Relative Basis:
A Better Measure of the Convenience Yield*

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Abstract

We propose a novel measure, dubbed "relative basis," to better capture the commodity convenience yield. Our measure is the difference between the traditional near-term basis and a similarly defined distant basis. This simple differencing purges out persistent commodity characteristics in traditional basis, such as storage and financing costs. Relative basis is closely tied to changes in physical inventories and dominates traditional basis in forecasting commodity futures returns. In contrast, relative basis does not forecast the returns of financial futures, which are not subject to inventory constraints. Our results provide new insights into the well-known relation between basis and expected futures returns.

Keywords: commodity markets, futures basis, convenience yield, commodity futures returns, theory of storage.

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1. Introduction

Commodity futures markets are of great importance to commodity consumers and producers, exporting and importing nations, and, increasingly, to global investors who view commodities as an integral part of their portfolios (Gorton and Rouwenhorst, 2006; Ready, Roussanov, and Ward, 2017). As a result, the price dynamics of commodity futures have attracted significant attention from policymakers, practitioners, as well as academics in recent decades. A unique feature of commodities is that, unlike stocks and bonds whose value is determined by discounted future cash flows, the value of a commodity is determined by its demand and supply in the real economy. According to the theory of storage, temporary shifts in demand and supply are reflected in the commodity's convenience yield, an implicit but important benefit to the physical commodity owners who can use the commodity for immediate production and consumption.[1] Specifically, the theory of storage predicts that when a commodity is in short supply, there is a large benefit for holding the physical commodity, therefore a relatively high convenience yield. Further, the marginal convenience yield on inventory falls at a decreasing rate as inventories increase, so there is a negative, convex relation between convenience yields and inventories (as illustrated in Figure 1).

The extant literature often uses a commodity's futures basis to proxy for its convenience yield (e.g., Fama and French, 1987; 1988; Szymanowska et al., 2014). In particular, the theory of storage postulates that a commodity's futures basis equals its (marginal) convenience yield minus the (marginal) cost of storage and foregone interest. In practice, due to the lack of detailed and timely information on commodities' storage and, to come extent, financing costs, futures basis – as a proxy for the convenience yield – is confounded by these cost factors, which can be large in magnitude and slow-moving in nature.

[1] The theory of storage is initially proposed by Kaldor (1939), Working (1948), and Brennan (1958). More recent studies in this literature include Wright and Williams (1982), Scheinkman and Schechtman (1983), Gibson and Schwartz (1990), Brennan (1991), Deaton and Laroque (1992, 1996), Ng and Pirrong (1994), Routledge, Seppi, and Spatt (2000), Geman and Nguyen (2005), Dewally, Ederington, and Fernando (2013), Gorton, Hayashi, and Rouwenhorst (2013), Basak and Pavlova (2016), among others.

In this paper, we propose a simple yet effective method – without relying on additional data – to isolate shocks to the convenience yield from the confounding factors in commodity futures basis. Specifically, we exploit the fact that commodity-specific characteristics – such as storage and financing costs – are far more persistent than physical inventories and convenience yields. For instance, the storage cost of natural gas is persistently higher than that of gold due to the differences in storage technology; similarly, because gold can be used as collateral, its financing cost is persistently lower than that of natural gas. Shocks to inventories, on the other hand, are often transitory. This is because the demand and supply of a commodity can adjust quickly (although not instantaneously) to absorb inventory fluctuations. For example, a positive demand shock to natural gas due to unexpectedly cold weather pushes up the natural gas price in the near term; the price hike then induces higher supply (lower demand) by natural gas producers (consumers) in the following weeks and months, which then alleviates the temporary demand-supply imbalance and restores the price.

To isolate the transient component of commodity futures basis, which mainly reflects the convenience yield, we take a simple difference between the near-term traditional basis and a similarly defined distant basis. Specifically, our measure – dubbed "relative basis" – is the time-scaled price difference between the first-nearby ($F_t(T1)$) and second-nearby futures contracts ($F_t(T2)$) *minus* that between the second-nearby ($F_t(T2)$) and third-nearby futures contracts ($F_t(T3)$). (We discuss in detail the economic motivation for the construction of relative basis in Section 3.1.) This simple differencing exercise allows us to purge out the difficult-to-observe and relatively persistent components of traditional basis.[2] We then label the residual part of traditional basis, after orthogonalizing with respect to relative basis, as the "residual basis," which reflects the persistent component of traditional basis.

[2] In untabulated results, we also decompose traditional basis into a fast-moving and a slow-moving component using the HP filter. The fast-moving component from this statistical approach is strongly correlated with relative basis. The reason that we adopt a simple-differencing approach is for the ease of implementation and interpretation. Our method does not rely on strong statistical assumptions (all that we require is that the convenience yield is less persistent than other commodity characteristics) and has an intuitive economic interpretation.

Our relative basis measure has several nice properties. First, relative basis is much less persistent than traditional basis. For example, the AR(1) coefficient of traditional basis at the monthly horizon is nearly 0.7, whereas that of relative basis is 0.34; the second to sixth autocorrelation coefficients of traditional basis range from 0.3 to 0.5, while those of relative basis are all statistically zero. In other words, a simple differencing exercise indeed eliminates most of the persistent components in traditional basis. Second, relative basis is more closely linked to physical inventories, particularly inventory decreases (due to the convex relation between convenience yields and inventories), than traditional and residual basis. Put differently, purging out the persistent components of traditional basis sharpens our measure of the convenience yield.

With these results in hand, we then turn to the expected returns of commodity futures and their relations to relative basis. One of the most intriguing findings in prior literature is that commodity futures with a positive basis (i.e., those with a downward-sloping futures curve) earn significantly higher average returns than commodity futures with a negative basis (e.g., Fama and French, 1987; 1988).[3] We show that traditional basis loses its return predictability once we control for relative basis, along with other known commodity characteristics, such as price momentum of Asness, Moskowitz, and Pedersen (2013) and basis momentum of Boon and Prado (2019). For example, in calendar-time portfolio sorts, the monthly return spread of commodity futures ranked by traditional basis is a statistically insignificant -2 bps (*t*-statistic = -0.12) after controlling for relative basis and other common factors. In contrast, the return spread of commodity futures sorted by relative basis is a highly statistically significant 63 bps (*t*-statistic = 3.35) per month after controlling for traditional basis and the same set of common factors.

There are two possible accounts for the strong association between relative basis and expected commodity futures returns. First, Gorton, Hayash, and Rouwenhorst (2013) argue (and provide consistent evidence) that inventory levels are negatively

[3] Other studies include, for example, Bailey and Chan (1993), Yang (2013), Szymanowska et al. (2014), Miffre (2016), Bakshi, Gao, and Rossi (2017), and Bhardwaj, Janardanan, and Rouwenhorst (2019).

related to the expected returns of commodity futures, possibly because inventories help absorb/cushion temporary fluctuations in demand and supply, so commodities with low inventories have riskier returns. (Note that comprehensive inventory data are difficult to come by for many commodities and, for the ones publicly available, are released with significant delays.[4]) To the extent that convenience yields arise from low inventories, the former should also forecast commodity futures returns.

An alternative view, drawing on the theory of normal backwardation (Keynes, 1930; Hicks, 1939), argues that commodity basis is driven by the net hedging demand of commodity consumers and producers (so having little to do with inventory constraints in the spot market). Consequently, the ability of commodity basis to forecast commodity futures returns reflects the risk premium earned by hedging insurance providers who take the opposite side of the net hedging demand.[5]

We conduct an array of additional tests to shed light on these two competing explanations. First, the inventory-based interpretation of return predictability should only apply to commodity futures and not to financial futures (e.g., equity index futures, currency futures, and interest rate futures), whereas the hedging-risk-premium based explanation applies to both. This is because financial instruments are not subject to physical inventory constraints, as investors can easily create additional supply through short selling. Consistent with the inventory-based view, and in sharp contrast to what we observe for commodity futures, relative basis does not forecast financial futures returns. Interestingly, traditional basis (as well as residual basis) strongly forecasts financial futures returns. Put differently, it is the slow-moving component of traditional basis – related to, for instance, the interest rate differentials – that predicts financial futures returns.

Second, given the convex relation between convenience yields and inventories (as predicted by the theory of storage and illustrated in Figure 1), there is much more

[4] See Gorton, Hayashi, and Rouwenhorst (2013) for a detailed discussion of inventory data.

[5] See, for example, Hong and Yogo (2012), Jia and Kang (2022), and Ooi et al. (2022).

variation in convenience yields when inventories are low. In other words, if the return predictability of relative basis operates through convenience yields, the effect should be stronger when relative basis is positive than when it is negative (the former is associated with relatively low inventories and high importance of convenience yields). This is precisely what we observe in the data. The coefficient on relative basis in our return-forecasting regression is more than three times larger when relative basis is positive than that when relative basis is negative. Following a similar logic, we also find that the return predictability of relative basis is stronger in economic expansions than in economic contractions, as expansionary periods are usually associated with higher demand for (thus lower inventories of) physical commodities.

Finally, our relative basis measure is statistically unrelated to the smoothed-hedging-pressure variable introduced in Kang, Rouwenhorst, and Tang (2020). When both are included in the regression to forecast commodity futures returns, relative basis retains its predictive power (so does the smoothed hedging pressure).

Taken together, our set of findings supports the view that the return predictability of relative basis arises from its relation with the convenience yield of a commodity, as advocated by the theory of storage. They are less consistent with the alternative view that our documented return predictability reflects the imbalance in hedging demand by commodity consumers and producers for commodity futures, thus the risk premium earned by insurance providers. Put differently, by purging out the confounding factors in traditional basis, we provide novel evidence that the return predictability of futures basis – an important result in the commodity futures literature – is at least partly driven by its relation to convenience yields. As such, our results call for a new theory of commodity futures that naturally ties together convenience yields and expected commodity futures returns.

Related Literature

Our paper contributes to the vast literature on commodity convenience yields by introducing a simple yet effective method to estimate the convenience yield from the commodity futures curve. Exploiting the fact that commodity-specific characteristics – such as storage costs and financing costs – are more persistent than physical inventories and convenience yields, we propose a novel measure, dubbed "relative basis," as the difference between the near-term traditional basis and a similarly defined distant basis. Empirically, relative basis is much less persistent than traditional basis as it captures the fast-moving component of the traditional basis. Moreover, relative basis is more closely linked to physical inventories, particularly large inventory decreases, than traditional basis.

Our paper also contributes to the large literature on commodity futures returns.[6] Relative basis strongly predicts commodity futures returns in both Fama-MacBeth regressions and calendar-time portfolio sorts, and dominates traditional basis in a horse race to forecast commodity futures returns. Moreover, relative basis is uncorrelated with many well-known return predictors in the commodity futures market (e.g., price momentum, basis momentum, and smoothed hedging pressure). Thus, it provides independent information about expected commodity futures returns and offers valuable implications for commodity investors, hedgers, and policymakers.

We further show that the return predictability of relative basis arises from its relation with convenience yields and physical inventories, and is unlikely driven by hedging demand imbalances of commodity consumers and producers. First, relative basis does not forecast returns of financial futures contracts, which are not subject to spot inventory constraints. Moreover, the return predictability of relative basis is stronger in situations that are more likely to be associated with inventory scarcity concerns. Our results, taken together, call for a new theory of commodity futures that ties together inventories, convenience yields, and expected commodity futures returns.

[6] See, for example, Chang (1985), Fama and French (1987), Hirshleifer (1988, 1990), Bessembinder (1992), De Roon, Nijman, and Veld (2000), Rouwenhorst and Tang (2012), Tang and Xiong (2012), Acharya, Lochstoer, and Ramadorai (2013), Gorton, Hayashi, and Rouwenhorst (2013), Cheng and Xiong (2014), Szymanowska et al. (2014), Boon and Prado (2019), Goldstein and Yang (2022).

The remainder of the paper is organized as follows. Section 2 describes our data sample and summary statistics. Section 3 discusses the motivation and empirical attributes of our relative basis measure. Section 4 presents the return predictability of relative basis for commodity futures. Section 5 explores potential explanations for the association between relative basis and commodity futures returns. Section 6 concludes.

2. Data and Summary Statistics

We collect data on monthly futures prices from Commodity Systems Inc. for all commodities traded on the New York Mercantile Exchange (NYMEX), Chicago Board of Trade (CBOT), and Chicago Mercantile Exchange (CME). Our sample includes 24 commodities for the period January 1979 to December 2019. We compute the excess futures return of commodity *i* in month *t* using the price of the nearest futures contract (i.e., the first-nearby futures contract) that does not expire in month *t*:

$$ret_{i,t} = \frac{F_{i,t}(T) - F_{i,t-1}(T)}{F_{i,t-1}(T)}, \qquad (1)$$

where $F_{i,t}(T)$ is the futures price of commodity *i* at the end of month *t* for the nearest contract with expiration date *T*, and $F_{i,t-1}(T)$ is the price of the same futures contract at the end of month *t*-1.

For the basis measure, we follow the related literature and define *Traditional Basis* (*TradtBasis*) as the log-difference in prices between the nearest and second-nearest futures contracts (i.e., the first-nearby and second-nearby contracts), scaled by their difference in time to maturity (annualized). More formally,

$$TradtBasis_{i,t} = \frac{ln(F_{i,t}(T1)) - ln(F_{i,t}(T2))}{T2 - T1}, \qquad (2)$$

where $F_{i,t}(T1)$ and $F_{i,t}(T2)$ are the futures prices for commodity *i* at the end of month *t* for futures contracts with expiration dates $T1$ and $T2$, respectively. Note that the formal definition of basis is the difference between the spot price and the price of the first-nearby futures contract. However, since it is usually difficult to obtain spot prices for most commodities, researchers often use the price difference between the first and second nearby futures as a measure of the convenience yield. (Since $T1$ is usually a short time period, $F_{i,t}(T1)$ is a good proxy for the spot price.)

Next, we propose a new basis measure, dubbed *Relative Basis* (*RelatBasis*), as the difference between traditional basis and a similarly defined distant basis. Specifically, relative basis is defined as:

$$RelatBasis_{i,t} = \frac{ln(F_{i,t}(T1)) - ln(F_{i,t}(T2))}{T2 - T1} - \frac{ln(F_{i,t}(T2)) - ln(F_{i,t}(T3))}{T3 - T2} \tag{3}$$

where $F_{i,t}(T1)$, $F_{i,t}(T2)$, and $F_{i,t}(T3)$ are the futures prices at the end of month t for the first-nearby, second-nearby, and third-nearby futures contracts with expiration dates $T1$, $T2$, and $T3$, respectively.[7]

We then conduct a cross-sectional regression of traditional basis on relative basis in each month:

$$TradtBasis_{i,t} = a_t + b_t * RelatBasis_{i,t} + \varepsilon_{i,t} \ . \tag{4}$$

We define *Residual Basis* (*ResidBasis*) as the sum of the intercept and residual term of equation (4). Therefore, relative basis and residual basis are two components of traditional basis that are orthogonal to each other by construction.

We also construct various commodity futures characteristics that are known to forecast commodity futures returns. These characteristics include price momentum (Erb and Harvey, 2006; Miffre and Rallis, 2007; Asness, Moskowitz, and Pedersen, 2013; Asness et al., 2014), basis momentum (Boons and Prado, 2019), and smoothed hedging pressure (Kang, Rouwenhorst, and Tang, 2020). Specifically, price momentum (*Momentum*) is the past twelve-month cumulative return of the commodity's first-nearby futures contract (with rollover). Basis momentum (*BasisMom*) is the difference between price momentum of the first-nearby and that of the second-nearby futures

[7] In unreported results, we show that the first- and second-nearby contracts exhibit comparable trading volume and open interest. The third-nearby contract has trading volume and open interest at approximately 30% and 43% of those of the first-nearby contract, respectively.

contract. Smoothed hedging pressure (*SHP*) is the average net short position (short minus long positions) of commercial traders over the past year, scaled by the commodity's most recent open interest. Commercial traders' holdings are obtained from the Commitments of Traders (COT) report provided by the Commodity Futures Trading Commission (CFTC).[8]

[Insert Table 1 Here]

Panel A of Table 1 reports the time-series averages and standard deviations of relative basis, traditional basis, and monthly returns of commodity futures. Our sample commodities are classified into five groups: energies, metals, softs, grains, and live stocks. Panel B presents the cross-sectional correlations between relative basis and other commodity characteristics. For instance, relative basis has a correlation of 0.52 with traditional basis, a correlation of 0.20 with basis momentum, and correlations of virtually zero with price momentum and smoothed hedging pressure. It should be noted that the correlations between relative basis and other commodity characteristics are much lower than those between traditional basis and these commodity characteristics.

Panel C reports the autocorrelations of the three basis variables. Relative basis has an AR(1) coefficient of 0.34, with the autocorrelation coefficient becoming statistically insignificant for additional lags. In contrast, traditional basis displays much higher persistence: its first-order autocorrelation is 0.68, which decreases to somewhere 0.3 to 0.5 with additional lags. As expected, residual basis also exhibits strong persistence. These results confirm that relative basis captures the fast-moving component of traditional basis and better reflects the temporary nature of inventory shocks in the commodity market.

[8] The Commitments of Traders (COT) data contain the aggregate long and short positions of different types of commodity futures traders, including commercial traders, non-commercial traders, and non-reportable traders. These positions are recorded every Tuesday and made available to the public three days later, typically after the market closes on Friday. For our monthly analyses, we use the COT positions closest to the month end.

3. Details of Relative Basis

3.1 A Simple Framework for Thinking about Relative Basis

The theory of storage (Working, 1949; Brennan, 1958) posits that when a commodity is in short supply, physical ownership of the commodity is preferred over ownership (i.e., long positions) of futures contracts on the same commodity. This preference arises because owners of the physical commodity receive an implicit but important benefit, referred to as the convenience yield, which does not accrue to investors in commodity futures.[9] The theory of storage (e.g., Brennan, 1958; Pindyck, 1994) further predicts that the convenience yield is a convex decreasing function in the inventory level. That is, as the inventory depletes, the marginal convenience yield on inventory rises at an increasing rate (see Figure 1).

Below is a textbook derivation of the futures price as a function of the spot price, which also provides a working definition of the convenience yield.

$$F_{i,t}(T) = S_{i,t}\exp\left[w_{i,t}(t,T) - \delta_{i,t}(t,T) + r_{i,t}(t,T)\right] . \qquad (5)$$

$F_{i,t}(T)$ is the futures price of commodity i at time t with maturity T, and $S_{i,t}$ is the spot price of the commodity. The difference (in logarithm) between the spot price and futures price is the basis. As discussed earlier, since it is difficult to obtain accurate commodity spot prices, prior studies typically use the difference between $F_{i,t}(T1)$ and $F_{i,t}(T2)$ (i.e., the difference between the first nearby and second nearby futures prices) as a measure of the commodity basis. The main determinants of the basis are the convenience yield ($\delta_{i,t}(t,T)$), storage cost ($w_{i,t}(t,T)$), and financing cost ($r_{i,t}(t,T)$) of the

[9] The convenience yield can arise through a few channels. First, it helps ensure uninterrupted production by providing a steady supply of commodity inputs. For example, when the commodity supply is low, manufacturers relying on the commodity as an input are worried about the costs associated with pausing and restarting production lines and lost client orders. Maintaining adequate inventories of the physical commodity therefore offers a significant advantage that cannot be achieved through long positions in commodity futures. Second, a decrease in commodity supply (or an increase in demand) leads to a price surge, which subsequently results in price increases for related goods. When such shocks occur, manufacturers with sufficient commodity inventories can sell their products at better prices and potentially increase their market shares compared to their competitors who are less prepared.

commodity. Both the storage and financing costs are persistent commodity characteristics that can vary substantially across commodities.

We construct a novel measure, relative basis, by taking the difference between two similarly defined basis measures:

$$RelatBasis_{i,t} = TradtBasis_{i,t}(T1, T2) - TradtBasis_{i,t}(T2, T3). \tag{6}$$

From equation (5), we have

$$TradtBasis_{i,t}(T1, T2) = \frac{1}{T2 - T1}[\delta_{i,t}(T1, T2) - r_{i,t}(T1, T2) - w_{i,t}(T1, T2)], \tag{7}$$

$$TradtBasis_{i,t}(T2, T3) = \frac{1}{T3 - T2}[\delta_{i,t}(T2, T3) - r_{i,t}(T2, T3) - w_{i,t}(T2, T3)]. \tag{8}$$

We can think of $\delta_{i,t}(T1, T2)$, $r_{i,t}(T1, T2)$, and $w_{i,t}(T1, T2)$ in equation (7) as the current-period convenience yield, financing cost, and storage cost of the commodity, respectively. Similarly, $\delta_{i,t}(T2, T3)$, $r_{i,t}(T2, T3)$, and $w_{i,t}(T2, T3)$ in equation (8) represent the (risk-neutral) expectations of the convenience yield, financing cost, and storage cost in the next period.

To simplify the difference between equations (7) and (8), and without loss of generality, let's consider a simple AR(1) process:

$$Y_t = b \times Y_{t-1} + \varepsilon_t. \tag{9}$$

A persistent series has a b close to one and a transient series has a b close to zero. The difference between Y_t and $E(Y_{t+1})$ (i.e., the difference in corresponding terms between equations (7) and (8)) can be written as:

$$Y_t - E_t(Y_{t+1}) = Y_t - b \times Y_t = (1 - b) \times (b \times Y_{t-1} + \varepsilon_t). \tag{10}$$

The first equality holds because $E_t(\varepsilon_{t+1}) = 0$. It is easy to see that for a persistent process where b is close to one, $Y_t - E_t(Y_{t+1})$ is close to zero. On the other hand, for a transient process where b is sufficiently small, $Y_t - E_t(Y_{t+1})$ is close to $b \times Y_{t-1} + \varepsilon_t$; it further reduces to ε_t, i.e., the time-t shock to Y.

Since storage and financing costs are highly persistent (with a b close one) at least in the short run, $w(T1,T2)$ and $w(T2,T3)$, as well as $r(T1,T2)$ and $r(T2,T3)$, roughly cancel out in equations (7) and (8). In other words, equation (6) is largely driven by variation in convenience yields. Let's further assume that $T1$, $T2$, and $T3$ are equally spaced out and ΔT is the difference between $T2$ and $T1$ (or between $T3$ and $T2$). Equation (6) can then be written as:

$$RelatBasis_{i,t} \approx \frac{1}{\Delta T}[\delta_{i,t}(T1,T2) - \delta_{i,t}(T2,T3)] \ . \qquad (11)$$

Equation (11) indicates that relative basis is approximately the time-scaled difference between the current-period convenience yield (the first term) and the expectation of the next-period convenience yield (the second term).

Schwartz (1997) and Casassus and Collin-Dufresne (2005) argue that inventories follow a mean-reverting process, which is empirically confirmed by Liu and Tang (2011) and Gorton, Hayashi, and Rouwenhorst (2013).[10] To the extent that convenience yields and inventories reflect the same underlying demand-supply forces, we also expect convenience yields to follow a mean-reverting pattern (i.e., a transient process with a small b). Consequently, as per equations (10) and (11), relative basis captures (time-scaled) shocks to convenience yields. It is important to note that we do not require $b = 0$, or put differently, shocks to convenience yields to completely dissipate within one period. As long as convenience yields are *less* persistent than storage and financing costs, our simple differencing exercise helps isolate the former from the latter.

To further illustrate the intuition by example, imagine a negative supply shock to a commodity, so its inventory declines and convenience yield rises. We then expect the next-period convenience yield to decline (or to revert back to its mean) as the demand and supply adjust to absorb the shock. As a result, relative basis – which is the difference between the current-period convenience yield and the expected next-period convenience yield – is also positive in this case.

[10] For instance, a negative shock to inventories leads to an increase in the commodity price, which in turn reduces consumption and stimulates production. As a result, inventories rebound in the next period.

Moreover, given the convex, inverse relation between convenience yields and inventories (see Figure 1), we expect a stronger association between relative basis and negative inventory shocks than the association between relative basis and positive inventory shocks. This is because with inventory decreases, the commodity is more likely to be in or near the stockout status. This leads to an immediate spike in convenience yield (which is expected to revert in the future) and hence high relative basis.

3.2 Relations to Inventory Changes

In this subsection, we examine the relations between various commodity basis measures and (changes in) commodity inventories. Specifically, following the approach in Gorton, Hayashi, and Rouwenhorst (2013), we collect monthly inventory data for our sample of commodities for the period January 1993 to December 2018.[11] We then take the following steps to clean up the inventory data. First, we divide the raw inventory level of each commodity in each month by its past 12-month average to account for any time trend in inventories. Second, we normalize the scaled inventory level constructed above by its time-series standard deviation for each commodity (so that inventories are more comparable across commodities). After that, we define the inventory change ($InventChg_{i,t}$) as the difference between the normalized inventory level for a commodity in month t and that in month t-1. We also introduce an increase-of-inventory variable ($InventIncrs_{i,t}$) that equals $InventChg_{i,t}$ if the inventory change is positive and zero otherwise, as well as a decrease-of-inventory variable ($InventDecrs_{i,t}$) that equals $InventChg_{i,t}$ if the inventory change is negative and zero otherwise.

[Insert Table 2 Here]

In Table 2, we conduct Fama-MacBeth regressions of relative basis and residual basis on past inventory levels and changes. The first two columns show that relative

[11] Our sample period is limited by the availability of inventory data.

basis is strongly associated with lagged inventory changes as well as levels. For example, in Column 2, the regression coefficient estimates of inventory change and inventory level are -0.029 (t-statistic = -5.55) and -0.009 (t-statistic = -3.87), respectively. This observation suggests that the relative basis increases when the inventory decreases and becomes scarcer, which is consistent with the prediction of theory of storage.

We then split inventory changes into increases and decreases in Columns 3 and 4. Consistent with the convex relationship between convenience yields and inventories, we find that relative basis is more strongly related to inventory decreases; the coefficient on *InventDecrs* is twice as large as that on *InventIncrs*. Specifically, in Column 4, the regression coefficient of inventory decrease (*InventDecrs*) is -0.038 (t-statistic = -3.51). This is in sharp contrast with the regression coefficient of inventory increase (*InventIncrs*), which is an insignificant -0.016. Columns 5-8 repeat these analyses for residual basis. In contrast to what we observe in Columns 1-4, residual basis is statistically unrelated to inventory levels and changes, with all the corresponding regression coefficients being virtually zero.[12]

In sum, by purging out the persistent components of commodity futures basis, we obtain a more precise measure of the commodity convenience yield. Compared to physical inventory data, which are usually incomplete, noisy, and disclosed with significant delays, our relative basis measure, which is derived from futures prices, offers real-time, market-based information on convenience yields. As such, it provides a valuable tool for policymakers and practitioners to gauge the fluctuations of the demand and supply in commodity markets.

4. Return Predictability of Relative Basis

[12] In Appendix Table A1, we employ an alternative measure of inventory changes, defined as the difference in inventories between month t and the average in months t-1 and t-2. The results are virtually unchanged. Relative basis is strongly associated with inventory changes, particularly inventory decreases, while residual basis is unrelated to inventory changes.

One of the most important findings of prior studies on commodity futures is that commodity futures with a positive basis (i.e., those with a downward-sloping futures curve) earn significantly higher returns than commodity futures with a negative basis (Fama and French, 1987; Szymanowska et al., 2014). We show in the previous section that our novel relative basis measure better captures shocks to convenience yields than traditional basis. In this section, we examine the return forecasting ability of both traditional basis and relative basis by stacking them in a horse race. This exercise can help shed light on the underlying mechanisms of the return predictability of commodity futures basis.

4.1 Fama-MacBeth Regressions

We start by conducting Fama-MacBeth forecasting regressions of commodity futures returns on various basis measures (traditional basis, relative basis, and residual basis):

$$ret_{i,t+1} = a_t + b_{1,t}RelatBasis_{i,t} + b_{2,t}ResidBasis_{i,t}\ (or\ TradtBasis_{i,t}) + \lambda_t controls_{i,t} + \varepsilon_{i,t} \quad (12)$$

The list of control variables includes price momentum, defined as the cumulative commodity futures return in the past 12 months (Asness, Moskowitz, and Pedersen, 2013; Moskowitz, Ooi, and Pedersen, 2012; Babu et al., 2020) and basis momentum, the difference in lagged 12-month returns between the first-nearby and second-nearby futures contracts (Boons and Prado, 2019).

[Insert Table 3 Here]

Panel A of Table 3 reports the regression results for commodity futures returns in the next month. In univariate regressions, as shown in Columns 1 to 3, both relative basis and traditional basis have statistically significant forecasting power for commodity futures returns. The coefficient on relative basis is 0.019 (*t*-statistic = 3.44) and that on traditional basis is 0.011 (*t*-statistic = 2.16). The coefficient on residual basis, however, is a statistically insignificant 0.010 (*t*-statistic = 1.43), already suggesting that the return predictability of commodity futures basis comes from its fast-moving component (i.e., relative basis).

In Columns 4-6, we control for other commodity characteristics in the regressions, such as commodity momentum and basis momentum. As shown in Column 4, the coefficient estimate on relative basis is largely unaffected by the controls and remains statistically significant at 0.018 (t-statistic = 2.65). In terms of the economic magnitude, a one-standard-deviation increase in relative basis is associated with a 31 bps higher monthly futures return. In contrast, as can be seen in Column 6, traditional basis loses its forecasting power for commodity futures returns once we include the controls in the regression. In Columns 7 and 8, we run a horserace between relative basis and traditional basis (or residual basis), together with the control variables. Relative basis dominates both traditional basis and residual basis in predicting commodity futures returns.

In Panel B, we repeat the forecasting exercise except that now the dependent variable is the commodity futures return in the following quarter. The results are by and large unchanged. In sum, our results suggest that relative basis possesses strong return predictive power and dominates both traditional basis and residual basis in forecasting commodity futures returns.

4.2 Calendar-Time Portfolio Sorts

We also conduct calendar-time portfolio sorts to gauge the economic magnitude of the return predictability of relative basis. Specifically, at the end of each month, we sort all commodity futures into terciles based on one of the basis measures (relative basis, traditional basis or residual basis). We then report the equal-weighted returns of the three portfolios.

[Insert Table 4 Here]

Table 4 reports the portfolio returns. When considered in isolation, all three basis measures positively forecast commodity futures returns. For example, a simple long-short portfolio that goes long the top one third commodity futures and short the bottom one third ranked by relative basis yields a return of 81 bps (t-statistic = 3.99) in the following month and a return of 2.71% (t-statistic = 6.64) in the following quarter. We also find statistically significant return spreads of commodity futures portfolios sorted by traditional basis (75bps in the following month and 2.89% in the following quarter), as well as those sorted by residual basis (65bps in the following month and 2.12% in the following quarter). These results are consistent with the findings of Yang (2013) and Bakshi, Gao, and Rossi (2017).

We then conduct a portfolio-spanning test in Table 5, where we regress the long-short portfolio return sorted by one of the basis measures on the contemporaneous long-short portfolio return sorted by another basis measure. We further control for common risk factors in the commodity market, including the market factor (equal-weighted returns of all commodities in our sample), the price momentum factor, and the basis momentum factor.[13]

[Insert Table 5 Here]

As can be seen from Column 1 of Table 5, the long-short portfolio sorted by relative basis has a statistically significant monthly alpha of 69 bps (t-statistic = 3.48) after controlling for the market, price momentum, and basis momentum factors. Including the contemporaneous long-short portfolio return ranked by residual basis (Column 2) or traditional basis (Column 3) on the right-hand side of the equation has little impact on this alpha. In contrast, as shown in Columns 4-7, the long-short portfolio sorted by either residual basis or traditional basis has an economically small and statistically insignificant alpha when controlling for the contemporaneous long-short portfolio return sorted by relative basis and other common risk factors. For instance,

[13] As shown in Appendix Table A2, the return correlations between the long-short portfolio sorted by relative basis and other factors in the commodity market are generally low.

the long-short portfolio ranked by traditional basis has a monthly alpha of -2 bps with a t-statistic of -0.12 in the full specification. These portfolio return results are consistent with the Fama-MacBeth regression estimates reported in Table 3.

4.3 Robustness Tests

We conduct an array of additional tests to ensure the robustness of our main findings. First, we divide our sample into two subperiods: 1979-1999 and 2000-2019. Appendix Table A3 shows that relative basis consistently forecasts commodity futures returns in both subperiods. Second, while most commodities in our sample have futures contracts that mature every two months, some energy commodities (including crude oil, heating oil, and natural gas) have futures contracts that mature every month. In Appendix Table A4, we focus on futures contracts that are two months apart in identifying the first, second, and third nearby contracts (so the timing of the basis calculation is aligned across all commodities in the sample). The results are by and large unchanged. Third, instead of using Fama-Macbeth regressions, we employ panel regressions with two-way fixed effects and clustered standard errors. The coefficient estimates, reported in Appendix Table A5, are similar to those from the Fama-MacBeth regressions in Table 3.

5. Underlying Economic Mechanisms

As discussed earlier, there are two possible accounts for the association between relative basis (or convenience yields) and expected commodity futures returns. The first explanation draws on the theory of storage. Prior research (e.g., Gorton, Hayash, and Rouwenhorst, 2013) shows that inventory is negatively related to expected commodity futures returns, possibly because inventories help absorb/cushion temporary fluctuations in demand and supply, so commodities with low inventories have riskier returns. To the extent that the convenience yield arises from inventory scarcity, the former should also forecast commodity futures returns.

The alternative view is motivated by the theory of normal backwardation (Keynes, 1930; Hicks, 1939). The argument is that commodity basis can be influenced by the net hedging demand of commodity consumers and producers. Consequently, the predictability of basis for commodity futures returns may reflect the risk premium earned by hedging insurance providers who take the opposite side of the net hedging demand. To illustrate by example, imagine that commodity producers become more risk averse and decide to hedge more of their inventory risk by going short in the futures market. To the extent that insurance providers have limited risk-bearing capacity, the short-futures trading by commodity producers pushes down the prices of commodity futures (relative to the future spot price), which may result in both a positive basis and a higher expected futures return.

5.1 Return Predictability for Financial Futures

To start, we investigate the return predictability of the three basis measures for financial futures contracts [14] Since financial instruments, such as equity indices, currencies, and interest rates, are not subject to physical inventory constraints (as investors can easily create additional supply through short selling), the inventory-based explanation should only apply to commodity futures and not to financial futures. In contrast, the hedging-risk-premium based explanation applies to both. In other words, if the return predictability of relative basis indeed operates through its association with convenience yields, we expect relative basis to have insignificant predictive power for financial futures returns.

[Insert Table 6 Here]

As shown in Table 6, consistent with the inventory-based interpretation, relative basis does not predict financial futures returns in all specifications. For example, in a univariate-regression (Column 1 of Panel A) to forecast the next-month futures returns,

[14] Appendix Table A6 reports summary statistics of our sample of financial futures contracts.

the coefficient estimate on relative basis is statistically insignificant at 0.013 (t-statistic = 0.11). In contrast, both residual basis and traditional basis exhibit strong predictive power for financial futures returns.[15] For example, in the full specification with all the controls, the coefficient estimate on residual basis is 0.083 (t-statistic = 2.92) when forecasting next-month returns (Column 7 of Panel A), and it is 0.208 (t-statistic = 2.68) when forecasting next-quarter returns (Column 7 of Panel B).[16]

This result is consistent with the finding in Koijen et al. (2018) that carry (with a similar construction to traditional basis) is an important characteristic that forecasts asset returns in many asset classes, including both commodity and financial futures markets. Our results suggest that the return predictability of basis (or carry) in different asset classes may arise from different mechanisms.

Given the stark contrast between commodity futures and financial futures, we next exclude from our sample a set of commodities that behave somewhat like financial instruments. This subset includes precious metals such as Gold, Silver, and Platinum, which are often viewed as stores of value and are not major inputs to production or consumption processes. As shown in Appendix Table A9, excluding the precious metal contracts from our sample of commodity futures has virtually no impact on the return predictability of relative basis. For example, the risk-adjusted return of the long-short relative-basis portfolio increases slightly from 69 bps per month in Table 5 (including all commodities) to 72 bps (t-statistic = 3.14) in Appendix Table A9 (excluding precious metals).

[15] In Appendix Table A7, we conduct a calendar-time portfolio sort for financial futures. There is a small and insignificant return difference between the high and low portfolios sorted by relative basis. In contrast, the return spread between the high and low portfolios ranked by traditional basis (or residual basis) is large and significant. These findings are consistent with the regression results presented in Table 6.

[16] In Appendix Table A8, we repeat the exercises in Tables 3 and 6 but now with standardized basis measures. Specifically, in each month, we standardize all independent variables by subtracting their cross-sectional means and then dividing by their cross-sectional standard deviations. This procedure addresses the concern that relative basis for financial futures is much smaller in magnitude than that for commodity futures. The results are by and large unchanged – the standardized relative basis measure predicts commodity futures returns but not financial futures returns, while the opposite is true for standardized traditional basis (as well as standardized residual basis).

In sum, in contrast to our earlier result that the fast-moving component of traditional basis forecasts commodity futures returns, it is the slow-moving component of traditional basis – related to, for instance, the interest rate differentials – that predicts financial futures returns. These findings suggest that the return predictability of relative basis for commodity futures returns is more consistent with the inventory-based interpretation where time-varying inventory constraints play an important role.

5.2 Asymmetric Return Predictability of Relative Basis

Our second test exploits a unique prediction of the theory of storage – that there is a convex relation between convenience yields and inventories. The theory of storage posits that the marginal convenience yield increases at an increasing rate as inventories deplete. When inventories are close to the stockout level, the marginal benefit of holding physical inventories rises sharply. Consequently, convenience yields have much more variation and become a more important consideration when inventories are low. If the return predictability of relative basis operates through convenience yields, we expect the effect to be stronger when relative basis is positive than when it is negative, as the former indicates low inventories and large variation in convenience yields.

To test this prediction, we conduct the following Fama-MacBeth regression:

$$ret_{i,t+1} = a_t + b_{1,t}RelatBasis\_pos_{i,t} + b_{2,t}RelatBasis\_neg_{i,t}$$

$$+b_{3,t}ResidBasis_{i,t}(or\ TradtBasis_{i,t}) + \lambda_t controls_{i,t} + \varepsilon_{i,t} \qquad (13)$$

where $RelatBasis\_pos_{i,t}$ ($RelatBasis\_neg_{i,t}$) is equal to relative basis of commodity i in month t if it is positive (negative) and zero otherwise. We include the same set of controls as in Table 3.

[Insert Table 7 Here]

Consistent with our prediction, Table 7 shows that positive relative basis ($RelatBasis\_pos_{i,t}$) significantly forecasts commodity futures returns across all regression specifications. In terms of the economic magnitude, as shown in Column 2 of Panel A, a one-standard-deviation increase in positive relative basis is associated with an 81 bps higher commodity futures return in the following month. In contrast, the coefficient on negative relative basis ($RelatBasis\_neg_{i,t}$) is far from being statistically significant. We find similar results in Panel B when predicting quarterly commodity futures returns. Together, our analysis suggests that it is the positive relative basis, which is associated with the shortage of inventories and high importance of convenience yields, that drives the return predictability of relative basis for commodity futures.

5.3 Conditional on Business Cycle

Following a similar logic, we argue that the return predictability of relative basis is stronger in economic expansions than in economic contractions. In economic expansions, the demand for commodities – from both manufacturers and consumers – is higher, so commodities are more likely to be in short supply; as a result, convenience yields have more variation and become more important in expansions. We utilize two measures of business cycles: a) the Philadelphia Fed Aruoba-Diebold-Scotti (ADS) Business Conditions Index and b) the Chicago Fed National Activity Index (CFNAI).[17] We then divide our sample into two equal subperiods – economy expansions and contractions – based on either index.

In Appendix Table A10, we repeat the calendar-time portfolio analysis of Table 4 for both economic expansions and contractions. In Panel A, where we use the ADS index to measure business cycles, the return spread of relative-basis-sorted commodity futures portfolios formed in expansionary periods is 1.24% (t-statistic = 4.45) in the following month. In contrast, the monthly return spread of relative-basis-sorted

[17] The Aruoba-Diebold-Scotti Business Conditions Index (ADS Index), maintained by Philadelphia Fed, is designed to track real business conditions at a relatively high frequency. The average value of the ADS Index is zero, with increases (decreases) indicating improved (deteriorating) macroeconomic conditions. The Chicago Fed National Activity Index (CFNAI Index), maintained by Chicago Fed, is a monthly index that evaluates overall economic activity and related inflationary pressure (see, for example, Allen, Bali, and Tang, 2012). For details of the two business cycle indices, please see https://www.philadelphiafed.org/surveys-and-data/real-time-data-research/ads and https://www.chicagofed.org/research/data/cfnai/current-data for more details.

portfolios formed in contractionary periods is only 0.38% (t-statistic = 1.40). The difference in monthly return spread between these two periods is 0.86% (t-statistic = 2.21). We obtain similar results when forecasting quarterly portfolio returns. In Panel B, we repeat the same exercises with the CFNAI Index, and the results are similar.[18]

[Insert Table 8 Here]

We then conduct Fama-MacBeth return forecasting regressions separately for economic expansions and contractions. As shown in Table 8, with both proxies for business cycles, the coefficient estimate on relative basis is significantly positive in the months of economic expansions and statistically insignificant in the months of economic contractions.[19] Moreover, the return predictability of relative basis during economic expansions mainly comes from the positive side of relative basis ($RelatBasis\_pos_{i,t}$) rather than the negative side ($RelatBasis\_neg_{i,t}$). These results again confirm that the return predictability of relative basis is stronger when the convenience yield has more variation and is relatively more important.[20]

5.4 Smoothed Hedging Pressure

Kang, Rouwenhorst, and Tang (2020) propose a measure of net hedging demand of commodity producers and consumers by isolating the long-term component of commercial hedgers' positions in the commodity futures market. This approach is

[18] Boons (2016) suggests that the business cycle risk is also an important factor for investors in the stock market.

[19] We repeat the same exercises for traditional basis. As shown in Appendix Table A11, similar to the unconditional test, once we include all the controls, traditional basis does not forecast commodity futures returns either in economic expansions or contractions. There is also no discernible difference between the return predictability of positive and negative traditional basis for commodity futures returns.

[20] Levine et al. (2018) document that commodity futures returns are higher in economy expansions than in economic contractions. We find that the market return difference between economic expansions and contractions is mostly driven by high relative-basis commodities. For example, the average monthly return difference of the high relative-basis tercile portfolio (P3) between economic expansions and contractions is 0.58%, while that of the other commodities (i.e., those in P1 and P2) is a statistically insignificant -0.03%. In short, our results suggest that convenience yields also play a role in the dynamics of commodity market returns.

motivated by the finding that the short-term component of commercial hedgers' positions is more related to the liquidity need of non-commercial speculators. Specifically, the smoothed-hedging pressure (SHP) variable of Kang, Rouwenhorst, and Tang (2020) is the one-year moving average of the net positions of commercial hedgers. As can be seen from Panel B of Table 1, the correlation between SHP and relative basis is nearly zero, suggesting that relative basis is largely distinct from hedging pressure.

[Insert Table 9 Here]

We then repeat the return forecasting regressions of Table 3 with both relative basis and smoothed hedging pressure (SHP). As shown in Table 9, in univariate regressions, both relative basis and SHP significantly forecast commodity futures returns. When relative basis and SHP are included in the same regression, along with other controls, both variables retain their return forecasting power (which is unsurprising given their low correlation.) We also perform a portfolio spanning test in Appendix Table A12 (similar to that of Table 5). Neither the long-short portfolio sorted by relative basis nor that sorted by SHP subsumes the other.

5.5 Basis Momentum

In a recent study, Boon and Prado (2019) propose a basis-momentum measure, defined as the difference between the 12-month cumulative return of the first-nearby futures contract and that of the second-nearby contract. They show that basis momentum is a strong predictor of commodity futures returns. We argue that our relative basis measure is intrinsically different from basis momentum. First, Panel B of Table 1 reveals a low correlation between relative basis and basis momentum of 0.20. Second, Table 3 shows that after controlling for basis momentum, relative basis retains its significant predictive power for commodity futures returns. This finding is further confirmed in Table 5, where the long-short portfolio of commodity futures sorted by relative basis produces a significant alpha after controlling for the basis-momentum factor and other known common factors in the commodity futures market.[21] Third, Table 6 shows that while basis momentum strongly forecasts financial futures returns, relative basis (which is more closely related to commodities' inventory constraints) does not. Taken together, our results indicate that the return predictability of relative basis and that of basis momentum likely arise from different economic channels.

6. Conclusion

We propose a novel measure of shocks to commodity convenience yields. Our measure, dubbed "relative basis," is the difference between the traditional near-term futures basis and a similarly defined distant futures basis. Doing so allows us to purge out confounding factors in traditional basis that are associated with persistent commodity characteristics such as storage and financing costs.

Our relative basis measure is an empirical success based on several findings. First, relative basis is much less persistent than traditional basis. Second, relative basis is more closely linked to commodities' physical inventories, particularly decreases in inventories, than traditional basis. Third, relative basis has much stronger predictive power for commodity futures returns than traditional basis, and dominates traditional basis when both are included in the return forecasting regressions.

We then conduct an array of additional analyses to shed more light on the economic mechanisms underpinning the observed return predictability. First, we show that relative basis only forecasts the returns of commodity futures and *not* the returns of financial futures, as financial contracts are not subject to inventory constraints. Second, the return predictability of relative basis is stronger when there is more variation in convenience yields – for example, when relative basis is positive or during periods of economic expansions. Third, we find that relative basis and smoothed hedging

[21] In Appendix Table A13, we show that the basis-momentum portfolio generates a significantly positive alpha after controlling for the relative-basis factor return, indicating that the two factors are largely uncorrelated with each other.

pressure are virtually uncorrelated and have independent return forecasting power. Together, our set of findings suggests that the return predictability of relative basis arises from its relation with the convenience yield of a commodity instead of the imbalance in hedging demand by commodity consumers and producers.

In conclusion, our simple differencing exercise produces a better measure of shocks to convenience yields, as well as a strong and independent predictor for commodity futures returns. Our approach provides useful insights into the underlying economic factors that drive the relation between commodity basis and commodity futures returns. Our findings therefore call for a new theory of commodity futures that ties together inventories, convenience yields, and expected commodity futures returns.

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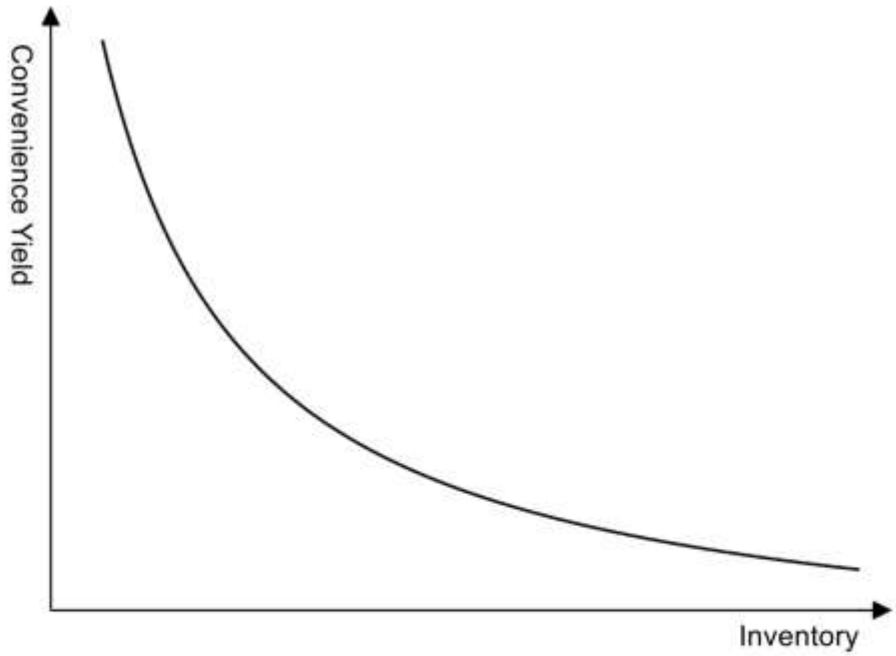
Figure 1: The Relation between Convenience Yields and Commodity Inventories



In this figure, the x-axis represents the inventory level and the y-axis represents the convenience yield.

Table 1: Summary Statistics

This table provides summary statistics of the main variables. *TradtBasis* is the traditional basis, defined as the log difference of the prices of the first-nearby and second-nearby futures contracts, scaled by their maturity time difference (annualized). *RelatBasis* is the relative basis, defined as the difference between the traditional basis measure and a distant basis measure from futures contracts with longer expiration dates (i.e., the second-nearby and third-nearby contracts). *ResidBasis* is the residual basis, defined as the sum of intercept and residual term from a cross-sectional regression of traditional basis (*TradtBasis*) on relative basis (*RelatBasis*). *Momentum* is the price momentum, which is the cumulative past twelve-month return of the first-nearby futures contract. *BasisMom* is the basis momentum, defined as the difference between the two price momentums from the first-nearby and second-nearby futures contracts. *SHP* is the smoothed hedging pressure, defined as the past one-year moving average of the net short position (short minus long positions) of commercial traders (as defined by the CFTC COT database), scaled by the commodity's most recent open interest. The sample period is January 1979 to December 2019 (*SHP* starts in January 1993 due to the availability of the COT data). Panel A reports the time-series average of *TradtBasis*, *RelatBasis*, and futures returns across 24 commodities. We sort commodities into five categories: energies, precious metals, softs, grains, and live stocks. Panel B reports the time-series average of cross-sectional correlations between the variables introduced above. Panel C reports the cross-sectional average of the autocorrelations (up to 6 lag months) of traditional basis (*TradtBasis*), relative basis (*RelatBasis*), and residual basis (*ResidBasis*).

Panel A: Time-series averages of traditional basis, relative basis, and futures returns

commodity name	traditional basis		relative basis		futures returns	
	mean	standard deviation	mean	standard deviation	mean	standard deviation
Crude Oil	0.38%	22.52%	-1.20%	10.29%	0.64%	9.48%
Heating Oil	0.47%	26.67%	0.70%	15.98%	0.58%	8.55%
Natural Gas	-19.80%	64.14%	-6.51%	51.26%	-0.59%	13.64%
Gold	-4.70%	3.90%	-0.01%	0.64%	0.13%	5.30%
Silver	-5.39%	5.41%	-0.44%	3.43%	0.19%	9.40%
Copper	0.87%	12.49%	-0.48%	5.02%	0.46%	7.60%
Platinum	-1.80%	5.25%	0.31%	5.13%	0.29%	7.39%
Palladium	-0.59%	5.56%	1.36%	15.67%	0.84%	9.00%
Cocoa	-5.80%	10.98%	0.18%	7.19%	-0.12%	8.46%
Coffee	-5.78%	16.35%	0.09%	7.35%	0.00%	10.06%
Orange Juice	-3.77%	16.82%	0.36%	11.24%	0.04%	8.82%
Sugar	-4.39%	25.69%	-4.23%	20.71%	0.00%	11.24%
Lumber	-12.60%	27.60%	-3.94%	21.11%	-0.53%	8.89%
Cotton	-3.10%	25.72%	-0.84%	27.18%	0.15%	7.35%
Soybean Oil	-5.30%	12.01%	-0.49%	6.57%	-0.12%	7.23%
Soybeans	-1.13%	20.72%	-1.93%	16.62%	0.17%	6.72%
Corn	-9.25%	18.52%	-1.67%	16.69%	-0.36%	7.21%
Wheat	-8.11%	18.87%	-3.96%	16.76%	-0.45%	7.57%
Oats	-6.54%	26.41%	-1.25%	18.18%	0.01%	9.58%
Soybean Meal	4.93%	30.04%	1.88%	22.04%	0.67%	7.66%
Rough Rice	-11.66%	20.13%	-3.48%	23.25%	-0.52%	7.58%
Feeder Cattle	1.17%	14.83%	0.50%	12.56%	0.18%	4.31%
Live Cattle	0.27%	21.25%	-0.96%	23.13%	0.28%	4.36%
Lean Hogs	-10.10%	51.46%	-6.27%	56.50%	0.05%	7.79%
average	-4.65%	20.97%	-1.34%	17.27%	0.08%	8.13%

Panel B: Cross-sectional correlations of main variables

	RelatBasis	TradtBasis	ResidBasis	Momentum	BasisMom	SHP
RelatBasis	1.00	0.52	0.00	0.04	0.20	0.04
TradtBasis		1.00	0.76	0.39	0.36	0.18
ResidBasis			1.00	0.44	0.29	0.19
Momentum				1.00	0.36	0.31
BasisMom					1.00	0.07
SHP						1.00

Panel C: Autocorrelations of relative basis, traditional basis, and residual basis

	RelatBasis	TradtBasis	ResidBasis
lag1	0.34	0.68	0.71
lag2	0.08	0.51	0.56
lag3	-0.02	0.40	0.45
lag4	-0.03	0.34	0.38
lag5	-0.03	0.31	0.34
lag6	0.00	0.30	0.31

Table 2: Relative Basis and Inventory Changes

This table examines the relation between various basis measures and commodity inventories (both the level and change). Specifically, we conduct a Fama-MacBeth regression of relative basis and residual basis on lagged inventory changes and levels, controlling for lagged basis measures. Relative basis and residual basis are defined in Table 1. The set of independent variables includes: $InventLvl_{i,t}$ is the normalized inventory level of commodity i in month t; $InventChg_{i,t}$ is the inventory change for commodity i in month t, calculated as the difference between $InventLvl_{i,t}$ and $InventLvl_{i,t-1}$; $InventIncrs_{i,t}$ ($InventDecrs_{i,t}$) is the increase-of-inventory (decrease-of-inventory) measure, which is the inventory change for commodity i in month t if it is positive (negative) and zero otherwise. The sample period is January 1993 to December 2018, limited by the availability of commodity inventory data. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

	$RelatBasis_{i,t+1}$				$ResidBasis_{i,t+1}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$InventChg_{i,t}$	-0.024	-0.029			0.002	0.001		
	(*-4.76*)	(*-5.55*)			(*0.48*)	(*0.27*)		
$InventIncrs_{i,t}$			-0.016	-0.016			0.000	0.000
			(*-1.23*)	(*-1.17*)			(*-0.01*)	(*-0.04*)
$InventDecrs_{i,t}$			-0.032	-0.038			-0.002	-0.005
			(*-3.10*)	(*-3.51*)			(*-0.19*)	(*-0.59*)
$InventLvl_{i,t-1}$		-0.009		-0.008		0.000		-0.001
		(*-3.87*)		(*-3.26*)		(*-0.01*)		(*-0.55*)
$RelatBasis_{i,t}$	0.349	0.339	0.355	0.346				
	(*15.46*)	(*14.37*)	(*15.61*)	(*14.70*)				
$ResidBasis_{i,t}$					0.700	0.700	0.703	0.702
					(*34.52*)	(*33.72*)	(*34.78*)	(*32.97*)
Adj R^2	32.2%	31.5%	33.9%	33.4%	46.3%	46.2%	46.8%	46.7%

Table 3: Return Predictability of Relative Basis: Baseline Regressions

This table examines the return predictability of relative basis. In Panel A, we conduct the following monthly Fama-MacBeth cross-sectional regression:

$$ret_{i,t+1} = a_t + b_{1,t}RelatBasis_{i,t} + b_{2,t}ResidBasis_{i,t}(\ or\ TradtBasis_{i,t}) + \lambda_t controls_{i,t} + \varepsilon_{i,t}$$

where $ret_{i,t+1}$ is the return of the futures contracts for commodity i in month $t+1$. The main explanatory variables are $RelatBasis_{i,t}$, $ResidBasis_{i,t}$, and $TradtBasis_{i,t}$. *TradtBasis* is the traditional basis, defined as the log difference of the prices of the first-nearby and second-nearby futures contracts, scaled by their maturity time difference (annualized). *RelatBasis* is the relative basis, defined as the difference between the traditional basis measure and a distant basis measure from the futures contracts with longer expiration dates (i.e., the second-nearby and third-nearby contracts). *ResidBasis* is the residual basis, defined as the sum of intercept and residual term from a cross-sectional regression of traditional basis (*TradtBasis*) on relative basis (*RelatBasis*). Other control variables include $Momentum_{i,t}$ and $BasisMom_{i,t}$. *Momentum* is the price momentum, which is the cumulative past twelve-month return of the first-nearby futures contract. *BasisMom* is the basis momentum, defined as the difference between the two price momentums from the first-nearby and second-nearby futures contracts. All variables are defined identically to those in Table 1. In Panel B, we employ the next-quarter commodity futures returns as the dependent variable and repeat the exercises in Panel A. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

Panel A: Dependent variable = commodity futures return in the next month

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$RelatBasis_{i,t}$	0.019			0.018			0.017	0.024
	(*3.44*)			(*2.65*)			(*2.53*)	(*2.85*)
$ResidBasis_{i,t}$		0.010			-0.008		-0.011	
		(*1.43*)			(*-1.06*)		(*-1.44*)	
$TradtBasis_{i,t}$			0.011			-0.002		-0.011
			(*2.16*)			(*-0.30*)		(*-1.44*)
$Momentum_{i,t}$				0.013	0.012	0.012	0.016	0.016
				(*2.68*)	(*2.19*)	(*2.25*)	(*2.95*)	(*2.95*)
$BasisMom_{i,t}$				0.035	0.050	0.048	0.042	0.042
				(*1.87*)	(*2.54*)	(*2.54*)	(*2.05*)	(*2.05*)
Adj R^2	2.3%	3.2%	3.3%	9.7%	10.7%	10.4%	12.7%	12.7%

Panel B: Dependent variable = commodity futures return in the next quarter

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$RelatBasis_{i,t}$	0.073			0.063			0.066	0.064
	(*6.67*)			(*5.15*)			(*5.07*)	(*3.75*)
$ResidBasis_{i,t}$		0.040			0.010		0.010	
		(*2.16*)			(*0.59*)		(*0.56*)	
$TradtBasis_{i,t}$			0.055			0.036		0.010
			(*3.99*)			(*2.59*)		(*0.56*)
$Momentum_{i,t}$				0.023	0.016	0.010	0.023	0.023
				(*1.67*)	(*1.12*)	(*0.77*)	(*1.59*)	(*1.59*)
$BasisMom_{i,t}$				0.084	0.106	0.074	0.074	0.074
				(*1.71*)	(*2.24*)	(*1.60*)	(*1.52*)	(*1.52*)
Adj R^2	2.6%	3.2%	3.5%	10.8%	11.0%	11.0%	13.8%	13.8%

Table 4: Calendar-Time Portfolio Returns

This table examines the return predictability of different basis measures using calendar-time portfolio sorts. The sorting variables include relative basis (*RelatBasis*), traditional basis (*TradtBasis*), and residual basis (*ResidBasis*), which are defined identically to those in Table 1. At the end of each month, we construct three equal-weighted commodity futures portfolios based on the corresponding basis measures. We report the returns of these three portfolios, as well as the return difference between the portfolios with the highest and lowest ranking variables (P3-P1), in the next one month and one quarter. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

	P1	P2	P3	P3-P1
Sorted by relative basis (RelatBasis)				
next-month return	-0.22%	-0.10%	0.59%	0.81%
				(*3.99*)
next-quarter return	-0.89%	-0.19%	1.82%	2.71%
				(*6.64*)
Sorted by traditional basis (TradtBasis)				
next-month return	-0.22%	-0.06%	0.54%	0.75%
				(*3.30*)
next-quarter return	-1.03%	-0.11%	1.86%	2.89%
				(*5.07*)
Sorted by residual basis (ResidBasis)				
next-month return	-0.24%	0.08%	0.41%	0.65%
				(*2.97*)
next-quarter return	-0.66%	-0.07%	1.46%	2.12%
				(*3.60*)

Table 5: Risk-adjusted Portfolio Returns

This table reports monthly risk-adjusted returns (i.e., alphas) of the long-short portfolio constructed from different basis measures. Specifically, we regress monthly long-short portfolio returns constructed from a basis measure on the market factor, the price momentum factor, the basis momentum factor, and other basis measures' long-short portfolio returns. $RelatBasisRet_t$, $TradtBasisRet_t$, and $ResidBasisRet_t$ are the long-short portfolio returns constructed from relative basis, traditional basis, and residual basis, respectively. The market factor $MKTRet_t$ is the equal-weighted average return of all commodities in our sample. $MomRet_t$ and $BasisMomRet_t$ are the returns of the price momentum and basis momentum factor portfolios. All portfolio returns are in percentage units. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

	$RelatBasisRet_t$			$TradtBasisRet_t$		$ResidBasisRet_t$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept (alpha)	0.685	0.686	0.633	0.172	-0.021	0.056	0.063
	(*3.48*)	(*3.48*)	(*3.35*)	(*0.90*)	(*-0.12*)	(*0.31*)	(*0.35*)
$RelatBasisRet_t$					0.282		-0.010
					(*6.74*)		(*-0.25*)
$ResidBasisRet_t$		-0.012					
		(*-0.25*)					
$TradtBasisRet_t$			0.303				
			(*6.74*)				
$MKTRet_t$	0.099	0.099	0.104	-0.017	-0.045	-0.031	-0.030
	(*1.74*)	(*1.73*)	(*1.92*)	(*-0.32*)	(*-0.86*)	(*-0.59*)	(*-0.57*)
$MomRet_t$	-0.090	-0.086	-0.179	0.294	0.319	0.388	0.387
	(*-2.40*)	(*-2.02*)	(*-4.66*)	(*8.07*)	(*9.10*)	(*11.25*)	(*11.15*)
$BasisMomRet_t$	0.196	0.200	0.091	0.346	0.290	0.279	0.282
	(*4.54*)	(*4.40*)	(*2.07*)	(*8.28*)	(*7.12*)	(*7.08*)	(*6.98*)
Adj R^2	4.5%	4.3%	12.5%	23.8%	30.2%	29.0%	29.0%

Table 6: Return Predictability of Relative Basis for Financial Futures

This table examines the return predictability of relative basis for a sample of 19 financial futures. In Panel A, we conduct the following monthly Fama-MacBeth cross-sectional regression:

$$ret_{i,t+1} = a_t + b_{1,t}RelatBasis_{i,t} + b_{2,t}ResidBasis_{i,t}(\ or\ TradtBasis_{i,t}) + \lambda_t controls_{i,t} + \varepsilon_{i,t}$$

where $ret_{i,t+1}$ is the return for financial futures i in month $t + 1$. The main explanatory variables are relative basis ($RelatBasis_{i,t}$), residual basis ($ResidBasis_{i,t}$), and traditional basis ($TradtBasis_{i,t}$). Other control variables include the price momentum ($Momentum_{i,t}$) and basis momentum ($BasisMom_{i,t}$). All variables are defined identically to those in Table 3. In Panel B, we use the next-quarter financial futures returns as the dependent variable and repeat the exercises in Panel A. The sample period is January 1993 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

Panel A: Dependent variable = financial futures return in the next month

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$RelatBasis_{i,t}$	0.013			0.067			0.099	0.013
	(0.11)			*(0.65)*			*(1.00)*	*(0.12)*
$ResidBasis_{i,t}$		0.120			0.082		0.083	
		(4.55)			*(2.78)*		*(2.92)*	
$TradtBasis_{i,t}$			0.100			0.078		0.083
			(3.41)			*(2.60)*		*(2.92)*
$Momentum_{i,t}$				0.030	0.024	0.023	0.027	0.027
				(3.85)	*(2.50)*	*(2.48)*	*(3.11)*	*(3.11)*
$BasisMom_{i,t}$				0.667	0.433	0.367	0.466	0.466
				(2.40)	*(1.96)*	*(1.52)*	*(1.78)*	*(1.78)*
Adj R^2	2.1%	3.8%	4.0%	23.0%	27.1%	28.4%	27.8%	27.8%

Panel B: Dependent variable = financial futures return in the next quarter

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$RelatBasis_{i,t}$	0.016			-0.148			-0.028	-0.111
	(*0.06*)			(*-0.50*)			(*-0.09*)	(*-0.34*)
$ResidBasis_{i,t}$		0.343			0.205		0.208	
		(*4.93*)			(*2.57*)		(*2.68*)	
$TradtBasis_{i,t}$			0.326			0.202		0.208
			(*4.47*)			(*2.80*)		(*2.68*)
$Momentum_{i,t}$				0.097	0.088	0.091	0.100	0.100
				(*5.16*)	(*4.12*)	(*4.26*)	(*4.93*)	(*4.93*)
$BasisMom_{i,t}$				1.319	1.099	1.038	0.967	0.967
				(*2.71*)	(*2.61*)	(*2.38*)	(*2.03*)	(*2.03*)
Adj R^2	2.1%	4.7%	5.0%	24.2%	28.4%	28.9%	30.9%	30.9%

Table 7: Asymmetry in Return Predictability of Positive and Negative Relative Basis

This table examines the asymmetry in the return predictability of positive and negative relative basis. In Panel A, we conduct the following monthly Fama-MacBeth cross-sectional regression:

$$ret_{i,t+1} = a_t + b_{1,t}RelatBasis\_pos_{i,t} + b_{2,t}RelatBasis\_neg_{i,t}$$
$$+b_{3,t}ResidBasis_{i,t}(\text{ or } TradtBasis_{i,t}) + \lambda_t controls_{i,t} + \varepsilon_{i,t}$$

where $ret_{i,t+1}$ is the futures return of commodity i in month $t+1$. The main explanatory variables are positive relative basis ($RelatBasis\_pos_{i,t}$) and negative relative basis ($RelatBasis\_neg_{i,t}$). We define $RelatBasis\_pos_{i,t}$ ($RelatBasis\_neg_{i,t}$) as the relative basis of commodity i in month t if it is positive (negative) and zero otherwise. Other control variables include $ResidBasis_{i,t}$ (*or* $TradtBasis_{i,t}$), $Momentum_{i,t}$, and $BasisMom_{i,t}$. All control variables are defined identically to those in Table 3. In Panel B, we use the next-quarter commodity futures returns as the dependent variables and repeat the exercises in Panel A. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

Panel A: Dependent variable = commodity futures return in the next month

	(1)	(2)	(3)	(4)
$RelatBasis\_pos_{i,t}$	0.045	0.047	0.048	0.060
	(*2.87*)	(*2.63*)	(*2.68*)	(*3.47*)
$RelatBasis\_neg_{i,t}$	0.016	0.007	0.006	0.019
	(*1.17*)	(*0.49*)	(*0.45*)	(*1.21*)
$ResidBasis_{i,t}$			-0.012	
			(*-1.42*)	
$TradtBasis_{i,t}$				-0.012
				(*-1.42*)
$Momentum_{i,t}$		0.012	0.016	0.016
		(*2.61*)	(*2.98*)	(*2.98*)
$BasisMom_{i,t}$		0.039	0.046	0.046
		(*1.93*)	(*2.22*)	(*2.22*)
Adj R^2	4.3%	11.8%	14.5%	14.5%

Panel B: Dependent variable = commodity futures return in the next quarter

	(1)	(2)	(3)	(4)
$RelatBasis\_pos_{i,t}$	0.110	0.103	0.115	0.127
	(*2.69*)	(*2.49*)	(*2.84*)	(*3.23*)
$RelatBasis\_neg_{i,t}$	0.041	0.024	0.033	0.045
	(*1.48*)	(*0.84*)	(*1.04*)	(*1.30*)
$ResidBasis_{i,t}$			-0.001	
			(*-0.06*)	
$TradtBasis_{i,t}$				-0.001
				(*-0.06*)
$Momentum_{i,t}$		0.021	0.027	0.027
		(*1.65*)	(*1.91*)	(*1.91*)
$BasisMom_{i,t}$		0.080	0.068	0.068
		(*1.61*)	(*1.36*)	(*1.36*)
Adj R^2	4.7%	12.5%	15.3%	15.3%

Table 8: Return Predictability of Relative Basis in the Business Cycle

This table re-estimates the baseline regression (Table 3) conditional on the business cycle. We divide the full sample equally into two subsamples: economic expansion and contraction periods. These periods are proxied by the Philadelphia Fed Aruoba-Diebold-Scotti Business Conditions Index (ADS Index) in Panel A and the Chicago Fed National Activity Index (CFNAI Index) in Panel B. We then conduct Fama-MacBeth regressions separately for the expansion and contraction periods. In both panels, columns (1) and (3) include *ResidBasis*, *Momentum*, and *BasisMom* as control variables, and columns (2) and (4) include *TradtBasis*, *Momentum*, and *BasisMom* as control variables. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

Panel A: Business cycles proxied by the ADS Index

	(1)	(2)	(3)	(4)
	Expansion periods			
$RelatBasis_{i,t}$	0.037	0.042		
	(*4.03*)	(*3.66*)		
$RelatBasis\_pos_{i,t}$			0.080	0.090
			(*2.39*)	(*2.61*)
$RelatBasis\_neg_{i,t}$			0.014	0.025
			(*0.81*)	(*1.34*)
Controls	ResidBasis, Momentum, BasisMom	TradtBasis, Momentum, BasisMom	ResidBasis, Momentum, BasisMom	TradtBasis, Momentum, BasisMom
Adj R^2	12.8%	12.8%	15.2%	15.2%
	Contraction periods			
$RelatBasis_{i,t}$	-0.003	0.007		
	(*-0.32*)	(*0.64*)		
$RelatBasis\_pos_{i,t}$			0.016	0.030
			(*0.79*)	(*1.57*)
$RelatBasis\_neg_{i,t}$			-0.002	0.013
			(*-0.08*)	(*0.56*)
Controls	ResidBasis, Momentum, BasisMom	TradtBasis, Momentum, BasisMom	ResidBasis, Momentum, BasisMom	TradtBasis, Momentum, BasisMom
Adj R^2	12.5%	12.5%	13.8%	13.8%

Panel B: Business cycles proxied by CFNAI Index

	(1)	(2)	(3)	(4)
	Expansion periods			
$RelatBasis_{i,t}$	0.026	0.029		
	(*2.78*)	(*2.48*)		
$RelatBasis\_pos_{i,t}$			0.067	0.073
			(*2.57*)	(*2.93*)
$RelatBasis\_neg_{i,t}$			0.012	0.017
			(*0.61*)	(*0.81*)
Controls	ResidBasis, Momentum, BasisMom	TradtBasis, Momentum, BasisMom	ResidBasis, Momentum, BasisMom	TradtBasis, Momentum, BasisMom
Adj R^2	13.3%	13.3%	14.9%	14.9%
	Contraction periods			
$RelatBasis_{i,t}$	0.009	0.019		
	(*0.90*)	(*1.56*)		
$RelatBasis\_pos_{i,t}$			0.029	0.048
			(*1.12*)	(*1.85*)
$RelatBasis\_neg_{i,t}$			0.001	0.021
			(*0.06*)	(*0.93*)
Controls	ResidBasis, Momentum, BasisMom	TradtBasis, Momentum, BasisMom	ResidBasis, Momentum, BasisMom	TradtBasis, Momentum, BasisMom
Adj R^2	12.0%	12.0%	14.1%	14.1%

Table 9: Return Predictability of Relative Basis Controlling for Smoothed Hedging Pressure

This table examines the return predictability of relative basis after controlling for smoothed hedging pressure. We repeat the Fama-MacBeth exercises of Table 3 with either the next-month return (Panel A) or the next-quarter return (Panel B) as the dependent variable; we further control for smoothed hedging pressure (*SHP*) on the righthand side. *SHP* is defined as the past one-year moving average of the net short position (short minus long positions) of commercial traders (as defined by the CFTC COT dataset), scaled by the commodity's most recent open interest. All other variables are defined identically to those in Table 3. The sample period is January 1993 to December 2019, limited by the availability of the COT data. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

Panel A: Dependent variable = commodity futures return in the next month

	(1)	(2)	(3)	(4)	(5)	(6)
$RelatBasis_{i,t}$	0.022		0.020	0.017	0.016	0.023
	(*3.45*)		(*3.17*)	(*2.24*)	(*2.21*)	(*2.31*)
$SHP_{i,t}$		0.023	0.021	0.016	0.016	0.016
		(*4.36*)	(*4.09*)	(*2.84*)	(*2.86*)	(*2.86*)
$ResidBasis_{i,t}$					-0.013	
					(*-1.32*)	
$TradtBasis_{i,t}$						-0.013
						(*-1.32*)
$Momentum_{i,t}$				0.006	0.010	0.010
				(*1.13*)	(*1.58*)	(*1.58*)
$BasisMom_{i,t}$				0.049	0.062	0.062
				(*2.28*)	(*2.47*)	(*2.47*)
Adj R^2	3.3%	1.2%	4.4%	10.3%	13.3%	13.3%

Panel B: Dependent variable = commodity futures return in the next quarter

	(1)	(2)	(3)	(4)	(5)	(6)
$RelatBasis_{i,t}$	0.075		0.070	0.055	0.057	0.062
	(*5.65*)		(*5.43*)	(*3.63*)	(*3.80*)	(*3.26*)
$SHP_{i,t}$		0.066	0.059	0.046	0.045	0.045
		(*4.17*)	(*3.85*)	(*2.83*)	(*2.82*)	(*2.82*)
$ResidBasis_{i,t}$					-0.002	
					(*-0.08*)	
$TradtBasis_{i,t}$						-0.002
						(*-0.08*)
$Momentum_{i,t}$				0.011	0.013	0.013
				(*0.74*)	(*0.86*)	(*0.86*)
$BasisMom_{i,t}$				0.115	0.105	0.105
				(*2.03*)	(*1.87*)	(*1.87*)
Adj R^2	3.2%	2.3%	5.4%	11.9%	14.5%	14.5%

Online Appendix to

Relative Basis:
A Better Measure of the Convenience Yield

Appendix Table A1: Relative Basis and Inventory Changes: Robustness Tests

This table examines the relation between various basis measures and commodity inventories. Specifically, we conduct a Fama-MacBeth regression of relative basis and residual basis on past inventory changes and levels. The definitions of relative basis and residual basis are identical to those in Table 1. Other control variables are defined as follows. $InventLvl_{i,t}$ is the normalized inventory level of commodity i in month t. $InventLvl_{i,\overline{t-1:t-2}}$ is the average of $InventLvl_{i,t-1}$ and $InventLvl_{i,t-2}$. $InventChg_{i,t,\overline{t-1:t-2}}$ is the inventory change for commodity i in the past months, calculated as the difference between $InventLvl_{i,t}$ and $InventLvl_{i,\overline{t-1:t-2}}$. $InventIncrs_{i,t,\overline{t-1:t-2}}$ ($InventDecrs_{i,t,\overline{t-1:t-2}}$) is the increase-of-inventory (decrease-of-inventory), defined as the inventory change for commodity i in the past months if it is positive (negative) and zero otherwise. The sample period is January 1993 to December 2018, limited by the availability of commodity inventory data. T-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

	Relative Basis				Residual Basis			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$InventChg_{i,t,\overline{t-1:t-2}}$	-0.021	-0.025			0.000	0.000		
	(*-5.54*)	(*-5.69*)			(*0.07*)	(*-0.07*)		
$InventIncrs_{i,t,\overline{t-1:t-2}}$			0.009	0.008			-0.010	-0.010
			(*1.07*)	(*0.90*)			(*-1.55*)	(*-1.61*)
$InventDecrs_{i,t,\overline{t-1:t-2}}$			-0.048	-0.058			0.006	0.005
			(*-5.83*)	(*-6.39*)			(*1.13*)	(*0.93*)
$InventLvl_{i,\overline{t-1:t-2}}$		-0.009		-0.009		0.000		-0.001
		(*-3.63*)		(*-3.50*)		(*-0.04*)		(*-0.34*)
$RelatBasis_{i,t}$	0.342	0.333	0.347	0.337				
	(*15.26*)	(*14.18*)	(*15.17*)	(*14.36*)				
$ResidBasis_{i,t}$					0.702	0.700	0.708	0.706
					(*35.01*)	(*33.74*)	(*37.07*)	(*35.82*)
Adj R^2	31.4%	30.9%	33.1%	32.8%	46.3%	46.2%	46.4%	46.4%

Appendix Table A2: Correlations of Factor Returns

This table reports the return correlations of various commodity factors. *RelatBasisRet*, *TradtBasisRet*, and *ResidBasisRet* are the returns of the long-short portfolios constructed from relative basis, traditional basis, and residual basis, respectively. The market factor *MKTRet* is calculated as the equal-weighted average return of all commodities in our sample. *MomRet* and *BasisMomRet* are the returns of the price momentum and basis momentum factor portfolios. The sample period is January 1979 to December 2019.

	RelatBasisRet	ResidBasisRet	TradtBasisRet	MKTRet	MomRet	BasisMomRet
RelatBasisRet	1.00	0.01	0.29	0.07	-0.07	0.19
ResidBasisRet		1.00	0.78	0.04	0.47	0.33
TradtBasisRet			1.00	0.04	0.37	0.38
MKTRet				1.00	0.13	0.03
MomRet					1.00	0.14
BasisMomRet						1.00

Appendix Table A3: Return Predictability in Subsamples

This table examines the return predictability of relative basis in two subperiods: 1979-1999 and 2000-2019. The regression specifications are similar to those in Table 3, with the next-month return (Panel A) or next-quarter return (Panel B) as the dependent variable. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

Panel A: Next-month commodity futures return as the dependent variable

	1979-1999			2000-2019		
$RelatBasis_{i,t}$	0.018	0.017	0.028	0.017	0.017	0.020
	(*1.87*)	(*1.78*)	(*2.51*)	(*1.89*)	(*1.96*)	(*1.92*)
$ResidBasis_{i,t}$		-0.023			0.001	
		(*-2.06*)			(*0.10*)	
$TradtBasis_{i,t}$			-0.023			0.001
			(*-2.06*)			(*0.10*)
$Momentum_{i,t}$	0.019	0.026	0.026	0.007	0.006	0.006
	(*2.59*)	(*3.18*)	(*3.18*)	(*1.16*)	(*0.95*)	(*0.95*)
$BasisMom_{i,t}$	0.017	0.022	0.022	0.055	0.063	0.063
	(*0.65*)	(*0.83*)	(*0.83*)	(*2.07*)	(*2.09*)	(*2.09*)
Adj R^2	9.6%	12.7%	12.7%	9.8%	12.7%	12.7%

Panel B: Next-quarter commodity futures return as the dependent variable

	1979-1999			2000-2019		
$RelatBasis_{i,t}$	0.063	0.064	0.065	0.063	0.067	0.063
	(*3.75*)	(*3.51*)	(*2.44*)	(*3.53*)	(*3.67*)	(*3.02*)
$ResidBasis_{i,t}$		-0.002			0.023	
		(*-0.06*)			(*1.00*)	
$TradtBasis_{i,t}$			-0.002			0.023
			(*-0.06*)			(*1.00*)
$Momentum_{i,t}$	0.024	0.027	0.027	0.021	0.018	0.018
	(*1.09*)	(*1.21*)	(*1.21*)	(*1.46*)	(*1.12*)	(*1.12*)
$BasisMom_{i,t}$	0.048	0.037	0.037	0.122	0.113	0.113
	(*0.70*)	(*0.53*)	(*0.53*)	(*1.82*)	(*1.73*)	(*1.73*)
Adj R^2	10.8%	14.3%	14.3%	10.8%	13.3%	13.3%

Appendix Table A4: Alternative Constructions of Relative Basis

This table examines the return predictability of relative basis using alternative constructions. Specifically, we adjust the maturities of the first, second, and third nearby contracts of crude oil, heating oil, and natural gas, so that relative basis of all commodities is constructed with the same time intervals. The regression specifications are similar to those in Table 3, with the next-month return (Panel A) or next-quarter return (Panel B) as the dependent variable. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

Panel A: Next-month commodity futures return as the dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$RelatBasis_{i,t}$	0.018			0.018			0.017	0.022
	(*3.06*)			(*2.85*)			(*2.63*)	(*2.81*)
$ResidBasis_{i,t}$		0.010			-0.009		-0.013	
		(*1.34*)			(*-1.09*)		(*-1.55*)	
$TradtBasis_{i,t}$			0.009			-0.007		-0.013
			(*1.68*)			(*-0.99*)		(*-1.55*)
$Momentum_{i,t}$				0.013	0.013	0.014	0.017	0.017
				(*2.73*)	(*2.38*)	(*2.61*)	(*3.27*)	(*3.27*)
$BasisMom_{i,t}$				0.039	0.044	0.053	0.039	0.039
				(*2.05*)	(*2.39*)	(*2.82*)	(*2.03*)	(*2.03*)
Adj R^2	2.5%	3.1%	3.4%	9.7%	10.3%	10.6%	12.5%	12.5%

Panel B: Next-quarter commodity futures return as the dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$RelatBasis_{i,t}$	0.069			0.064			0.064	0.068
	(*5.75*)			(*5.07*)			(*4.93*)	(*3.89*)
$ResidBasis_{i,t}$		0.032			0.001		0.000	
		(*1.66*)			(*0.06*)		(*0.01*)	
$TradtBasis_{i,t}$			0.049			0.028		0.000
			(*3.56*)			(*1.98*)		(*0.01*)
$Momentum_{i,t}$				0.024	0.021	0.015	0.029	0.029
				(*1.78*)	(*1.49*)	(*1.07*)	(*2.07*)	(*2.07*)
$BasisMom_{i,t}$				0.074	0.103	0.087	0.062	0.062
				(*1.50*)	(*2.24*)	(*1.91*)	(*1.30*)	(*1.30*)
Adj R^2	2.9%	3.4%	3.5%	11.0%	11.3%	11.1%	14.2%	14.2%

Appendix Table A5: Return Predictability in Panel Regressions

This table conducts a panel regression with two-way fixed effects to examine the return predictability of different basis measures. The dependent and independent variables are the same as those in Table 3. The panel regression controls for commodity and time fixed effects. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors clustered by both commodity and time, are reported in parentheses below the coefficients.

Panel A: Next-month commodity futures return as the dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$RelatBasis_{i,t}$	0.012			0.010			0.010	0.021
	(*2.58*)			(*2.09*)			(*2.01*)	(*3.28*)
$ResidBasis_{i,t}$		0.000			-0.008		-0.007	
		(*0.01*)			(*-1.05*)		(*-0.94*)	
$TradtBasis_{i,t}$			0.001			-0.006		-0.018
			(*0.15*)			(*-1.21*)		(*-2.68*)
$Momentum_{i,t}$				0.005	0.006	0.006	0.006	0.009
				(*1.12*)	(*1.27*)	(*1.26*)	(*1.31*)	(*1.87*)
$BasisMom_{i,t}$				0.037	0.046	0.048	0.040	0.045
				(*3.15*)	(*4.14*)	(*4.31*)	(*3.63*)	(*4.02*)
fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R^2	12.8%	12.7%	12.7%	12.9%	12.8%	12.8%	12.9%	13.0%

Panel B: Next-quarter commodity futures return as the dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$RelatBasis_{i,t}$	0.056			0.049			0.049	0.049
	(*3.99*)			(*3.82*)			(*3.97*)	(*2.76*)
$ResidBasis_{i,t}$		0.022			0.011		0.015	
		(*1.42*)			(*0.64*)		(*0.86*)	
$TradtBasis_{i,t}$			0.035			0.028		-0.000
			(*3.51*)			(*2.79*)		(*-0.00*)
$Momentum_{i,t}$				0.004	-0.000	-0.004	0.001	0.004
				(*0.37*)	(*-0.02*)	(*-0.38*)	(*0.08*)	(*0.33*)
$BasisMom_{i,t}$				0.089	0.114	0.096	0.084	0.089
				(*3.51*)	(*4.81*)	(*4.13*)	(*3.60*)	(*3.82*)
fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R^2	14.7%	14.1%	14.4%	14.9%	14.4%	14.6%	14.9%	14.9%

Appendix Table A6: Summary Statistics of Financial Futures

This table reports the time-series average of traditional basis, relative basis, and futures returns for a sample of 19 financial futures. The table reports the mean and standard deviation of each variable. The sample period is January 1993 to December 2019.

Financial Futures	traditional basis		relative basis		futures returns	
	mean	standard deviation	mean	Standard deviation	mean	standard deviation
Dow Jones Industrial Mini-Sized	0.66%	1.79%	0.02%	0.38%	0.68%	3.77%
NASDAQ 100 Index, E-mini	-1.10%	1.95%	0.11%	0.30%	0.52%	6.54%
NIKKEI 225 Index	-0.45%	1.35%	-0.20%	1.37%	0.22%	5.87%
S&P 500 Index, E-mini	0.86%	1.27%	0.07%	0.19%	0.67%	4.32%
S&P 500 Index	-1.01%	2.36%	0.08%	0.24%	0.62%	4.12%
Federal Funds / 30-day	0.24%	1.26%	-0.02%	0.87%	0.02%	0.13%
Treasury Note, U.S., 2-year	0.89%	0.71%	0.26%	0.99%	0.08%	0.32%
Treasury Note, U.S., 5-year	1.81%	1.55%	0.86%	1.75%	0.19%	1.01%
Treasury Note, U.S., 10-year	2.83%	1.84%	0.50%	1.46%	0.34%	1.70%
Treasury Bonds, U.S., 30-year	2.36%	5.43%	0.22%	6.40%	0.38%	2.78%
Australian Dollar / U.S. Dollar	1.69%	1.63%	0.03%	0.20%	0.21%	3.34%
British Pound / U.S. Dollar	0.58%	1.23%	0.01%	0.18%	0.04%	2.42%
Canadian Dollar / U.S. Dollar	0.07%	0.98%	-0.01%	0.18%	0.03%	2.34%
Eurodollar, 3-month	0.37%	0.90%	-0.11%	0.59%	0.03%	0.19%
Euro FX	-0.68%	1.38%	0.04%	0.19%	-0.01%	2.81%
Japanese Yen / U.S. Dollar	-2.62%	1.97%	0.07%	0.26%	-0.13%	3.09%
New Zealand Dollar / U.S. Dollar	2.05%	1.60%	0.00%	0.59%	0.24%	3.72%
U.S. Dollar Index	-0.59%	1.51%	-0.05%	0.31%	-0.02%	2.30%
Swiss Franc / U.S. Dollar	-1.86%	1.49%	0.04%	0.25%	0.02%	3.00%
average	0.32%	1.69%	0.10%	0.88%	0.22%	2.83%

Appendix Table A7: Portfolio Analyses of Financial Futures

This table examines the return predictability of different basis measures for financial futures using calendar-time portfolio sorts. Sorting variables include relative basis (*RelatBasis*), traditional basis (*TradtBasis*), and residual basis (*ResidBasis*). At the end of each month, we construct three equal-weighted portfolios based on the corresponding basis measure. We then report the returns of these three portfolios, as well as the return difference between the portfolios with the highest and lowest ranking variable (P3-P1), in the next one month or one quarter. The sample period is January 1993 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

	P1	P2	P3	P3-P1
Sorted by relative basis (RelatBasis)				
next-month return	0.17%	0.10%	0.24%	0.07%
				(*0.55*)
next-quarter return	0.51%	0.32%	0.68%	0.17%
				(*0.63*)
Sorted by traditional basis (TradtBasis)				
next-month return	-0.06%	0.19%	0.38%	0.44%
				(*3.30*)
next-quarter return	-0.26%	0.58%	1.16%	1.42%
				(*3.78*)
Sorted by residual basis (ResidBasis)				
next-month return	-0.11%	0.18%	0.40%	0.51%
				(*4.70*)
next-quarter return	-0.29%	0.59%	1.12%	1.41%
				(*4.64*)

Appendix Table A8: Return Predictability of Standardized Relative Basis

This table examines the return predictability based on standardized basis measures. In Panel A, we conduct the following monthly Fama-MacBeth cross-sectional regression:

$$ret_{i,t+1} = a_t + b_{1,t}RelatBasis^{\text{standz}}_{\text{i,t}}$$
$$+b_{2,t}ResidBasis^{\text{standz}}_{\text{i,t}}(\ or\ TradtBasis^{\text{standz}}_{\text{i,t}}) + \lambda_t Controls^{\text{standz}}_{\text{i,t}} + \varepsilon_{i,t}$$

where $ret_{i,t+1}$ is the futures return for futures i in month $t+1$. The main explanatory variables are the standardized $RelatBasis^{standz}_{i,t}$, $ResidBasis^{standz}_{i,t}$, and $TradtBasis^{standz}_{i,t}$. Other control variables include standardized $Momentum^{standz}_{i,t}$ and standardized $BasisMom^{standz}_{i,t}$. In each month, we standardize all variables by subtracting their cross-sectional means and then dividing by their cross-sectional standard deviations. In each panel, the first three columns report regression results for commodity futures and the next three columns report results for financial futures. In Panel B, we use the next-quarter return as the dependent variable and repeat the exercises in Panel A. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

Panel A: Next-month return as the dependent variable

	commodity futures			financial futures		
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{RelatBasis}^{\text{standz}}_{\text{i,t}}$	0.0032	0.0032	0.0042	-0.0002	-0.0000	-0.0003
	(*3.08*)	(*2.98*)	(*2.65*)	(*-0.44*)	(*-0.01*)	(*-0.42*)
$\text{ResidBasis}^{\text{standz}}_{\text{i,t}}$		-0.0021			0.0014	
		(*-1.92*)			(*3.02*)	
$\text{TradtBasis}^{\text{standz}}_{\text{i,t}}$			-0.0026			0.0013
			(*-1.63*)			(*2.16*)
$\text{Momentum}^{\text{standz}}_{\text{i,t}}$	0.0035	0.0046	0.0046	0.0029	0.0026	0.0026
	(*2.74*)	(*3.13*)	(*3.13*)	(*3.26*)	(*2.82*)	(*2.82*)
$\text{BasisMom}^{\text{standz}}_{\text{i,t}}$	0.0019	0.0023	0.0023	0.0023	0.0013	0.0013
	(*1.63*)	(*1.90*)	(*1.90*)	(*3.45*)	(*1.78*)	(*1.78*)
Adj R^2	9.7%	12.7%	12.7%	23.0%	27.8%	27.8%

Panel B: Next-quarter return as the dependent variable

	commodity futures			financial futures		
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{RelatBasis}^{\text{standz}}_{\text{i,t}}$	0.0108	0.0112	0.0103	-0.0003	0.0001	0.0002
	(*5.45*)	(*5.52*)	(*3.35*)	(*-0.20*)	(*0.09*)	(*0.15*)
$\text{ResidBasis}^{\text{standz}}_{\text{i,t}}$		0.0016			0.0037	
		(*0.62*)			(*2.79*)	
$\text{TradtBasis}^{\text{standz}}_{\text{i,t}}$			0.0016			0.0035
			(*0.46*)			(*2.19*)
$\text{Momentum}^{\text{standz}}_{\text{i,t}}$	0.0057	0.0056	0.0056	0.0084	0.0087	0.0087
	(*1.55*)	(*1.42*)	(*1.42*)	(*3.57*)	(*3.62*)	(*3.62*)
$\text{BasisMom}^{\text{standz}}_{\text{i,t}}$	0.0049	0.0043	0.0043	0.0048	0.0025	0.0025
	(*1.56*)	(*1.39*)	(*1.39*)	(*2.52*)	(*1.16*)	(*1.16*)
Adj R^2	10.8%	13.8%	13.8%	24.2%	30.9%	30.9%

Appendix Table A9: Risk-adjusted Portfolio Returns: Excluding Precious Metals

This table reports monthly risk-adjusted returns (i.e., alphas) of the long-short portfolio based on different basis measures, after excluding commodities in the precious metals category (Gold, Silver, Platinum, Palladium, and Copper). Specifically, we regress monthly long-short portfolio returns constructed from a basis measure on the market factor, the price momentum factor, the basis momentum factor, and other basis measures' long-short portfolio returns. $RelatBasisRet_t$, $TradtBasisRet_t$, and $ResidBasisRet_t$ are the long-short portfolio returns constructed from relative basis, traditional basis, and residual basis, respectively. The market factor $MKTRet_t$ is the equal-weighted average return of all commodities in our sample. $MomRet_t$ and $BasisMomRet_t$ are the returns of the price momentum and basis momentum factor portfolios. All portfolio returns are in percentage units. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

	$RelatBasisRet_t$			$TradtBasisRet_t$		$ResidBasisRet_t$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept (alpha)	0.719	0.705	0.702	0.070	-0.082	-0.167	-0.120
	(*3.14*)	(*3.08*)	(*3.14*)	(*0.33*)	(*-0.39*)	(*-0.80*)	(*-0.57*)
$RelatBasisRet_t$					0.211		-0.066
					(*5.14*)		(*-1.60*)
$ResidBasisRet_t$		-0.080					
		(*-1.60*)					
$TradtBasisRet_t$			0.245				
			(*5.14*)				
$MKTRet_t$	0.103	0.098	0.114	-0.043	-0.065	-0.068	-0.061
	(*1.56*)	(*1.48*)	(*1.77*)	(*-0.70*)	(*-1.08*)	(*-1.14*)	(*-1.02*)
$MomRet_t$	-0.060	-0.030	-0.135	0.308	0.321	0.374	0.370
	(*-1.53*)	(*-0.70*)	(*-3.32*)	(*8.50*)	(*9.05*)	(*10.53*)	(*10.41*)
$BasisMomRet_t$	0.198	0.219	0.108	0.364	0.323	0.268	0.281
	(*4.51*)	(*4.79*)	(*2.35*)	(*8.96*)	(*7.98*)	(*6.74*)	(*6.94*)
Adj R^2	3.9%	4.2%	8.7%	27.0%	30.6%	27.2%	27.5%

Appendix Table A10: Return Predictability of Relative Basis in the Business Cycle
Calendar-Time Portfolio Sorts

This table examines the returns of the long-short relative-basis portfolio formed in different parts of the business cycle. We split the full sample equally into two subperiods: economic expansions and contractions. These subperiods are defined by the Philadelphia Fed Aruoba-Diebold-Scotti Business Conditions Index (ADS Index) in Panel A and the Chicago Fed National Activity Index (CFNAI Index) in Panel B. This table reports the average return of the long-short relative-basis portfolio in the following month or quarter, depending on whether the portfolios are constructed in economy expansions or contractions. We also report the difference of the high-minus-low portfolio returns between economic expansions and contractions. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

Panel A: Business cycle proxied by ADS Index

		P1	P3	P3-P1
Expansion	next-month return	-0.36%	0.88%	1.24%
				(*4.45*)
	next-quarter return	-1.10%	2.56%	3.66%
				(*7.81*)
Contraction	next-month return	-0.08%	0.30%	0.38%
				(*1.40*)
	next-quarter return	-0.68%	1.07%	1.75%
				(*3.44*)
Expansion - Contraction	next-month return			0.86%
				(*2.21*)
	next-quarter return			1.91%
				(*2.77*)

Panel B: Business cycle proxied by CFNAI Index

		P1	P3	P3-P1
Expansion	next-month return	-0.23%	0.89%	1.12%
				(*4.03*)
	next-quarter return	-1.04%	2.64%	3.69%
				(*7.78*)
Contraction	next-month return	-0.21%	0.31%	0.51%
				(*1.86*)
	next-quarter return	-0.74%	0.99%	1.73%
				(*3.45*)
Expansion - Contraction	next-month return			0.61%
				(*1.55*)
	next-quarter return			1.96%
				(*2.84*)

Appendix Table A11: Return-Forecasting Regressions of Traditional Basis

This table examines asymmetric return predictability of positive and negative traditional basis. The dependent variable is the commodity futures' return in the following month. The main explanatory variables are traditional basis ($TradtBasis_{i,t}$), positive traditional basis ($TradtBasis\_pos_{i,t}$), and negative traditional relative basis ($TradtBasis\_neg_{i,t}$). We define $TradtBasis\_pos_{i,t}$ ($TradtBasis\_neg_{i,t}$) as the traditional basis of commodity i in month t if it is positive (negative) and zero otherwise. We further the return predictability of traditional basis in different parts of the business cycle. The business cycle is proxied by the Philadelphia Fed Aruoba-Diebold-Scotti Business Conditions Index (ADS Index) in columns (3)-(6) and by the Chicago Fed National Activity Index (CFNAI Index) in columns (7)-(10). Other control variables include *Momentum* and *BasisMom*. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

	Full sample period		Business cycle proxied by ADS index				Business cycle proxied by CFNAI Index			
			Expansion		Contraction		Expansion		Contraction	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$TradtBasis_{i,t}$	-0.002		0.000		-0.004		-0.007		0.003	
	(-0.30)		*(0.04)*		*(-0.59)*		*(-0.71)*		*(0.49)*	
$TradtBasis\_pos_{i,t}$		-0.007		-0.025		0.010		-0.006		-0.009
		(-0.42)		*(-0.83)*		*(0.42)*		*(-0.28)*		*(-0.35)*
$TradtBasis\_neg_{i,t}$		0.007		0.007		0.007		0.014		0.000
		(0.80)		*(0.57)*		*(0.60)*		*(1.25)*		*(-0.03)*
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R^2	10.4%	12.9%	10.5%	13.0%	10.2%	12.8%	10.9%	12.8%	9.9%	13.0%

Appendix Table A12: Relative Basis and Smoothed Hedging Pressure Calendar-Time Portfolio Returns

This table reports monthly risk-adjusted returns (i.e., alphas) of the long-short relative-basis portfolio, controlling for the smoothed-hedging-pressure (SHP) portfolio return. Specifically, we regress monthly long-short portfolio returns constructed from relative basis on the market factor, the price momentum factor, the basis momentum factor, and the long-short SHP portfolio return. The market factor $MKTRet_t$ is the equal-weighted average return of all commodities in our sample. $MomRet_t$ and $BasisMomRet_t$ are the returns of the price momentum and basis momentum factor portfolios. *SHPRet* is the long-short portfolio return that goes long (short) commodities with the highest (lowest) smoothed hedging pressure. All portfolio returns are in percentage units. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

	$RelatBasisRet_t$			$SHPRet_t$		
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept (alpha)	0.784	0.566	0.579	0.929	0.607	0.620
	(*3.19*)	(*2.37*)	(*2.40*)	(*3.49*)	(*2.41*)	(*2.44*)
$RelatBasisRet_t$				-0.002		-0.023
				(*-0.03*)		(*-0.39*)
$SHPRet_t$	-0.002		-0.021			
	(*-0.03*)		(*-0.39*)			
$MKTRet_t$		0.031	0.035		0.197	0.197
		(*0.44*)	(*0.49*)		(*2.68*)	(*2.68*)
$MomRet_t$		-0.124	-0.119		0.246	0.243
		(*-2.58*)	(*-2.39*)		(*4.87*)	(*4.76*)
$BasisMomRet_t$		0.284	0.287		0.141	0.147
		(*4.99*)	(*4.99*)		(*2.34*)	(*2.35*)
Adj R^2	0.0%	7.2%	7.0%	0.0%	12.4%	12.1%

Appendix Table A13: Basis Momentum Strategy Returns

This table reports monthly risk-adjusted returns (i.e., alphas) of the long-short portfolio constructed from basis momentum of Boon and Prado (2019). Specifically, we regress monthly long-short portfolio returns sorted by basis momentum on the market factor, the price momentum factor, and various basis portfolio returns. $RelatBasisRet_t$, $TradtBasisRet_t$, and $ResidBasisRet_t$ are the long-short portfolio returns constructed from relative basis, traditional basis, and residual basis, respectively. The market factor $MKTRet_t$ is the equal-weighted average return of all commodities in our sample. $MomRet_t$ and $BasisMomRet_t$ are the returns of the price momentum and basis momentum factor portfolios. All portfolio returns are in percentage units. The sample period is January 1979 to December 2019. *T*-statistics, based on standard errors with Newey-West adjustments of 12 lags, are reported in parenthesis below the corresponding coefficients.

	$BasisMomRet_t$			
	(1)	(2)	(3)	(4)
Intercept (alpha)	0.878	0.700	0.777	0.708
	(*4.33*)	(*3.46*)	(*4.01*)	(*3.71*)
$RelatBasisRet_t$		0.207		
		(*4.54*)		
$ResidBasisRet_t$			0.334	
			(*7.08*)	
$TradtBasisRet_t$				0.357
				(*8.28*)
$MKTRet_t$	0.012	-0.009	0.021	0.017
	(*0.20*)	(*-0.16*)	(*0.37*)	(*0.30*)
$MomRet_t$	0.122	0.136	-0.019	0.002
	(*3.12*)	(*3.53*)	(*-0.44*)	(*0.05*)
Adj R^2	1.6%	5.4%	10.6%	13.6%