Expected Skewness, Forecast Combination, and Commodity Futures Returns

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Abstract

In this paper, we construct ex-ante measures of skewness from ten major commodity futures contract characteristics including lagged skewness. We adopt two approaches. The first approach is based on monthly cross-sectional regressions of skewness on several lagged contract characteristics. The second approach is based on a forecast combination approach. We run monthly cross-sectional regressions of skewness on one contract characteristic only and then take the simple average of ten predicted skewness values. The performance of skewness prediction models is much better in the commodity futures market than in the U.S. equity market with much higher R^2s. Both approaches generate expected skewness that is significantly and negatively correlated with commodity futures contract returns. Our empirical evidence therefore provides strong support for the key prediction of the Mitton and Vorkink (2007) and Barberis and Huang (2008) models relating asset return skewness to asset returns.

Keywords: Commodity futures, skewness, expected skewness, forecast combination

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1. Introduction

There is growing evidence that commodity investment strategies based on commodity futures characteristics, such as, momentum, contrarian return, idiosyncratic volatility, and skewness generate highly significant long-short hedge portfolio returns.[1] In addition, some commodity futures contract specific characteristics, such as, basis, basis momentum, and hedging pressure can also generate highly significant long-short hedge portfolio returns.[2] Miffre (2016) provides a comprehensive review of various investment strategies in commodities market. Sakkas and Tessaromatis (2020) discuss literature related to nine major commodity futures characteristics they use to form commodity factor portfolios.

In this paper, we examine the pricing implications of expected skewness in the commodity futures market. Existing research suggests that the one-month lagged value of skewness of a commodities futures contract is one of the most important characteristics that can reliably predict commodity futures returns (Fernandez-Perez et al., 2018). During our sample period from 1987 to 2022, the Fama-MacBeth (1973) *t*-statistic from regressing monthly returns on characteristics consistently exceeds 3.0 in absolute value, crossing the threshold of Harvey et al. (2016). In addition, the one-month lagged skewness value generates large and significant long-short hedge portfolio returns and alphas relative to several commodity market risk factors.

Barberis and Huang (2008) study the asset pricing implications of cumulative prospect theory of Tversky and Kahneman (1992). One of their key predictions is that a positively skewed security can be overpriced and can earn a negative average return. The empirical evidence comes mainly from the equity market, but results tend to be mixed. For example, both Boyer et al. (2010) and Bali et al. (2011) construct expected skewness related to stock returns and find opposite estimated signs for expected skewness. To the best of our knowledge, there is no empirical evidence relating expected skewness, which is ex-ante in nature, to commodity futures contract returns.

We add to the literature in the following ways. First, we run monthly cross-sectional regressions of skewness in month *t* on three- and six-month lagged commodity futures contract characteristics to obtain estimated coefficients. Then the estimated coefficients are employed

[1]See Miffre and Rallis (2007), Bianchi et al. (2015), Asness et al. (2013), Szymanowska et al. (2014), Fuertes et al. (2015), Fernandez-Perez et al. (2018), and Bakshi et al. (2019).

[2]See Gorton et al. (2013), Yang (2013), Basu and Miffre (2013), Dewally et al. (2013), Boon and Prado (2019), and De Noon et al. (2000).

to predict skewness in month *t+1* using commodity futures contract characteristics in month *t-2* when the lag is three months and in month *t-5* when the lag is six months. Therefore, we construct our predicted skewness value using information with a three- or six-month lag. We initially construct expected skewness including lagged skewness as one of the predictors. We then construct expected skewness excluding lagged skewness as one of the predictors and using other characteristics only. Given the existing evidence that lagged skewness is related to commodity futures returns in a reliable way, it will be more challenging for the latter (expected skewness constructed from using other characteristics only) to be related to commodity futures returns in a reliable way.

Second, the number of commodity futures contracts employed in the literature is usually between 30 and 40, much smaller compared with the number of stocks in the equity market. This makes it difficult to simultaneously include many futures contract characteristics in the cross-sectional regressions to predict skewness. This issue is more pronounced during the early years when the number of contracts with available data is often less than 10 and when the predictors are correlated. As a result, we can only pick a small number of futures contract characteristics to predict skewness in each model. In these cases, we try different sets of contract characteristics in different models. This approach is similar to that of Chen et al. (2001) and Boyer et al. (2010).

In this study, we also adopt a forecast combination approach to resolve the issue. We predict skewness using each contract's characteristics and then form a combined forecast based on the simple average of forecasts from each individual characteristic. As pointed out by Bates and Granger (1969), combinations of individual forecasts can outperform the individual forecasts themselves. Timmermann (2006) provides a survey on the application of forecast combination approach in economics. Rapach et al. (2010) use 15 financial and macroeconomic variables to predict the equity premium on the S&P 500 index. Huang et al. (2021) predict cross-sectional stock returns using each of the seven profit-related fundamental variables and then take the simple average of the seven predicted values.

Third, we provide strong evidence that expected skewness in commodity futures contracts is reliably related to commodity futures contract returns in cross-sectional regressions and generate large hedge portfolio returns and significant alphas relative to the same four factor model used in Fernandez-Perez et al. (2018). Our results are robust to whether we use lagged skewness plus other characteristics to predict skewness or we use other characteristics only to predict skewness. Our results are also robust to whether we use expected skewness constructed following the method of Chen et al. (2001) and Boyer et al. (2010) or use expected skewness from a forecast combination approach (Bates and Granger, 1969).

Our main findings can be summarized as follows. First, when we use three-month lagged skewness, $SKEW_{i,t-3}$, and other contract characteristics to predict skewness in a monthly cross-sectional regression, the average estimated coefficient on $SKEW_{i,t-3}$ is around 0.73 with a Fama-MacBeth (1973) *t*-statistic of around 50. When we use six-month lagged skewness, $SKEW_{i,t-6}$, and other contract characteristics to predict skewness in a monthly cross-sectional regression, the average estimated coefficient on $SKEW_{i,t-3}$ is around 0.50 with a Fama-MacBeth (1973) *t*-statistic of around 30. Other contract characteristics are also useful in predicting skewness. For example, trading volume and open interest are negatively and significantly related to skewness. Speculation pressure (*HPSP*) is negatively related to skewness while hedging pressure (*HPHE*) is positively related to skewness. Both are highly significant. The R^2s from models including three-month lagged skewness, $SKEW_{i,t-3}$, are around 0.70. The R^2s from models including six-month lagged skewness, $SKEW_{i,t-6}$, are around 0.50.

When we exclude three-month lagged skewness, $SKEW_{i,t-3}$, and six-month lagged skewness, $SKEW_{i,t-6}$, to predict skewness, other characteristics become more important in predicating skewness. As expected, the R^2s drop significantly after excluding lagged skewness (ranging from 0.25 to 0.32, about half the size of R^2s from models including lagged skewness). We report empirical results for six individual models when we use three-month lagged characteristics and six individual models when we use six-month lagged characteristics. The baseline predictors include the following three characteristics: 12-month momentum, 36-month contrarian measure, and idiosyncratic volatility. Then we add each of the following six characteristics, volume, open interest, basis, 12-month basis momentum, speculation pressure, and hedging pressure. The average estimated coefficient on three-month lagged speculation pressure, $HPSP_{i,t-3}$, is -0.132 with a Fama-MacBeth *t*-statistic of -8.73. The average estimated coefficient on three-month lagged hedging, $HPHE_{i,t-3}$, is 0.178 with a *t*-statistic of 13.56. The average estimated coefficient on six-month lagged speculation pressure, $HPSP_{i,t-6}$, is -0.152 with a *t*-statistic of -10.54. The average estimated coefficient on six-month lagged hedging, $HPHE_{i,t-3}$, is 0.196 with a *t*-statistic of 15.96. Therefore, both speculation and hedging pressure are important predictors of skewness in commodity futures markets. However, we do not include both lagged speculation pressure and lagged hedging pressure in the same model due to their high correlations. This is an issue we address using the forecast combination approach.

In short, the performance of skewness prediction models for commodity futures markets is much better than the performance of skewness prediction models for the U.S. equity market. Boyer et al. (2010) show that the R^2 is only 0.06 for a model that uses both six-month lagged skewness, lagged idiosyncratic volatility, and other variables.[3] Chen et al. (2001) use a pooled time-series and cross-sectional regression approach to predict skewness. They report R^2s between 0.03 and 0.082 in various model specifications.[4] Both studies include lagged skewness, and lagged idiosyncratic volatility in predicting skewness. We show that in commodity futures markets, the minimum R^2 for predicting skewness is above 0.25 even when we exclude lagged skewness in the prediction models.

Second, we have 12 skewness prediction models that include lagged skewness as a predictor. We also have 12 skewness prediction models that exclude lagged skewness as a predictor and use other characteristics only. We report expected skewness results for eight out of 24 models.[5] The correlations between lagged skewness at time t and time t expected skewness for time $t+1$ range from 0.64 to 0.74 when lagged skewness is included as one of the predictors. The corresponding correlations range from 0.44 to 0.49 when lagged skewness is excluded as one of the predictors. We run Fama-MacBeth cross-sectional regressions of commodity futures returns, $R_{i,t+1}$, on these eight measures of expected skewness. We have a total of 48 different model specifications adding other characteristics. All of the eight measures of expected skewness are highly significant at either the 5% or 1% level, with only two exceptions that are significant at the 10% level. Therefore, we provide strong evidence that in commodity futures markets, expected skewness is reliably and negatively related to futures returns.

Sorting on these eight measures of expected skewness also generates large and highly significant long-short hedge portfolio returns ranging from -1.269% to -0.945% per month. The corresponding t-statistics range from -4.42 to -3.04. The alphas relative to a four factor model range from -1.149% to -0.745% per month. All of them are highly significant. For comparison, sorting on lagged skewness generates a long-short hedge portfolio return of -1.182% per month with a t-statistic of -4.36. The corresponding highly significant alpha is -1.013% per month. The performance of our ex-ante measures of skewness is as good as the performance of lagged skewness, which is a proxy for ex-ante skewness, in predicting futures returns.

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[3]See Table 2 of Boyer et al. (2010).
[4]See Table 2, 3, and 4 of Chen et al. (2001).
[5]The results from other 16 models are similar.

Finally, we construct expected skewness using a forecast combination approach. We predict skewness using three- and six-month lagged values of each of the nine widely used commodity futures contract characteristics. These nine characteristics do not include skewness. Then, we take the simple average of these nine predictions to construct expected skewness. We repeat this procedure for 10 characteristics that include skewness. We also repeat this procedure for skewness only. This is equivalent to only using one characteristic, i.e., lagged skewness, to predict skewness. In total, we have six measures of expected skewness from a forecast combination approach, three measures are from models with a lag of three months and three measures are from models with a lag of six months.

Overall, three measures of expected skewness constructed using one, nine, and ten characteristics with a lag of three months are significantly negatively related to futures returns. The average estimated coefficient (*t*-stat.) are -0.475 (-2.82), -3.147 (-3.25), and -2.263 (-3.40), respectively. The monthly long-short hedge portfolio returns are -0.991 (-3.77), -1.188 (-4.05), and -1.153 (-3.89), respectively. Monthly alphas relative to a four-factor model are -0.850, -0.846, and -0.822, respectively. All of them are highly significant. Therefore, the results from the forecast combination approach are similar to the results from the traditional approach of using alternative sets of characteristics when the lag is three months. When the lag is six months, the results related to the significance level of alphas from the forecast combination approach are weaker. The results related from cross-sectional regressions and long-short hedge portfolio returns are strong.

The rest of the paper proceeds as follows. Section 2 provides a brief review of the related literature. Section 3 discusses the detailed procedure for predicting skewness using lagged information. Section 4 explains the data sources, sample period, and commodity futures characteristics employed in this study. Section 5 presents summary statistics. Section 6 reports out main empirical results. Section 7 concludes the paper.

2. Literature Review

2.1 Studies on Skewness of Asset Prices

There is early theoretical research regarding the relationship between skewness and expected stock returns. Based on the cumulative prospect theory of Tversky and Kahneman (1992), Mitton and Vorkink (2007) and Barberis and Huang (2008) study the implications of skewness for stock returns. They show that rather than fully diversifying in equilibrium, some investors prefer to hold more stocks with positively skewed returns. As a result, more positively skewed stocks become over-priced and earn lower average returns. Zhang (2013) offers a concise summary of the differences in early theoretical work on skewness and asset prices.

Kumar (2009) uses idiosyncratic skewness as one of the characteristics of lottery-like stocks and finds evidence that investors tilt their portfolios towards lottery-like stocks. Harvey and Siddique (2000) decompose total skewness into idiosyncratic and systematic skewness. Total and idiosyncratic skewness are similar for most stocks due to the low explanatory power of the regression using daily data. Bali et al. (2011) provide empirical evidence regarding the relationship between stock returns and total skewness, idiosyncratic skewness, systematic skewness, and expected skewness. Amaya et al. (2015) use intraday data to compute weekly skewness for equity returns and study whether realized skewness predicts the cross-section of equity returns.

Fernandez-Perez et al. (2018) focus on commodity futures and examine whether skewness of daily commodity futures returns is related to expected returns on these futures contracts. They examine the performance of a long-short portfolio sorted on skewness, where skewness is measured over the past 12 months using daily futures returns. They report that long positions in commodity futures contracts with the most negative skewness and short positions in those with the most positive skewness earn a statistically significant average excess return of 8.01% per annum. The average alpha of the long-short skewness-sorted portfolio is 6.47% per annum relative to a four-factor commodity market model.[6]

2.2 Expected Skewness

From a theoretical perspective, there should be a negative relation between expected skewness and expected return. Both expected skewness and expected returns are not observable. The common practice is to use realized returns as the dependent variable in a cross-sectional regression, while a proxy for expected skewness is one of the independent variables. However, ex-ante expected skewness is difficult to measure (Boyer et al., 2010) Harvey and Siddique (1999) report that periods of high skewness are followed by low skewness using daily returns to estimate an autoregressive conditional skewness model. Fernandez-Perez et al. (2018) use lagged value of skewness as a proxy for expected skewness. Chen et al. (2001) use lagged skewness, daily standard deviation, firm size, turnover, and lagged returns to predict skewness. Boyer et al. (2010) employ lagged skewness, momentum, turnover, idiosyncratic volatility,

[6]See Tables IV and V of Fernandez-Perez et al. (2018).

firm size indicators, and industry indicators to predict idiosyncratic skewness. They find a strong negative cross-sectional relation between expected idiosyncratic skewness and realized returns. Bali et al. (2011) construct expected skewness in a similar way and report opposite results as Boyer et al. (2010).[7]

3. Predict Skewness Using Lagged Information

We first develop two measures of expected skewness. The first measure employs lagged skewness plus other commodity futures contract characteristic. The second measure does not use lagged skewness and only use other commodity futures contract characteristics. For the first measure, we first regress individual contracts' skewness on lagged skewness plus other contract characteristics:

$$SKEW_{i,t} = \gamma_{0,t} + \gamma_{1,t} SKEW_{i,t-3} + \gamma_{2,t}^{'} Z_{i,t-3} + \varepsilon_{i,t}, \quad (1)$$

where $SKEW_{i,t-3}$ is lagged skewness for contract *i* with a lag of three months. $Z_{i,t-3}$ is a vector of other contract characteristics with a lag of three months. For example, $Z_{i,t-3}$ can be a 4×1 vector consisting of lagged measures of 12-month momentum return, 36-month contrarian return, idiosyncratic volatility, and trading volume, i.e., $Z_{i,t-3}$ = [$MOM12_{i,t-3}$, $CTR36_{i,t-3}$, $IVOL_{i,t-3}$, and $VOLM_{i,t-3}$]'. In subsequent empirical analysis, we try different combinations of individual contract characteristics in $Z_{i,t-3}$. We also use lagged skewness and other contract characteristics with a lag of six months. The model specification is similar to Chen et al. (2001) and Boyer et al. (2010). We estimate the model in each month, *t*. The estimated coefficients from Equation (1) are used to construct the expected skewness for month *t+1* as follows:

$$ESKEW_{i,t+1} = SKEW_{i,t+1} = \gamma_{0,t} + \gamma_{1,t} SKEW_{i,t-2} + \gamma_{2,t}^{'} Z_{i,t-2}, \quad (2)$$

where $\gamma_{0,t}$ and $\gamma_{1,t}$ are estimated coefficients from Equation (1) in month *t*. $SKEW_{i,t-2}$ is skewness measure in month *t*-2. $Z_{i,t-2}$ is a vector of contract characteristics in month *t-2*. The

[7]Boyer et al. (2010) use horizons of 6 months to 60 months to estimate expected skewness. They argue that investors typically focus on a stock's long-run upside potential.

monthly regression allows $\gamma_{0,t}$ and $\gamma_{1,t}$ to vary over time. Therefore, the relation between skewness and lagged contract characteristics changes over time. We also carry out the same regression but using skewness and other contract characteristics with a lag of six months:

$$SKEW_{i,t} = \gamma_{0,t} + \gamma_{1,t} SKEW_{i,t-6} + \gamma_{2,t}^{'} Z_{i,t-6} + \varepsilon_{i,t}, \tag{3}$$

The estimated coefficients from Equation (3) are used to construct the expected skewness for month *t+1* as follows:

$$ESKEW_{i,t+1} = SKEW_{i,t+1} = \gamma_{0,t} + \gamma_{1,t} SKEW_{i,t-5} + \gamma_{2,t}^{'} Z_{i,t-5}, \tag{4}$$

where now the predictors for expected skewness in month *t+1* are $SKEW_{i,t-5}$ and $Z_{i,t-5}$ with a lag of five months in Equation (4).

The choice of lags in constructing expected skewness is subjective. We also experiment with lags of 12-, 24-, and 36-months. The magnitude and significance level of the estimated coefficients dissipate quickly. The relation between expected skewness and contract returns become insignificant to a large extent. The most likely reason is that lagged information from contract characteristics has become stale and therefore useless in pricing futures contract returns.

Now, we attempt to construct expected skewness without using lagged skewness. The Equations (1) and (3) become:

$$SKEW_{i,t} = \delta_{0,t} + \delta_{1,t}^{'} Z_{i,t-3} + \varepsilon_{i,t}, \tag{5}$$

and

$$SKEW_{i,t} = \delta_{0,t} + \delta_{1,t}^{'} Z_{i,t-6} + \varepsilon_{i,t}, \tag{6}$$

respectively. In Equations (5) and (6) lagged three- and six-month measures of skewness $SKEW_{i,t-3}$ and $SKEW_{i,t-6}$ are excluded in the monthly regressions. The corresponding expected skewness for month $t+1$ is calculated as:

$$ESKEW_{i,t+1} = SKEW_{i,t+1} = \delta_{0,t} + \delta_{1,t}^{'} Z_{i,t-2}, \tag{7}$$

and

$$ESKEW_{i,t+1} = SKEW_{i,t+1} = \delta_{0,t} + \delta_{1,t}^{'} Z_{i,t-5}, \tag{8}$$

respectively. The explanatory power or R^2s from Equations (5) and (6) should be lower than R^2s from Equations (1) and (3). This is confirmed in our empirical results. However, the constructed measures of expected skewness from Equations (7) and (8) using information $Z_{i,t-2}$ and $Z_{i,t-5}$ only remain significantly related to futures contract returns in month t+1. This is one of our main contributions to the literature.

4. Data and Commodity Futures Contracts Characteristics

4.1 Data Sources and Sample Period

We acquire the S&P Goldman Sachs commodity total return indices (GSCI) on individual commodity futures contracts from Datastream. GSCI is the leading fully collateralized investable commodity index followed by exchange-traded products. Bianchi et al. (2015) and Gao and Nardari (2018) motivate the choice of GSCI indices versus alternative commodities indexes or individual futures contracts.

Futures data from Datastream go back to 1974. But we start our empirical analysis in 1987 for two reasons. First, the number of futures contracts is small in the early years. This makes it infeasible to run monthly cross-sectional regressions and construct expected skewness measures. Second, the hedge and speculation positions data only become available after 1987. Our empirical evidence indicates these two variables are important determinants of skewness and are crucial in the constructing of expected skewness.

Our sample of monthly GSCI indices covers the period of 1987:01-2022:06. In addition to GSCI indices, we also obtain daily settlement prices on the most nearby and second most nearby contracts from Datastream. We construct basis and basis momentum using the nearby and second most nearby futures prices. The data for hedge and speculation positions are from the Commodity and Futures Trading Commission website.

Our dataset covers 34 commodity futures contracts that fall into the following five major categories, energy, grains and oilseeds, livestock, metals, and softs. Our coverage is similar to that used in earlier studies (Gorton et al., 2013; Hong and Yogo, 2012; Szymanowska et al., 2014; Bakshi et al., 2019; and Sakka and Tessaromatis, 2020). Some commodities futures contracts are excluded from our sample because some data items are missing.[8]

42. Commodity Futures Contract Characteristics

Our primary contract characteristics is skewness (*SKEW*). The skewness measure in each month *t* is measured using daily returns over a 12-month window from *t-12* to *t-1*. We then consider the other nine commodity futures contracts characteristics. These are 12-month momentum (*MOM12*), 36-month contrarian return (*CTR36*), idiosyncratic volatility (*IVOL*), trading volume (*VOLM*), open interest (*OPNI*), basis (*BASIS*), 12-month basis momentum (*BASM12*), speculating pressure (*HPSP*), and hedging pressure (*HPHE*).[9]

For all nine contract characteristics, we use data during a period prior to the portfolio formation month *t*. For example, *MOM12* is measured as the cumulative futures contract monthly return over prior months *t-12* to *t-2*. For futures contract daily basis, we use the second nearby futures contract daily price and the first nearby futures contract daily price. This is because commodity spot markets are illiquid and spot prices may not be available. We use the first nearby futures price as the spot price. This procedure is similar to that of Szymanowska et al. (2014) and most other earlier studies. Appendix A provides a detailed definition of the futures characteristics used in this study. We winsorize all characteristics at the 1% and 99% levels among all observations.

5. Summary Statistics

5.1 Basic Statistics for Commodity Futures Contract Characteristics

[8]For example, 2nd nearest contract futures prices are not available for propane, pork belly, rough rice, and milk and therefore the basis cannot be constructed. The GSCI individual futures contract index for ethanol only starts in 2019 and is too short for empirical analysis.

[9]An indicator variable measuring 52-week high has a correlation of 0.59 with the 12-month momentum measure. The empirical results using a 52-week high indicator variable are similar to those from using the 12-month momentum measure. The 52-week indicator is calculated as the ratio of monthly price in the past 12 months to the highest price in the past 12 months (George and Huang, 2004 ; Bianchi et al., 2016).

Table 1 provides summary statistics for our 10 commodity futures contract characteristics. Panel A shows that the mean (median) value of *SKEW* is -0.096 (-0.062). The mean value of *MOM12* is 0.029, or 2.9% per month. *IVOL* is the standard deviation of the residuals from a regression of daily returns commodity market index daily returns over prior months from *t-12* to *t-1*. The mean value of *IVOL* is 0.014 from our pooled time-series and cross-sectional sample.

Panel B reports the pairwise correlations among selected variables. *SKEW* has a negative correlation of -0.08 with *MOM12* and a negative correlation of -0.15 with *CTR36*, respectively. *SKEW* is significantly and positively correlated with *IVOL*. *SKEW* is significantly and negatively correlated with both *VOLM* and *OPNI*. Both of them are highly significant. The correlation between *SKEW* and e *HPSP* is the most negative, -0.19, and highly significant. The correlation between *SKEW* and *HPSP* is the most positive, 0.19, and highly significant.

6. Empirical Results

6.1 The Determinants of Skewness

We start our empirical analysis with the prediction of *SKEW*. Panel A of Table 2 summarizes the average coefficient (*t*-statistic) from a Fama-MacBeth monthly regression of 34 commodity futures contract skewness, $SKEW_{i,t}$, on lagged skewness and other contract characteristics. The first six columns in Panel A include three-month lagged skewness, $SKEW_{i,t-3}$, as in Equation (1). Then the first six columns in Panel A include one of the following contract characteristics one at a time: $VOLM_{i,t-3}$, $OPNI_{i,t-3}$, $BASIS_{i,t-3}$, $BASM12_{i,t-3}$, $HPSP_{i,t-3}$, and $HPHE_{i,t-3}$. The estimated coefficients on $SKEW_{i,t-3}$ range from 0.728 to 0.736 with *t*-statistics around as large as around 50. The estimated coefficients (*t*-stats) on $VOLM_{i,t-3}$ and $OPNI_{i,t-3}$ are -0.019 (-2.82) and -0.018 (-2.67), respectively. The estimated coefficients (*t*-stats) on $HPSP_{i,t-3}$ and $HPHE_{i,t-3}$ are -0.046 (-4.53) and 0.058 (5.98), respectively. Therefore, *SKEW* is significantly related to three-month lagged measures of skewness, trading volume, open interest, speculation pressure, and hedging pressure. The R^2s are high, ranging from 0.687 to 0.720. The highest R^2s are from the two models that include lagged measures of *HPSP* and *HPHP*, respectively.

The next six columns in Panel A include six-month lagged skewness $SKEW_{i,t-6}$ as in Equation (3). The following six columns in Panel A include one of the following contract characteristics one at a time: $VOLM_{i,t-6}$, $OPNI_{i,t-6}$, $BASIS_{i,t-6}$, $BASM12_{i,t-6}$, $HPSP_{i,t-6}$, and $HPHE_{i,t-6}$. The empirical results essentially confirm the findings from using three-month lagged contract characteristics, but with some important differences. For example, the magnitude of estimated coefficients on $SKEW_{i,t-6}$ have become smaller, ranging from 0.486 to 0.503. The corresponding *t*-statistics have also become smaller but remain highly significant; all of the six *t*-statistics are around 30. The magnitude of R^2s has also become smaller, ranging from 0.500 to 0.534. The highest R^2s are still from the two models that include lagged measures of *HPSP* and *HPHP*, respectively.

In Panel B, we attempt to exclude lagged skewness and rely only on the rest of the nine contract characteristics to predict skewness. The first six columns in Panel B show that the significant predictors include $CTR36_{i,t-3}$, $IVOL_{i,t-3}$, $VOLM_{i,t-3}$, $OPNI_{i,t-3}$, $BASIS_{i,t-3}$, $HPSP_{i,t-3}$, and $HPHP_{i,t-3}$. In general, these characteristics are associated with larger estimated coefficients and large *t*-statistics in absolute value when compared with the results in the first six columns in Panel A. For example, the estimated coefficients (*t*-stats) on $HPSP_{i,t-3}$ and $HPHE_{i,t-3}$ have become -0.132 (-8.73) and 0.178 (13.56), respectively. The magnitude of estimates more than double while the magnitude of *t*-statistic essentially double. As expected, the R^2s drop significant after we exclude lagged skewness. Now the R^2s range from 0.261 to 0.315, which are less than half of the R^2s from models including lagged skewness.

We can draw the same conclusions from the next six columns of Panel B. For example, both estimated coefficients and *t*-statistics on $HPSP_{i,t-6}$ and $HPHE_{i,t-6}$ have increased in absolute value. The highest R^2s are still from the two models that include lagged measures of *HPSP* and *HPHP*, respectively. But there are some differences between the first and next six columns of Panel B. From Panel A, the drop in R^2 using 6-month lagged skewness instead of using 3-month lagged skewness is highly notable at about 19%. On the other hand, the drop in R^2s using 6-month lagged values of other contract characteristics instead of using 3-month lagged values of other contract characteristics is negligible.

The interpretation is that three-month lagged skewness is much more informative about future skewness than six-month lagged skewness. On the other hand, three-month lagged values of other characteristics are as informative about future skewness as six-month lagged values of other characteristics. Notice that we measure skewness in each month *t* using daily futures contract returns over prior months *t-1* to *t-12*. The same procedure is applied when we measure other characteristics including 12-month momentum, idiosyncratic volatility, volume, open interest, basis, basis momentum, speculation pressure, and hedging pressure. Our evidence suggests that the dissipation of information regarding future skewness is faster in lagged skewness.[10]

6.2 Summary Statistics for Expected Skewness

There are a total 24 models reported in Table 2 for the prediction of future skewness. To conserve space, we use monthly estimated coefficients from eight models to construct expected skewness. *ESKEW_Y1_L3* and *ESKEW_Y2_L3* refer to expected skewness constructed from Models 1 and 6, respectively. These two measures include three-month lagged skewness and other contract characteristics to construct expected skewness. *ESKEW_Y3_L6* and *ESKEW_Y4_L6* refer to expected skewness constructed from Models 7 and 12. These two measures include six-month lagged skewness and other contract characteristics to construct expected skewness. Similarly, *ESKEW_N1_L3*, *ESKEW_N2_L3*, *ESKEW_N3_L6*, *ESKEW_N4_L6* refer to expected skewness constructed from Models 13, 18, 19, and 24, respectively. These four measures exclude lagged skewness and only use other contract characteristics to construct expected skewness. The first two use a lag of three months while the last two use a lag of six months.

Table 3 provides summary statistics for skewness and expected skewness. Notice that skewness is measured using information at time *t*. The expected skewness is also constructed using information at time *t*. The expectation is for month *t+1*. Panel A shows that the standard deviation of expected skewness constructed using both lagged skewness and lagged values of other characteristics are larger than that of expected skewness using constructed using lagged values of other characteristics only. Panel B shows that the correlations between skewness and expected skewness constructed using both lagged skewness and lagged values of other characteristics are larger than that of expected skewness constructed using lagged values of other characteristics only.

6.3 Skewness and Commodity Futures Contract Returns

Here, we begin to examine the relation between commodity futures contract returns, $R_{i,t+1}$, and various contract characteristics measured at time *t*. Table 4 summarizes the average coefficient (*t*-statistic) from Fama-MacBeth (1973) monthly regressions of 34 commodity futures contract monthly returns on contract characteristics. Table 4 contains eight model

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[10] We also examine skewness with a lag of 12 months. The predictive power is even lower.

specifications. Two characteristics, $SKEW_{i,t}$ and $MOM12_{i,t}$, are always included in the regressions. Then, Table 4 adds each of the following eight characteristics $CTR36_{i,t}$, $IVOL_{i,t}$, $VOLM_{i,t}$, $OPNI_{i,t}$, $BASIS_{i,t}$, $BASM12_{i,t}$, $HPSP_{i,t}$, and $HPHE_{i,t}$ one at a time. All characteristics are standardized cross-sectionally (each characteristic is adjusted for the cross-sectional mean and scaled by cross-sectional standard deviation).

There is clear evidence that among the 10 commodity futures contract characteristics, skewness is the most important characteristic that predict futures contract returns. The estimated coefficients on $SKEW_{i,t}$ range from -0.414 to -0.320. The corresponding *t*-statistics range from -3.84 to -3.25. All of them pass the threshold of 3.0 in absolute value (Harvey et al. 2016). In sharp contrast, 12-momentum measure *MOM12* is significant at the 5% level in only three out of eight model specifications. 36-month contrarian return $CTR36_{i,t}$ is also significant at the 5% level. So is the basis measure, $BASIS_{i,t}$. Since all characteristics are standardized cross-sectionally, the estimated coefficients from different characteristics can be directly compared. None of the other characteristics have any slope coefficient that is large than 0.300 in absolute value with only one exception from $MOM12_{i,t}$ in Model 1. The R^2s from these eight models range from 0.211 to 0.227.

6.4 Expected Skewness and Commodity Futures Contract Returns:

Our primary objective is to examine the relation between expected skewness for time $t+1$ measured using information available at time t and commodity future contract returns at time $t+1$. Now, we come to the point of summarizing our main findings.

Table 5 presents the results when expected skewness is constructed using both lagged skewness and lagged values of other characteristics as predictors. Table 6 presents the results when expected skewness is constructed using only lagged values of other characteristics as predictor.

Panel A of Table 5 includes two measures of expected skewness constructed using predictors with a lag of three months: $ESKEW\_Y1\_L3_{i,t}$ and $ESKEW\_Y2\_L3_{i,t}$. Panel B of Table 5 includes two measures of expected skewness constructed using predictors with a lag of six months: $ESKEW\_Y3\_L6_{i,t}$ and $ESKEW\_Y4\_L6_{i,t}$. The cross-sectional regressions add one of the following six contract characteristics at a time: $VOLM_{i,t}$, $OPNI_{i,t}$, $BASIS_{i,t}$, $BASM12_{i,t}$, $HPSP_{i,t}$, and $HPHE_{i,t}$.

Panel A of Table 5 shows that expected skewness for time $t+1$ is related to commodity futures contract returns at time $t+1$ in a reliable way. The estimated coefficients for

$ESKEW\_Y3\_L3_{i,t}$ range from -0.533 to -0.366. The corresponding *t*-statistics range from -3.51 to -2.41. The estimated coefficients for $ESKEW\_Y2\_L3_{i,t}$ range from -0.431 to -0.374. The corresponding *t*-statistics range from -3.05 to -2.47. The results from Panel B of Table 5 for $ESKEW\_Y3\_L6_{i,t}$ and $ESKEW\_Y4\_L6_{i,t}$ are similar.

In short, all 24 models in Table 5 suggest a significant role of expected skewness in relation to futures contract monthly returns at the 5% level. Other contract characteristics are only significant occasionally depending on the model specification.

The most impressive results come from Table 6, when expected skewness is constructed using only lagged values of other characteristics as predictors. Panel A of Table 6 includes two measures of expected skewness constructed using predictors with a lag of three months: $ESKEW\_N1\_L3_{i,t}$ and $ESKEW\_N2\_L3_{i,t}$. Panel B of Table 6 includes two measures of expected skewness constructed using predictors with a lag of six months: $ESKEW\_N3\_L6_{i,t}$ and $ESKEW\_N4\_L6_{i,t}$. The cross-sectional regressions add one of the following six contract characteristics at a time: $VOLM_{i,t}$, $OPNI_{i,t}$, $BASIS_{i,t}$, $BASM12_{i,t}$, $HPSP_{i,t}$, and $HPHE_{i,t}$.

Panel A of Table 6 shows that four out of six estimated coefficients on $ESKEW\_N1\_L_{i,t}$ are highly significant at the 5% level. The other two are significant at the 10% level. Under an alternative specification for expected skewness, all six estimated coefficients on $ESKEW\_N2\_L_{i,t}$ are highly significant at the 5% level. The results from Panel B of Table 6 are stronger. All six estimated coefficients on $ESKEW\_N3\_L_{i,t}$ are highly significant at the 5% level. All six estimated coefficients on $ESKEW\_N4\_L_{i,t}$ are also highly significant at the 5% level.

In short, 22 out of 24 models in Table 6 suggest a significant role of expected skewness in relation to futures contract monthly returns at the 5% level or the 1% level. Other contract characteristics are only significant occasionally depending on the model specification. In addition, R^2s from 24 models in Table 5 and 24 models in Table 6 are close. In other words, the explanatory power of expected skewness for futures contract returns increases substantially when we add lagged skewness, whether it is a lag of three months of a lag of six months in constructing expected skewness.

6.6 One-Way Hedge Portfolio Returns Sorted on Skewness and Expected Skewness

The previous section employs Fama and MacBeth (1973) regressions to examine the predictive power of skewness and expected skewness. As a common practice in the literature, we constructed long-short hedge portfolio returns sorted on skewness and expected skewness.

We use the same eight measures of expected skewness as in the cross-sectional regressions to do the sorting in month *t*. The sorting is based on the 20% and 80% cutoff points in each month. Then we calculate equal-weighted portfolio returns in month *t+1*.

For simplicity, we omit subscripts for expected skewness. *ESKEW_Y1_L3*, *ESKEW_Y2_L3*, *ESKEW_Y3_L6*, and *ESKEW_Y4_L6* refer to expected skewness constructed using both lagged skewness and lagged values of other contract characteristics. *ESKEW_N1_L3*, *ESKEW_N2_L3*, *ESKEW_N3_L6*, and *ESKEW_N4_L6* refer to expected skewness constructed using only lagged values of other contract characteristics.

Table 7 shows that when the sorting variable is skewness, the long-short hedge portfolio yields a return of -1.182% per month with a *t*-statistic of -4.36. When the sorting variable is one of the four measures of expected skewness, when we include both lagged skewness and lagged values of other characteristics to construct expected skewness, the long-short hedge portfolio returns range from -1.346% to -0.975% per month. The corresponding *t*-statistics all exceed 3.0 in absolute value. When the sorting variable is one of the four measures of expected skewness when we only use lagged value of other characteristics to constructing expected skewness, the long-short hedge portfolios' returns range from -1.143% to -0.945% per month. The corresponding *t*-statistics all exceed 3.0 in absolute value.

Overall, the magnitude of long-short hedge portfolio returns is large and statistical significance levels are high for all eight measures of expected skewness. The empirical results from long-short hedge portfolios returns in Table 7 are consistent with Fama-MacBeth regression results from Tables 5 and 6.

6.7 Alphas Relative to Commodity Market Risk Factors

As in the asset pricing literature, we need to regress these long-short hedge portfolio returns on widely used risk factors in the commodities market and examine whether alphas from these regressions are significant. The alphas capture risk-adjusted abnormal returns. Significant alphas indicate that hedge portfolio returns are not spanned by the risk factors used in the regressions (Barillas and Shanken, 2017; Fama and French, 2018). We construct four observable risk factors related to market risk, momentum, basis, and hedging pressure. We refer to them as the *CMKT*, *CMOM12*, *CBASIS*, and *CHP* factors. These are the primary benchmarks used by Fernandez-Perez et al. (2018) to study the anomalous returns related to skewness in commodities futures contracts.[11]

Table 8 reports the alphas from regressing long-short hedge portfolio returns on the two-, three-, and four-factor models. The two-factor model includes the market and momentum factors (*CMKT*, *CMOM12*). The three-factor model includes the market, momentum, and basis factors (*CMKT*, *CMOM12*, and *CBASIS*). The four-factor model includes the market, momentum, basis, and hedging pressure factors (*CMKT*, *CMOM12*, *CBASIS*, and *CHP*).

Our discussion focuses on the alphas from the four-factor model. Sorted on skewness, *SKEW*, generates an alpha of -1.013% per month which is highly significant. Sorted on the first four measures of expected skewness generates alphas ranging from -1.029% to -0.759% per month. All of them are significant at the 5% level. Sorted on the last four measures expected skewness generates alphas ranging from -0.908 to -0.694% per month. All of them are highly significant. But the alphas are slightly smaller when compared with alphas from sorting on the first four measures of expected skewness.

6.8 Expected Skewness from Using a Forecast Combination Approach

The number of commodity futures contracts employed in empirical studies is usually between 30 and 40. This is much smaller compared with the number of stocks in the equity market and makes it difficult to simultaneously include all futures contract characteristics in the cross-sectional regressions, either in predicting contract returns or predicting skewness. This is particularly true during early years of the sample period when the number of contracts with available data is less than 10. In this section, we adopt a forecast combination approach to resolve this issue. The forecast combination approach was first proposed by Bates and Granger (1969). Timmermann (2006) provides a survey of the forecast combination approach. Rapach et al. (2010) and Huang et al. (2021) apply it to time-series and cross-sectional forecasting in finance, respectively.

In our case, we first use one of the 10 contract characteristics only and run the following two regression in each month:

$$SKEW_{i,t} = \lambda_{0,t} + \lambda_{1,t} X_{i,t-3} + \varepsilon_{i,t}, \tag{9}$$

[11]This corresponds to the EW, TS, MOM, and HP factors in Fernandez-Perez et al. (2018). See Table II of their paper.

$$SKEW_{i,t} = \lambda_{0,t} + \lambda_{1,t} X_{i,t-6} + \varepsilon_{i,t}, \tag{10}$$

where X refers to *SKEW*, *MOM12*, *CTR36*, *IVOL*, *VOLM*, *OPNI*, *BASIS*, *BASM12*, *HPSP*, and *HPHE*, respectively. After obtaining predicted skewness for month $t+1$ using X measured at time t-2 and t-5, i.e., $X_{i,t-2}$, and $X_{i,t-5}$, we construct two sets of expected skewness measures using a forecast combination approach by taking the simple average of several skewness forecasts. The first set includes *ESKEW_L3_FCB1*, *ESKEW_L3_FCB9*, and *ESKEW_L3_FCB10*. These three measures use lagged skewness, nine other contract characteristics, and lagged skewness plus nine other contract characteristics to construct expected skewness, respectively. The lag is three months. The second set includes *ESKEW_L6_FCB1*, *ESKEW_L6_FCB9*, and *ESKEW_L6_FCB10*. These three measures use lagged skewness, nine other contract characteristics, and lagged skewness plus nine other contract characteristics to construct expected skewness, respectively. The lag is six months.

We repeat the standard analysis in three panels of Table 9. Panel A reports the average coefficient (t-statistic) from Fama-MacBeth monthly regressions of 34 commodity futures contract monthly returns on each of the six measures of expected skewness. Panel B reports the long-short hedge portfolio returns sorted on each of six measures of expected skewness. Panel C reports the alphas from regressing long-short hedge portfolio returns on the two-, three-, and four-factor models, respectively.

Panel A shows that expected skewness constructed from using lagged skewness only is strongly negatively related to futures contract returns at time $t+1$; the estimated coefficient (t-stat.) on *ESKEW_L3_FCB1* is -0.475 (-2.82). The estimated coefficient (t-stat.) on *ESKEW_L3_FCB9* is -3.147 (-3.25). Based on either the magnitude of the estimate, the level of siginificance, and the R^2, *ESKEW_L3_FCB9* outperforms *ESKEW_L3_FCB1*. The estimated coefficient (t-stat.) on *ESKEW_L3_FCB10* is -2.263 (-3.40). These results come from prediction models with a lag of three months as in Equation (9). Panel A also shows the results from prediction models with a lag of six months as in Equation (10). Now *ESKEW_L6_FCB1* has become insignificant while *ESKEW_L6_FCB9* remains highly significant.

Panels B and C summarize the results from long-short hedge portfolio returns and report alphas relative to the two, three, and four commodity market risk factor models. There are two major patterns. First, the results from using a lag of three months are stronger than the results from using a lag of six months, with both larger long-short hedge portfolio returns and risk-adjusted alphas. Second, expected skewness from nine characteristics under the forecast combination approach generate more negative long-short returns than expected skewness from lagged skewness only.

In Figure 1, we plot the cumulative returns from the long-short hedge portfolios sorted on *ESKEW_L3_FCB1*, *ESKEW_L3_FCB9, and ESKEW_L3_FCB10*, respectively. The picture confirms our conclusions drawn from the results in Table 9.

6.9 Two-Way Hedge Portfolio Returns

In this section, we explore whether we can generate large long-short hedge portfolio returns by employing more than one contract characteristics as in Bianchi et al (2015) and Fuertes et al. (2014). We pair skewness and each of the eight measures of expected skewness with each of the nine other contract characteristics. We find that pairing skewness and each of the eight measures of expected skewness with 12-month basis momentum, *BASM12*, generates much larger long-short hedge portfolio returns. The sorting is carried out independently on each characteristic from the pair under consideration. The sorting is based on the 30% and 70% value of each contract characteristic in each month.

In the case of *BASM12×SKEW* two-way sorting, the long portfolio consists of contracts with below 30% cutoff value of *BASM12* and above 70% cutoff value of *SKEW*. The short portfolio consists of contracts with above 70% cutoff value of *BASM12* and below 30% value of *SKEW*.

Panel A of Table 10 reports the raw returns of the hedge portfolios. The *BASM12×SKEW* sorting generates an impressive hedge portfolio return of -1.576% per month with a *t*-statistic of -4.02. This is equivalent to an annualized return of 18.91%. Using expected skewness *ESKEW_Y1_L3* as the second sorting variable, the *BASM12×ESKEW_Y1_L3* sorting also generates an impressive hedge portfolio return of -1.758% per month with a *t*-statistic of -4.11. This is equivalent to an annualized return of 21.10%. Similarly, using expected skewness, *ESKEW_N1_L3*, as the second sorting variable, the *BASM12×ESKEW_N1_L3* sorting generates an impressive hedge portfolio return of -1.579% per month with a *t*-statistic of -3.69. This is equivalent to an annualized return of 18.95%. As mentioned in earlier sections, *ESKEW_Y1_L3* includes lagged skewness while *ESKEW_N1_L3* excludes lagged skewness in constructing expected skewness.

Panel B of Table 10 reports risk-adjusted alphas from the two-, three-, and four-factor models used in studying commodity futures contract returns. All of the alphas are significant with only one exception. For the three pairs of contract characteristics we discussed in Panel

A, i.e., *BASM12×SKEW*, *BASM12×ESKEW_Y1_L3*, *BASM12×ESKEW_N1_L3*, the alphas relative to the four-factor model are -1.481%, -1.477%, and -1.281%, respectively. All of them are highly significant.

7. Conclusions

Asset pricing models predict an ex-ante relation between alternative measures of risk and expected returns. Therefore, the relationship between risk and return should be contemporaneous and measures or risk and returns should be ex-ante. In empirical implementation, it is often difficult to measure both expected returns and expected measures of risk. The common practice is to use realized returns as the dependent variable in cross-sectional regressions. Various proxies for ex-ante risk measures are the independent variables. This approach is realistic and feasible. The problem is that the measure of ex-ante risk needs to be of high quality. In the case of skewness risk, the empirical evidence from U.S. equity market is mixed. One potential explanation is that the variables used to construct ex-ante measures of skewness cannot fully capture the cross-sectional and time-series variation in skewness risk. R^2s from alternative models of predicting skewness tend to be low.

In this paper, construct ex-ante skewness for commodity futures and see whether there is a negative relation between commodity futures contract returns and predicted ex-anted measures of skewness. This negative relation will provide a strong support for theoretical work related to the implication of asset return skewness on asset returns (Mitton and Vorkink, 2007; Barberis and Huang, 2008). We focus on 10 major commodity futures contract characteristics and include lagged skewness itself to predict future skewness.

The performance of skewness prediction models in the commodity futures market is much more successful when compared to skewness prediction models in the U.S. equity market. The R^2s from skewness prediction models including lagged skewness reach 0.70. The R^2s from skewness prediction models excluding lagged skewness exceeds 0.25. We find that both lagged measures hedging pressure and speculation pressure are reliable predictors of skewness in commodity futures market, together with other variables. We also use a forecast combination approach to construct ex-ante measures of skewness. The forecast combination approach is particularly suitable for predicting skewness in commodity futures market because the relatively small number of contracts available.

Finally, we test the relation between expected skewness and commodity futures contract returns and find a strong and negative relation, consistent with the prediction of theoretical work on skewness risk and asset returns.

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Table 1 Commodity Futures Contract Characteristics

The sample covers the period from January 1987 to June 2022. Panel A reports summary statistics on the following 10 commodity futures contract characteristics: *SKEW*, *MOM12*, *CTR36*, *IVOL*, *VOLM*, *OPNI*, *BASIS*, *BASM12*, *HPSE*, and *HPHE*. The summary statistics including the definition of each characteristic, mean, the 5th percentile value, median, the 95th percentile value, the standard deviation, and number of observations. The summary statistics are calculated from pooled time-series cross-sectional observations. The details of the construction of the sorting variables are provided in Appendix A. Panel B reports the pair-wise correlations among selected variables. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Basic Statistics

	Definition	Number of Observations	Mean	5%	Median	95%	Standard Deviation
SKEW	Skewness	12,851	-0.096	-0.904	-0.062	0.561	0.580
MOM12	12-month momentum return	12,903	0.029	-0.401	-0.010	0.599	0.307
CTR36	36-month contrarian return	12,362	0.057	-0.588	-0.060	1.083	0.550
IVOL	Idiosyncratic volatility	12,851	0.014	0.006	0.013	0.024	0.007
VOLM	Average Daily Trading volume (million $)	10,683	2,798.671	1.928	268.875	12,754.531	9,054.974
OPNI	Average Daily Open interest (million $)	10,780	7,653.502	3.959	1,290.518	32,191.666	18,764.068
BASIS	Basis	11,971	0.005	-0.044	0.004	0.053	0.054
BASM12	12-month basis momentum	11,845	-0.002	-0.073	-0.000	0.063	0.060
HPSP	Speculating Pressure	10,088	0.621	0.377	0.628	0.841	0.147
HPHE	Hedging Pressure	10,088	0.435	0.239	0.448	0.579	0.097

Panel B: Pairwise Correlations

	SKEW	*MOM12*	*CTR36*	*IVOL*	*VOLM*	*OPNI*	*BASIS*	*BASM12*	*HPSE*
MOM12	-0.08***								
CTR36	-0.15***	0.49***							
IVOL	0.02***	-0.03***	-0.01						
VOLM	-0.08***	0.03***	-0.07***	-0.18***					
OPNI	-0.07***	0.03***	-0.08***	-0.13***	0.85***				
BASIS	0.05***	-0.23***	-0.26***	0.01	-0.01	-0.01			
BASM12	0.01	0.16***	0.01	-0.04***	0.01	0.01	-0.30***		
HPSP	-0.19***	0.41***	0.24***	-0.02**	0.07***	0.04***	-0.12***	0.07***	
HPHE	0.19***	-0.29***	-0.21***	-0.08***	0.01	0.05***	0.09***	-0.05***	-0.75***

Table 2 Cross-Sectional Regressions: The Determinants of Skewness

The sample covers the period from January 1987 to June 2022. The table summarizes the average coefficient (*t*-statistic) from Fama-MacBeth monthly regressions of 34 commodity futures contract skewness $SKEW_{i,t}$ on lagged skewness and other contract characteristics. The table considers two lagged measures of skewness, $SKEW_{i,t-3}$ and $SKEW_{i,t-6}$, with a lag of three and six months, respectively. Panel A reports the results including lagged skewness as a predictor. Models 1-6 always include the following four contract characteristics: $SKEW_{i,t-3}$, $MOM12_{i,t-3}$, $CTR36_{i,t-3}$, and $IVOL_{i,t-3}$. Models 1-6 then add each of the following six commodity futures contract characteristics one at a time: $VOLM_{i,t-3}$, $OPNI_{i,t-3}$, $BASIS_{i,t-3}$, $BASM12_{i,t-3}$, $HPSP_{i,t-3}$, and $HPHE_{i,t-3}$. Models 7-12 always include the following four contract characteristics: $SKEW_{i,t-6}$, $MOM12_{i,t-6}$, $CTR36_{i,t-6}$, and $IVOL_{i,t-6}$. Models 7-12 add each of the following six commodity futures contract characteristics with a lag of three months one at a time: $VOLM_{i,t-6}$, $OPNI_{i,t-6}$, $BASIS_{i,t-6}$, $BASM12_{i,t-6}$, $HPSP_{i,t-6}$, and $HPHE_{i,t-6}$. Panel B repeats the regression analysis excluding lagged skewness as the predictor. Models 13-18 excludes $SKEW_{i,t-3}$ while Models 19-24 exclude $SKEW_{i,t-6}$. All characteristics are standardized in the cross-section. Each characteristic is adjusted for the cross-sectional means and scaled by cross-sectional standard deviations. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Including Lagged Skewness as a Predictor

	Dependent Variable is $SKEW_{i,t}$						Dependent Variable is $SKEW_{i,t}$					
	1	2	3	4	5	6	7	8	9	10	11	12
Intercept	-0.009*	-0.009*	-0.012***	-0.015***	-0.001	-0.001	-0.018***	-0.019***	-0.025***	-0.030***	-0.004	-0.002
	(-1.84)	(-1.86)	(-2.85)	(-3.14)	(-0.15)	(-0.08)	(-2.85)	(-2.95)	(-4.70)	(-5.05)	(-0.57)	(-0.40)
$SKEW_{i,t-3}$	0.736***	0.736***	0.731***	0.728***	0.729***	0.731***						
	(50.74)	(51.12)	(49.01)	(48.00)	(52.51)	(51.31)						
$MOM12_{i,t-3}$	-0.098***	-0.101***	-0.106***	-0.098***	-0.068***	-0.060***						
	(-6.41)	(-6.78)	(-7.12)	(-5.82)	(-4.57)	(-4.39)						
$CTR36_{i,t-3}$	0.010	0.013	0.031**	0.020	0.008	0.005						
	(0.76)	(1.05)	(2.29)	(1.27)	(0.66)	(0.42)						
$IVOL_{i,t-3}$	0.014	0.017	0.022**	0.026**	0.023**	0.028***						
	(1.36)	(1.60)	(2.15)	(2.46)	(2.14)	(2.72)						
$VOLM_{i,t-3}$	-0.019***											
	(-2.82)											
$OPNI_{i,t-3}$		-0.018***										
		(-2.67)										
$BASIS_{i,t-3}$			0.012									
			(1.35)									
$BASM12_{i,t-3}$				-0.011								
				(-1.24)								
$HPSP_{i,t-3}$					-0.046***							
					(-4.53)							

$HPHE_{i,t-3}$						0.058***						
						(5.98)						
$SKEW_{i,t-6}$							0.501***	0.503***	0.491***	0.495***	0.486***	0.486***
							(29.94)	(30.22)	(26.90)	(27.40)	(30.00)	(29.04)
$MOM12_{i,t-6}$							-0.129***	-0.139***	-0.122***	-0.130***	-0.083***	-0.071***
							(-7.39)	(-8.05)	(-7.13)	(-7.16)	(-4.94)	(-4.62)
$CTR36_{i,t-6}$							0.013	0.025	0.038**	0.029*	0.013	0.014
							(0.84)	(1.48)	(2.29)	(1.68)	(0.94)	(0.95)
$IVOL_{i,t-6}$							0.043***	0.049***	0.055***	0.062***	0.057***	0.071***
							(3.82)	(4.17)	(4.64)	(4.99)	(4.43)	(5.92)
$VOLM_{i,t-6}$							-0.030***					
							(-3.26)					
$OPNI_{i,t-6}$								-0.033***				
								(-3.35)				
$BASIS_{i,t-6}$									0.035***			
									(2.89)			
$BASM12_{i,t-6}$										-0.017		
										(-1.47)		
$HPSP_{i,t-6}$											-0.085***	
											(-6.97)	
$HPHE_{i,t-6}$												0.108***
												(9.74)
R^2	0.707	0.704	0.687	0.688	0.718	0.720	0.520	0.516	0.500	0.502	0.533	0.534
No. of Month	423	423	423	423	423	423	420	420	420	420	420	420

Panel B: Excluding Lagged Skewness as a Predictor

	Dependent Variable is $SKEW_{i,t}$						Dependent Variable is $SKEW_{i,t}$					
	13	14	15	16	17	18	19	20	21	22	23	24
Intercept	-0.009	-0.012*	-0.034***	-0.038***	0.016**	0.018***	-0.015**	-0.017**	-0.041***	-0.044***	0.012*	0.015**
	(-1.40)	(-1.73)	(-6.30)	(-5.32)	(2.51)	(2.96)	(-2.04)	(-2.46)	(-7.07)	(-6.90)	(1.75)	(2.28)
$MOM12_{i,t-3}$	-0.031	-0.031	-0.046**	-0.046*	0.029	0.027						
	(-1.46)	(-1.50)	(-2.14)	(-1.83)	(1.48)	(1.41)						
$CTR36_{i,t-3}$	-0.090***	-0.084***	-0.044**	-0.066***	-0.047***	-0.044***						
	(-5.26)	(-4.84)	(-2.55)	(-3.47)	(-2.88)	(-2.80)						
$IVOL_{i,t-3}$	0.034***	0.040***	0.054***	0.062***	0.034**	0.062***						
	(2.74)	(3.22)	(4.34)	(4.64)	(2.39)	(4.60)						
$VOLM_{i,t-3}$	-0.046***											
	(-4.36)											
$OPNI_{i,t-3}$		-0.037***										
		(-3.81)										
$BASIS_{i,t-3}$			0.050***									
			(4.34)									
$BASM12_{i,t-3}$				-0.021*								
				(-1.70)								
$HPSP_{i,t-3}$					-0.132***							
					(-8.73)							
$HPHE_{i,t-3}$						0.178***						
						(13.56)						
$MOM12_{i,t-6}$							-0.093***	-0.098***	-0.093***	-0.103***	-0.026	-0.025
							(-4.50)	(-4.94)	(-4.70)	(-4.98)	(-1.40)	(-1.37)
$CTR36_{i,t-6}$							-0.050***	-0.039**	-0.004	-0.021	-0.011	-0.006
							(-2.85)	(-2.14)	(-0.20)	(-1.18)	(-0.71)	(-0.38)
$IVOL_{i,t-6}$							0.048***	0.056***	0.071***	0.080***	0.055***	0.087***
							(3.84)	(4.50)	(5.55)	(6.15)	(3.81)	(6.43)
$VOLM_{i,t-6}$							-0.046***					
							(-4.37)					
$OPNI_{i,t-6}$								-0.046***				
								(-4.39)				
$BASIS_{i,t-6}$									0.060***			
									(5.29)			

$BASM12_{i,t-6}$										-0.021*		
										(-1.81)		
$HPSP_{i,t-6}$											-0.152***	
											(-10.54)	
$HPHE_{i,t-6}$												0.196***
												(15.96)
R^2	0.277	0.271	0.261	0.261	0.315	0.313	0.270	0.264	0.253	0.252	0.306	0.303
No. of Month	423	423	423	423	423	423	420	420	420	420	420	420

Table 3 Summary Statistics for Skewness and Expected Skewness

The sample covers the period from January 1987 to June 2022. Panel A reports summary statistics on skewness, *SKEW*, and expected skewness. Expected skewness constructed from Models 1, 6, 7, and 12 are referred to as *ESKEW_Y1_L3*, *ESKEW_Y2_L3*, *ESKEW_Y3_L6*, *ESKEW_Y4_L6*. These four measures include lagged skewness and other contract characteristics to construct expected skewness. Expected skewness constructed from Models 13, 18, 19, and 24 are referred to as *ESKEW_N1_L3*, *ESKEW_N2_L3*, *ESKEW_N3_L6*, *ESKEW_N4_L6*. These four measures exclude lagged skewness and only use other contract characteristics to construct expected skewness. Panel B reports pair-wise correlations among expected skewness. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Basic Statistics

	Definition	Number of Observations	Mean	5%	Median	95%	Standard Deviation
SKEW	Skewness	12,851	-0.096	-0.904	-0.062	0.561	0.580
Include lagged skewness to construct expected skewness							
ESKEW_Y1_L3	Expected skewness from Model 1	10,227	0.007	-1.440	0.042	1.261	0.854
ESKEW_Y2_L3	Expected skewness from Model 6	8,993	0.025	-1.428	0.062	1.263	0.871
ESKEW_Y3_L6	Expected skewness from Model 7	10,138	0.005	-1.194	0.032	1.093	0.729
ESKEW_Y4_L6	Expected skewness from Model 12	8,924	0.027	-1.213	0.048	1.131	0.747
Exclude lagged skewness to construct expected skewness							
ESKEW_N1_L3	Expected skewness from Model 13	10,227	0.006	-0.818	0.028	0.782	0.515
ESKEW_N2_L3	Expected skewness from Model 18	8,993	0.035	-0.906	0.048	0.910	0.565
ESKEW_N3_L6	Expected skewness from Model 19	10,138	0.004	-0.824	0.027	0.794	0.516
ESKEW_N4_L6	Expected skewness from Model 24	8,924	0.035	-0.903	0.046	0.890	0.558

Panel B: Pairwise Correlations

	SKEW	*ESKEW_Y1_L3*	*ESKEW2_Y2_L3*	*ESKEW3_Y3_L6*
Include lagged skewness to construct expected skewness				
ESKEW_Y1_L3	0.74***			
ESKEW_Y2_L3	0.75***	0.96***		
ESKEW_Y3_L6	0.64***	0.80***	0.77***	
ESKEW_Y4_L6	0.65***	0.78***	0.81***	0.92***
Exclude lagged skewness to construct expected skewness				
	SKEW	*ESKEW_N1_L3*	*ESKEW_N2_L3*	*ESKEW_N3_L6*
ESKEW_N1_L3	0.46***			
ESKEW_N2_L3	0.49***	0.78***		
ESKEW_N3_L6	0.44***	0.80***	0.65***	
ESKEW_N4_L6	0.48***	0.66***	0.84***	0.77***

Table 4 Skewness and Commodity Futures Contract Returns

The sample covers the period from January 1987 to June 2022. The table summarizes the average coefficient (*t*-statistic) from Fama-MacBeth monthly regressions of 34 commodity futures contract monthly returns on contract characteristics. All characteristics are measured in month *t* while monthly returns $R_{i,t+1}$ are measured in month *t+1*. Models 1 to 8 includes three commodity futures contract characteristics, with two of the 10 characteristics being always included in the model: $SKEW_{i,t}$ and $MOM12_{i,t}$. Then Models 1 to 8 adds one of the following eight commodity futures contract characteristics one at a time: $CTR36_{i,t}$, $IVOL_{i,t}$, $VOLM_{i,t}$, $OPNI_{i,t}$, $BASIS_{i,t}$, $BASM12_{i,t}$, $HPSP_{i,t}$, and $HPHE_{i,t}$. All characteristics are standardized in the cross-section. Each characteristic is adjusted for the cross-sectional mean and scaled by cross-sectional standard deviation. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Dependent Variable is $R_{i,t+1}$							
	1	2	3	4	5	6	7	8
Intercept	0.247	0.257	0.200	0.198	0.223	0.172	0.257	0.248
	(1.37)	(1.44)	(1.12)	(1.10)	(1.25)	(0.97)	(1.43)	(1.38)
$SKEW_{i,t}$	-0.348***	-0.320***	-0.379***	-0.366***	-0.330***	-0.329***	-0.414***	-0.409***
	(-3.62)	(-3.32)	(-3.78)	(-3.59)	(-3.50)	(-3.25)	(-3.84)	(-3.75)
$MOM12_{i,t}$	0.365***	0.185*	0.208*	0.224*	0.281**	0.142	0.267**	0.234*
	(2.66)	(1.67)	(1.74)	(1.87)	(2.26)	(1.11)	(2.01)	(1.88)
$CTR36_{i,t}$	-0.280**							
	(-2.31)							
$IVOL_{i,t}$		-0.160						
		(-1.59)						
$VOLM_{i,t}$			-0.092					
			(-1.07)					
$OPNI_{i,t}$				-0.115				
				(-1.28)				
$BASIS_{i,t}$					0.231**			
					(2.21)			
$BASM12_{i,t}$						0.118		
						(1.25)		
$HPSP_{i,t}$							0.068	
							(0.65)	
$HPHE_{i,t}$								-0.121
								(-1.27)

R^2	0.227	0.214	0.211	0.214	0.214	0.216	0.224	0.221
No. of Months	426	426	426	426	426	426	426	426

Table 5 Expected Skewness and Commodity Futures Contract Returns: Including Lagged Skewness as a Predictor for Expected Skewness

The sample covers the period from January 1987 to June 2022. The table summarizes the average coefficient (t-statistic) from Fama-MacBeth monthly regression of 34 commodity futures contract monthly returns on expected skewness and contract characteristics. Panel A includes two measures of expected skewness constructed using predictors with a lag of three months: $ESKEW\_Y1\_L3_{i,t}$ and $ESKEW\_Y2\_L3_{i,t}$. Panel B includes two measures of expected skewness constructed using predictors with a lag of six months: $ESKEW\_Y3\_L6_{i,t}$ and $ESKEW\_Y4\_L6_{i,t}$. The cross-sectional regressions add one of the following six contract characteristics at a time: $VOLM_{i,t}$, $OPNI_{i,t}$, $BASIS_{i,t}$, $BASM12_{i,t}$, $HPSP_{i,t}$, and $HPHE_{i,t}$. All characteristics are standardized in the cross-section. Each characteristic is adjusted for the cross-sectional mean and scaled by cross-sectional standard deviation. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Predictors with a Lag of Three Months

	Dependent Variable is $R_{i,t+1}$						Dependent Variable is $R_{i,t+1}$					
	1	2	3	4	5	6	7	8	9	10	11	12
Intercept	0.166	0.163	0.166	0.139	0.168	0.149	0.150	0.152	0.149	0.132	0.179	0.167
	(0.91)	(0.90)	(0.90)	(0.76)	(0.92)	(0.82)	(0.83)	(0.85)	(0.81)	(0.73)	(0.98)	(0.92)
$ESKEW\_Y1\_L3_{i,t}$	-0.533***	-0.484***	-0.448***	-0.366**	-0.451***	-0.455***						
	(-3.51)	(-3.21)	(-3.02)	(-2.41)	(-2.99)	(-3.09)						
$ESKEW\_Y2\_L3_{i,t}$							-0.417***	-0.388***	-0.395***	-0.374***	-0.376**	-0.431***
							(-3.05)	(-2.80)	(-2.78)	(-2.64)	(-2.47)	(-2.80)
$MOM12_{i,t}$	0.156	0.181	0.262*	0.069	0.245*	0.205	0.148	0.184	0.289**	0.091	0.240*	0.192
	(1.21)	(1.42)	(1.81)	(0.45)	(1.77)	(1.54)	(1.20)	(1.51)	(2.03)	(0.64)	(1.72)	(1.45)
$VOLM_{i,t}$	-0.108						0.001					
	(-1.18)						(0.01)					
$OPNI_{i,t}$		-0.138						-0.068				
		(-1.45)						(-0.65)				
$BASIS_{i,t}$			0.265**						0.289**			
			(2.05)						(2.19)			
$BASM12_{i,t}$				0.148						0.174*		
				(1.46)						(1.77)		
$HPSP_{i,t}$					0.060						0.037	
					(0.55)						(0.33)	
$HPHE_{i,t}$						-0.134						-0.105
						(-1.36)						(-0.98)
R^2	0.218	0.221	0.250	0.243	0.231	0.228	0.230	0.237	0.256	0.251	0.233	0.231
No. of Month	423	423	423	423	423	423	423	423	423	423	423	423

Panel B: Predictors with a Lag of Six Months

	Dependent Variable is $R_{i,t+1}$						Dependent Variable is $R_{i,t+1}$					
	1	2	3	4	5	6	7	8	9	10	11	12
Intercept	0.128	0.129	0.175	0.141	0.170	0.161	0.157	0.159	0.169	0.153	0.199	0.205
	(0.71)	(0.71)	(0.94)	(0.77)	(0.94)	(0.90)	(0.88)	(0.90)	(0.93)	(0.86)	(1.10)	(1.13)
$ESKEW\_Y3\_L6_{i,t}$	-0.667***	-0.667***	-0.665***	-0.608***	-0.588***	-0.589***						
	(-3.74)	(-3.72)	(-3.79)	(-3.51)	(-3.31)	(-3.42)						
$ESKEW\_Y4\_L6_{i,t}$							-0.624***	-0.614***	-0.710***	-0.656***	-0.645***	-0.699***
							(-3.47)	(-3.34)	(-3.62)	(-3.42)	(-3.08)	(-3.26)
$MOM12_{i,t}$	0.120	0.140	0.231	0.099	0.146	0.125	0.121	0.143	0.225	0.053	0.176	0.134
	(0.97)	(1.12)	(1.64)	(0.72)	(1.06)	(0.97)	(0.98)	(1.17)	(1.60)	(0.39)	(1.28)	(1.04)
$VOLM_{i,t}$	-0.065						-0.007					
	(-0.70)						(-0.07)					
$OPNI_{i,t}$		-0.121						-0.070				
		(-1.25)						(-0.67)				
$BASIS_{i,t}$			0.193						0.266**			
			(1.20)						(2.11)			
$BASM12_{i,t}$				0.150						0.160*		
				(1.55)						(1.65)		
$HPSP_{i,t}$					0.100						0.032	
					(0.90)						(0.28)	
$HPHE_{i,t}$						-0.130						-0.068
						(-1.38)						(-0.64)
R^2	0.219	0.222	0.249	0.243	0.234	0.228	0.233	0.241	0.260	0.255	0.239	0.233
No. of Month	420	420	420	420	420	420	420	420	420	420	420	420

Table 6 Expected Skewness and Commodity Futures Contract Returns: Excluding Lagged Skewness as a Predictor for Expected Skewness

The sample covers the period from January 1987 to June 2022. The table summarizes the average coefficient (*t*-statistic) from Fama-MacBeth monthly regressions of 34 commodity futures contract monthly returns on expected skewness and contract characteristics. Panel A includes two measures of expected skewness constructed using predictors with a lag of three months: $ESKEW\_N1\_L3_{i,t}$ and $ESKEW\_N2\_L3_{i,t}$. Panel B includes two measures of expected skewness constructed using predictors with a lag of six months: $ESKEW\_N3\_L6_{i,t}$ and $ESKEW\_N4\_L6_{i,t}$. The cross-sectional regressions add one of the following six contract characteristics at a time: $VOLM_{i,t}$, $OPNI_{i,t}$, $BASIS_{i,t}$, $BASM12_{i,t}$, $HPSP_{i,t}$, and $HPHE_{i,t}$. All characteristics are standardized in the cross-section. Each characteristic is adjusted for the cross-sectional mean and scaled by cross-sectional standard deviation. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Predictors with a Lag of Three Months

	Dependent Variable is $R_{i,t+1}$						Dependent Variable is $R_{i,t+1}$					
	1	2	3	4	5	6	7	8	9	10	11	12
Intercept	0.175	0.174	0.186	0.141	0.197	0.203	0.159	0.149	0.163	0.139	0.180	0.215
	(0.93)	(0.93)	(1.00)	(0.75)	(1.07)	(1.11)	(0.89)	(0.83)	(0.89)	(0.77)	(0.98)	(1.17)
$ESKEW\_N1\_L3_{i,t}$	-1.192***	-0.995**	-0.733**	-0.801**	-0.613*	-0.651*						
	(-2.74)	(-2.47)	(-2.26)	(-2.30)	(-1.82)	(-1.93)						
$ESKEW\_N2\_L3_{i,t}$							-0.896***	-0.873***	-0.958***	-0.842***	-0.823***	-0.948***
							(-3.38)	(-3.31)	(-3.46)	(-3.15)	(-2.74)	(-2.61)
$MOM12_{i,t}$	0.220	0.271*	0.227	0.081	0.207	0.206	0.071	0.104	0.156	-0.011	0.184	0.161
	(1.48)	(1.88)	(1.52)	(0.54)	(1.42)	(1.46)	(0.54)	(0.81)	(1.05)	(-0.07)	(1.22)	(1.04)
$VOLM_{i,t}$	-0.162						-0.050					
	(-1.46)						(-0.53)					
$OPNI_{i,t}$		-0.153						-0.100				
		(-1.33)						(-0.98)				
$BASIS_{i,t}$			0.195						0.212*			
			(1.61)						(1.79)			
$BASM12_{i,t}$				0.097						0.143		
				(0.99)						(1.47)		
$HPSP_{i,t}$					0.167						0.032	
					(1.57)						(0.27)	
$HPHE_{i,t}$						-0.219**						-0.081
						(-2.30)						(-0.54)
R^2	0.226	0.229	0.257	0.251	0.239	0.236	0.236	0.242	0.260	0.252	0.237	0.240
No. of Month	423	423	423	423	423	423	423	423	423	423	423	423

Panel B: Predictors with a Lag of Six Months

	Dependent Variable is $R_{i,t+1}$						Dependent Variable is $R_{i,t+1}$					
	1	2	3	4	5	6	7	8	9	10	11	12
Intercept	0.151	0.137	0.166	0.149	0.191	0.184	0.169	0.159	0.182	0.162	0.215	0.256
	(0.81)	(0.73)	(0.85)	(0.79)	(1.04)	(1.01)	(0.94)	(0.88)	(0.99)	(0.89)	(1.16)	(1.37)
$ESKEW\_N3\_L3_{i,t}$	-1.335***	-1.187***	-1.167***	-1.212***	-1.216***	-1.222***						
	(-3.16)	(-2.80)	(-3.52)	(-3.44)	(-3.55)	(-3.68)						
$ESKEW\_N4\_L3_{i,t}$							-1.008***	-1.029***	-1.127***	-1.158***	-1.061***	-1.203***
							(-3.66)	(-3.65)	(-3.96)	(-3.91)	(-3.27)	(-3.37)
$MOM12_{i,t}$	0.194	0.222*	0.206	0.129	0.163	0.156	0.176	0.193	0.260*	0.142	0.266*	0.224*
	(1.49)	(1.69)	(1.42)	(0.93)	(1.18)	(1.19)	(1.43)	(1.59)	(1.81)	(1.01)	(1.90)	(1.67)
$VOLM_{i,t}$	-0.211**						-0.019					
	(-2.00)						(-0.20)					
$OPNI_{i,t}$		-0.216*						-0.096				
		(-1.87)						(-0.95)				
$BASIS_{i,t}$			0.164						0.219*			
			(0.84)						(1.78)			
$BASM12_{i,t}$				0.136						0.172*		
				(1.34)						(1.74)		
$HPSP_{i,t}$					0.157						-0.007	
					(1.44)						(-0.06)	
$HPHE_{i,t}$						-0.202**						-0.016
						(-2.06)						(-0.12)
R^2	0.227	0.231	0.254	0.247	0.240	0.237	0.243	0.250	0.268	0.261	0.247	0.248
No. of Month	420	420	420	420	420	420	420	420	420	420	420	420

Table 7 One-Way Hedge Portfolio Returns Sorted on Skewness and Expected Skewness

The sample covers the period from January 1987 to June 2022. Skewness is measured by *SKEW*. Expected skewness constructed from Models 1, 6, 7, and 12 in Panel A of Table 2 are referred to as *ESKEW_Y1_L3*, *ESKEW_Y2_L3*, *ESKEW_Y3_L6*, *ESKEW_Y4_L6*. These four measures include lagged skewness and other contract characteristics to construct expected skewness. Expected skewness constructed from Models 13, 18, 19, and 24 in Panel B of Table 2 are referred to as *ESKEW_N1_L3*, *ESKEW_N2_L3*, *ESKEW_N3_L6*, *ESKEW_N4_L6*. These four measures exclude lagged skewness and only use other contract characteristics to construct expected skewness. Skewness and expected skewness are measured using information prior to month *t* when equal weighted portfolio returns are constructed for month *t+1*. The sorting is based on 20% and 80% value of each characteristic in each month *t*. The table reports the mean returns on the long position, the mean returns on the short position, the returns on the hedge portfolios (long – short), and *t*-statistic. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Long	Short	Long - Short	*T*-statistic
SKEW	-0.441	0.741	-1.182***	-4.36
Including lagged skewness in constructing expected skewness				
ESKEW_Y1_L3	-0.557	0.712	-1.269***	-4.24
ESKEW_Y2_L3	-0.472	0.503	-0.975***	-3.29
ESKEW_Y3_L6	-0.484	0.862	-1.346***	-4.42
ESKEW_Y4_L6	-0.496	0.707	-1.203***	-3.90
Excluding lagged skewness in constructing expected skewness				
ESKEW_N1_L3	-0.307	0.836	-1.143***	-3.72
ESKEW_N2_L3	-0.221	0.724	-0.945***	-3.04
ESKEW_N3_L6	-0.202	0.874	-1.076***	-3.48
ESKEW_N4_L6	-0.313	0.754	-1.067***	-3.28

Table 8 Alphas Relative to Commodity Market Risk Factors

The sample covers the period from January 1987 to June 2022. Skewness is measured by *SKEW*. Expected skewness constructed from Models 1, 6, 7, and 12 in Panel A of Table 2 are referred to as *ESKEW_Y1_L3*, *ESKEW_Y2_L3*, *ESKEW_Y3_L6*, *ESKEW_Y4_L6*, respectively. These four measures include lagged skewness and other contract characteristics to construct expected skewness. Expected skewness constructed from Models 13, 18, 19, and 24 in Panel B of Table 2 are referred to as *ESKEW_N1_L3*, *ESKEW_N2_L3*, *ESKEW_N3_L6*, *ESKEW_N4_L6*, respectively. These four measures exclude lagged skewness and only use other contract characteristics to construct expected skewness. Skewness and expected skewness are measured using information prior to month *t* when equal weighted portfolio returns are constructed for month *t+1*. The sorting is based on 20% and 80% value of each characteristic in each month *t*. The table reports the alphas from regressing long-short hedge portfolio returns on the two-, three-, four-, and five-factor models. The two-factor model includes the market and momentum factors (*CMKT*, *CMOM12*). The three-factor model includes the market, momentum, and basis factors (*CMKT*, *CMOM12*, and *CBASIS*). The four-factor model includes the market, momentum, basis, and hedging pressure factors (*CMKT, CMOM12*, *CBASIS*, and *CHP*). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Two-Factor Model	Three-Factor Model	Four-Factor Model
SKEW	-1.104***	-1.101***	-1.013***
Including lagged skewness in constructing expected skewness			
ESKEW_Y1_L3	-1.135***	-1.131***	-1.029***
ESKEW_Y2_L3	-0.902***	-0.895***	-0.759**
ESKEW_Y3_L6	-1.248***	-1.244***	-1.149***
ESKEW_Y4_L6	-1.143***	-1.134***	-1.009***
Excluding lagged skewness in constructing expected skewness			
ESKEW_N1_L3	-1.051***	-1.048***	-0.908***
ESKEW_N2_L3	-0.877***	-0.872***	-0.694**
ESKEW_N3_L6	-0.969***	-0.967***	-0.846***
ESKEW_N4_L6	-0.957***	-0.953***	-0.745**

Table 9 Expected Skewness from Using a Forecast Combination Approach and Commodity Futures Contract Returns

The sample covers the period from January 1987 to June 2022. The table constructs two sets of expected skewness measures using a forecast combination approach. The first set includes *ESKEW_L3_FCB1*, *ESKEW_L3_FCB9*, and *ESKEW_L3_FCB10*. These three measures use the lagged value of skewness, nine other contract characteristics, and lagged value of skewness plus nine other contract characteristics to construct expected skewness, respectively. The lag is three months. The second set includes *ESKEW_L6_FCB1*, *ESKEW_L6_FCB9*, and *ESKEW_L6_FCB10*. These three measures use lagged skewness, nine other contract characteristics, and lagged skewness plus nine other contract characteristics to construct expected skewness, respectively. The lag is six months. Panel A reports the average coefficient (*t*-statistic) from Fama-MacBeth monthly regressions of 34 commodity futures contract monthly returns on each of the six measures of expected skewness. Panel B reports the long-short hedge portfolio returns sorted on each of six measures of expected skewness. Panel C reports the alphas from regressing long-short hedge portfolio returns on the two-, three-, and four-factor models, respectively. The two-factor model includes the market and momentum factors (*CMKT*, *CMOM12*). The three-factor model includes the market, momentum, and basis factors (*CMKT*, *CMOM12*, and *CBASIS*). The four-factor model includes the market, momentum, basis, and hedging pressure factors (*CMKT*, *CMOM12*, *CBASIS*, and *CHP*). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Cross-Sectional Regressions

	1	2	3	4	5	6
Intercept	0.249	0.236	0.252	0.244	0.223	0.216
	(1.39)	(1.26)	(1.38)	(1.36)	(1.18)	(1.17)
ESKEW_L3_FCB1	-0.475***					
	(-2.82)					
ESKEW_L3_FCB9		-3.147***				
		(-3.25)				
ESKEW_L3_FCB10			-2.263***			
			(-3.40)			
ESKEW_L6_FCB1				-0.738		
				(-0.96)		
ESKEW_L6_FCB9					-2.409**	
					(-2.40)	
ESKEW_L6_FCB10						-2.055**
						(-2.56)
R^2	0.062	0.073	0.074	0.061	0.067	0.069
Number of Months	426	426	426	426	426	426

Panel B: Long-Short Hedge Portfolio Returns

	Long	Short	Long - Short	*T*-statistic
ESKEW_L3_FCB1	-0.269	0.722	-0.991***	-3.77
ESKEW_L3_FCB9	-0.355	0.833	-1.188***	-4.05
ESKEW_L3_FCB10	-0.328	0.825	-1.153***	-3.89
ESKEW_L6_FCB1	-0.083	0.593	-0.676**	-2.53
ESKEW_L6_FCB9	-0.216	0.617	-0.834***	-2.95
ESKEW_L6_FCB10	-0.027	0.744	-0.771***	-2.68

Panel C: Alphas Relative to Commodity Market Risk Factors

	Two-Factor Model	Three-Factor Model	Four-Factor Model
ESKEW_L3_FCB1	-0.881***	-0.876***	-0.850***
ESKEW_L3_FCB9	-1.022***	-1.019***	-0.846***
ESKEW_L3_FCB10	-0.989***	-0.986***	-0.822***
ESKEW_L6_FCB1	-0.555**	-0.551**	-0.462*
ESKEW_L6_FCB9	-0.693**	-0.690**	-0.499*
ESKEW_L6_FCB10	-0.631**	-0.628**	-0.420

Table 10 Two-Way Hedge Portfolio Returns and Alphas Relative to Commodity Market Risk Factors

The sample covers the period from January 1987 to June 2022. The table constructs two-way sorted hedge portfolio returns. The first sorting variable is 12-month basis momentum, *BASM12*. The second sorting variable is skewness measure, *SKEW*, and each of the eight measures of expected skewness. Expected skewness constructed from Models 1, 6, 7, and 12 in Panel A of Table 2 are referred to as *ESKEW_Y1_L3*, *ESKEW_Y2_L3*, *ESKEW_Y3_L6*, *ESKEW_Y4_L6*, respectively. These four measures include lagged skewness and other contract characteristics to construct expected skewness. Expected skewness constructed from Models 13, 18, 19, and 24 in Panel B of Table 2 are referred to as *ESKEW_N1_L3*, *ESKEW_N2_L3*, *ESKEW_N3_L6*, *ESKEW_N4_L6*, respectively. These four measures exclude lagged skewness and only use other contract characteristics to construct expected skewness. The two-way sorting is carried out independently. Panel A reports the long-short hedge portfolio returns. Panel B reports the alphas from regressing long-short hedge portfolio returns on the two-, three-, and four-factor models, respectively. The two-factor model includes the market and momentum factors (*CMKT*, *CMOM12*).The three-factor model includes the market, momentum, and basis factors (*CMKT*, *CMOM12*, and *CBASIS*). The four-factor model includes the market, momentum, basis, and hedging pressure factors (*CMKT*, *CMOM12*, *CBASIS*, and *CHP*). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Long-Short Hedge Portfolio Returns

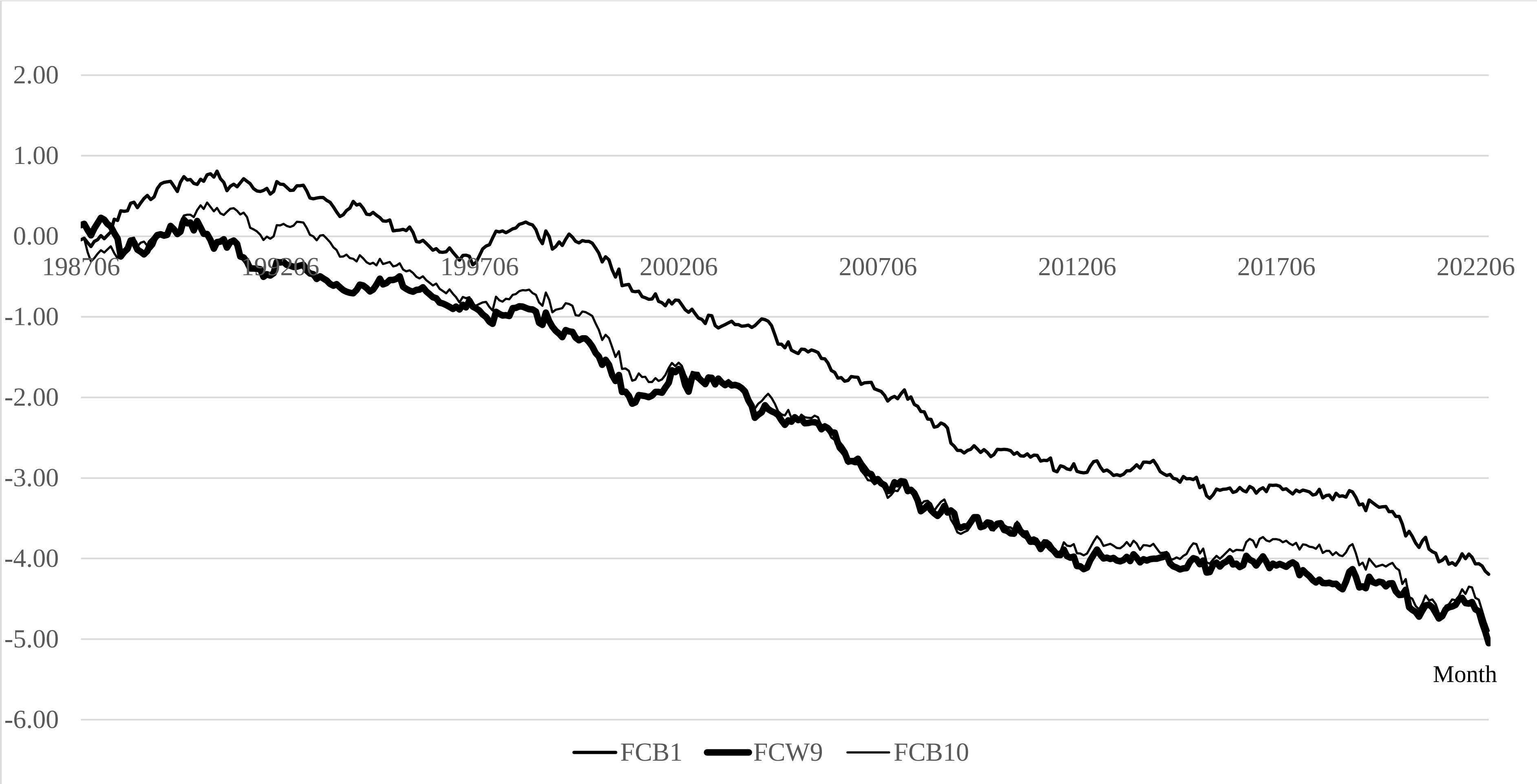
	Long	Short	Long - Short	*T*-statistic
BASM12×SKEW	-0.729	0.847	-1.576***	-4.02
Lagged skewness used in constructing expected skewness				
BASM12×ESKEW_Y1_L3	-1.054	0.704	-1.758***	-4.11
BASM12×ESKEW_Y2_L3	-0.810	0.549	-1.359***	-3.20
BASM12×ESKEW_Y3_L6	-0.556	1.147	-1.704***	-3.97
BASM12×ESKEW_Y4_L6	-0.577	0.965	-1.542***	-3.33
No lagged skewness used in constructing expected skewness				
BASM12×ESKEW_N1_L3	-0.665	0.914	-1.579***	-3.69
BASM12×ESKEW_N2_L3	-0.407	0.752	-1.159***	-2.60
BASM12×ESKEW_N3_L6	-0.551	1.088	-1.639***	-3.81
BASM12×ESKEW_N4_L6	-0.581	0.981	-1.563***	-3.35

Panel B: Alphas Relative to Commodity Market Risk Factors

	Two-Factor Model	Three-Factor Model	Four-Factor Model
BASM12×SKEW	-1.534***	-1.553***	-1.481***
Lagged skewness used in constructing expected skewness			
BASM12×ESKEW_Y1_L3	-1.586***	-1.568***	-1.477***
BASM12×ESKEW_Y2_L3	-1.226***	-1.219***	-1.139***
BASM12×ESKEW_Y3_L6	-1.578***	-1.540***	-1.422***
BASM12×ESKEW_Y4_L6	-1.379***	-1.336***	-1.180***
No lagged skewness used in constructing expected skewness			
BASM12×ESKEW_N1_L3	-1.384***	-1.395***	-1.281***
BASM12×ESKEW_N2_L3	-0.993**	-1.004**	-0.827*
BASM12×ESKEW_N3_L6	-1.454***	-1.391***	-1.284***
BASM12×ESKEW_N4_L6	-1.407***	-1.376***	-1.166**

Figure 1 Cumulative Returns from A Forecasting Combination Approach

Figure 1 shows the cumulative returns from long-short hedge portfolio returns sorting on expected skewness constructed using a forecast combination approach. The three measures of expected skewness are *ESKEW_L3_FCB1*, *ESKEW_L3_FCB9*, and *ESKEW_L3_FCB10*. These three measures use the lagged value of skewness, nine other contract characteristics, and lagged value of skewness plus nine other contract characteristics to construct expected skewness, respectively. The lag is three months.


2.00
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202206
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FCB1
FCW9
FCB10

Appendix A: Construction of 20 Commodity Futures Contract Characteristics

Appendix A provides details of the construction of ten characteristic of commodity futures contracts: *SKEW*, *MOM12*, *CTR36*, *IVOL*, *VOLM*, *OPNI*, *BASIS*, *BASM12*, *HPSE*, and *HPHE*. All characteristics are measured in month *t* prior to month *t+1* when equal weighted portfolio returns are constructed.

Panel A: Characteristics of Commodity Futures Contracts

Variable Names	Details of Construction
Skewness (*SKEW*)	*SKEW* = skewness of daily returns over months *t-12* to *t-1*
12-month momentum measure (*MOM12*)	*MOM12* = cumulative return over prior months *t-12* to *t-2*
36-month contrarian measure (*CTR36*)	*CTR36* = cumulative return over prior months *t-36* to *t-1*
Idiosyncratic volatility (*IVOL*)	Residual standard deviation from the following regression: $r_{i,t} = \beta_0 + \beta_1 r_{m,t} + \varepsilon_{i,t}$, where $r_{i,t}$ is daily individual futures contract return over prior months *t-12* to *t-1* and $r_{m,t}$ is the corresponding daily return on the GSCI commodity futures contract market return index.
Futures contract trading volume in US$ terms (*VOLM*)	Average of daily trading volume of individual futures contract in USD terms over prior months *t-12* to *t-1*
Futures contract open interest in US$ terms (*OPNI*)	Average of daily open interest of individual futures contract in USD terms over prior months *t-12* to *t-1*
BASIS (*BASIS*)	Daily $BASIS_t$ = 2nd near-by futures contract daily price/1st nearby futures contract daily price – 1.0 = $F_t^{T_2} / F_t^{T_1} - 1$, where $F_t^{T_1}$ is the end-of-month price of the 1st-nearby futures contract and $F_t^{T_2}$ is the end-of-month price of the 2nd-nearby futures contract . Monthly basis equals average of daily basis in prior month *t-1*.
12-month basis momentum (*BASM12*)	*12-month basis momentum BASM12* for month *t* is measured as $BASM12_t = \prod_{j=0}^{11}(1+R_{t-j}^{T_1}) - \prod_{j=0}^{11}(1+R_{t-j}^{T_2})$

	where $R_t^{T_1} = F_t^{T_1} / {}_{t-1}^{T_1} - 1.0$, $R_t^{T_2} = F_t^{T_2} / {}_{t-1}^{T_2} - 1.0$, $F_t^{T_1}$ is the end-of-month price of the 1st-nearby futures contract, and $F_t^{T_2}$ is the end-of-month price of the 2nd-nearby futures contract .
Speculating pressure (*HPSP*)	The average of speculation pressure ratios over prior months *t-12* to *t-1*. Speculation pressure ratio = long positions/(long positions + short positions) by speculators.
Hedging pressure (*HPHE*)	The average of hedge pressure ratio over prior months *t-12* to *t-1*. Hedge pressure ratio = long positions/(long positions + short positions) by hedgers.