Was Allen Paul Right? Liquidation Bias in Commodity Futures Markets

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Abstract: *This study examines liquidation bias—the systematic rise in nearby commodity futures prices relative to deferred contracts before expiration—using 27 U.S. commodity futures contracts from 1990-2021. We find spreads increase 0.65% over the final 15 trading days, with strongest effects in grains (0.94%) and livestock (1.75%). The phenomenon persists across market conditions and changes in trading technology, suggesting it is driven by contract design. We argue that delivery options are the primary driver, particularly in markets with seller-only delivery initiation. These findings highlight important trade-offs in futures contract design and demonstrate how embedded options systematically affect commodity futures pricing, with implications for analyzing hedging effectiveness and market efficiency.*

Keywords: bias, commodity, futures, delivery, spread

JEL categories: G12, G13, G14, Q02

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Introduction

One of the longest-standing controversies in the study of commodity futures markets is the existence of systematic tendencies in prices. According to the traditional "normal backwardation" theory of Keynes (1930), hedging demand for futures contracts is net short in aggregate, and as a result, the current futures price is quoted at a discount relative to the expected future 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 60 years investigates the existence of risk premiums in commodity futures prices, but with decidedly mixed results (e.g., Telser 1958; Cootner 1960; Dusak 1973; Carter, Rausser, and Schmitz 1983; Fama and French 1987; Kolb 1992; Gorton and Rouwenhorst 2006; Moran, Irwin, and Garcia 2020).

There is intriguing evidence of a systematic tendency in commodity futures prices that has not received as much attention in literature. 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, McNeill, 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 tendency uncovered in these two studies has not been investigated since the articles were published more than 30 years ago.

The purpose of this article is to revisit the question of liquidation bias in commodity futures markets using data for 27 commodities traded on U.S. exchanges from January

1990 through December 2021. The sample period begins after the end of those used by Paul (1986) and Thompson, McNeill, and Eales (1990), so our tests can be considered out-of-sample tests of liquidation bias relative to the original studies. We find that the spread between the nearby and first deferred contract prices (referred to as "the spread" if not specified otherwise) increases, on average, by 0.65% over the final 15 trading days leading up to expiration and the increase is statistically significant. This is remarkably close to what Paul originally found in grain futures markets. The pattern is consistent across contango and backwardation market conditions and before and after commodity futures markets transition to electronic trading. Importantly, we do not observe a similar increase in spreads in financial futures markets that have cash settlement rather than physical delivery. Overall, the evidence shows that liquidation bias is present in a broad cross-section of commodity futures markets during recent periods.

We argue that the most likely explanation for liquidation bias is the location, quality, and timing options that are embedded in the delivery systems of commodity futures markets (e.g., Chance and Hemler 1993). More specifically, the increase in the nearby spread is consistent with the value of delivery options decaying non-linearly leading up to and including the delivery period. We take advantage of the fact that some of the markets in our sample allow shorts or longs to exercise delivery options. If delivery options drive liquidation bias, then markets with dual delivery exercise rights should not show evidence of increasing or decreasing spreads, whereas markets where shorts control the rights should show evidence of increasing spreads. This is precisely what we find. In sum, a compelling explanation for the liquidation bias first observed by Paul (1986) is the resolution of uncertainty that drives the value of delivery options.

Data and Measurement of Spreads

We analyze 27 US-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.[2] All the commodify futures are physically settled except the lean hog contract, which switched

[2] See Appendix A for detailed contract specifications.

from physical delivery of live animals to cash settlement on a lean carcass basis 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). We obtain daily settlement prices from *barchart.com*.

Following Paul (1986) and Thompson, McNeill, and Eales (1990), 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,

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

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 ratio between the nearby and first deferred contract prices, multiplied by 100 and 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.

Our analysis follows a financial event study methodology, where the event is the last 35 trading days for a futures contract. In such studies, abnormal return during an event is defined as the raw return minus the expected return derived from a multi-factor model. The abnormal return isolates the effects of the event on market prices. For instance, Henderson, Pearson and Wang (2015) use 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 are likely 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), so we assume the expected return equals zero. This assumption 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. To summarize, in the presence of liquidation bias, we expect average spreads to deviate from 100 as maturity approaches. Otherwise, average spreads should remain relatively unchanged during the 35-day event window.

Tests of Liquidation Bias

Figure 1 shows 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. The average spread remains stable from days 35 to 15 prior to expiration. From day 15, the average spread starts 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. On average, spreads increased by 0.65% over the final 15 trading days and the increase is statistically significant. The average change is remarkably close to what Paul (1986) originally found in grain futures markets. As noted earlier, he found that the spread over the last 15 days of trading between the 1920s and the early 1980s increased between 0.25% and 0.75%. Hence, we find that Paul's liquidation bias, discovered in selected markets nearly forty years ago, persists across a broader cross-section of commodity futures markets and in more recent periods.

To demonstrate that the increasing spread is primarily due to an increase in the price of the nearby contract, Figure 2 shows the average price of the nearby and first deferred contracts during the last 35 trading days.[3] Both prices remain nearly constant until day 15 and then tend to rise thereafter. However, nearby prices increase to a much larger extent than first deferred prices and the increase in nearby prices is statistically significant, whereas the increase in first deferred prices is not. As an additional check, we calculate

[3] 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.

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 demonstrates that 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. Collectively, Figures 2 and 3 suggest that the increasing spread is almost exclusively driven by an increase in the nearby price. These findings support the hypothesis that if a liquidation bias exists, it should be reflected as an increase in the nearby contract price.

We also investigate whether the increasing spread is consistent across different maturity months and commodity sectors. Figure 4 shows the average spread 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 maturity months, implying that the liquidation bias is a widespread phenomenon.

Figure 5 illustrates that the average spreads for grains, softs, and metals exhibit a similar increasing trend from days 15 to 1, albeit at varying magnitudes. The average spreads for livestock begin to rise earlier, around day 30 before expiration. On average, the spreads increase over the 35-day event window by 0.94% for grains, 1.75% for livestock, 0.30% for metals, and 0.58% for softs. The increases are statistically significant in each of these four commodity sectors. In contrast, the average spreads for energy commodities decline from days 20 to 7, after which they climb, reaching positive values on days 2 and 1. Over the 35 days, spreads in energy markets increased on net only 0.14% and this increase is not statistically significant. Energies are an exception to the general tendency of commodity futures markets to exhibit a liquidation bias.

We consider several robustness checks. First, 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 of the last century (Irwin and Sanders 2012). Electronic trading has sharply reduced the costs of trading and made commodity futures markets more accessible. Figure 6 shows average spreads for 1990-2006 and 2007-2021, corresponding to the pit and electronic trading eras. In both periods, the average spreads exhibit an increasing trend during the last 10 trading days, although the spreads start to rise earlier and reach a slightly lower peak on day 1 during the electronic trading period. On average, the spreads increased by 0.66% during the pit trading era and 0.53% in the electronic era. Both changes remain statistically significant. These results suggest that liquidation bias is consistent throughout the sample period and is not related to the trading mechanism used in commodity futures markets.

Second, we investigate whether liquidation bias varies with a key indicator of market conditions in storable commodity markets—the cost of carry. 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 defined as in backwardation. Figure 7 presents the average spread between the nearby and first deferred contracts in contango and backwardation market conditions. While the increase in the spread initially lags under backwardation conditions, spreads under both contango and backwardation eventually end up at essentially the same level by contract expiration. The increase is statistically significant starting on day 20 under contango and on day 4 under backwardation. The difference in spread patterns between contango and backwardation likely reflects the impact of the cost of carry on traders' delivery strategies. Nonetheless, there is clear evidence of liquidation bias under both contango and backwardation.

Third, we compare the spread between the nearby and first deferred contracts for our sample of 27 commodity futures markets and 10 financial futures during the last 35 days of trading. The financial futures markets include the S&P 500 Index, Dow Jones Industrial Index, NASDAQ 100 Index/E-mini, FTSE 100 Index, NIKKEI 225 Index, Hang Seng Index, Federal Funds/30-day, U.S. Treasury Bill/3-month, Eurodollar/3-month, and S&P GSCI Commodity Index.[4] Unlike commodity futures, the average spreads for financial futures shown in Figure 8 exhibit little to no variation throughout the 35-day period. Since the commodity futures contracts included in our sample are physically delivered (except for lean hogs after February 1997) and the financial futures are cash-settled, the results suggest that the liquidation bias is related to the physical delivery features of commodity futures contracts.

Fourth, we examine the spread for the lean hog futures contract before and after the switch from physical delivery to cash settlement in February 1997. As expected, Figure 9 indicates that the average spread for an individual market is more variable than the average across all 27 commodity futures markets. Nonetheless, the upward movement in the spread is larger and more consistent during the physical delivery period for hog futures. In addition, the average spread for the physical settled period is statistically significant each of the last eight trading days. Only one of the average spreads is statistically significant for the cash settled period, and this occurred early in the event window. Once again, this evidence points towards physical delivery as the source of the liquidation bias.

Explaining Liquidation Bias

Before exploring physical delivery and liquidation bias, we consider two other possible explanations. As Paul (1986) pointed out, liquidation bias may appear to be consistent with a classic Keynesian risk premium in the sense that nearby futures prices tend to increase over the life of a contract. However, the increase is only evident during the last 15 days of the nearby contract, whereas a Keynesian risk premium should be observable throughout the life of a contract. It is difficult to construct a theory of normal backwardation that is only resolved during the delivery period. Furthermore, a Keynesian risk premium should be evident in both nearby and deferred futures contracts, and it is not. A Keynesian premium should also occur in both commodity and financial futures

[4] See Appendix B for detailed contract specifications.

contracts, which we do not find to be the case. These differences imply that the behavior of liquidation bias is inconsistent with a classic Keynesian risk premium.

A second possible explanation is market manipulation in the form of corners and squeezes (e.g., Pirrong 2017). In a standard short manipulation, a trader or group of traders acquires market power by building up a large, long position in futures and the cash market at delivery locations. Once they have cornered the market, the trader or group of traders can use their market power to squeeze the shorts in the market and force prices during the delivery period to be much higher than otherwise would be the case. While market manipulation may produce price movements for a single nearby contract that resembles a liquidation bias, we agree with Paul (1986) that it is difficult to imagine such manipulation occurring frequently enough and across a wide enough cross-section of markets to explain the observed bias. Evidence for the consistency of liquidation bias is presented in Table 1, which shows the average change and proportion of positive changes over the last 10 trading days for the individual futures markets in our sample. The average change is positive for all 27 markets over the last 10 days, and the change is statistically significant in 22 out of the 27 markets. The proportion of positive changes is greater than 50% in all 27 markets and the average proportion across markets is 69%. In grains, the average proportion of positive changes is nearly 80%. If one also considers the difficulty of sustaining manipulations due to longs moving additional supplies into deliverable position, it is clear that manipulation does not explain liquidation bias.

Delivery options provide an explanation that is broadly consistent with the persistence and magnitude of liquidation bias in commodity futures markets. Futures contracts with physical delivery have embedded location, quality, and timing options (e.g., Chance and Hemler 1993). These options are written into contract specifications to provide flexibility to participants in the delivery process. In addition, the options play an important role in expanding the deliverable supply of a commodity, which is a deterrent to market manipulation. For example, the delivery territory for the CME corn and soybean futures contracts starts in Chicago, runs the length of the Illinois river, and ends on the Mississippi River in St. Louis (Garcia, Irwin, and Smith 2015). Generally, the short in the delivery process controls the exercise of these options. If the options are valuable, then the short is willing to pay a fair market price for the options. However, the options are not directly traded in the market, so they must be bid into the futures price. For example, longs (traders who may take delivery) are willing to pay less to buy the commodity through futures because of the possibility that the commodity may be delivered to an inconvenient location. As the delivery period approaches, it becomes clear where delivery would take place and uncertainty about delivery terms is resolved, causing the nearby futures price to increase as the option price goes to zero.

It should be noted that we are not the first to propose this explanation for liquidation bias. In his classic 1954 article on the role of hedging in wheat futures markets, Holbrook Working stated (p.7) that, "Multiplicity of deliverable classes of a commodity, as for Chicago wheat, creates a sort of bias in favor of hedgers of stocks (short hedgers) and against hedgers of forward orders (long hedgers)." Although Working did not formally estimate liquidation bias in grain futures markets, he was clearly was aware of its existence and the likely source.[5]

Simulation results presented in Silk (1988) demonstrate more precisely how location and timing options impact futures prices. Figure 10 is reproduced from his work and it shows simulation estimates of the value of either a location or quality option for a hypothetical wheat futures contract, with model parameters calibrated to actual cash and futures prices.[6] The delivery option value starts at 0.40% on day 30 before expiration, declines

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[5] In his original study of liquidation bias, Paul (1986) came close to identifying delivery options as the driving force. He noted on p. 319 that, "A fourth possible explanation is quite different from the three discussed to this point. It essentially rests on a provision in most commodity futures contracts that gives the shorts the right to select a particular day in the delivery period in which to deliver." He is obviously discussing the timing delivery option here. But he proposes that this privilege results in expiring futures prices behaving as spot prices with respect to the cost-of-carry, rather than a direct reflection of the value of the timing option on expiring futures prices. It does not appear that Paul was familiar with the emerging literature on delivery options in the 1980s.

[6] See Table 3.1 on p. 37 in Silk (1988).

relatively slowly to 0.28% by day 15, and then decays rapidly towards zero at the end of the delivery period. This non-linear decay in value relative to time-to-maturity is a well-known property of option values. The decay is also consistent with the non-linear pattern of spread changes shown earlier in Figure 1. More specifically, the increase in the nearby spread is consistent with the value of delivery options decaying non-linearly leading up to and including the delivery period, which in turn reflects the nearby futures price increasing relative to the first deferred futures price. These findings are consistent with Smith (2005), who found that up to half the variation in nearby corn futures prices is unrelated to deferred contract prices during the last month of trading. In sum, a compelling explanation for the liquidation bias first observed by Paul (1986) is the resolution of uncertainty that drives the value of delivery options. Finally, it is interesting to note that the magnitude of the delivery option values simulated by Silk are comparable to the changes in the spread estimated in this study.

While the exercise of delivery options is controlled by shorts in most commodity futures markets, this is not universally the case. As documented in Appendix A, 23 of the 27 markets included in our sample allow only sellers to initiate delivery, while in four 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.[7] These differences provide a natural experiment to directly test the hypothesis that delivery options explain liquidation bias. If delivery options drive liquidation bias, then markets with dual delivery exercise rights (shorts or longs) should not show evidence of increasing or decreasing spreads, whereas markets where shorts control the rights should show evidence of increasing spreads.

Figure 11 presents the nearby spreads for markets in our sample with seller versus dual exercise delivery rights. The average spreads in seller-initiated markets show a marked increase from day 20, while in the four energy markets spreads begin to fall starting on day 20, remain negative until day 5, and then approach zero in the final trading days. It

[7] The New York Mercantile Exchange (NYMEX) is now owned by the CME Group Inc.

is not obvious why the average spread for the four energy markets declines by a statistically significant amount between days 22 and 5 before returning to the level prevailing earlier in the event window. It appears that during this window delivery options are more advantageous for longs, and consequently the nearby spread declines to reflect this value. In energy futures markets, where delivery can be initiated by either party, the clearing house allocates notices of intention to deliver and notices of intention to accept delivery by matching the size of positions whenever possible. It may be that this matching process is more advantageous to longs. More detailed information on the delivery specifications in energy futures markets is needed to explain this anomalous pattern. Nevertheless, these results generally align with the hypothesis that liquidation bias is driven by delivery options.

A few studies have attempted to estimate the value of delivery options in commodity futures markets using option pricing methods (Gay and Manaster 1984; Pirrong, Kormendi and Meguire 1994; Hranaiova, Jarrow and Tomek 2005). Estimated values range widely from as little as 0.04% to as much as 5.2% of spot or futures prices. It is not surprising that estimates range so widely given the paucity of accurate spot price data in delivery locations. Public spot price data is often unavailable for all delivery locations, and when available it is typically a bid price rather than a transaction price.

The results of our study provide an alternative estimate of the value of delivery options for a broad cross-section of commodity futures markets over multiple decades. From this perspective, the spread results earlier in Figure 5 indicate that the average value of delivery options is 0.14% of nearby futures prices for energies, 0.94% for grains, 1.75% for livestock, 0.30% for metals, and 0.58% for softs. These are economically significant values. For example, futures prices for soybeans and live cattle have recently been near $10 per bushel and $220 per hundredweight, respectively. Using sector averages, delivery options would be valued at 9.4 cents per bushel for soybeans and $3.90 per hundredweight for cattle. It is important to emphasize that these values are unlikely to represent arbitrage opportunities for futures traders. More likely, they represent the rational market value of delivery options embedded in contract specifications.

Conclusions

This study provides compelling evidence that liquidation bias—the systematic tendency for nearby commodity futures prices to rise relative to deferred contract prices during the final weeks before expiration—persists across a broad cross-section of U.S. commodity markets. Using data from 27 physically delivered commodity futures contracts spanning 1990 through 2021, we find that spreads between nearby and first deferred contracts increase by an average of 0.65% over the final 15 trading days, a result that is both statistically and economically significant. This finding corroborates Paul's (1986) original discovery in commodity futures markets, demonstrating the robustness and persistence of this market phenomenon.

The consistency of liquidation bias across different market conditions and technological changes is noteworthy. The phenomenon persists during both contango and backwardation market conditions and survives the transition from pit trading to electronic trading platforms. This consistency suggests that liquidation bias reflects fundamental features of commodity futures contract design.

Our analysis provides strong evidence that delivery options embedded in commodity futures contracts offer the most plausible explanation for liquidation bias. The non-linear decay in option values as expiration approaches aligns closely with the observed pattern of spread increases. Most tellingly, we find that markets where only sellers can initiate delivery exhibit the classic liquidation bias pattern, while markets allowing dual delivery initiation exhibit markedly different behavior. This natural experiment strengthens the case that delivery option dynamics drive the observed price patterns.

The sector-specific results reveal important heterogeneity in liquidation bias across commodity groups. Grains and livestock futures markets show the strongest effects, with average spread increases of 0.94% and 1.75% respectively over the final 15 trading days. These sectors typically feature complex delivery specifications with multiple location and quality options, consistent with our delivery option hypothesis. In contrast, energy futures markets show minimal bias, likely reflecting their unique dual-exercise delivery mechanisms.

From a policy perspective, our findings highlight the importance of delivery specifications in futures contract design. While delivery options serve valuable economic functions—facilitating deliverable supply and deterring manipulation—they also create systematic pricing effects that market participants must navigate. Exchanges and regulators should consider these trade-offs when designing new contracts or modifying existing specifications.

For academic researchers, delivery options represent a robust phenomenon that theoretical and empirical research should accommodate. For example, most regression models of optimal hedging do not account for delivery options. This may lead to lower hedging effectiveness because futures and spot prices do not track as closely as predicted due to the presence of delivery options (Chance and Hemler 1993). Likewise, failure to account for delivery options may lead to spurious conclusions about market efficiency. What appears to be robust arbitrage profits may disappear after delivery options are considered (Kamara 1990). Similar problems may confound tests for risk premiums in commodity futures prices.

Since the impact of delivery options generally is only realized in the last 15 days before contract expiration, switching ("rolling over") contracts before the last 15 days of trading may be a practical strategy for avoiding the most serious of the previous problems in research on futures prices. It also underscores the conventional wisdom to avoid the delivery period in research on futures markets if possible. Paul (1986, p. 321) concluded his study by stating, "…it is prudent practice in most studies of futures price behavior to exclude delivery month prices from the analyses…" Our results indicate that in addition to delivery month prices, prices at least one to two weeks before the delivery month begins should be excluded.

In sum, our research contributes to a broader understanding of how contract design features influence futures prices. The delivery option mechanism we identify may have applications beyond commodity markets, potentially explaining pricing anomalies in other derivative instruments with embedded delivery optionality. As commodity markets continue to evolve, particularly with growing interest in environmental and nontraditional markets, the fundamental role of delivery mechanisms in price formation remains a critical area for ongoing research and policy attention.

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Appendix A. Contract specifications of physical delivery commodity futures

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 Gold Silver Palladium Platinum	NYMEX NYMEX NYMEX NYMEX 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

Appendix B. Contract specifications of cash-settled financial futures

Futures	Exchange	Maturity	Expiration	Start Date
S&P 500 Index	CME	March, June, September, December	The 3rd Friday of the contract month	April 1982
Dow Jones Industrial Index	CBOT	March, June, September, December	The 3rd Friday of the contract month	October 1997
NASDAQ 100 Index, E-mini	CME	March, June, September, December	The 3rd Friday of the contract month	June 1999
FTSE 100 Index	ICE Futures Europe	March, June, September, December	The 3rd Friday of the contract month	May 1985
NIKKEI 225 Index	CME	March, June, September, December	Thursday preceding the 2nd Friday of the contract month	September 1990
Hang Seng Index	HKFE	All months	The 2nd last business day of the contract month	August 1987
Federal Funds / 30-day	CBOT	All months	The last business day of the contract month	October 1988
Treasury Bill, U.S., 3-month	CME	March, June, September, December	Monday preceding the 3rd Wednesday of the contract month.	January 1976
Eurodollar, 3-month	CME	All months	The 2nd business day preceding the 3rd Wednesday of the contract month	December 1981
S&P GSCI Commodity Index	CME	All months	The11th business day of the contract month	July 1992

Figures and Tables

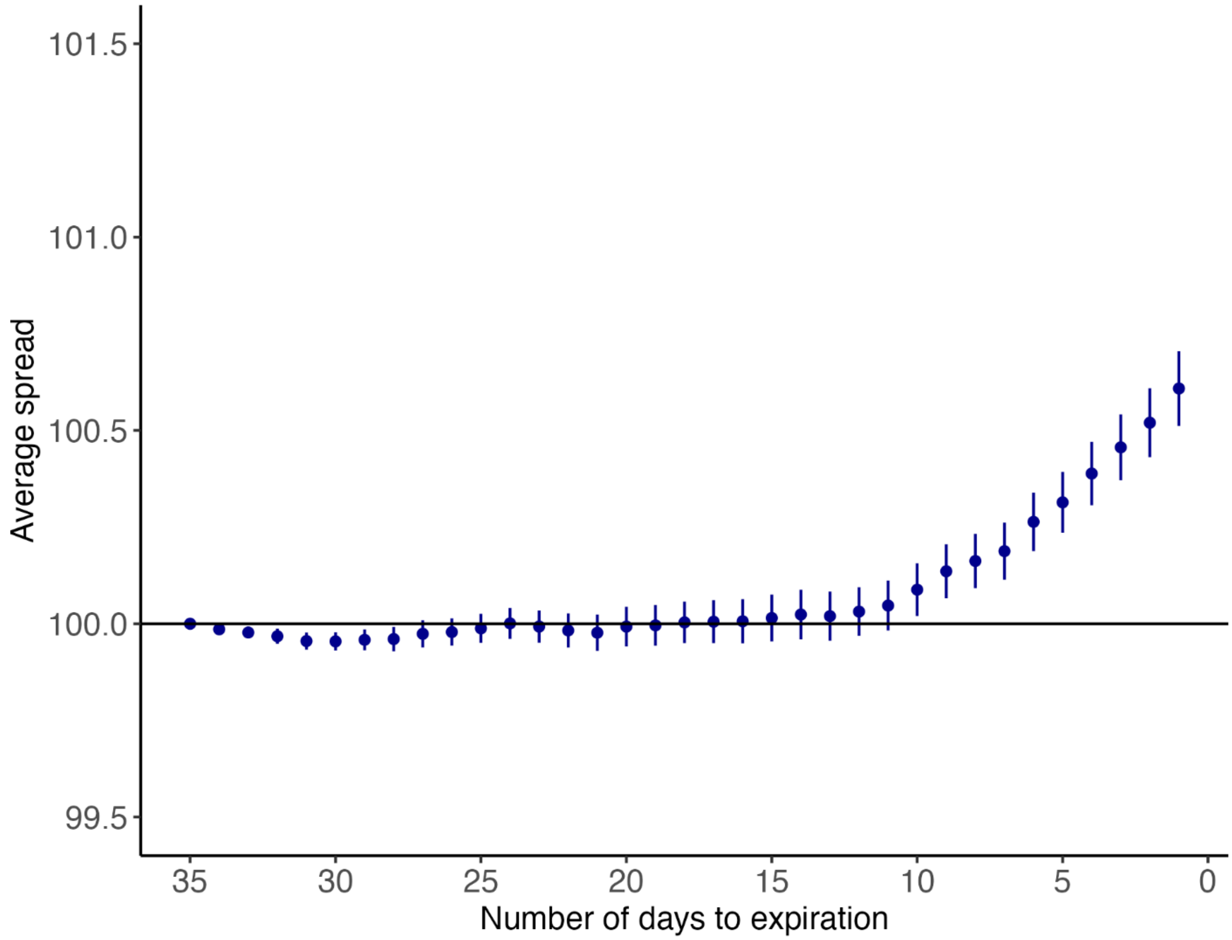

Figure 1. Average spreads between the nearby and first deferred contracts during the last 35 days of trading in commodity futures markets

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 for all commodities. The sample consists of 27 physically settled commodity futures for 1990-2021. Error bars indicate 95% confidence intervals.

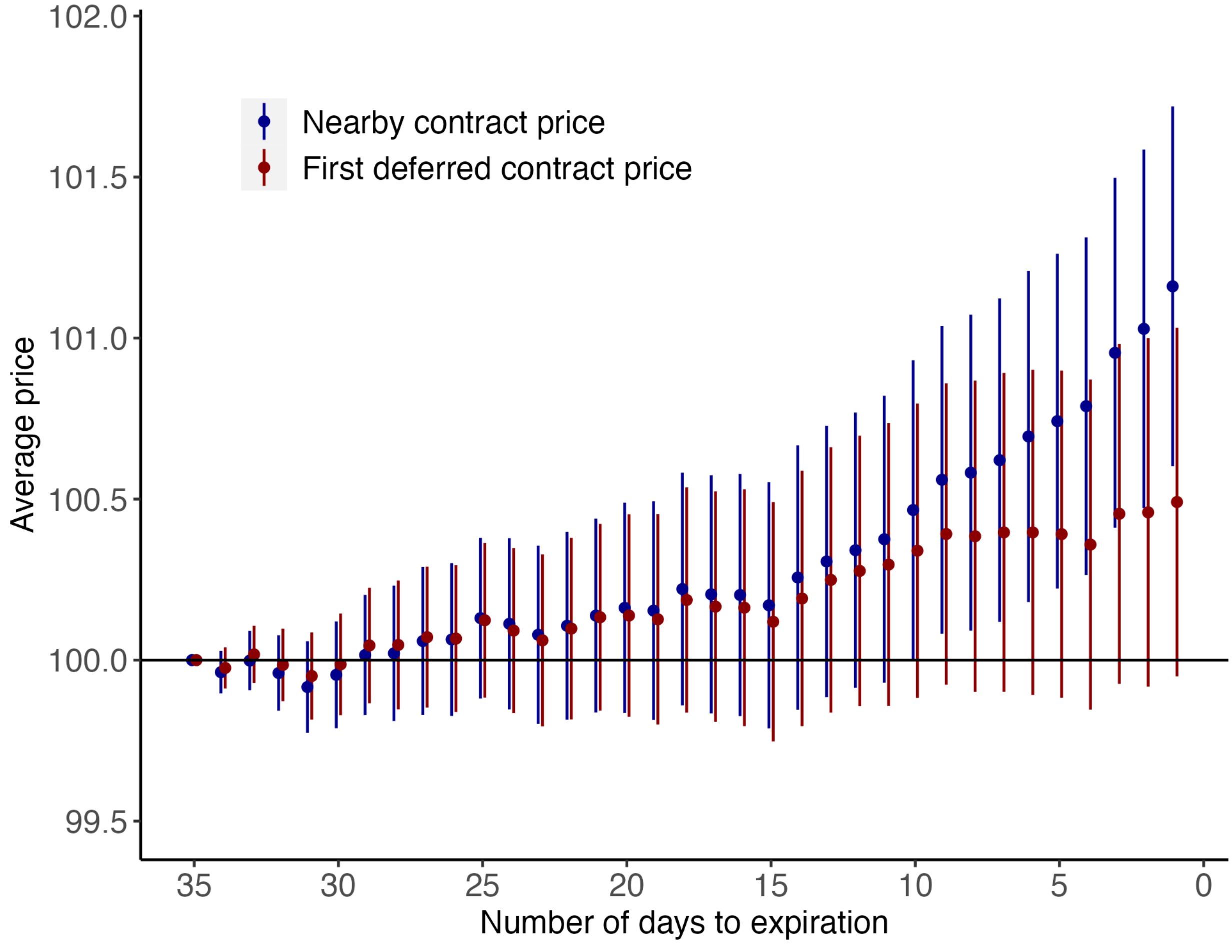

Figure 2. Average prices of the nearby and first deferred contracts during the last 35 days of trading in commodity futures markets

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.

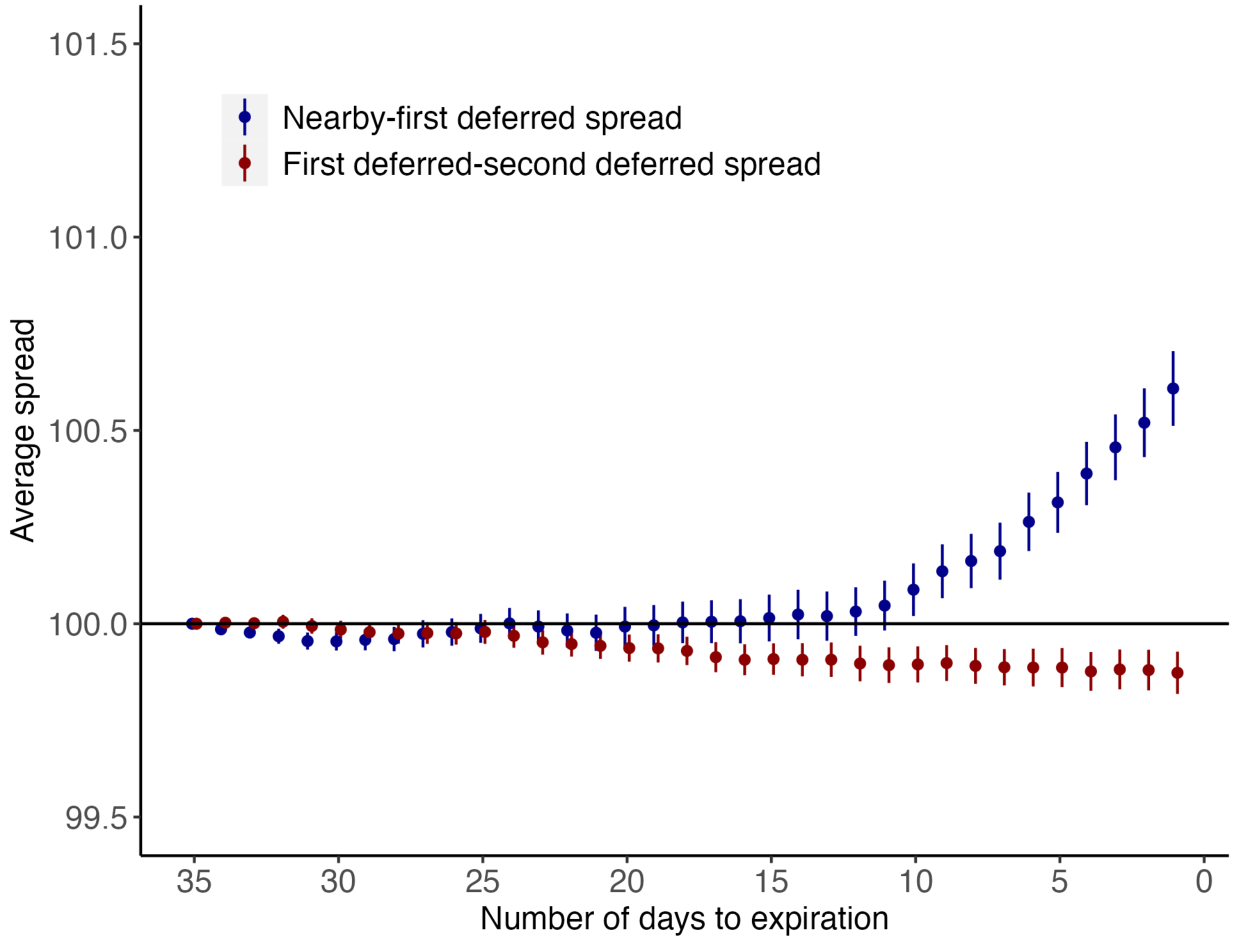

Figure 3. Average spreads between the first and second deferred contracts during the last 35 days of trading of the nearby contract in commodity futures markets

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.

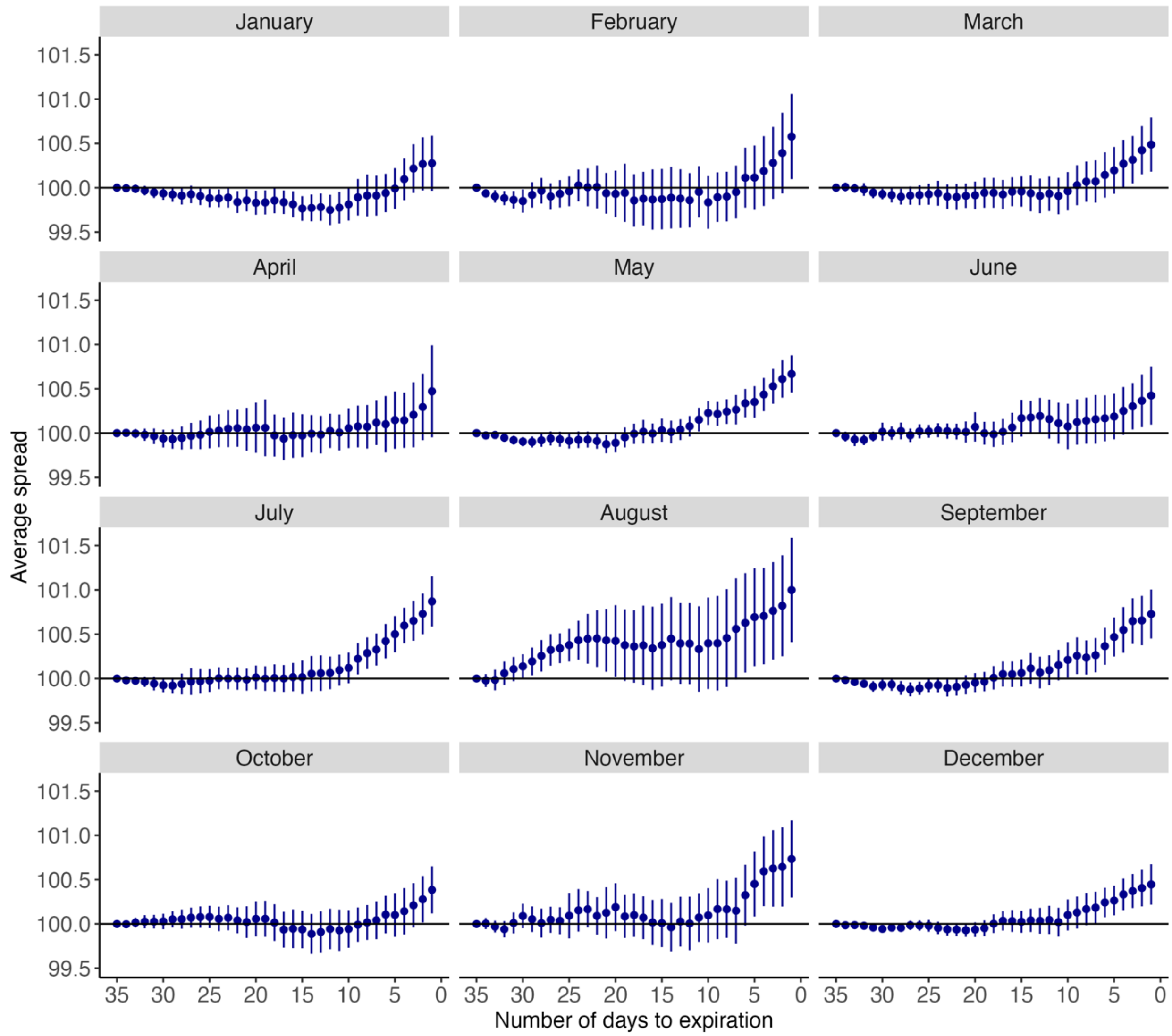

Figure 4. Average spreads between the nearby and first deferred contracts during the last 35 days of trading for commodity futures markets in each maturity month

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.

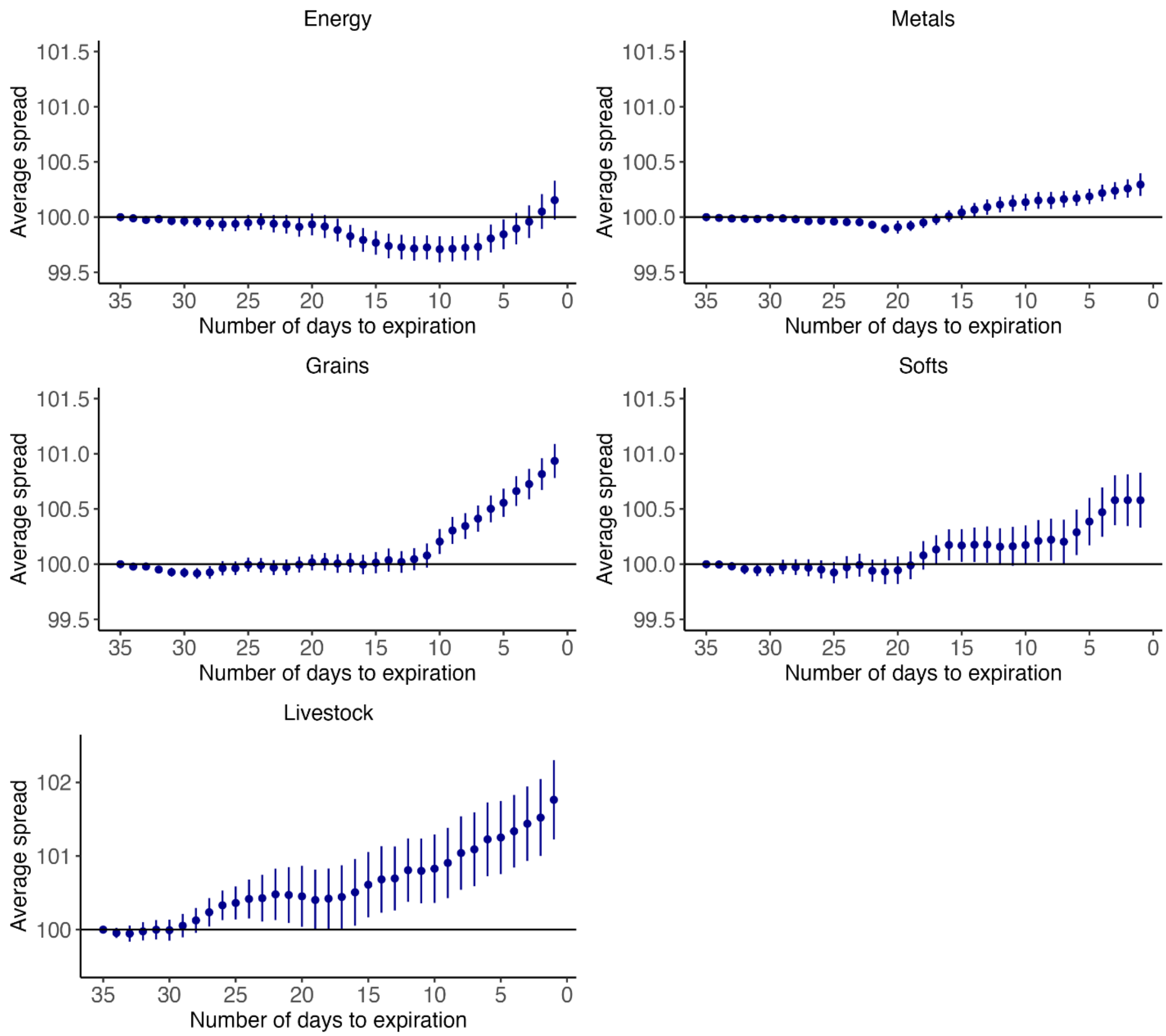

Figure 5. Average spreads between the nearby and first deferred contracts during the last 35 days of trading in commodity futures markets by sector

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.

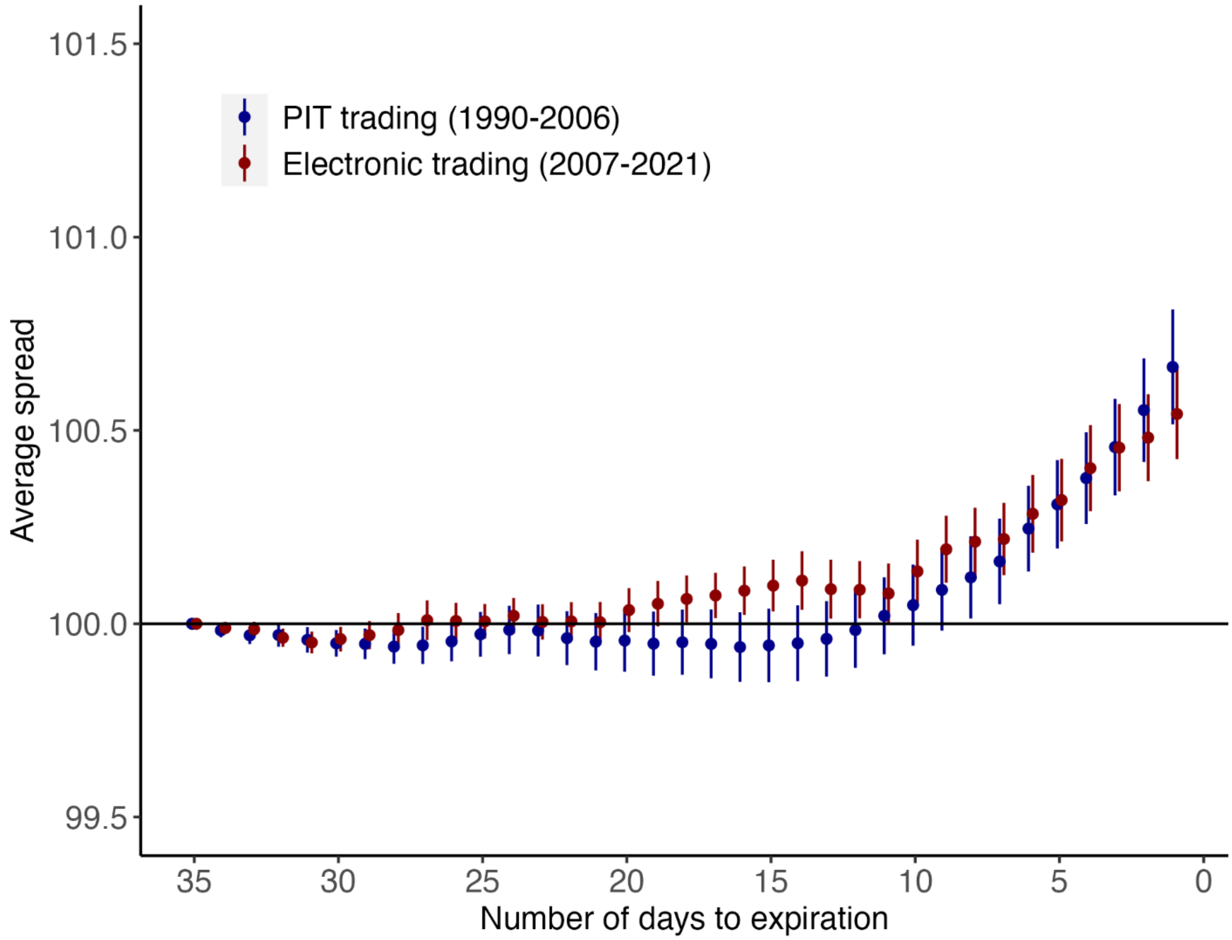

Figure 6. Average spreads between the nearby and first deferred contracts during the last 35 days of trading in commodity futures markets by pit trading and electronic trading periods

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.

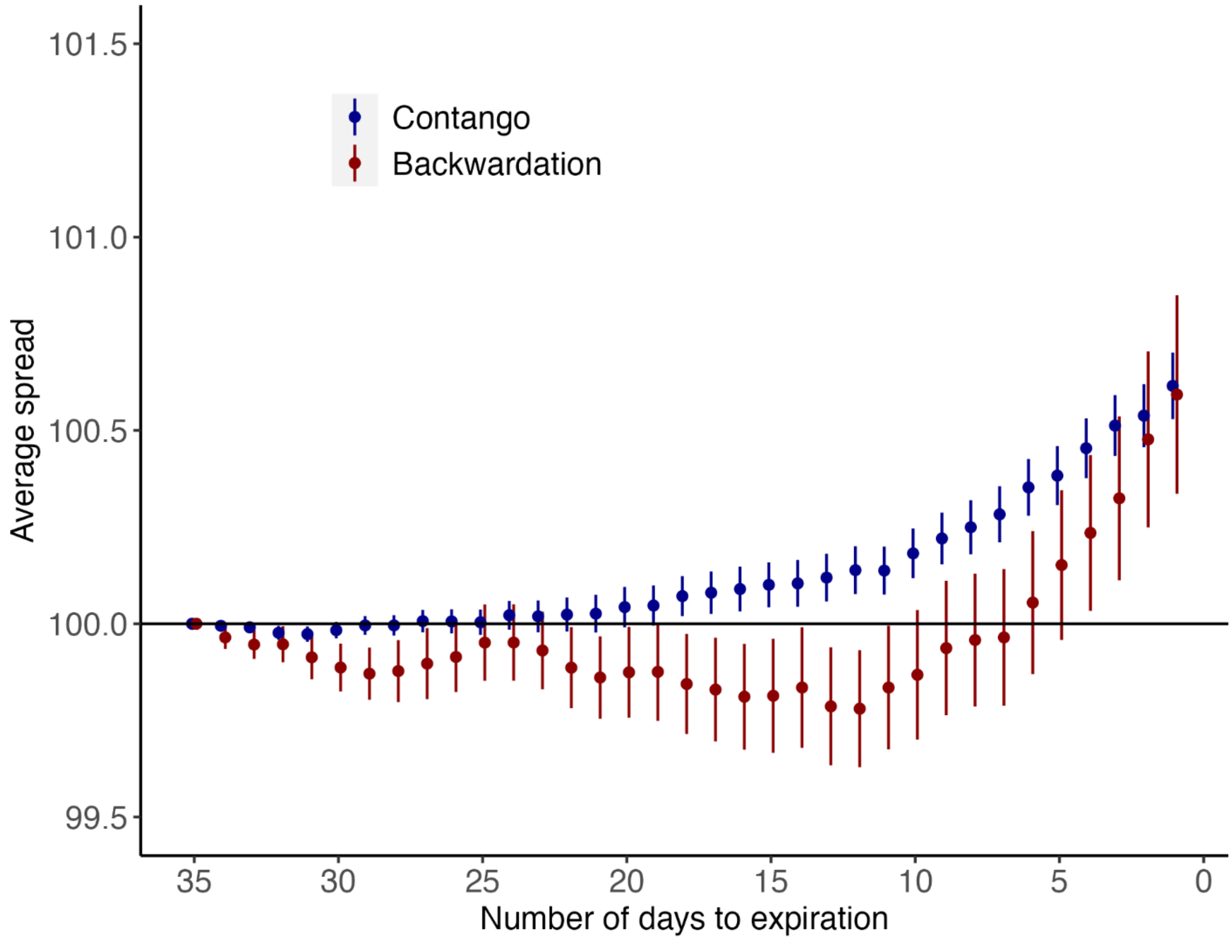

Figure 7. Average spreads between the nearby and first deferred contracts during the last 35 days of trading in commodity futures markets by contango and backwardation conditions

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.

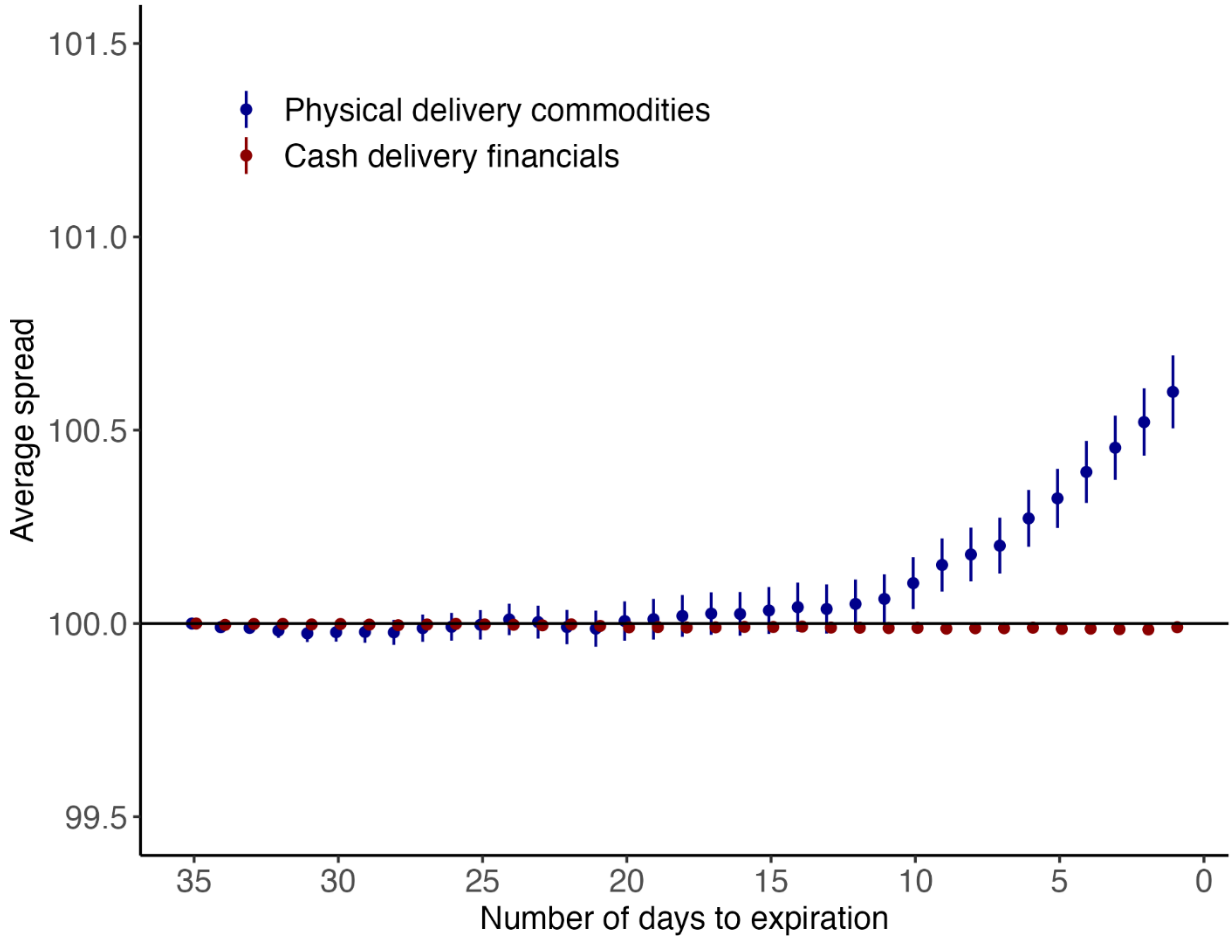

Figure 8. Average spreads between the nearby and first deferred contracts during the last 35 days of trading in commodity futures and financial futures markets

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 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 the S&P 500 Index, Dow Jones Industrial Index, NASDAQ 100 Index/E-mini, FTSE 100 Index, NIKKEI 225 Index, Hang Seng Index, Federal Funds/30-day, U.S. Treasury Bill/3-month, Eurodollar/3-month, and S&P GSCI Commodity Index.

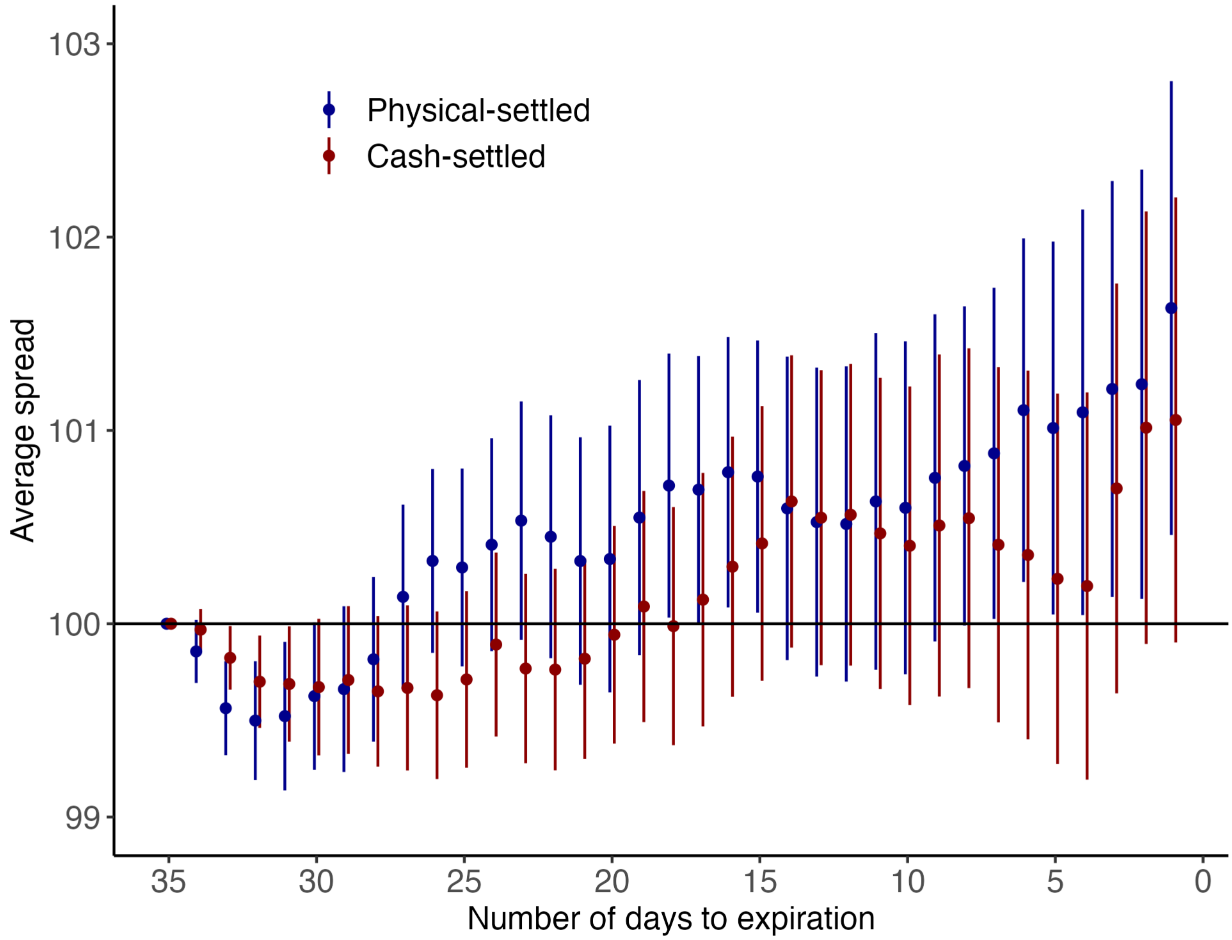

Figure 9. Average spreads between the nearby and first deferred contracts during the last 35 days of trading for the lean hog futures market

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. The live hog contract changed from physical delivery of live animals to cash settlement on a lean carcass basis starting in February 1997. Error bars indicate 95% confidence intervals.

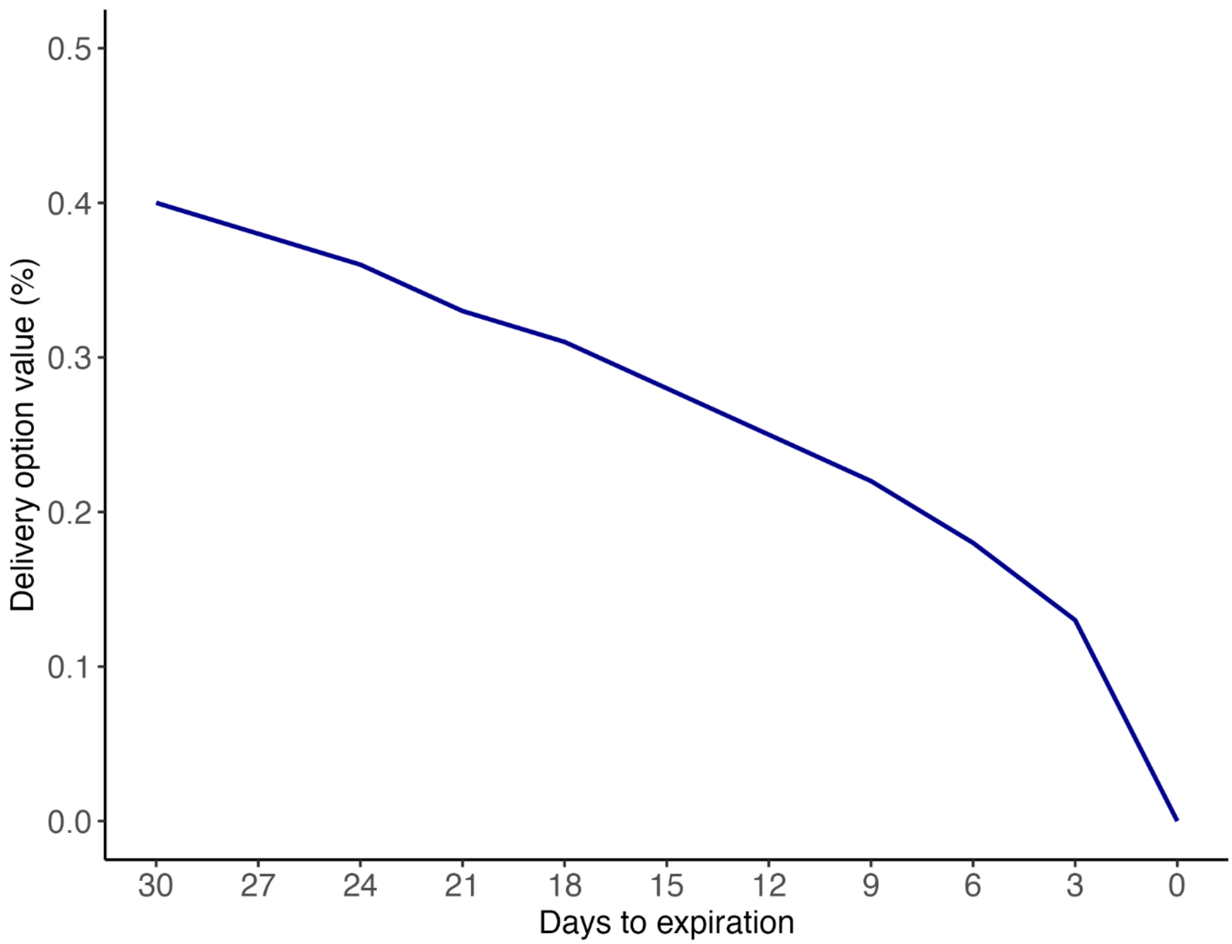

Figure 10. Simulated value of quality or location delivery options versus time-to-maturity for a hypothetical wheat futures market

Notes: The value of the delivery option is defined as a percentage of the expiring nearby wheat futures price. The source for the simulation values is Table 3.1 on p. 37 of Silk (1988). See the discussion of these results in Silk for the specific parameters used in the simulation.

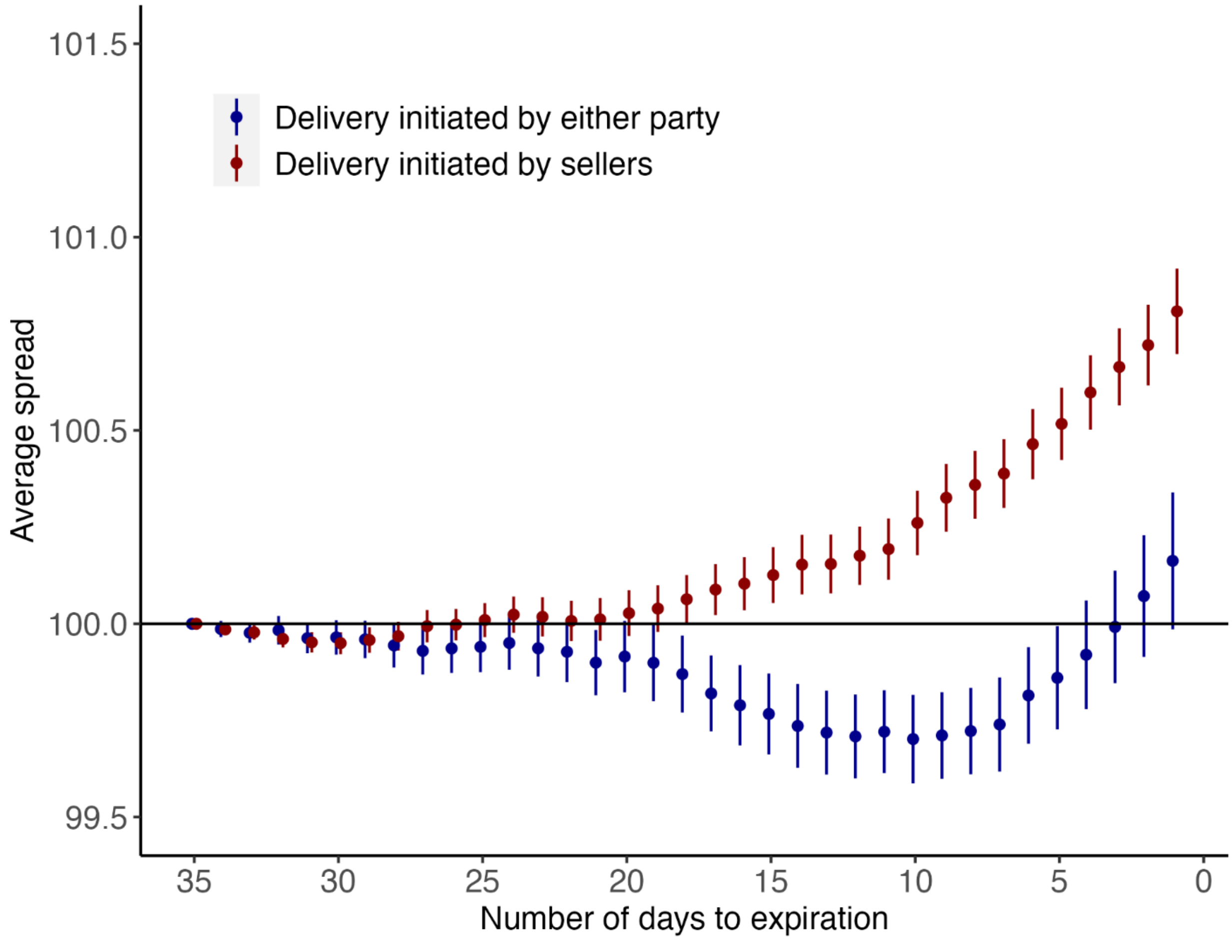

Figure 11. Average spreads between the nearby and first deferred contracts during the last 35 days of trading for commodity futures markets by seller-initiated and seller-or-buyer-initiated delivery

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.

Table 1. Average change in spreads and proportion of positive values during the last 10 days of trading in commodity futures markets

	Commodity	N	Mean	Std. Err.	p-value	Proportion Positive	p-value
Energy	Crude Oil, WTI	381	0.057	0.076	0.453	0.525	0.356
	NY Harbor ULSD	383	0.337	0.106	0.002	0.601	0.000
	RBOB Gasoline	383	0.539	0.103	0.000	0.627	0.000
	Natural Gas	376	0.783	0.182	0.000	0.614	0.000
Grains	Corn	159	0.982	0.132	0.000	0.818	0.000
	Soybeans	223	0.667	0.107	0.000	0.803	0.000
	Soybean Oil	255	0.292	0.042	0.000	0.839	0.000
	Soybean Meal	255	0.821	0.112	0.000	0.741	0.000
	Oats	159	2.498	0.310	0.000	0.824	0.000
	Rough Rice	191	0.749	0.170	0.000	0.817	0.000
	Wheat, Chicago	159	0.797	0.112	0.000	0.811	0.000
	Wheat, Kansas	159	0.575	0.141	0.000	0.717	0.000
	Wheat, Minneapolis	159	0.785	0.204	0.000	0.667	0.000
Softs	Cocoa	159	0.036	0.103	0.728	0.553	0.204
	Coffee "C"	159	0.436	0.118	0.000	0.686	0.000
	Cotton No. 2	159	0.516	0.225	0.023	0.692	0.000
	Orange Juice	191	0.760	0.178	0.000	0.623	0.001
	Sugar #11	127	0.614	0.290	0.036	0.551	0.287
	Lumber	191	0.164	0.327	0.617	0.508	0.885
Livestock	Live Cattle	191	0.681	0.128	0.000	0.717	0.000
	Pork Bellies	111	1.442	0.492	0.004	0.613	0.023
	Lean Hogs	43	1.000	0.435	0.026	0.558	0.542
Metals	Copper	159	0.162	0.077	0.038	0.629	0.002
	Gold	191	0.122	0.009	0.000	0.921	0.000
	Silver	159	0.144	0.010	0.000	0.925	0.000
	Palladium	127	0.120	0.089	0.180	0.614	0.013
	Platinum	127	0.326	0.212	0.126	0.669	0.000

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. N denotes the number of contracts. The p-value for the mean is based on a t-test for the hypothesis that the mean spread equals zero. The p-value for the proportion is based on a Chi-squared test for the hypothesis that the proportion of positive spreads equals 0.5. The sample is 1990 – 2021.