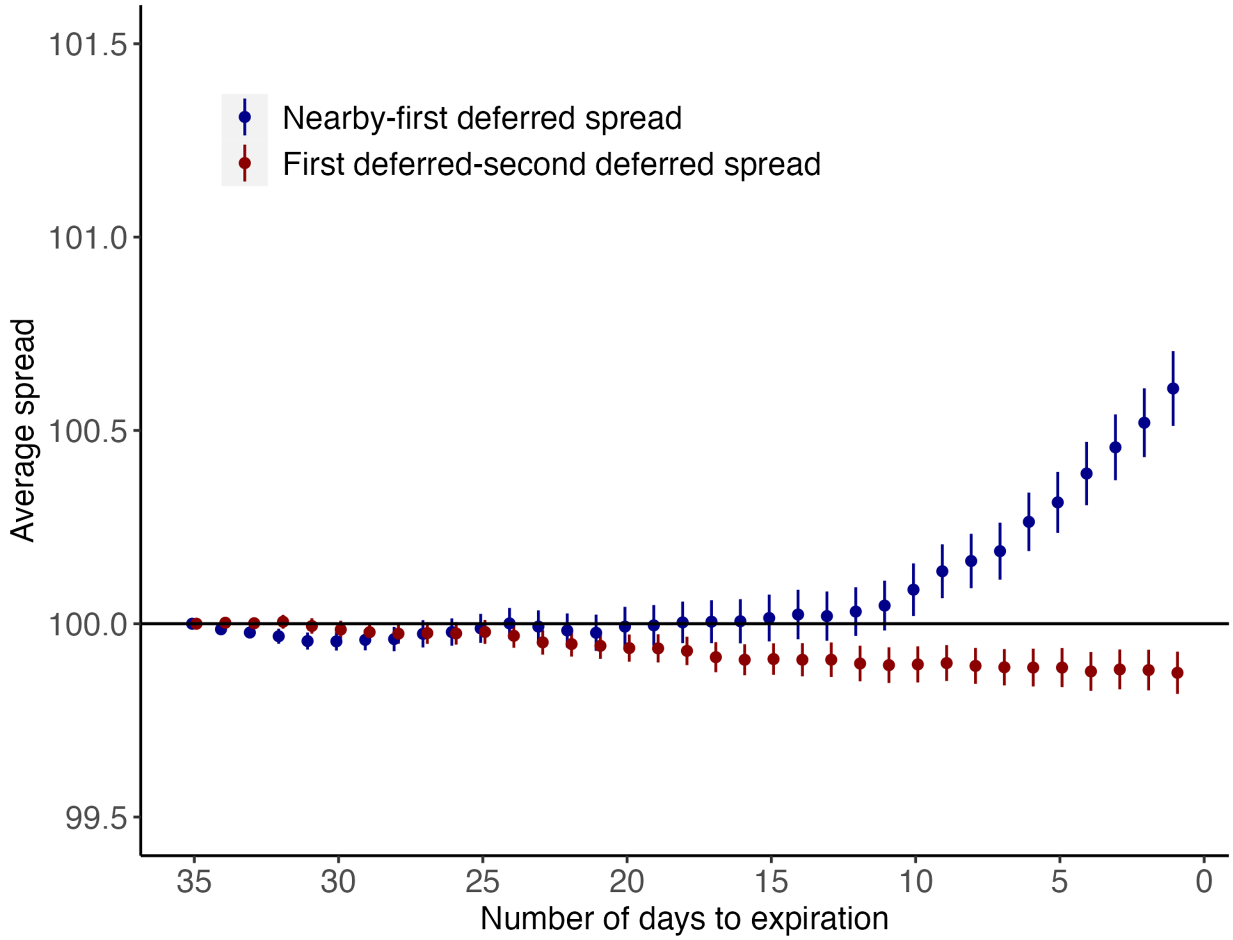

Figure 3. Average spreads between the first and second deferred contracts during the last 35 days of trading of the nearby contract

Notes: The spread is defined as the ratio of the first deferred contract price to the second deferred contract price divided by the number of months between their expirations, with the spread on day 35 normalized to 100. Spreads are then averaged over contracts for all commodities. The average spreads between the nearby and first deferred contracts are included for comparison. Error bars indicate 95% confidence intervals. The sample consists of 27 commodities for 1990-2021.

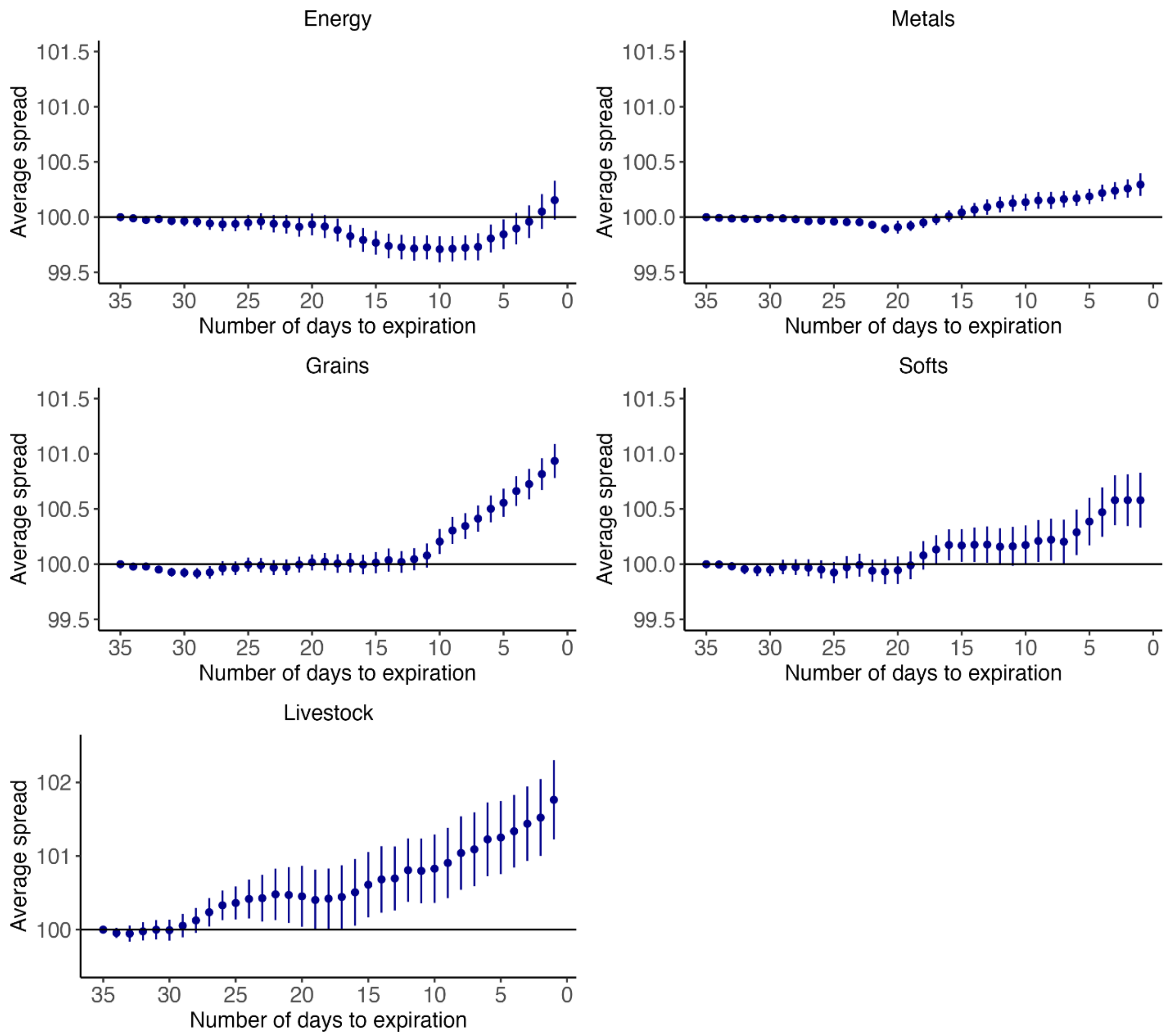

Figure 4. Average spreads between the nearby and first deferred contracts during the last 35 days of trading in each commodity sector

Notes: The spread is defined as the ratio of the nearby contract price to the first deferred contract price divided by the number of months between their expirations, with the spread on day 35 normalized to 100. Spreads are then averaged over contracts for each sector of commodities. Error bars indicate 95% confidence intervals. The sample consists of 27 commodities for 1990-2021.

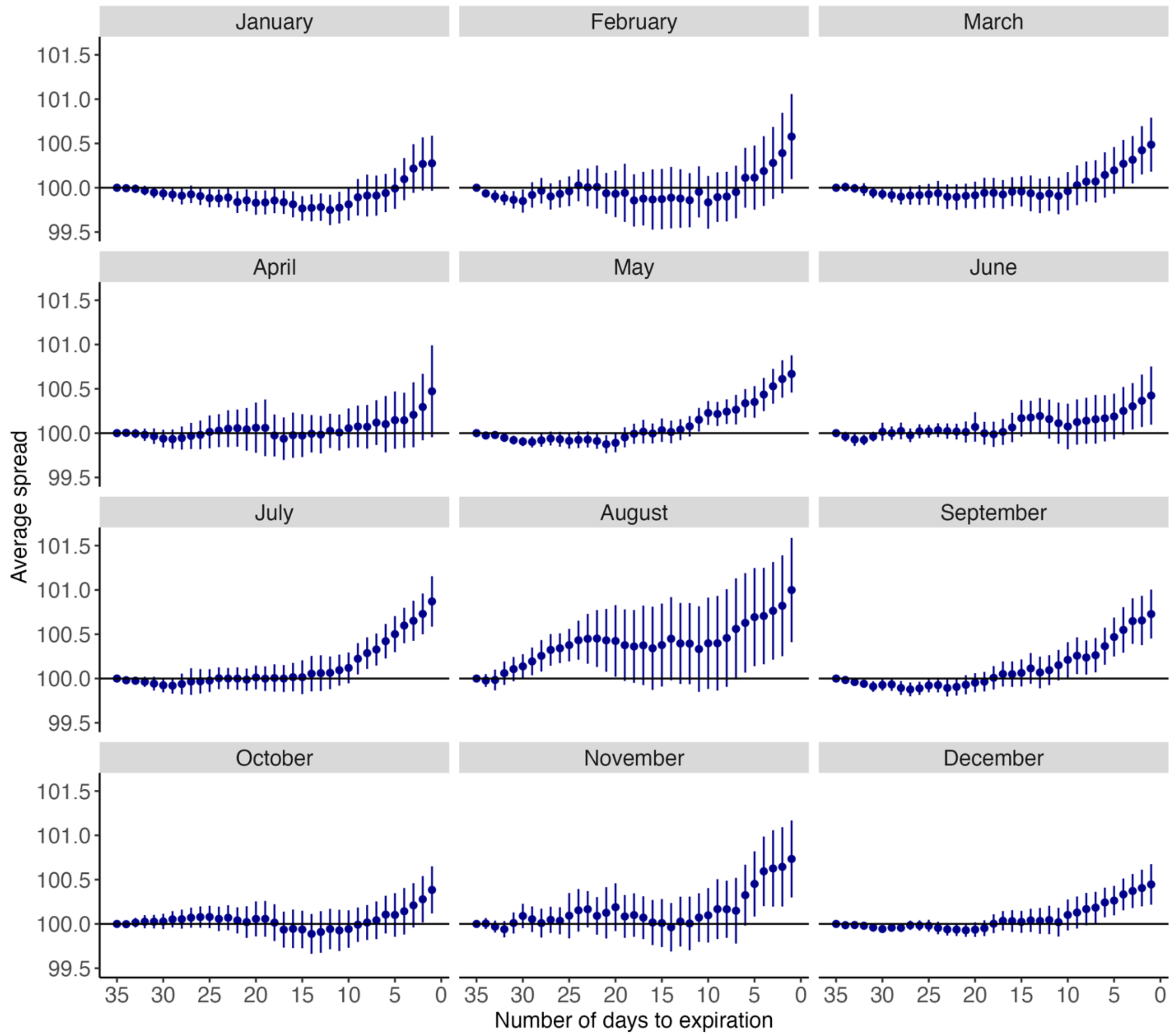

Figure 5. Average spreads between the nearby and first deferred contracts during the last 35 days of trading in each maturity month

Notes: The spread is defined as the ratio of the nearby contract price to the first deferred contract price divided by the number of months between their expirations, with the spread on day 35 normalized to 100. Spreads are then averaged over contracts for each maturity month. Error bars indicate 95% confidence intervals. The sample consists of 27 commodities for 1990-2021.

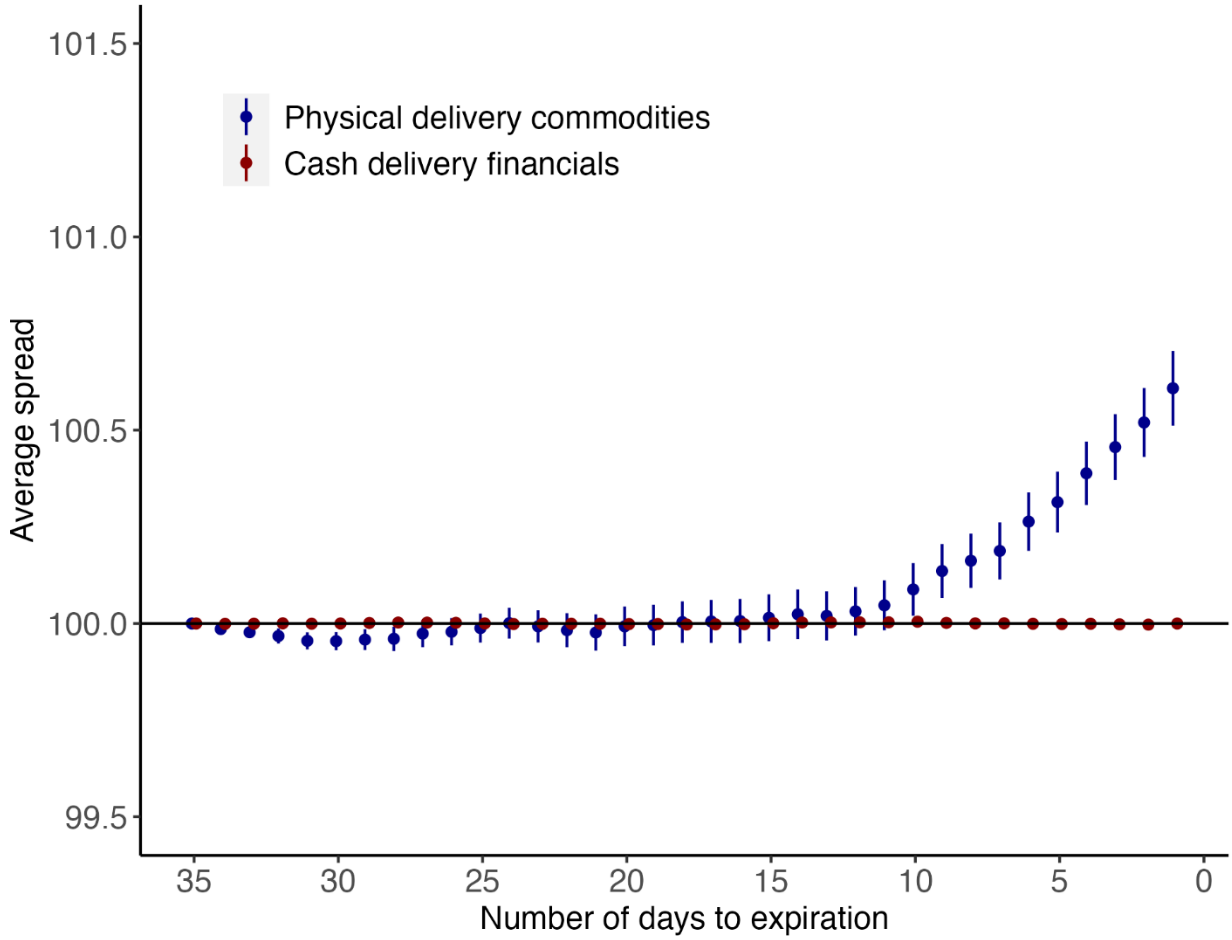

Figure 6. Average spreads between the nearby and first deferred contracts during the last 35 days of trading between commodity futures and financial futures

Notes: The spread is defined as the ratio of the nearby contract price to the first deferred contract price divided by the number of months between their expirations, with the spread on day 35 normalized to 100. Spreads are then averaged over contracts for all commodities. The sample consists of 27 physically settled commodity futures and 10 cash settled financial futures for 1990-2021. Error bars indicate 95% confidence intervals. The 10 cash settled financial futures include S&P 500 Index, Dow Jones Industrial Index, Treasury Bill 3-month, Treasury Note 2-year, Treasury Note 3-year, Treasury Note 5-year, Treasury Note 10-year, Treasury Bonds 30-year, U.S. Dollar Index, and U.S. Dollar/Mexican Peso.

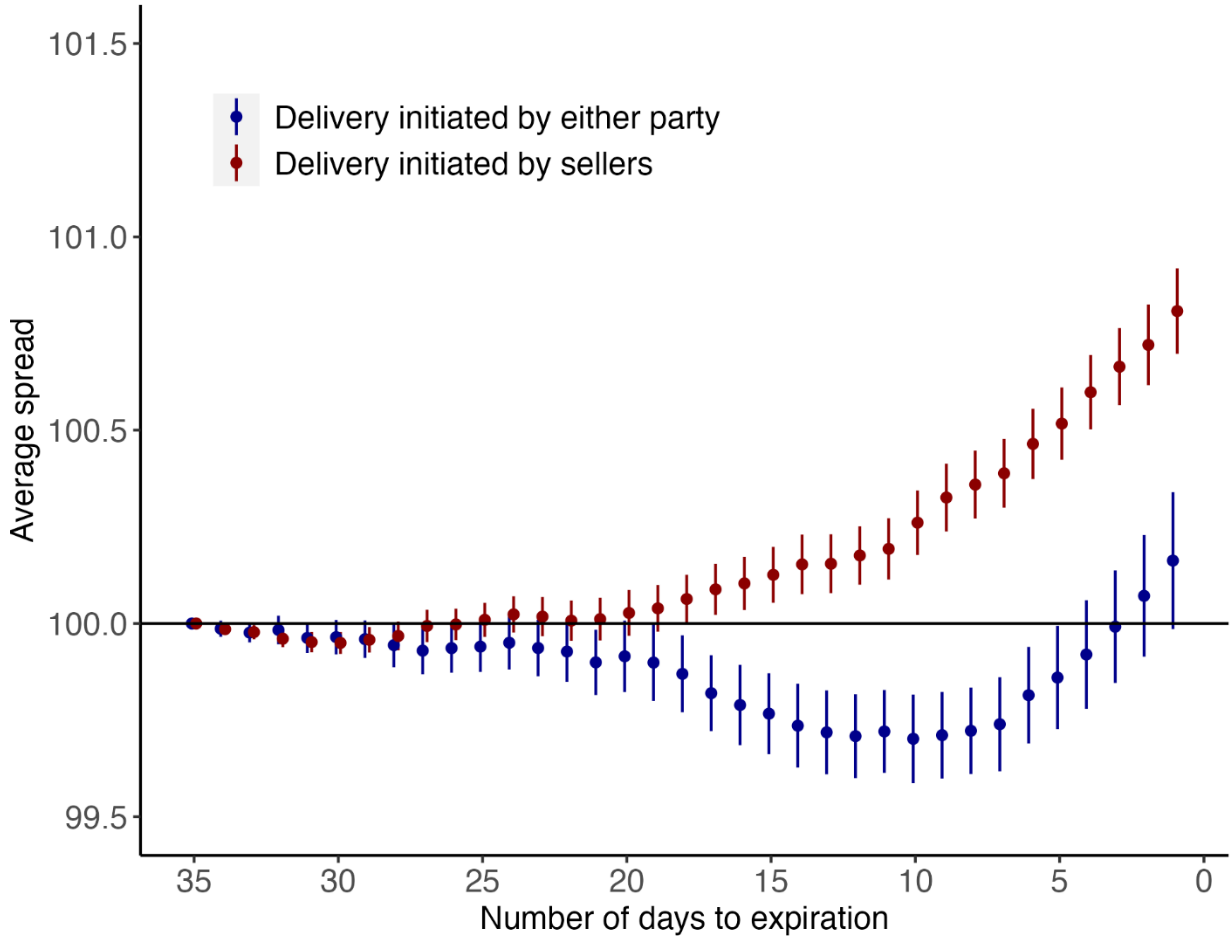

Figure 7. Average spreads between the nearby and first deferred contracts during the last 35 days of trading between seller-initiated and dual-initiated commodities

Notes: The spread is defined as the ratio of the nearby contract price to the first deferred contract price divided by the number of months between their expirations, with the spread on day 35 normalized to 100. Spreads are then averaged over contracts based on the initiation party of delivery. Error bars indicate 95% confidence intervals. The sample consists of 27 commodities for 1990-2021.

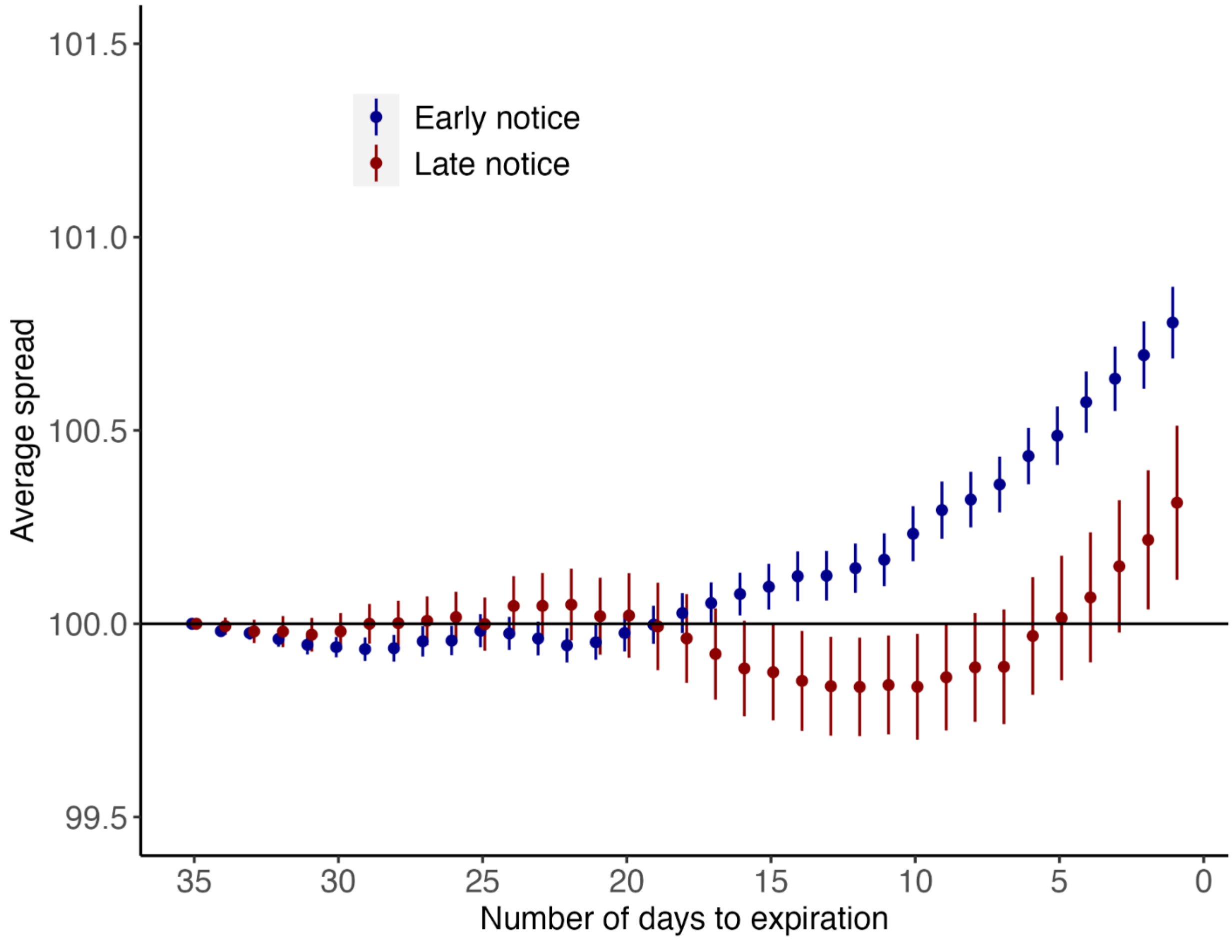

Figure 8. Average spreads between the nearby and first deferred contracts during the last 35 days of trading between early notice and late notice commodities

Notes: The spread is defined as the ratio of the nearby contract price to the first deferred contract price divided by the number of months between their expirations, with the spread on day 35 normalized to 100. Spreads are then averaged over contracts of commodities based on whether the notice of delivery falls before the maturity date (early notice) or after the maturity date (late notice). Error bars indicate 95% confidence intervals. The sample consists of 27 commodities for 1990-2021.

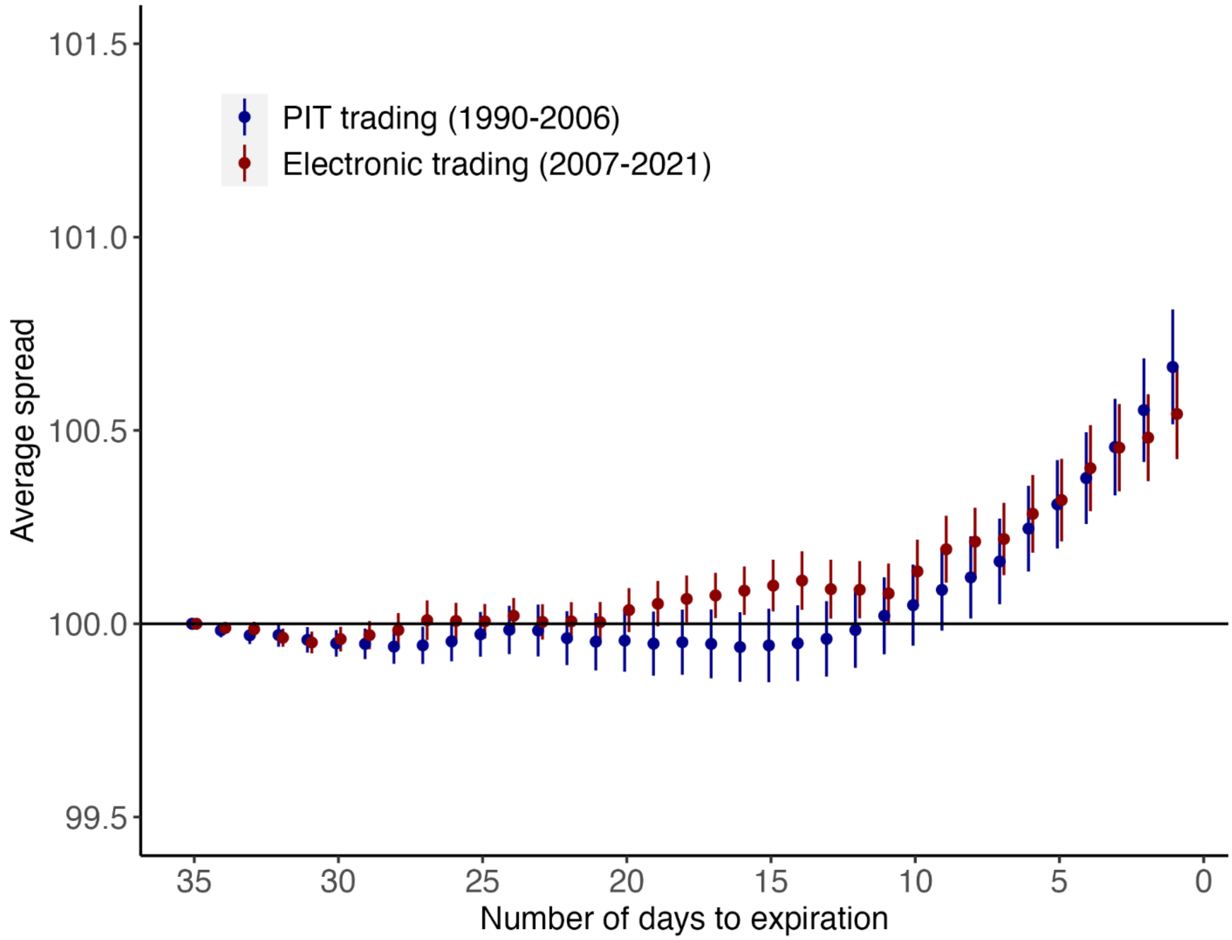

Figure 9. Average spreads between the nearby and first deferred contracts during the last 35 days of trading between pit trading and electronic trading periods

Notes: The spread is defined as the ratio of the nearby contract price to the first deferred contract price divided by the number of months between their expirations, with the spread on day 35 normalized to 100. Spreads are then averaged over contracts for the pit trading (1990-2006) and electronic trading (2007-2021) periods, respectively. Error bars indicate 95% confidence intervals. The sample consists of 27 commodities for 1990-2021.

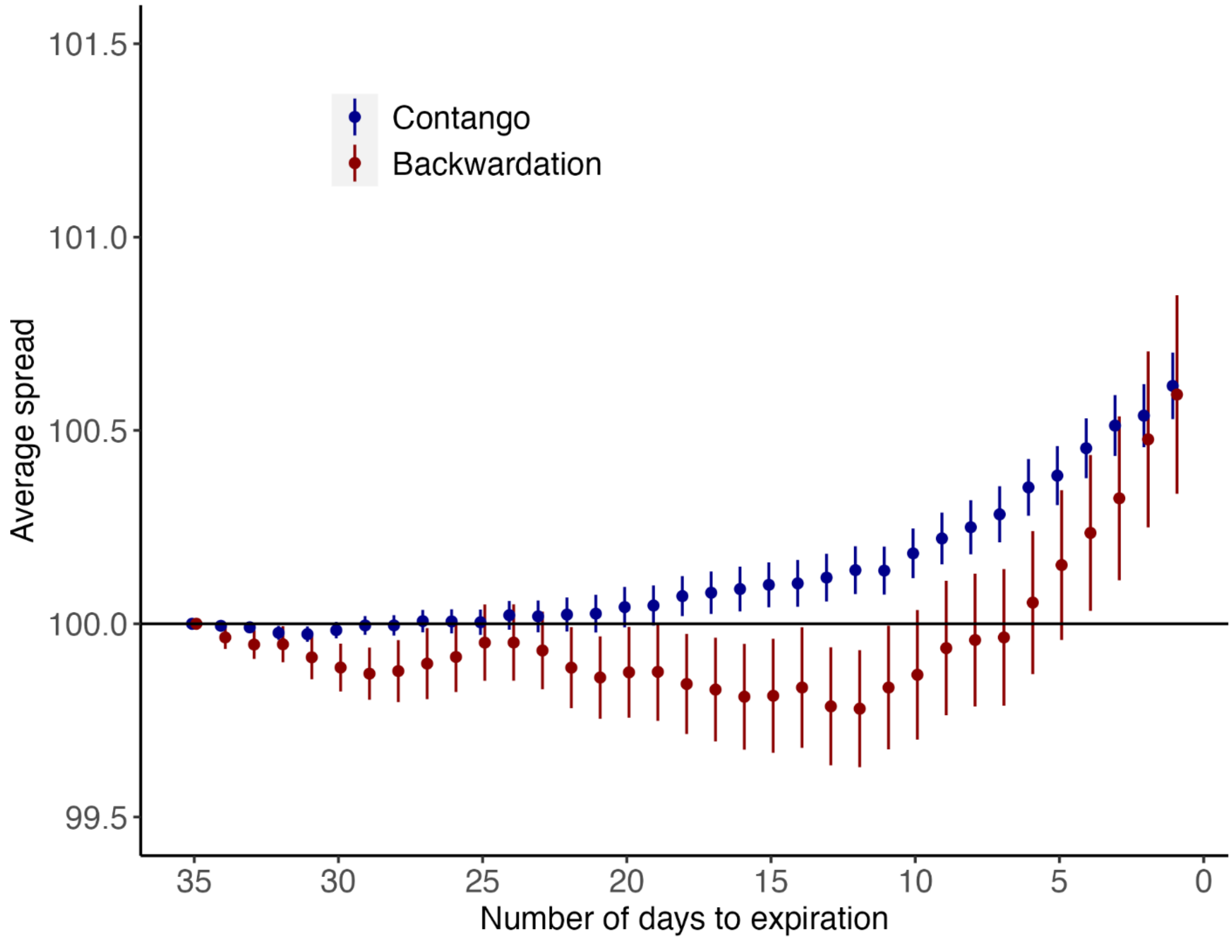

Figure 10. Average spreads between the nearby and first deferred contracts during the last 35 days of trading between contango markets and backwardation markets

Notes: The spread is defined as the ratio of the nearby contract price to the first deferred contract price divided by the number of months between their expirations, with the spread on day 35 normalized to 100. Spreads are then averaged over contracts based on whether the market is in contango or backwardation. The market is considered in contango (backwardation) if the nearby price is less (greater) than the first deferred price on day 35. Error bars indicate 95% confidence intervals. The sample consists of 27 commodities for 1990-2021.

Table 1. Commodity futures specification

Commodity	Exchange	Last Trade Day	First Notice Day	First Delivery Day	Delivery initiated by
Energy					
Crude Oil, WTI	NYMEX	The 3rd business day prior to the 25th calendar day of the month preceding the contract month	The 2nd business day following last trade date	The 1st calendar day of the contract month	Buyer/Seller
NY Harbor ULSD RBOB Gasoline	NYMEX NYMEX	The last business day of the month preceding the contract month	The 2nd business day following last trade date	The 6th business day of the contract month	Buyer/Seller
Natural Gas	NYMEX	The 3rd last business day of the month preceding the contract month	The 1st business day following last trade date	The 1st calendar day of the contract month	Seller/Seller
Grains					
Corn Soybeans Soybean Oil Soybean Meal Oats Rough Rice Wheat, Chicago Wheat, Kansas	CBOT CBOT CBOT CBOT CBOT CBOT CBOT CBOT	The business day preceding the 15th calendar day of the contract month	The last business day of the month preceding the contract month	The 1st business day of the contract month	Seller
Wheat, Minneapolis	MGEX	The business day preceding the 15th calendar day of the contract month	The last business day of the month preceding the contract month	The 1st business day of the contract month	Seller
Softs					

Cocoa	ICE	The 12th last business day of the contract month	10 business days prior to the 1st business day of the contract month	The 1st business day of the contract month	Seller
Coffee "C"	ICE	The 9th business day of the contract month	7 business days prior to the 1st business day of the contract month	The 1st business day of the contract month	Seller
Cotton No. 2	ICE	The 17th last business day of the contract month	5 business days prior to the 1st business day of the contract month	The 1st business day of the contract month	Seller
Orange Juice	ICE	The 15th last business day of the contract month	The 1st business day of the contract month	The 6th business day of the contract month	Seller
Sugar #11	ICE	The last business day of the month preceding the contract month (the 2nd business day prior to the preceding Dec 24th for January contract)	The 1st business day following last trade date		Buyer/Seller
Lumber	CME	The business day preceding the 16th calendar day of the contract month	The 1st business day following last trade date		Seller
Livestock					
Live Cattle	CME	The last business day of the contract month	The 1st Monday of the contract month	The 9th (5th) business day following the 1st Friday of the contract month for live graded (carcass graded)	Seller
Pork Bellies[1]	CME	The business day preceding the last 3 business days of the contract month	The 1st business day following the 1st Friday of the contract month	The 2nd business day following the 1st Friday of the contract month	Seller

Lean Hogs	CME	The 10th business day of the contract month	The 1st business day following the 1st Friday of the contract month	The 2nd business day following the 1st Friday of the contract month	Seller
Metals					
Copper	NYMEX	The 3rd last business day of the contract month	The last business day of the month preceding the contract month	The 1st business day of the contract month	Seller
Gold	NYMEX				
Silver	NYMEX				
Palladium	NYMEX				
Platinum	NYMEX				

Notes: Pork bellies futures was delisted in July 2011. Lean hogs futures switched to cash-settled in February 1997. NYMEX: The New York Mercantile Exchange, CBOT: The Chicago Board of Trade, MGEX: The Minneapolis Grain Exchange, ICE: The Intercontinental Exchange, CME: The Chicago Mercantile Exchange

Table 2. Factors associated with the change in spread during the last 35 days of trading

	(1)	(2)	(3)	(3)
Intercept	0.9e-4***	-0.7e-4	-0.6e-4	2.0e-4**
	[2.71]	[-1.00]	[-0.91]	[2.11]
ΔlogOI	-4.2e-4***	-3.9e-4***	-3.8e-4***	-5.7e-4***
	[-3.34]	[-3.28]	[-3.27]	[-2.78]
TTM				-0.2e-4***
				[-4.97]
TTMxΔlogOI				0.6e-4***
				[2.97]
D(initiated by sellers)		0.9e-4**		
		[2.00]		
D(early notice)			0.9e-4***	1.6e-4***
			[2.63]	[3.44]
D(2007-2021)		-0.2e-4	-0.2e-4	0.3e-5
		[-0.58]	[-0.59]	[0.13]
D(backwardation)		-0.2e-4	-0.2e-4	-0.3e-4
		[-0.48]	[-0.46]	[-0.69]
Lagged dependent variable	2.6e-3*	2.6e-3*	2.6e-3*	2.4e-3*
	[1.93]	[1.89]	[1.89]	[1.75]
Control for sector	No	Yes	Yes	Yes
Control for delivery month	No	Yes	Yes	Yes

Notes: Dependent variable is the daily change in log(spread), where the spread is defined between the nearby and first deferred contracts according to Equation (1). Explanatory variables include the time to maturity (TTM) for the nearby contract, which ranges from 34 to 1 days before expiration, daily change in log open interest of the nearby contract (ΔlogOI), dummy for commodities whose first notice day falls before the last trading day (D(early notice)), dummy for markets where delivery can be initiated by sellers only (D(initiated by sellers)), dummy for the electronic trading period (D(2007-2021)), dummy for backwardation markets (D(backwardation)), dummies for commodity sectors, dummies for maturity months, and the lagged dependent variable. Backwardation is defined when the nearby price is below the first deferred price on day 35. The t statistics shown in square brackets are based on the standard errors clustered by commodity and maturity month. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.