

Hedging Pressure and Commodity Option Prices

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Abstract

A new measure of hedging pressure in commodity options markets—commercial hedgers’ net short option exposure—predicts option returns and changes in the slope of implied volatility curves. Puts are more expensive, and calls are cheaper, when values of option hedging pressure are greater. This pattern is consistent with commercial traders’ natural hedging motives. A strategy that provides liquidity to hedgers earns an average excess return of 6.4% per month before transaction costs and consideration of margin requirements. Overall, our results confirm the existence of hedging premiums, demand effects, and limits to arbitrage in commodity option markets.

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Hedging provides an important economic rationale for derivatives markets. Commodity futures markets facilitate the transfer of risk from those who seek insurance against future price fluctuations to those who are willing to assume it. In the original theory of normal backwardation (Keynes, 1923; Hicks, 1939), hedgers take net short positions in the futures market to hedge their long positions in the physical commodity market. Such “hedging pressure” tends to drive down futures prices relative to expected spot prices and provides hedging premiums to counterparties such as speculators. While the literature has studied hedging pressure extensively in commodity futures markets (Rouwenhorst and Tang, 2012), it has paid comparatively much less attention to commodity option markets.

Distinct from trading futures, trading options allows commercial hedgers—primarily a combination of producers and processors—to hedge a portion of their commodity price risk while retaining others. For example, producers may buy put options to establish a minimum selling price for their output while retaining opportunities to gain from price increases. Producers may also sell calls to help offset the cost of buying these puts. Analogously, processors who take commodities as inputs may buy call options to establish a maximum purchase price and potentially sell puts in combination. The popularity of such strategies and overall trading in commodity options markets has increased over time. For instance, the options trading volume for WTI crude oil, corn, and live cattle increased by 15, 15, and 10 times from 2012 to 2019, respectively.

This paper shows hedging pressure in commodity option markets predicts option returns and confirms the existence of hedging premiums in commodity options prices. We define option hedging pressure (HPO), our key predictor variable, as commercial traders’ net short option exposure to the commodity, scaled by option open interest. Large positive values of HPO suggest that producers, who may take net short positions in options markets by buying puts, selling calls,

or both, are hedging aggressively and that they dominate net hedging demand. Large negative values suggest that commodity processors, who may take net long positions by buying calls, selling puts, or both, dominate net hedging demand. We construct HPO using data from the weekly Commodity Futures Trading Commission (CFTC) *Commitment of Traders* (COT) reports.

If a hedging premium exists in the option markets, then greater hedging pressure should positively predict the returns to providing liquidity to option hedging demand. Specifically, greater values of hedging pressure should imply that puts are expensive and/or calls are cheap compared to lower values of hedging pressure. When HPO is high, producers who buy put options should drive up put prices in the presence of frictions and limited risk-sharing capacity of speculators who take the other side (Hirshleifer, 1988), and producers who sell calls should analogously drive down call prices. Conversely, when HPO is low and negative, processors who sell put options should drive down put prices, and processors who buy call options should drive up call prices. A strategy that sells puts and buys calls in high-HPO commodities, and buys puts and sells calls in low-HPO commodities, should then earn abnormal subsequent returns since it provides liquidity to both types of hedging demand.

Our main result is that such a positive relationship holds empirically. Sorting 24 commodities by HPO since the inception of the COT report in 1995, a strategy that sells puts and buys calls earns +0.72% over one week ($t = 2.69$) in high-HPO commodities (average HPO: 23%) and -1.84% ($t = -5.91$) in low-HPO commodities (average HPO: -23%). The return of a strategy providing liquidity to hedging demand thus equals the return spread of +2.56% over one week ($t = 6.25$), cumulating to 6.41% over four weeks ($t = 5.78$). In Fama-MacBeth regressions, a one-standard-deviation increase in HPO (15%) predicts a 60 to 144 basis point increase in the long-short strategy return going from a one- to four-week horizon, magnitudes in line with portfolio sort

estimates. Robustness checks confirm that our main finding is insensitive to the controlling for several benchmark predictors, using alternative position data, and subsample splits. HPO positively predicts returns to selling puts more strongly than it does for buying calls, which further supports the hedging pressure hypothesis since margin requirements for selling puts are a significant friction for liquidity supply (Santa-Clara and Saretto, 2009). One should thus interpret our findings, particularly their large magnitudes, as reflecting an equilibrium relationship between limits to arbitrage and option pricing.

To our knowledge, this is the first study that proposes a measure of options hedging pressure and documents the existence of hedging premiums in options markets. Our findings contribute directly to the literature on hedging premiums in commodity derivatives markets, which has thus far focused on futures markets. Rockwell (1967), Dusak (1973), and Hartzmark (1987) find limited evidence supporting the existence of hedging premiums in commodity futures prices. However, recent studies find more supporting evidence. Bessembinder (1992) shows that returns in foreign currency and agricultural futures vary with the net holdings of hedgers after controlling for systematic risk. De Roon, Nijman, and Veld (2000) show that futures price premiums depend on both own-market and cross-market hedging pressures. Kang, Rouwenhorst, and Tang (2020) disentangle the short-term and long-term variation in trader position imbalances and relate long-term hedging pressure to variation in excess commodity futures returns.

Our result that hedging premiums exist in options markets complements this literature on futures hedging premiums. Furthermore, we show that futures hedging pressure and option hedging pressure are correlated: hedgers tend to adjust their futures and option positions in the same direction as their needs for hedging change over time. Nevertheless, option hedging pressure is incrementally informative about option returns.

Our work is also closely related to the literature on demand-based option pricing. Bollen and Whaley (2004) show that net buying pressure plays an important role in determining the shape of implied volatility functions for index and individual stock options. Ni, Pan, and Poteshman (2008) find that the demand for volatility trades, constructed from the trading volume of individual equity options, is informative about future option prices and that the impact is larger in the days leading up to earnings announcements. To explain these findings, Gârleanu, Pedersen, and Poteshman (2009) develop a model to show that end-users' net demand in one option contract raises its own price and the prices of other options on the same underlying when market-makers cannot perfectly hedge their inventories. Our evidence provides supporting evidence for this theory in commodity options through a new, simple measure of hedging demand.

Our paper goes as follows. Section 1 describes our data. Section 2 presents the main empirical findings on the effects of hedging pressure on option prices. Section 3 explores alternative explanations for our main result, and Section 4 provides several robustness tests. Section 5 concludes.

1. Data and Summary Statistics

1.1. Hedging Pressure in Options

Our data on option positions comes from the weekly public *Commitments of Traders* reports released by the Commodity Futures Trading Commission. The COT reports provide a breakdown of each Tuesday's open interest for futures and options on futures markets in which traders hold positions equal to or above the reporting levels established by the CFTC. The report measures positions on Tuesday, but the CFTC releases the report to the public three days later, after the market closes on Friday. The CFTC classifies a reportable trader as either "commercial" or "non-

commercial.” A commercial trader engages in business activities hedged using futures or options markets.² We follow the convention in the literature to designate commercial traders and non-commercial traders as hedgers and speculators, respectively, for our main analysis, and examine alternative classifications in a robustness check.

The COT reports have two forms: futures-only and futures-and-options-combined. The futures-and-options-combined report uses delta factors provided by the exchanges to report option positions and open interest on a futures-equivalent basis. Specifically, the report converts long call and short put positions to long futures-equivalent contracts and short call and long put positions to short futures-equivalent contracts. For example, the report converts a long put position of 500 contracts with a delta factor of -0.5 to a short futures-equivalent position of 250 contracts. The report adds together long and short futures-equivalent options positions with long and short futures positions and reports “combined long” and “combined short” positions for aggregate trader groups.

Our sample covers 24 commodities that are traded on four U.S. exchanges (The Chicago Board of Trade (CBOT), The Chicago Mercantile Exchange (CME), The Intercontinental Exchange (ICE), and The New York Mercantile Exchange (NYMEX) for the period from March 21, 1995, through December 24, 2018. While the futures-only report dated back to July 1986, the futures-and-options-combined report was first released on March 21, 1995.

We calculate hedging pressure in options (HPO) for each commodity i in week t following two steps. First, we infer hedgers’ positions in options that are long the underlying commodity, $HedgersLong_{i,t}^{option}$, by taking the futures-and-option-combined long positions of commercial traders and subtracting their futures-only long position. We analogously infer hedgers’ positions in options that are short the underlying commodity, $HedgersShort_{i,t}^{option}$. Option open interest is

² See rules at <https://www.gpo.gov/fdsys/granule/CFR-1998-title17-vol1/CFR-1998-title17-vol1-sec1-3>.

equal to futures-and-option-combined open interest minus futures-only open interest. Second, we calculate HPO as the net short option position of hedgers divided by option open interest,

$$HPO_{i,t} = \frac{HedgersShort_{i,t}^{option} - HedgersLong_{i,t}^{option}}{OpenInterest_{i,t}^{option}}, \quad (1)$$

using these values of $HedgersShort_{i,t}^{option}$, $HedgersLong_{i,t}^{option}$, and $OpenInterest_{i,t}^{option}$ constructed from the COT data.

Our hypothesis is that greater values of HPO are associated with puts that are more expensive and/or calls that are less expensive relative to lower values of HPO. For example, when HPO is large and positive, producers who take net short positions in options markets by buying puts, selling calls, or both represent the bulk of net commercial positions and are hedging aggressively. Under the hedging pressure hypothesis, these values of HPO should be associated with relatively more expensive puts and cheaper calls when compared to lower values of HPO. Conversely, when HPO is large and negative, commodity processors who take net long positions by buying calls, selling puts, or both represent the bulk of net commercial positions and are hedging aggressively. These values of HPO should be associated with cheaper puts and more expensive calls.

1.2. Commodity Option Returns

We evaluate our hypothesis by examining the relationship between HPO and option returns. The data come from *Barchart* and consist of daily settlement prices for the 24 sample commodities over the same period as the COT data. Details about the markets in which option contracts are traded, maturity months, and termination date of trading are listed in Appendix A.

We apply the following standard filters to the option universe. First, we include only standard option contracts that have the same maturity months as the underlying futures contracts. We exclude serial option contracts, which are created for months without an expiring futures contract and exercised on the next nearby futures contract, because they are thinly traded especially in the early years. Second, we eliminate option prices that violate no-arbitrage boundary conditions. Third, we discard options that have Black's (1976) implied volatilities less than 1% to minimize the influence of recording errors. Last, we remove options in the last week prior to expiration to avoid microstructure noise that may occur due to sharply lower trading volumes.

Our overall strategy is to use the panel data to test the predictive relationship between HPO and the commodity option returns in the cross-section of commodities. For each commodity, we consider the returns to a strategy that simultaneously buys calls and sells puts and delta-hedges with the underlying futures contract. The "long-short" (specifically, long-put/short-call) strategy should earn greater returns in high-HPO commodities than in low-HPO commodities in the weeks after we measure HPO.

To construct the returns to such a strategy for each commodity, we start by calculating delta-hedged returns to individual options. We follow two steps to do so: First, one option (call or put) is bought at the end of Tuesday of week t . Second, the option position is held for k weeks ($k = 1, 2, 3$, and 4) and hedged with the underlying futures contract, with the hedge ratio recomputed weekly on every Tuesday. Following Cao and Han (2013) and Ramachandran and Tayal (2021), we calculate the k -week delta-hedged option return of an option in week t as,

$$Ret_{t+k}^T = \frac{O_{t+k}^T - O_t^T - \sum_{j=1}^k \Delta_{t+j-1}^T (F_{t+j}^T - F_{t+j-1}^T)}{O_t^T} \times 100, \quad (2)$$

where O_t^T is the week t price of the option contract with a maturity date of T , F_t^T is the underlying futures price, and $\Delta_{t,t}^T$ is the hedge ratio measured by the option's delta. The same superscript T is

used in $F_{i,t}^T$ and $O_{i,t}^T$ to reflect the fact that option returns are always calculated based on the prices of the futures and option contracts that have the same maturity date. Each week, we calculate the k -week delta-hedged return for the front-month option contract and switch to the next month option contract when the front-month contract has less than k weeks until the expiration date.

We then use these individual option returns to calculate the returns of out-of-the-money (OTM) option portfolios. We focus on option portfolio returns because individual option returns may be noisy and on OTM options because of their relatively greater trading volume. We follow Bollen and Whaley (2004) to measure moneyness by the option's delta calculated based on the Black (1976) model for options on futures contracts. Specifically, the deltas of a call and a put in week t are given by:

$$\Delta_t^{Call} = e^{-r_t(T-t)} N \left[\frac{\ln(F_t^T/X) + (\sigma_t^2/2)(T-t)}{\sigma_t \sqrt{T-t}} \right], \text{ and} \quad (3)$$

$$\Delta_t^{Put} = \Delta_t^{Call} - e^{-r_t(T-t)}, \quad (4)$$

respectively, where F_t^T is the futures price, X is the option's exercise price, $T-t$ is the time remaining to the expiration of the option, r_t is the risk-free rate of interest, σ_t is the price volatility of the underlying futures contract, and $N(\cdot)$ is the normal cumulative density function. We use the 3-month Treasury bill rate for the risk-free rate. The proxy for σ_t is realized volatility, which is computed as the annualized standard deviation of daily returns of the underlying futures over the most recent 60 trading days.

We categorize an option as out-of-the-money if its absolute delta is between 0.125 and 0.375. We exclude in-the-money options and deep-out-of-the-money options with absolute deltas below 0.125 due to concerns about unreliable prices stemming from low trading volume. Appendix B provides the average Greeks (delta, gamma, and vega) for our option portfolios. In robustness

analyses, we also consider portfolios of at-the-money (ATM) options, which we define as having an absolute moneyness between 0.375 and 0.5.

Finally, we calculate the return to the long-short strategy that simultaneously buys delta-hedged OTM calls and sells delta-hedged OTM puts. Specifically, for each commodity i and week t , the k -week return to the long-short strategy equals the difference in average delta-hedged returns between OTM calls and OTM puts:

$$Ret_{i,t+k}^{long-short} = \overline{Ret}_{i,t+k}^{OTM Call} - \overline{Ret}_{i,t+k}^{OTM Put}, \quad (5)$$

where $\overline{Ret}_{i,t+k}^{OTM Call}$ and $\overline{Ret}_{i,t+k}^{OTM Put}$ are the equal-weighted average delta-hedged returns of OTM calls and OTM puts, respectively, and the return of individual options is calculated based on Equation 2.

To summarize, we test the predictive relationship between $HPO_{i,t}$ and the returns to a long call-short put strategy $Ret_{i,t+k}^{long-short}$ in the cross-section of commodities. Under the hedging pressure hypothesis, $HPO_{i,t}$ should positively predict $Ret_{i,t+k}^{long-short}$. Greater values of HPO may also be associated with a steeper implied volatility smile, and we examine this relationship in the robustness section.

1.3. Summary Statistics

Table 1 reports the summary statistics for weekly HPO for the 24 commodities. The average HPO is positive in 15 out of 24 markets and has an average of 2.13% across commodities. HPO is on average positive in the energy, precious metals, softs (except coffee and cocoa), and livestock markets and negative in the grain markets (except Chicago wheat), suggesting that the use of options by hedgers is more similar within than between sectors. The frequency of hedgers being net short in options differs substantially by market and an average of 54.9% indicates that net long

positions by hedgers are almost as common as net short positions across commodity option markets. Comparing the standard deviation to the mean indicates a large time variation in HPO within commodities. The high volatility of hedging pressure is further illustrated in Figure 1, which shows the weekly times series of HPO for WTI crude oil, gold, copper, corn, coffee, and live cattle from March 21, 1995 to December 24, 2018.

Table 1 also provides the summary statistics for the weekly long-short delta-hedged strategy return. The average strategy return across commodities equals -0.58% and is negative in 18 out of 24 markets. The percentage of positive returns is less than 50% in all markets except Chicago wheat and live cattle. Nevertheless, there is significant variation in average returns across commodities, with a standard deviation of 19.2%.

2. Hedging Pressure and Commodity Option Returns

2.1. A Visual Check

Prior to a formal analysis, we illustrate a cross-sectional relationship between option hedging pressure and the variation in returns in a scatter plot. Figure 2 plots the average HPO and the average 1-week return of the long-short strategy for the 24 commodities from March 21, 1995 to December 24, 2018. Clearly, there is a positive relationship between the two variables: a long-short strategy of buying OTM calls and selling OTM puts tends to generate a larger return in the markets where HPO is high. The estimated coefficient for HPO in the cross-sectional regression is positive with a t -statistic of 4.09 with an R-squared of 0.43. This provides the first indication of hedging pressure effects on option prices in commodity markets.

2.2. Portfolio Sorting Analysis

Next, we examine the effects of hedging pressure on option prices using a portfolio sorting approach. At the end of each Tuesday, we rank the 24 commodities in ascending order based on HPO and form five equal-weight quintile portfolios, which consist of 5, 5, 4, 5, 5 commodities, respectively. Each week, we calculate the k -week ($k = 1, 2, 3$, and 4) return of the long-short strategy for each commodity using prices of the front-month contract based on Equation (5), which is then averaged over commodities within each portfolio.

Table 2 reports the average HPO and returns of the long-short strategy for each portfolio. For commodities in the bottom quintile (Portfolio 1), the option positions by hedgers are net long the underlying asset with an average HPO of -23.41%, and the average strategy return is -1.84% in the subsequent week ($k = 1$). For commodities in the top quintile (Portfolio 5), hedgers hold net short positions in options with an average HPO of 22.98%, and the long-short strategy earns 0.72% per week. The average return of the long-short strategy increases as HPO rises from Portfolio 1 to Portfolio 5. The difference in the strategy returns between Portfolio 5 and Portfolio 1 is 2.56% per week with a t -statistic of 6.25, suggesting that significant returns can be obtained by buying calls and selling puts in the markets where hedgers hold the most net short positions and simultaneously selling calls and buying puts in the markets where hedgers hold the most net long positions. Doing so would provide liquidity to both net short hedging demand and net long hedging demand. These observations are consistent with the hedging pressure hypothesis.

Table 2 also presents the average delta-hedged returns of the long-short strategy in longer horizons from two to four weeks. Various lengths of holding periods allow us to check if the identified hedging pressure effects persist. The average strategy returns maintain the same sign and are statistically significant for all portfolios except Portfolio 4. The difference in the strategy

returns between Portfolio 5 and Portfolio 1 becomes larger in magnitude at longer horizons, although at a slower pace. For instance, the spread across Portfolios 5 and 1 in the long-short strategy return equals 4.19% at a 2-week horizon, which is less than twice 1-week return. These results suggest that the effects of hedging pressure on option prices can last for up to four weeks.

We next evaluate the economic significance of the long-short strategy return with transaction costs. Researchers have developed various liquidity proxies to estimate the costs of trading in commodity futures markets, but no formal analysis has been done in commodity option markets. Marshall, Nguyen, and Visaltanachoti (2012) estimate that the average effective half-spread for large commodity futures trades is 4.4 basis points. Shah, Brorsen, and Anderson (2012) show that the bid-ask spreads of options contracts are at least double the effective bid-ask spreads of futures contracts in the Kansas wheat market. If we conservatively assume that the cost of option trading is four times as large as that of futures trading, the half-spread for trading an option would be 17.6 basis points. The cost incurred by a round trip is 8.8 basis points for futures and 35.2 basis points for options. The cost of implementing the long-short strategy, which includes trading one call, one put, and two futures contracts, would be 88 basis points or 0.88%. The cost associated with Portfolio 5-minus-Portfolio 1 is then 1.76%, smaller than the return differences for one to four weeks. The net-of-cost returns from Portfolio 5-minus-Portfolio 1 are 0.8%, 2.43%, 3.88%, and 4.65%, respectively, corresponding to a holding period of one to four weeks.³

2.3. Regression Tests

To further test the predictability of hedging pressure, we run a Fama-MacBeth regression of the return of the long-short strategy on HPO and control variables. Specifically, we estimate:

³ While these return magnitudes are large, they also do not account for the cost of margin associated with selling puts, which we address in Section 4.2.

$$Ret_{i,t+k}^{long-short} = \alpha_0 + \alpha_1 HPO_{i,t} + \alpha_2 MFV_{i,t} + \alpha_3 TTM_{i,t} + \alpha_4 CY_{i,t} + \alpha_5 Ret_{i,t}^{long-short} + \epsilon_{i,t+k}, \quad (6)$$

where $Ret_{i,t+k}^{long-short}$ is the long-short strategy return for commodity i from week t to $t+k$, calculated as the difference in average delta-hedged returns between OTM calls and OTM puts using prices of the front-month option contracts based on Equation (5). As before, the key predictor is HPO. If hedging pressure affects option prices in the hypothesized direction, we should see $\alpha_1 > 0$ and reject $\alpha_1 = 0$.

Control variables in the regression include: (i) $MFV_{i,t}$, the model-free implied volatility at time t , which is calculated based on prices of all options available in a model-free approach (Bakshi, Kapadia, and Madan, 2003). The implied volatility is included to allow for the possibility that the long-short strategy return may contain compensations for the exposure to variance risk. (ii) $TTM_{i,t}$, the time to maturity in years, which captures any systematic change in the strategy return as the option's expiration date approaches. (iii) $CY_{i,t}$, the convenience yield, which may contribute to an upward sloping implied volatility smile pattern by introducing a positive correlation between futures return and volatility (Liu and Tang, 2011).⁴ (iv) $Ret_{i,t}^{long-short}$, the lagged return from week $t-k$ to t , which captures the persistence in the strategy return. All predictors are known up to t . The table reports the time-series average of weekly cross-sectional coefficients and the average adjusted R^2 . We compute t -statistics based on Newey and West (1987) standard errors with 4 lags.

Table 3 presents the results. The estimated coefficients for HPO range from 4.39 to 12.51 and have t -statistics between 4.06 and 6.87 depending on the length of the holding period,

⁴ We follow Liu and Tang (2011) to define convenience yield as $r_t - (\ln F_t^{T_2} - \ln F_t^{T_1}) / (T_2 - T_1)$, where $F_t^{T_1}$ and $F_t^{T_2}$ are the futures prices of the first and second nearby contracts with maturities of T_1 and T_2 , respectively, and r_t is the risk-free rate.

suggesting that hedging pressure significantly impacts subsequent option price changes. The coefficient estimate is also economically significant. To illustrate, the mean and standard deviation of HPO across commodities are 2.13% and 15.49% (reported in Table 1), respectively. A one-standard-deviation increase in HPO corresponds to a 67 to 188 basis point increase in the weekly strategy return going from a one to four-week horizon.

In multivariate regressions (columns 5-8), the estimated coefficients for HPO remain positive and are statistically significant at the 1% level regardless of the length of the holding period. These estimates suggest that a one-standard-deviation increase in HPO corresponds to a 60 to 144 basis point increase in the weekly strategy return, again going from a one to four-week horizon. These estimates are in line with but slightly smaller in magnitude than the estimates from the univariate analysis.

Regarding control variables, the estimated coefficient for implied volatility is negative and statistically significant in all holding periods (t-statistics of 2.76–5.66), suggesting that the long-short strategy is exposed to variance risk and a portion of its return may reflect variance risk premium. The estimated coefficient for time to maturity does not significantly differ from zero when the holding period is short ($k = 1$ or 2), but with a longer holding period, the estimate becomes larger and even statistically significant at the 5% level ($k = 4$). This suggests that the long-short strategy tends to achieve a lower return as the option approaches its expiration date with other things held constant. The difference in coefficient estimates between short and long horizons is likely due to the use of different option contracts. Recall that only the front-month option contracts are used each week. The contracts used for $k = 1$ are likely to be different from those used for $k = 4$ because the former may have less than four weeks until expiration.

We find little evidence of convenience yield influencing the prices of the strategy return. While Liu and Tang (2011) show that convenience yield can help shape an upward sloping implied volatility smile in the crude oil market for January 2000 to February 2006, we find that this prediction does not hold in a wide range of markets for a longer sample period. The coefficient for lagged returns is negative and statistically significant only for a holding period of one week, indicating a certain degree of short-term reversal. R-squared values range from 0.01 to 0.08.

The Tuesday-Tuesday returns underlying the long-short option strategy are not realizable because the COT reports are released after the market closes on the Friday following the measurement of positions on Tuesday. We repeat the analysis above by calculating option returns from the Monday that follows the release of positions on Friday to the next Monday and present the results in Table 4. The portfolio sorting approach (Panel A) gives similar results as Table 2. The average returns of the long-short strategy tend to be negative (positive) when hedging pressure is negative (positive). The return differences between Portfolio 5 and Portfolio 1 range from 2.84% to 6.89% and the associated t -statistics exceed five. Subtracting a transaction cost of 1.76%, the returns from Portfolio 5-minus-Portfolio 1 reduce to 1.08% to 5.13% corresponding to a holding period of one to four weeks. In the Fama-MacBeth regressions (Panel B), the estimated coefficient for HPO is positive and statistically significant at the 1% level when option positions are held for one or two weeks. In longer holding periods ($k = 3$ or 4), the estimate for hedging pressure remains positive but is no longer significant. The coefficient estimates and statistical significance for all control variables are similar as reported in Table 3.

Overall, we show that hedging pressure has strong predictive power for subsequent changes in the prices of OTM calls and OTM puts, and that a strategy tied to hedging pressure can generate

economically large and statistically significant returns up to four weeks. This result is consistent with a hedging premium in commodity option prices.

2.4. Implied Volatility Slopes

Next, we examine whether hedging pressure has a similar impact on option implied volatilities, following Bollen and Whaley (2004). For each commodity (i), date (t), and maturity (T), we calculate the slope of implied volatilities as,

$$slope_{i,t}^T = \frac{IV_{i,t}^{OTM\ Call^T} - IV_{i,t}^{OTM\ Put^T}}{IV_{i,t}^{ATM\ option^T}}, \quad (7)$$

where $IV_{i,t}^{OTM\ call^T}$, $IV_{i,t}^{OTM\ put^T}$, and $IV_{i,t}^{ATM\ option^T}$ are the average implied volatilities of OTM calls, OTM puts, and ATM options (calls and puts), respectively. We calculate implied volatilities based on the finite difference method for American commodity options and use options on the front-month futures contract to form a weekly series of slopes. The k -week ($k = 1, 2, 3$, and 4) change in slope is the difference between $slope_{i,t}$ and $slope_{i,t+k}$, where the two slopes are based on options on the same underlying futures contract.

Figure 3 provides a visual check by plotting average HPO versus average slopes and their 1-week changes for the 24 commodities. The figure shows that HPO is negatively associated with the slope and positively associated with the change in slope in the subsequent week. Greater values of HPO, due to either greater buying pressure on puts or selling pressure on calls, are associated with more expensive OTM puts and less expensive OTM calls in terms of their implied volatilities. Greater values of HPO are subsequently followed by OTM puts becoming less expensive and OTM calls becoming more expensive as option prices gradually adjust to their “fair” values.

We formally test the relationship between implied volatility slopes and HPO by regressing the k -week change in slope on HPO and report the results in Table 5. The estimated coefficient of

HPO is significantly positive with a t -statistic between 3.04 and 4.41 in univariate regressions. When control variables are included, the estimate for HPO declines in magnitude while remaining statistically significant (t -statistic of 2.32 to 3.5). The predictive power of HPO for changes in implied volatility slopes further confirms the existence of hedging premiums in commodity option prices since implied volatility is embedded in option prices and is a measure of option expensiveness.

3. Further Analysis

3.1. Hedging Pressure versus Price Pressure

The empirical evidence so far suggests that hedging pressure plays an important role in explaining option returns. An alternative explanation is related to price pressure, which may result from any change in demand or supply of option contracts, including but not limited to hedging demand. The hedging pressure hypothesis implies that the future return of the long-short strategy will be large when the level of hedging pressure is high, whereas the price pressure hypothesis implies that the strategy return will be large when there is a large increase in hedging pressure. Following De Roon, Nijman, and Veld (2000), we proxy price pressure with the *change* in hedging pressure and include it as an additional predictor in the regression model (Equation (6)).

Table 6 reports the estimation results from Fama-MacBeth regressions. The estimated coefficient for the change in hedging pressure is not significant at any reasonable level, suggesting that price pressure plays little role in explaining future returns of calls relative to puts. In contrast, the estimate for hedging pressure is significantly positive and has a similar magnitude and level of statistical significance as when price pressure is not included. These results suggest that the identified effects on option returns are due to hedging pressure rather than price pressure.

3.2. *Smoothed Hedging Pressure*

Kang, Tang, and Rouwenhorst (2020) highlight the importance of distinguishing between variation in net positions that is driven by the insurance demands of hedgers and variation driven by the short-term speculative pressure induced by the trading of non-commercial market participants. They suggest using smoothed hedging pressure as a more accurate measure of hedging demand. We follow Kang, Tang, and Rouwenhorst (2020) to define smoothed HPO as a trailing 52-week moving average of HPO, which is expected to contain little demands from short-term liquidity trading. We replace HPO with smoothed HPO in the regression model and present the results in Table 7. The estimated coefficients for smoothed HPO are significantly positive with t -statistics between 2.82 to 3.7, slightly larger compared to those reported in Table 3. Although Kang, Tang, and Rouwenhorst (2020) find it important to subtract short-term trading noise from the measurement of futures hedging pressure, we show that the effects of hedging pressure on option returns are robust to whether short-term trading needs are removed.

3.3. *Futures Hedging Pressure*

Both futures and options are used as hedging instruments, and one worry is that options hedging pressure is simply a reflection of futures hedging pressure. Futures hedging pressure (HPF) equals the net short futures position of hedgers divided by futures open interest based on position data from the COT report, and the literature has studied the link between futures hedging pressure and futures returns extensively (Bessembinder 1992, De Roon, Nijman, and Veld 2000).

Empirically, options hedging pressure is related to, but distinct from, futures hedging pressure. Table 1 presents summary statistics for HPF alongside HPO. Unlike HPO, the average HPF is positive in 21 out of 24 markets and has an average of 11.13% across commodities, suggesting that net futures positions by hedgers are primarily short. This is consistent with the

theory of normal backwardation. The volatility of HPF, measured by an average standard deviation of 15.89%, is of similar size to that of HPO (15.49%). The average percentage of hedgers being net short across commodity markets is 66.8%, confirming that hedgers are more often short in the futures markets than in option markets.

The correlation of HPO and HPF tends to be positive: The summary statistics in Table 1 report that the correlation between HPO and HPF is positive in 19 markets. Table 8 explores this correlation in a regression context. Panel A shows that HPO and HPF are related both in levels and in changes in cross-sectional Fama-MacBeth regressions. Panel B shows that HPO and HPF respond to factors such as volatility, convenience yields, momentum, and basis-momentum in a similar fashion. One should interpret the coefficients on these variables as the contemporaneous association of each variable on HPO and HPF since the specification conditions on the lagged value of the dependent variable. This evidence suggests that hedgers tend to adjust their futures and option positions in the same direction as their needs for hedging change over time.

Although HPO and HPF are related, HPO is incrementally informative about options returns. We include futures hedging pressure as an additional predictor in the regression model and report the results in Table 9. The estimated coefficients for HPO remain positive and statistically significant, just as those reported in Table 3 where futures hedging is not considered. Futures hedging pressure HPF is negatively associated with the subsequent strategy return. This is consistent with the fact that the strategy shorts futures contracts to delta-hedge the underlying long exposure of the long call and short put option positions. In the presence of a hedging pressure effect in futures markets, high values of HPF are associated with futures prices that are too low and expected subsequent futures price increases. High values of HPF would then predict a lower strategy return through the option strategy's short futures position.

3.4. Futures Return Prediction

A natural follow-up question to whether options hedging pressure simply reflects futures hedging pressure is whether option hedging pressure could also help predict futures returns. To address this question, we consider HPO as an additional factor in forecasting the return of futures contracts. Other than HPO, we include smoothed futures hedging pressure, net trading pressure, basis, momentum, and basis-momentum (Boons and Prado, 2019; Kang, Tang, and Rouwenhorst, 2020) as control variables in the futures return regression. Consistent with previous studies, we find that futures hedging pressure, net trading pressure, and basis-momentum significantly impact futures return. However, the estimated coefficient for HPO is close to zero and does not differ from zero at any reasonable significance level, suggesting that option hedging pressure has little impact on futures prices despite the no-arbitrage link between the two markets. The Online Appendix reports detailed results for the futures return regression.

4. Robustness Tests

4.1. DCOT Data

As discussed earlier, the COT data may suffer from misclassification issues. In particular, the commercial hedgers' category lumps together swap dealers with producers and processors, and swap dealers may hedge exposure to speculative commodity index swaps rather than the physical product. As a remedy, the CFTC introduced the weekly Disaggregate Commitment of Traders (DCOT) report in 2009 with historical data available back to June 13, 2006. The DCOT report separates swap dealers from commercial traders, providing a finer classification of traders in commodity markets. Cheng, Kirilenko, and Xiong (2015) find that using DCOT and internal proprietary CFTC data leads to similar conclusions about trading patterns.

We check the robustness of our results using the DCOT data. The categories of traders in the DCOT report are producers/merchant/processor/user, money managers, swap dealers, other reportable, and non-reportable. We treat the first group of traders as hedgers since they consist of market participants with a clear hedging motive. Just as the COT data, the DCOT positions are available in one of two forms—futures-only and futures-and-options-combined. We derive option positions by subtracting futures-only positions from futures-and-options-combined positions and define HPO in exactly the same way as we do with the COT data.

Table 10 presents Fama-MacBeth estimates based on the DCOT data. The estimated coefficient for HPO is negative and statistically significant, supporting the existence of hedging pressure effects. Compared to those in Table 3, the t -statistics are smaller in magnitude because of fewer observations. Results confirm that option hedging pressure helps explain the strategy return although the estimates lose statistical significance at longer horizons. The estimated coefficients for all the other variables have the same sign and similar size as those reported in Table 3 where the COT data are used.

4.2. *Calls versus Puts*

We explore whether the effects of hedging pressure differ between calls and puts. Unfortunately, one cannot break down HPO by option type from what is available in the CFTC reports. However, we can decompose the long-short strategy return by option type. Specifically, we separately examine the relationship between HPO and the two components of the long-short strategy: First, the returns to buying calls, $\overline{Ret}_{i,t+k}^{OTM\ Call}$, and second, the return to selling puts, $-\overline{Ret}_{i,t+k}^{OTM\ Put}$.

Table 11 reports the Fama-MacBeth estimates of the relationship between the returns of these strategies and HPO. We include the control variables but omit them in the reported Table for brevity. Point estimates for the coefficient on HPO are positive for both buying calls and selling

puts. However, the estimates and t -statistics are larger in size on the put side, suggesting that hedging pressure is more strongly related to put returns than call returns.

This finding supports the hedging pressure hypothesis, which predicts that hedging demand affects prices when there are significant frictions in liquidity supply (Hirshleifer, 1988). Specifically, liquidity providers who sell out-of-the-money put options to producers who buy put options must post significant margin, and this friction “blunts the effectiveness of option markets for risk-sharing” (Santa-Clara and Saretto, 2009). In contrast, the purchase of call options imposes no additional margin requirement on liquidity providers. Moreover, hedgers may prefer buying puts over selling calls due to the maximum limited market loss. Therefore, we should expect that hedgers who buy puts influence prices more than hedgers who sell calls, and thus a stronger predictive relationship between HPO and put returns than call returns.

4.3. Subsamples

We also check whether the results are sensitive to the choice of the sample period. We split our sample period into two: 3/21/1995–12/26/2006 and 1/3/2007–12/24/2018. We run separate regressions for each period and report the results in Table 12. The same set of control variables are included but not reported for brevity. In both periods, the estimates for HPO are positive and statistically significant for short holding periods ($k = 1$ or 2). At longer horizons, the estimates for HPO are positive but are noisier in the second period from 1/3/2007 to 12/24/2018. A two-sample t test fails to reject the null hypothesis that the mean of estimates for HPO in the first period is equal to that in the second period when k is less than 4. These results suggest that the effects of hedging pressure differ only slightly between the first and second halves of the sample.

Overall, the robustness checks using DCOT data, subsamples, and different types of options are all consistent with our main hedging pressure hypothesis that hedging pressure does

play a role in commodity option price formation. The results confirm the existence of hedging premiums in the commodity option markets.

5. Conclusion

We provide new evidence of hedging premiums in commodity option markets. Using data from CFTC, we construct a measure of hedging pressure in commodity option markets, and show that hedging pressure tends to push up (down) out-of-the-money put (call) option prices. Hedging pressure predicts the returns to a strategy that provides liquidity to hedging demand in addition to changes in implied volatilities. Our results support the hypothesis that hedging demand affects option pricing due to frictions in liquidity supply, consistent with the literature on demand-based option pricing. Furthermore, they suggest that future research should closely examine commodity option markets to understand the determinants of hedging behavior and the information contained in hedging pressure (Hong and Yogo, 2012).

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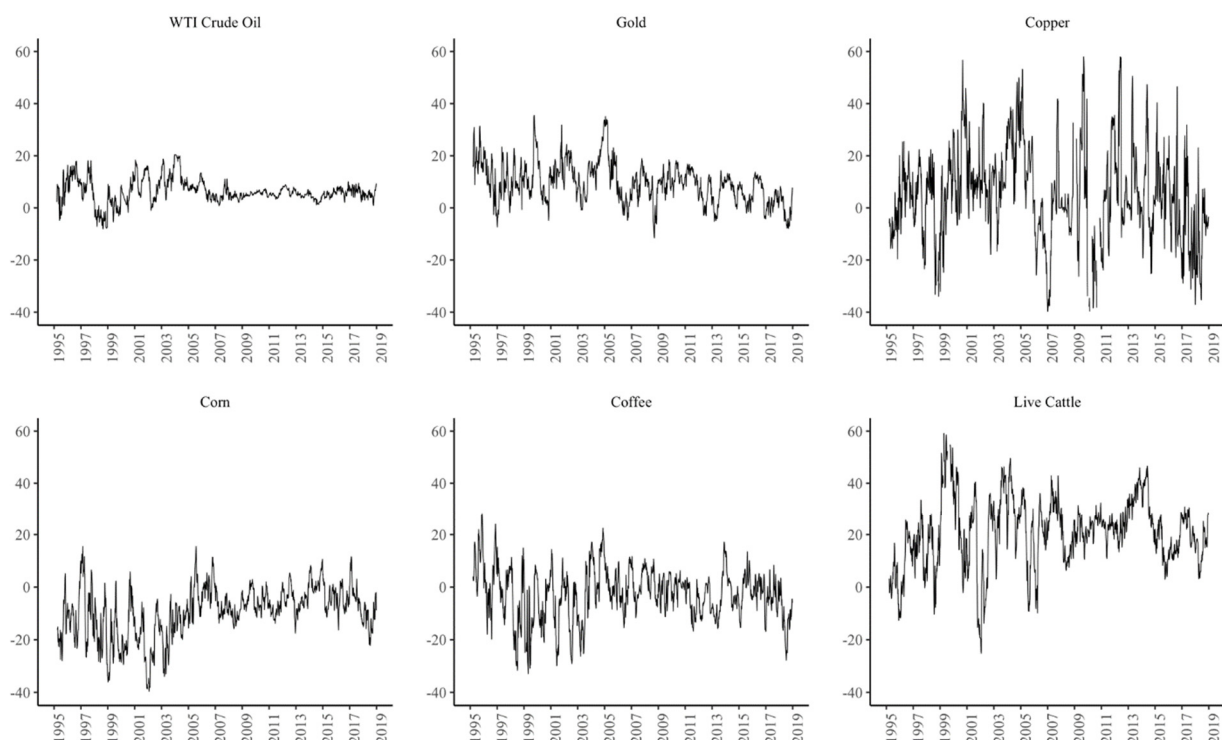


Figure 1. Option Hedging Pressure in Selected Commodity Markets

The figure shows the time series of hedging pressure in options (HPO) for WTI crude oil, gold, copper, corn, coffee, and live cattle for the period from 3/21/1995 to 12/24/2018. HPO is defined as the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC COT reports. HPO is in percentage terms.

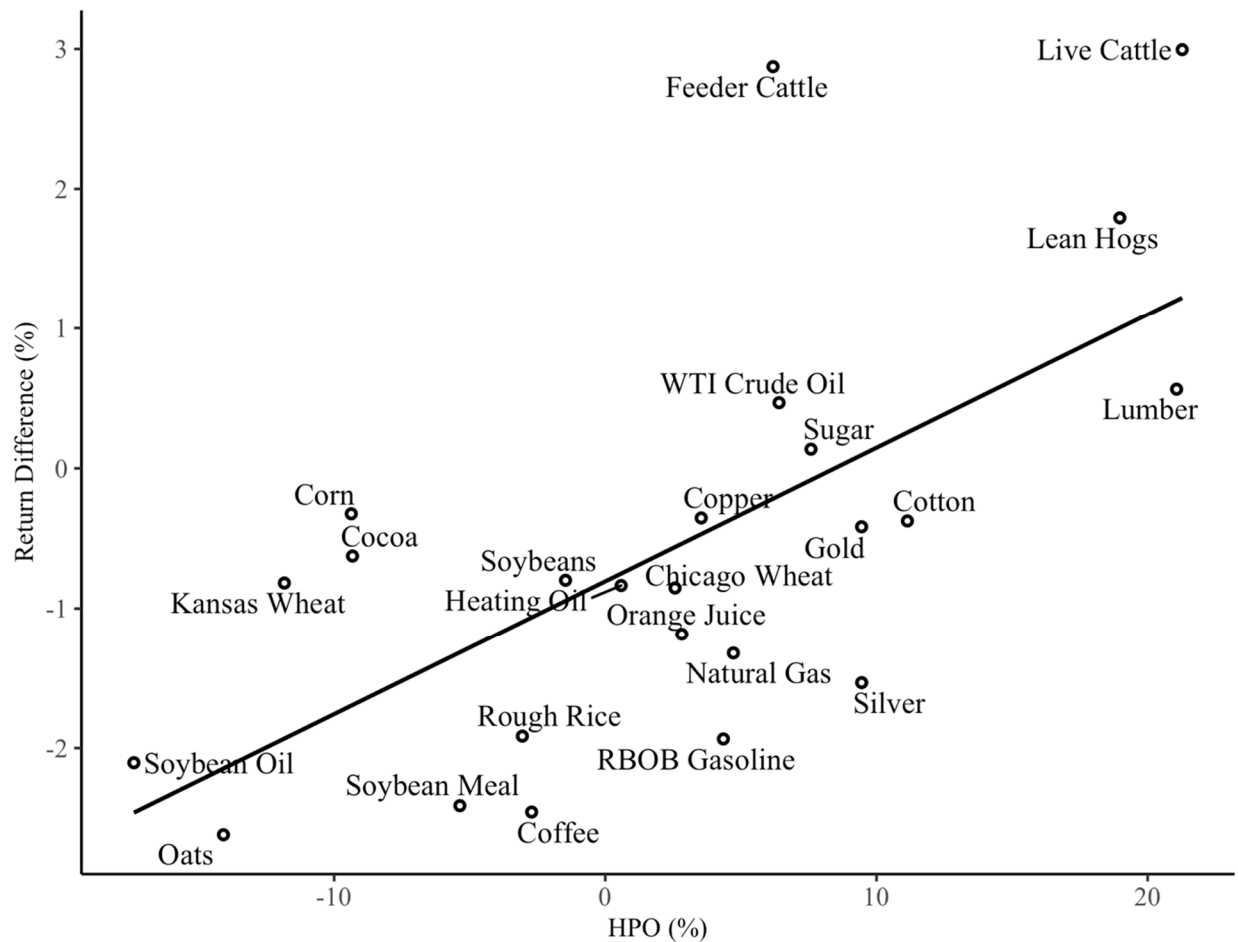
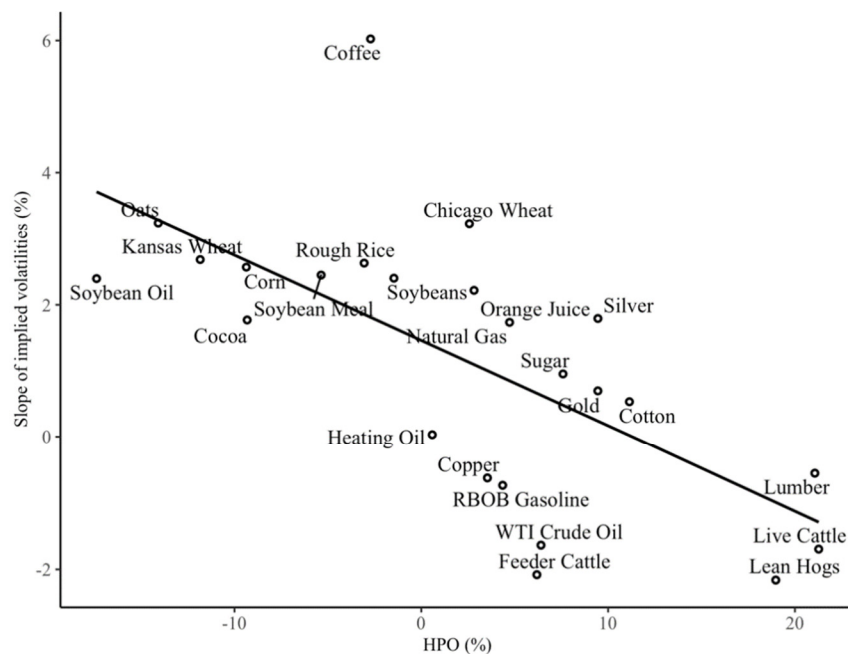
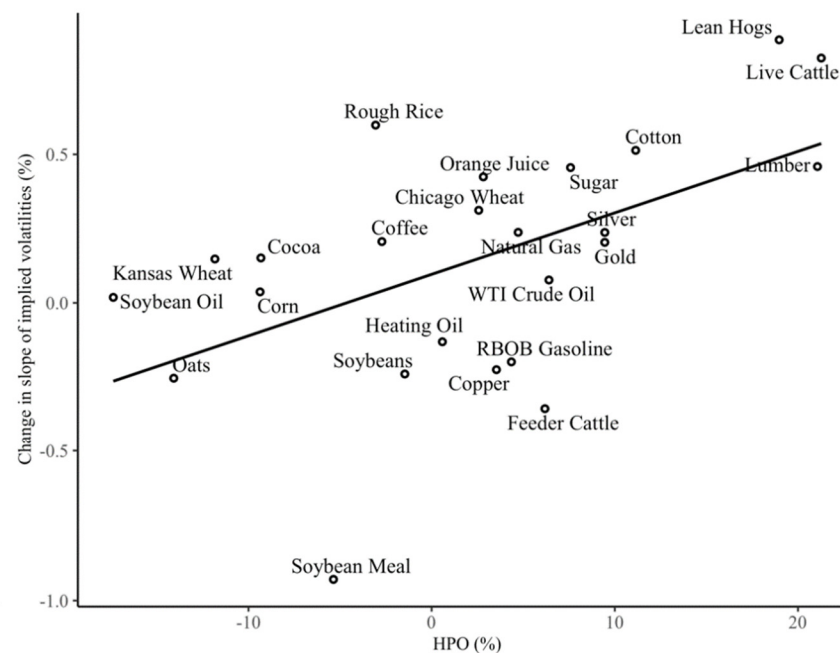


Figure 2. Option Hedging Pressure and the Delta-Hedged Return of Buying OTM Calls and Selling OTM Puts

The figure provides a scatterplot of average hedging pressure in options (HPO) and average delta-hedged return of the long-short strategy that buys OTM calls and sells OTM puts. HPO is defined as the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC COT reports. The delta-hedged return of each week is calculated using prices of the front-month option contract based on Equation (5), which is further averaged over time and shown in the figure. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. The cross-section regression line has a slope coefficient of 0.048 with a t -statistic of 4.09 and an R^2 of 0.43.



(a) HPO vs. slope of implied volatility smile



(b) HPO vs. change in slope of implied volatility smile

Figure 3. Hedging pressure in options and the slope of implied volatility smile

This figure provides a scatter plot of average hedging pressure in options (HPO) and average slope of implied volatility smile. HPO is defined as the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC COT reports. The slope of implied volatility smile is defined as the difference in average implied volatilities between OTM calls and OTM puts scaled by the average implied volatility of at-the-money options. Options on the front-month futures contract are used to form a weekly time series of implied volatility slope. Implied volatilities are computed based on a binomial method for American-style commodity options. Both HPO and the slope are in percentage terms. The sample period is from 3/21/1995 through 12/24/2018.

Table 1. Summary Statistics

The table provides the summary statistics of hedging pressure in options (HPO), hedging pressure in futures (HPF), and delta-hedged return of the long-short strategy that buys OTM calls and sells OTM puts. HPO (HPF) is the net short option (futures) positions of commercial traders divided by option (futures) open interest based on position data from weekly CFTC COT reports. The delta-hedged return of each week is calculated using prices of the front-month option contract based on Equation (5). The sample includes 24 commodities from 3/21/1995 to 12/24/2018. SD is the standard deviation. “> 0” is the percentage of positive values. Corr(HPO, HPF) is the Pearson correlation coefficient between HPO and HPF.

	HPO (%)			$Ret^{long-short}$ (%)			HPF (%)			Corr(HPO, HPF)
	Mean	SD	> 0	Mean	SD	> 0	Mean	SD	> 0	
WTI Crude Oil	6.34	4.65	92.5	0.47	18.10	44.9	8.07	10.13	77.5	-0.14
Heating Oil	0.79	11.44	59.3	-0.83	16.17	43.4	8.77	8.80	82.0	0.03
RBOB Gasoline	6.06	12.84	36.8	-1.93	17.25	37.8	21.17	5.91	55.9	0.04
Natural Gas	4.23	17.46	51.3	-1.32	19.95	42.2	-1.48	11.32	42.8	-0.40
Gold	9.30	7.62	89.4	-0.42	18.99	45.1	25.40	26.30	81.4	0.09
Silver	9.14	11.38	76.7	-1.53	19.45	45.3	37.20	17.14	99.3	0.46
Copper	3.28	20.68	59.6	-0.35	18.49	44.3	5.47	20.10	58.2	0.17
Corn	-9.25	9.49	15.7	-0.32	20.42	47.8	2.22	12.70	57.8	0.20
Soybeans	-1.77	9.90	40.8	-0.80	20.92	46.1	8.15	15.88	67.5	-0.20
Chicago Wheat	2.10	12.57	55.9	-0.85	16.99	50.3	-0.67	13.56	42.1	0.05
Kansas Wheat	-12.13	18.25	23.2	-0.82	16.45	47.3	8.35	13.56	71.8	0.14
Soybean Oil	-16.64	18.39	17.8	-2.10	21.68	45.3	11.38	16.71	70.9	-0.01
Soybean Meal	-5.83	16.54	34.4	-2.41	24.08	42.9	19.37	14.41	88.0	0.19
Rough Rice	-3.89	31.87	45.7	-1.91	21.95	45.9	8.53	24.12	63.3	0.31
Oats	-12.83	33.98	34.3	-2.62	17.26	42.0	29.70	18.48	82.1	0.47
Coffee	-2.98	9.82	39.4	-2.46	15.78	46.1	9.57	16.18	63.8	0.37
Cocoa	-9.37	14.39	23.6	-0.62	16.08	45.9	11.47	15.62	73.9	0.19
Sugar	6.72	14.58	63.4	0.14	15.38	48.6	13.13	17.33	72.9	0.31
Cotton	10.57	12.64	79.1	-0.37	17.00	46.6	9.64	22.32	65.4	-0.23
Orange Juice	1.40	22.60	52.4	-1.19	21.96	46.0	21.98	25.29	79.9	0.30
Lumber	20.66	20.70	80.2	0.56	19.42	47.2	9.19	20.94	59.5	0.31
Live Cattle	20.88	13.90	92.6	3.00	18.70	51.4	6.44	11.15	68.9	0.16
Feeder Cattle	5.55	12.10	65.7	2.87	26.79	43.9	-7.32	10.08	24.0	0.03
Lean Hogs	18.85	13.95	88.7	1.79	21.36	45.6	1.51	13.25	54.0	0.35
Average	2.13	15.49	54.9	-0.58	19.19	45.5	11.13	15.89	66.8	0.13

Table 2. Option Returns Following Hedging Pressure: Portfolio Sorting

The table presents the average delta-hedged return of the long-short strategy that buys OTM calls and sells OTM puts for various portfolios of commodities sorted by hedging pressure in options (HPO). HPO is the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC COT reports. The delta-hedged return of the long-short strategy is calculated using prices of the front-month option contract based on Equation (5). On Tuesday of each week, the 24 commodities are ranked based on HPO and grouped into five quantile portfolios containing 5, 5, 4, 5, and 5 commodities each. The long-short strategy returns are averaged over commodities within each portfolio, which are then averaged over time and reported in percentage terms. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with four lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. */**/** indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

	HPO_t (%)	Delta-hedged return of the long-short strategy from t to $t + k$ (%)			
		$k = 1$	$k = 2$	$k = 3$	$k = 4$
Portfolio 1	-23.41	-1.84*** (-5.91)	-2.99*** (-5.66)	-4.29*** (-5.77)	-5.60*** (-5.88)
Portfolio 2	-5.72	-1.21*** (-4.38)	-2.42*** (-5.04)	-3.59*** (-5.34)	-4.43*** (-5.16)
Portfolio 3	2.95	-0.37 (-1.14)	-1.09** (-2.14)	-1.84*** (-2.69)	-2.50*** (-2.99)
Portfolio 4	10.09	0.09 (0.32)	-0.27 (-0.55)	-0.45 (-0.69)	-1.10 (-1.40)
Portfolio 5	22.98	0.72*** (2.69)	1.20*** (2.82)	1.35** (2.29)	0.80 (1.05)
Portfolio 5 – Portfolio 1		2.56*** (6.25)	4.19*** (6.18)	5.64*** (6.09)	6.41*** (5.78)
Summary statistics of weekly returns to Portfolio 5-minutes-Portfolio 1					
SD (%)		14.37	19.32	23.06	25.68
Sharpe Ratio (Mean/SD)		0.18	0.22	0.24	0.25
Skewness		0.41	0.31	0.17	0.11
Median (%)		2.49	3.31	4.80	5.78

Table 3. Option Returns Following Hedging Pressure: Fama-MacBeth Regression

The table reports the results from weekly Fama-MacBeth cross-sectional regressions of the long-short strategy return in week $t + k$ ($k = 1, 2, 3$, and 4) on option hedging pressure and controls in week t .

$$Ret_{i,t+k}^{long-short} = \alpha_0 + \alpha_1 HPO_{i,t} + Controls + \epsilon_{i,t+k},$$

where $Ret_{i,t+k}^{long-short}$ is the delta-hedged return of the long-short strategy that buys OTM calls and sells OTM puts from week t to $t + k$ for commodity i . The long-short strategy return is calculated based on Equation (5) using prices of the front-month option contract that has at least k weeks until expiration. $HPO_{i,t}$ is the hedging pressure in options that equals the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC COT reports. The control variables are model-free risk neutral volatility ($MFV_{i,t}$), time to maturity ($TTM_{i,t}$), convenience yield ($CY_{i,t}$), and lagged strategy return ($Ret_{i,t}^{long-short}$). The time-series average of weekly cross-sectional coefficients and the average adjusted R^2 are reported. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with four lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. */**/** indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $Ret_{i,t+k}^{long-short}$							
	k = 1	k = 2	k = 3	k = 4	k = 1	k = 2	k = 3	k = 4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$HPO_{i,t}$	4.39*** (5.42)	8.79*** (6.87)	12.15*** (6.87)	12.51*** (4.06)	4.00*** (4.46)	7.99*** (5.66)	7.83*** (3.31)	9.61*** (2.76)
$MFV_{i,t}$					-5.47*** (-3.01)	-11.76*** (-3.60)	-12.36*** (-3.08)	-16.46*** (-3.10)
$TTM_{i,t}$					0.02 (0.01)	1.08 (0.09)	26.16 (1.25)	20.16** (2.18)
$CY_{i,t}$					-0.36 (-0.42)	0.03 (0.02)	0.75 (0.39)	-1.25 (-0.57)
$Ret_{i,t}^{long-short}$					-0.05*** (-4.60)	0.00 (0.03)	0.02 (1.32)	0.00 (0.22)
<i>Intercept</i>	-0.64*** (-3.60)	-1.37*** (-4.60)	-2.08*** (-5.20)	-2.60*** (-3.51)	0.85 (1.20)	1.19 (0.81)	-1.85 (-0.84)	-1.21 (-0.56)
<i>Adj. R²</i>	0.01	0.01	0.01	0.01	0.08	0.07	0.07	0.06
<i>Obs (weeks)</i>	1236	1235	1234	1233	1235	1233	1231	1229

Table 4. Monday-Monday Option Returns Following Hedging Pressure

The table presents the results about hedging pressure effects using option returns that are calculated from the Monday that follows the Friday when a COT report is released to the next Monday. Hedging pressure in options (HPO) is the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC COT reports. For each commodity, we calculate the delta-hedged return to the long-short strategy that buys OTM calls and sells OTM puts. Each week, the long-short strategy return is calculated based on Equation (5) using prices of the front-month option contract that has at least k weeks until expiration ($k = 1, 2, 3$, and 4). Panel A presents results from the portfolio sorting approach as described in the note of Table 2. Panel B presents results from the Fama-MacBeth regression approach as described in the note of Table 3. The time-series average of weekly cross-sectional coefficients and the average adjusted R^2 are reported. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with four lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. ***/** indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

Panel A: Portfolio sorting					
	HPO_t (%)	Delta-hedged return of the long-short strategy from t to $t + k$ (%)			
		$k = 1$	$k = 2$	$k = 3$	$k = 4$
Portfolio 1	-23.03	-1.75*** (-6.05)	-2.99*** (-5.38)	-4.45*** (-5.93)	-5.72*** (-5.90)
Portfolio 2	-5.66	-1.31*** (-4.53)	-2.61*** (-5.08)	-3.60*** (-5.07)	-4.85*** (-5.38)
Portfolio 3	3.05	-0.52 (-1.61)	-1.13** (-2.14)	-1.93*** (-2.76)	-2.64*** (-3.04)
Portfolio 4	10.12	-0.03 (-0.08)	-0.01 (-0.02)	-0.06 (-0.09)	-0.61 (-0.78)
Portfolio 5	22.98	1.08*** (4.06)	1.33*** (3.07)	1.37** (2.16)	1.18 (1.38)
Portfolio 5 – Portfolio 1		2.84*** (7.12)	4.32*** (6.24)	5.83*** (6.30)	6.89*** (5.84)
Panel B: Fama-MacBeth regression					
	Dependent variable: $Ret_{i,t+k}^{long-short}$				
	$k = 1$	$k = 2$	$k = 3$	$k = 4$	
$HPO_{i,t}$	5.46*** (3.71)	11.48*** (2.60)	2.97 (0.43)	6.06 (0.90)	
$MFV_{i,t}$	-6.08*** (-2.98)	-10.05*** (-3.11)	-12.82*** (-3.07)	-14.75*** (-2.78)	
$TTM_{i,t}$	-11.22 (-0.79)	-0.41 (-0.05)	21.50 (1.91)	27.51*** (2.40)	
$CY_{i,t}$	0.99 (0.52)	0.38 (0.25)	0.66 (0.31)	1.69 (0.81)	
$Ret_{i,t}^{long-short}$	-0.09** (-2.12)	-0.00 (-0.18)	0.01 (0.69)	0.01 (0.36)	
Intercept	1.88 (1.51)	0.52 (0.36)	-0.42 (-0.18)	-2.03 (-0.86)	
Adj. R^2	0.08	0.07	0.06	0.06	
Obs (weeks)	1223	1222	1219	1216	

Table 5. Hedging Pressure and the Slope of Implied Volatilities

The table reports the results from weekly Fama-MacBeth cross-sectional regressions of the k -week ($k = 1, 2, 4$, and 4) change in slope of implied volatilities on hedging pressure in options and controls in week t .

$$\Delta slope_{i,t+k} = \alpha_0 + \alpha_1 HPO_{i,t} + controls + \epsilon_{i,t+k},$$

where $\Delta slope_{i,t+k}$ is the change in slope of implied volatilities from t to $t + k$ for commodity i . $HPO_{i,t}$ is the hedging pressure in options which equals the net short option positions of commercial traders divided by option open interest based on position data from the weekly CFTC COT reports. The control variables are model-free risk neutral volatility ($MFV_{i,t}$), time to the option's maturity date ($TTM_{i,t}$), convenience yield ($CY_{i,t}$), and lagged change in slope ($\Delta slope_{i,t}$). The time-series average of weekly cross-sectional coefficients and the average adjusted R^2 are reported. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with 4 lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. */**/** indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $\Delta slope_{i,t+k}$							
	k = 1	k = 2	k = 3	k = 4	k = 1	k = 2	k = 3	k = 4
$HPO_{i,t}$	1.10*** (3.88)	2.51*** (4.41)	3.36*** (4.04)	3.29*** (3.04)	1.21*** (3.50)	2.04*** (3.24)	2.83*** (3.18)	2.44*** (2.32)
$MFV_{i,t}$					-0.08 (-0.12)	-1.23 (-0.93)	-2.14 (-0.73)	0.71 (0.30)
$TTM_{i,t}$					-0.88 (-0.59)	0.14 (0.08)	-19.34 (-0.71)	3.22 (0.59)
$CY_{i,t}$					-1.70*** (-5.24)	-2.24*** (-3.83)	-4.61** (-2.18)	-3.06*** (-3.06)
$\Delta slope_{i,t}$					-0.09*** (-7.17)	-0.06*** (-4.26)	-0.02 (-1.23)	-0.02 (-1.36)
<i>Intercept</i>	0.14* (1.91)	0.37*** (2.60)	0.51** (2.29)	0.68** (2.07)	0.11 (0.33)	0.47 (0.82)	2.71 (1.20)	-0.16 (-0.14)
<i>Adj. R²</i>	0.02	0.02	0.02	0.02	0.11	0.09	0.09	0.09
<i>Obs</i>	1236	1235	1234	1233	1235	1233	1231	1229

Table 6. Hedging Pressure and Price Pressure

This table presents the results from the following weekly Fama-MacBeth regressions.

$$Ret_{i,t+k}^{long-short} = \alpha_0 + \alpha_1 HPO_{i,t} + \alpha_2 \Delta HPO_{i,t} + Controls + \epsilon_{i,t+k},$$

where $Ret_{i,t+k}^{long-short}$ is the delta-hedged return of the long-short strategy that buys OTM calls and sells OTM puts from week t to $t + k$ for commodity i . The long-short strategy return is calculated based on Equation (5) using prices of the front-month option contract that has at least k weeks until expiration. $HPO_{i,t}$ is the hedging pressure in options that equals the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC COT reports. $\Delta HPO_{i,t}$ is the change in $HPO_{i,t}$ as a measure of price pressure (De Roan, Nijman, and Veld, 2000). The control variables are model-free risk neutral volatility ($MFV_{i,t}$), time to maturity ($TTM_{i,t}$), convenience yield ($CY_{i,t}$), and lagged strategy return ($Ret_{i,t}^{long-short}$). The time-series average of weekly cross-sectional coefficients and the average adjusted R^2 are reported. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with four lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. */**/** indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $Ret_{i,t+k}^{long-short}$			
	k = 1	k = 2	k = 3	k = 4
$HPO_{i,t}$	4.43*** (4.85)	7.84*** (5.29)	8.99*** (4.27)	10.31*** (2.91)
$\Delta HPO_{i,t}$	-4.68 (-1.55)	-3.52 (-0.64)	7.84 (1.37)	4.19 (0.71)
$MFV_{i,t}$	-3.99* (-1.93)	-9.11*** (-2.34)	-11.62*** (-2.79)	-14.67*** (-2.76)
$TTM_{i,t}$	0.77 (0.23)	5.02 (0.57)	11.85 (1.44)	7.80 (1.24)
$CY_{i,t}$	-0.03 (-0.03)	1.00 (0.76)	0.50 (0.26)	-1.71 (-0.70)
$Ret_{i,t}^{long-short}$	-0.05*** (-4.71)	-0.00 (-0.22)	0.02* (1.79)	0.01 (0.42)
<i>Intercept</i>	0.52 (0.70)	0.42 (0.31)	-0.30 (-0.16)	0.23 (0.10)
<i>Adj. R²</i>	0.09	0.08	0.08	0.07
<i>Obs (weeks)</i>	1234	1232	1230	1228

Table 7. Smoothed Hedging Pressure

This table presents the results from the following weekly Fama-MacBeth regressions.

$$Ret_{i,t+k}^{long-short} = \alpha_0 + \alpha_1 \overline{HPO}_{i,t} + Controls + \epsilon_{i,t+k},$$

where $Ret_{i,t+k}^{long-short}$ is the delta-hedged return of the long-short strategy that buys OTM calls and sells OTM puts from week t to $t + k$ for commodity i . The long-short strategy return is calculated based on Equation (5) using prices of the front-month option contract that has at least k weeks until expiration. $\overline{HPO}_{i,t}$ is the smoothed hedging pressure in options, which equals a trailing 52-week moving average of HPO. HPO is the hedging pressure in options that equals the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC COT reports. The control variables are model-free risk neutral volatility ($MFV_{i,t}$), time to maturity ($TTM_{i,t}$), convenience yield ($CY_{i,t}$), and lagged strategy return ($Ret_{i,t}^{long-short}$). The time-series average of weekly cross-sectional coefficients and the average adjusted R^2 are reported. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with four lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. */**/* indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $Ret_{i,t+k}^{long-short}$			
	k = 1	k = 2	k = 3	k = 4
$\overline{HPO}_{i,t}$	4.60*** (3.70)	7.77*** (3.69)	10.92*** (3.66)	12.98*** (2.82)
$MFV_{i,t}$	-4.67** (-1.99)	-4.90 (-0.63)	-22.54*** (-3.91)	-5.10 (-0.32)
$TTM_{i,t}$	1.41 (0.33)	5.21 (0.58)	14.99*** (2.36)	51.27 (1.42)
$CY_{i,t}$	-0.55 (-0.60)	-0.09 (-0.07)	0.23 (0.11)	-1.98 (-0.81)
$Ret_{i,t}^{long-short}$	-0.05*** (-4.23)	-0.00 (-0.07)	0.02 (1.12)	0.01 (0.78)
<i>Intercept</i>	0.66 (0.82)	-0.14 (-0.08)	1.32 (0.70)	-10.56 (-0.97)
<i>Adj. R²</i>	0.09	0.07	0.08	0.07
<i>Obs (weeks)</i>	1134	1133	1132	1131

Table 8. Option and Futures Hedging Pressure

This table presents the results from two sets of Fama-MacBeth regressions that explain the cross-sectional variation of option and futures hedging pressure. Hedging pressure in options (HPO) is measured as the net short option positions of commercial traders divided by option open interest and hedging pressure in futures (HPF) is measured as the net short futures positions of commercial traders divided by futures open interest. Both HPO and HPF are based on position data from weekly CFTC COT reports. In Panel A, the level and change in HPO is regressed on the level and change in HPF, respectively. In Panel B, the level of hedging pressure is regressed on a set of fundamental variables, including model-free risk neutral volatility (MFV), convenience yield (CY), momentum (M), basis-momentum (BM), and lagged dependent variable (coefficient omitted for brevity). Separate regressions are estimated for HPO and HPF. The time-series average of weekly cross-sectional coefficients and the average adjusted R^2 are reported. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with four lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. */**/** indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

Panel A: Levels and changes

	Dependent variable	
	$HPO_{i,t}$	$\Delta HPO_{i,t}$
$HPF_{i,t}$	0.053*** (3.37)	
$\Delta HPF_{i,t}$		0.289*** (15.72)
Intercept	0.019*** (5.38)	0.000 (-0.087)
Adj. R^2	0.017	0.076
Obs	1236	1234

Panel B: Fundamentals

	Dependent variable	
	$HPO_{i,t}$	$HPF_{i,t}$
$MFV_{i,t}$	0.011 (1.57)	0.019*** (2.97)
$CY_{i,t}$	0.009*** (2.79)	0.004* (1.69)
$M_{i,t}$	0.014** (2.31)	0.031*** (5.54)
$BM_{i,t}$	0.012 (0.54)	0.027 (1.40)
Intercept	-0.001 (-0.36)	-0.001 (-0.58)
Adj. R^2	0.872	0.948
Obs	1234	1234

Table 9. Option Hedging Pressure and Futures Hedging Pressure

This table presents the results from the following weekly Fama-MacBeth regressions.

$$Ret_{i,t+k}^{long-short} = \alpha_0 + \alpha_1 HPO_{i,t} + \alpha_2 HPF_{i,t} + Controls + \epsilon_{i,t+k},$$

where $Ret_{i,t+k}^{long-short}$ is the delta-hedged return of the long-short strategy that buys OTM calls and sells OTM puts from week t to $t + k$ for commodity i . The long-short strategy return is calculated based on Equation (5) using prices of the front-month option contract that has at least k weeks until expiration. $HPO_{i,t}$ is the hedging pressure in options which equals the net short option positions of commercial traders divided by option open interest. $HPF_{i,t}$ is the hedging pressure in futures which equals the net short futures positions of commercial traders divided by futures open interest. $HPO_{i,t}$ and $HPF_{i,t}$ are calculated based on position data from weekly CFTC COT reports. The control variables are model-free risk neutral volatility ($MFV_{i,t}$), time to maturity ($TTM_{i,t}$), convenience yield ($CY_{i,t}$), and lagged strategy return ($Ret_{i,t}^{long-short}$). The time-series average of weekly cross-sectional coefficients and the average adjusted R^2 are reported. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with four lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. */**/** indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $Ret_{i,t+k}^{long-short}$			
	k = 1	k = 2	k = 3	k = 4
$HPO_{i,t}$	4.30*** (4.59)	8.36*** (5.60)	9.11*** (4.82)	10.65*** (3.65)
$HPF_{i,t}$	-3.23*** (-3.38)	-6.15*** (-3.56)	-6.67*** (-3.21)	-8.19*** (-3.16)
$MFV_{i,t}$	-5.12*** (-2.68)	-11.86*** (-3.45)	-12.74*** (-3.10)	-15.47*** (-2.88)
$TTM_{i,t}$	-0.31 (-0.09)	8.00 (1.38)	18.12 (1.48)	21.20* (1.94)
$CY_{i,t}$	-0.16 (-0.19)	0.47 (0.35)	0.36 (0.18)	-0.74 (-0.29)
$Ret_{i,t}^{long-short}$	-0.05*** (-4.70)	0.01 (0.45)	0.02 (1.31)	0.01 (0.40)
<i>Intercept</i>	1.25* (1.66)	1.43 (1.06)	0.05 (0.03)	-0.28 (-0.13)
<i>Adj. R²</i>	0.10	0.09	0.08	0.08
<i>Obs (weeks)</i>	1235	1233	1231	1229

Table 10. Hedging Pressure Effects based on DCOT Data

This table presents the results from the following weekly Fama-MacBeth regressions.

$$Ret_{i,t+k}^{long-short} = \alpha_0 + \alpha_1 HPO_{i,t}^{DCOT} + Controls + \epsilon_{i,t+k},$$

where $Ret_{i,t+k}^{long-short}$ is the delta-hedged return of the long-short strategy that buys OTM calls and sells OTM puts from week t to $t + k$ for commodity i . The long-short strategy return is calculated based on Equation (5) using prices of the front-month option contract that has at least k weeks until expiration. $HPO_{i,t}^{DCOT}$ is the hedging pressure in options which equals the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC DCOT reports. The control variables are model-free risk neutral volatility ($MFV_{i,t}$), time to maturity ($TTM_{i,t}$), convenience yield ($CY_{i,t}$), and lagged strategy return ($Ret_{i,t}^{long-short}$). The time-series average of weekly cross-sectional coefficients and the average adjusted R^2 are reported. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with four lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. */**/** indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $Ret_{i,t+k}^{long-short}$			
	k = 1	k = 2	k = 3	k = 4
$HPO_{i,t}^{DCOT}$	3.74*** (2.96)	7.06*** (3.01)	4.33 (1.17)	4.29 (0.83)
$MFV_{i,t}$	-4.30 (-1.58)	-11.92*** (-2.34)	-9.88 (-1.48)	-14.42** (-1.95)
$TTM_{i,t}$	0.85 (0.11)	-4.42 (-0.15)	40.05 (1.13)	32.54** (2.30)
$CY_{i,t}$	-0.35 (-0.28)	-0.59 (-0.26)	2.84 (0.93)	-0.20 (-0.06)
$Ret_{i,t}^{long-short}$	-0.03** (-2.32)	0.01 (0.72)	-0.00 (-0.22)	-0.02 (-0.95)
<i>Intercept</i>	0.19 (0.17)	1.32 (0.52)	-4.21 (-1.20)	-3.99 (-1.31)
<i>Adj. R²</i>	0.10	0.08	0.07	0.07
<i>Obs (weeks)</i>	649	648	647	646

Table 11. Hedging Pressure Effects by Option Type

This table presents the results from the following weekly Fama-MacBeth regressions.

$$\overline{Ret}_{i,t+k}^{OTM\ Call} \text{ or } -\overline{Ret}_{i,t+k}^{OTM\ Put} = \alpha_0 + \alpha_1 HPO_{i,t} + Controls + \epsilon_{i,t+k},$$

where $\overline{Ret}_{i,t+k}^{OTM\ Call}$ is the delta-hedged return of the strategy that buys OTM calls and $-\overline{Ret}_{i,t+k}^{OTM\ Put}$ is the delta-hedged return of the strategy that sells OTM puts from week t to $t+k$ ($k = 1, 2, 3$, and 4) for commodity i . The strategy return is calculated based on Equation (5) using prices of the front-month option contract that has at least k weeks until expiration. $HPO_{i,t}$ is the hedging pressure in options which equals the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC DCOT reports. The control variables are model-free risk neutral volatility ($MFV_{i,t}$), time to maturity ($TTM_{i,t}$), convenience yield ($CY_{i,t}$), and lagged dependent variable. The time-series average of weekly cross-sectional coefficients and the average adjusted R^2 are reported. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with four lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. */**/** indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

	k = 1	k = 2	k = 3	k = 4
Dependent variable: $\overline{Ret}_{i,t+k}^{OTM\ Call}$				
$HPO_{i,t}$	0.17 (0.16)	1.79 (0.91)	1.58 (0.70)	2.72 (1.01)
Intercept	-3.53*** (-3.38)	-7.71*** (-4.35)	-12.83*** (-5.70)	-13.41*** (-4.63)
Controls	Yes	Yes	Yes	Yes
Adj. R^2	0.08	0.08	0.08	0.07
Obs (weeks)	1235	1233	1231	1229
Dependent variable: $-\overline{Ret}_{i,t+k}^{OTM\ Put}$				
$HPO_{i,t}$	3.83*** (3.82)	6.20*** (3.38)	6.25*** (2.36)	6.89* (1.93)
Intercept	4.38*** (5.17)	8.90*** (5.55)	10.98*** (3.86)	12.20*** (3.93)
Controls	Yes	Yes	Yes	Yes
Adj. R^2	0.06	0.07	0.07	0.06
Obs (weeks)	1235	1233	1231	1229

Table 12. Hedging Pressure Effects in Subsamples

This table presents the results from the following weekly Fama-MacBeth regressions in two time periods—3/21/1995–12/26/2006 and 1/3/2007–12/24/2018.

$$Ret_{i,t+k}^{long-short} = \alpha_0 + \alpha_1 HPO_{i,t} + Controls + \epsilon_{i,t+k},$$

where $Ret_{i,t+k}^{long-short}$ is the delta-hedged return of the long-short strategy that buys OTM calls and sells OTM puts from week t to $t + k$ for commodity i . The long-short strategy return is calculated based on Equation (5) using prices of the front-month option contract that has at least k weeks until expiration. $HPO_{i,t}$ is the hedging pressure in options that equals the net short option positions of commercial traders divided by option open interest based on position data from weekly CFTC COT reports. The control variables are model-free risk neutral volatility ($MFV_{i,t}$), time to maturity ($TTM_{i,t}$), convenience yield ($CY_{i,t}$), and lagged dependent variable. Separate regressions are estimated in the two time periods. The time-series average of weekly cross-sectional coefficients and the average adjusted R^2 are reported. The t -statistics in parentheses are computed based on Newey and West (1987) standard errors with four lags. The sample includes 24 commodities from 3/21/1995 to 12/24/2018. */**/** indicates statistically significant at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $Ret_{i,t+k}^{long-short}$			
	k = 1	k = 2	k = 3	k = 4
3/21/1995–12/26/2006				
$HPO_{i,t}$	2.99*** (2.38)	7.52*** (3.97)	9.72*** (3.69)	13.47*** (3.93)
Intercept	1.47 (1.61)	1.72 (1.10)	1.84 (0.94)	2.22 (0.84)
Controls	yes	yes	yes	yes
Adj. R^2	0.07	0.06	0.07	0.06
Obs (weeks)	615	614	613	612
1/3/2007–12/24/2018				
$HPO_{i,t}$	5.00*** (4.14)	8.46*** (4.18)	5.95 (1.49)	5.78 (0.95)
Intercept	0.24 (0.23)	0.66 (0.27)	-5.51 (-1.42)	-4.62 (-1.42)
Controls	yes	yes	yes	yes
Adj. R^2	0.10	0.08	0.07	0.07
Obs (weeks)	620	619	618	617
p value for testing the null that the mean of estimates for HPO is equal between two sample periods	0.25	0.73	0.32	0.06

Appendix A. Description of Commodity Options

	Commodity	Exchange ^a	Maturity Months	Termination of Option Trading
	WTI Crude Oil	NYMEX	Every month	The day which precedes by 6 business days the 25 th calendar day of the month prior to the contract month
Energy	Heating Oil	NYMEX	Every month	The 4 th last business day of the month prior to the contract month
	RBOB Gasoline	NYMEX	Every month	Same as above
	Natural Gas	NYMEX	Every month	Same as above
Metals	Gold ^b	NYMEX	Feb, Apr, Jun, Aug, Oct, Dec	Same as above
	Silver ^b	NYMEX	Jan, Mar, May, Jul, Sep, Dec	Same as above
	Copper ^c	NYMEX	Mar, May, Jul, Sep, Dec	Same as above
Grains	Corn	CBOT	Mar, May, Jul, Sep, Dec	The last Friday which precedes by at least 2 business days the last business day of the month prior to the contract month
	Soybeans	CBOT	Jan, Mar, May, Jul, Aug, Sep, Nov	Same as above
	Chicago Wheat	CBOT	Mar, May, Jul, Sep, Dec	Same as above
	Kansas Wheat	CBOT	Mar, May, Jul, Sep, Dec	Same as above
	Soybean Oil	CBOT	Jan, Mar, May, Jul, Aug, Sep, Oct, Dec	Same as above
	Soybean Meal	CBOT	Jan, Mar, May, Jul, Aug, Sep, Oct, Dec	Same as above
	Rough Rice	CBOT	Jan, Mar, May, Jul, Sep, Nov	Same as above
	Oats	CBOT	Mar, May, Jul, Sep, Dec	Same as above
Softs	Coffee	ICE	Mar, May, Jul, Sep, Dec	The 2 nd Friday of the calendar month preceding the contract month
	Sugar	ICE	Mar, May, Jul, Oct	The 15 th calendar day of the month prior to the contract month
	Cocoa	ICE	Mar, May, Jul, Sep, Dec	The 1 st Friday of the month prior to the contract month
	Cotton	ICE	Mar, May, Jul, Oct, Dec	The last Friday which precedes by at least 10 business days the first business day of the contract month
	Orange Juice	ICE	Jan, Mar, May, Jul, Sep, Nov	The 3 rd Friday of the month prior to the contract month
	Lumber	CME	Jan, Mar, May, Jul, Sep, Nov	The last business day of the month prior to the contract month
Livestock	Live Cattle	CME	Feb, Apr, Jun, Aug, Oct, Dec	The 1 st Friday of the contract month
	Feeder Cattle	CME	Jan, Mar, Apr, May, Aug, Sep, Oct, Nov	The last Thursday of the contract month with exceptions for November, which is the Thursday prior to Thanksgiving Day
	Lean Hogs ^d	CME	Feb, Apr, Jun, Jul, Aug, Oct, Dec	The 10 th business day of the contract month

^a NYMEX: New York Mercantile Exchange. ICE: Intercontinental Exchange. CME: Chicago Mercantile Exchange. CBOT: Chicago Board of Trade.

^b For gold and silver, futures contracts are listed for 3 consecutive months and any months indicated in the table. Because short-maturity contracts typically have small open interests, we only include options on futures contracts listed in the table.

^c Copper futures contracts, despite listed in every month, are mainly traded in five contracts (Mar, May, Jul, Sep, and Dec), so we only include copper options on these five futures contracts.

^d A May contract was introduced in 2002 but has been thinly traded, and therefore we exclude lean hog options on May futures contract.

Appendix B. Option Category and Greeks

Panel A lists three categories of options and their delta ranges used in the study. Options with absolute deltas below 0.125 and above 0.5 are excluded. Panel B presents the average deltas, gammas, and vegas for each category of options. The Greeks are calculated using prices of the front-month option contract that has at least k weeks to maturity.

Panel A: Option category		Delta range			
Out-of-the-money (OTM) puts		$-0.375 < \Delta_p \leq -0.125$			
At-the-money (ATM) options		$0.375 < \Delta_c \leq 0.5$ and $-0.5 < \Delta_p \leq -0.375$			
Out-of-the-money (OTM) call		$0.125 < \Delta_c \leq 0.375$			
Panel B: Average option Greeks		k = 1	k = 2	k = 3	k = 4
Delta (in absolute value)	OTM puts	0.239	0.240	0.240	0.241
	ATM options	0.439	0.438	0.438	0.438
	OTM calls	0.238	0.238	0.239	0.239
Gamma	OTM puts	3.825	3.614	3.441	3.298
	ATM options	4.977	4.696	4.465	4.273
	OTM calls	3.817	3.608	3.435	3.292
Vega	OTM puts	0.119	0.126	0.133	0.139
	ATM options	0.155	0.163	0.172	0.180
	OTM calls	0.119	0.126	0.132	0.139