Momentum in the international commodity futures markets

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Abstract

This paper examines the existence of the momentum in the international commodity futures markets including five countries, US, China, UK, Japan, and India, and investigates the source of the commodity futures momentum. We find that the global momentum and the momentum in US and China show highly significant profits even after controlling for the basis, but we find that the momentum profits are largely reduced and insignificant in most of the cases by controlling for the basis effects in UK, Japan, and India. Though the profits of the momentum strategies are not fully explained by the basis premium, we find the worldwide evidence of a significant comovement in the basis premium and the momentum profits. We also find that the traditional risk factor models, the commodity sector's characteristics, or macroeconomic variable model cannot fully account for the momentum. Based on those failures on explaining the commodity futures momentum, we regard the momentum as a risk factor of the commodity futures market and show that it predicts the future GDP growth, indicating its possible role as a state variable.

Keywords: commodity futures, momentum, roll return, basis, inventory risk

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1. Introduction

The literature on commodity futures markets has reported that the risk premium of commodity futures is related to the past returns (Erb and Harvey 2006; Miffre and Rallis, 2007; Fuertes, et al., 2010; Narayan, Ahmed, and Narayan, 2015), and this positive relation between the past return and the future return is generally called *momentum*. Erb and Harvey (2006) show that the momentum strategy with a 12-month ranking period and a 1-month holding period is profitable in the US commodity futures markets. Miffre and Rallis (2007) examine the profitability of momentum and contrarian strategies in the US commodity futures markets and report that momentum strategies in commodity futures markets are profitable while contrarian strategies do not. Asness, et al. (2013) also document that the momentum profits exist in the commodity futures market as well as other asset markets.

In this paper, we explore the profitability of the commodity futures momentum in the international markets including five countries, US, China, UK, Japan, and India, and investigate the source of the profitability in various aspects. We mainly focus on the relation between the momentum and the basis, which is the difference between the spot price and the futures price, but we extensively examine whether the commodity futures momentum can be explained by the traditional risk factor models, the commodity sector's characteristics, or macroeconomic variables.

In the literature, the significant relation between the commodity futures returns and the basis has been consistently reported basis (Fama and French, 1987; Miffre and Rallis, 2007; Gorton, Hayashi, and Rouwenhorst, 2012). Miffre and Rallis (2007) define the term-structure strategies as buying backwardated commodity futures contracts, the basis of which is positive, and sell contangoed commodity futures contracts, the basis of which is negative, and find that the term-structure strategy generates significant profits in the US commodity futures markets. Other studies on the profitability of the term-structure strategies report consistent results supporting the existence of the positive basis premium (Erb and Harvey, 2006; Fuertes, Miffre, and Rallis, 2010).

Regarding both the basis premium and the momentum, several studies report that the profitability of momentum strategies is closely associated with the basis premium (Erb and Harvey 2006; Miffre and Rallis, 2007; Gorton, Hayashi, and Rouwenhorst, 2012; Szymanowska, De Roon, Nijman, and Goorbergh, 2014). Recently, Gorton, et al. (2012) suggests a model which provides the theoretical predictions on the relations among the basis, past returns, and the risk premium of commodity futures. They document that the futures basis, past futures returns, past spot returns, and spot price volatilities reflect the current state of inventories, thus are related to the risk premium since it varies with the state of inventories. According to their findings, the profits of momentum strategies can be regarded as compensation for bearing the inventory risk. Indeed, Miffre and Rallis (2007) document that the profits of momentum strategies can be generated by buying backwardated contracts and selling contangoed contracts. This means that momentum strategies can be interpreted as buying contracts with high inventory risk and selling contracts with low inventory risk. Szymanowska, et al. (2014) also show that the momentum returns based on the past 12 month returns can be explained by the basis premium. Those studies consistently suggest the explanatory power of the basis premium for the momentum, but most of them are restricted to a small sample of contracts or markets, or focus on only one specific type of momentum strategies.[1] We extensively examine the relation between the basis premium and the momentum in the international markets and for the 16 momentum strategies having different ranking periods and holding periods.

The stock momentum has been actively investigated in the literature, but the commodity futures momentum is much less explored than the stock momentum. Applying the previous studies on the stock momentum to the commodity futures momentum, we verify the possible explanations for the profitability of the commodity futures momentum. First, we investigate the three traditional risk factor models in the

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[1] Szymanowska, et al. (2014) show that the returns sorted on the past 12 month returns can be explained by the returns sorted on the basis, but Shen, Szakmay, and Sharma (2007) report that momentum strategies in the commodity futures markets generate the largest profits for short ranking and holding period. Indeed, we also find that the momentum profits are largest for one-month ranking period and one-month holding period. Thus, the explanatory power of the basis premium for the most profitable momentum strategy is still unexplored.

stock markets: Fama and French's (1992) three factor model, Carhart's (1997) four factor model, and Fama and French's (2015) five factor model. Second, we categorize the commodity futures contracts into five sectors based on the characteristics of the underlying commodities: Metals, Softs, Grains, Meats, and Energies. Then, we explore the role of the sector momentum in explaining the individual commodity futures momentum as Moskowitz and Grinblatt (1999) examine the relation between the industry momentum and the individual stock momentum. Finally, we predict the next month return on each commodity futures contract based on the time-series regression model with the macroeconomic variables following Chordia and Shivakumar (2002), and examine whether the momentum profits are predictable by the macroeconomic variables.

We first confirm the existence of the momentum and the basis premium in the international commodity futures markets, and then find that the basis premium cannot fully explain the global momentum and the momentum in US and China. The global momentum and the momentum in US and China show highly significant profits even after controlling for the basis, but we find that the momentum profits are largely reduced and insignificant in most of the cases by controlling for the basis effects in UK, Japan, and India. Considering the time-series movements of the momentum and the basis premium, we find that there are significant and positive relations between them globally and within each of the sample countries. Though the profits of the momentum strategies are not fully explained by the basis premium, our findings suggest the worldwide evidence of a significant comovement in the basis premium and the momentum profits. Regarding other possible explanations for the commodity futures momentum, we find that the traditional risk factor models, the sector momentum, and the macroeconomic model also fail to explain the momentum profits. The one-factor model in which the basis risk is the only risk factor shows better explanatory power for the commodity futures momentum than the traditional risk factor models. The sector momentum appears to partially contribute to only the one-month momentum, but it cannot explain a substantial portion of the individual commodity futures momentum. The results from the macroeconomic variable model show that the part of momentum profit is predictable by the macroeconomic variables, but the unpredictable part of the momentum is also substantial.

Based on those failures on explaining the commodity futures momentum, we regard the momentum as a risk factor of the commodity futures market and explore the economic meaning of the momentum factor in the spirit of Liew and Vassalou (2000). Liew and Vassalou (2000) examine whether the size, book-to-market, and stock momentum factors in the stock markets have a predictive power for the future GDP growth. They document that the performances of these factors should be related to future economic growth to act as state variables according to the hypothesis of Fama and French (1993, 1995) based on Merton's (1973) intertemporal capital asset pricing model. We find that the commodity futures momentum factor negatively predicts the future GDP growth, from one quarter to a year, and this predictability seems to be independent from other macroeconomic variables.

The remainder of the paper is organized as follows. Section 2 describes the data and Section 3 presents the empirical results. In Section 3.1, we first verify the existence of the momentum in the international commodity futures markets, and in Section 3.2, we examine the relation between the basis premium and the momentum. Section 3.3 and 3.4 present the performance of the traditional risk factor models and the commodity sector momentum in explaining the momentum, respectively, and Section 3.5 shows the relation between the momentum and the returns predicted by the macroeconomic variables. In Section 3.6, we investigate the predictability of the momentum risk factor for the future GDP growth. Lastly, Section 4 concludes.

2. Data

The data, obtained from *Datastream*, comprise daily settlement prices on 32 US commodity futures contracts, 20 Chinese commodity futures contracts, 16 UK commodity futures contracts, 16 Japanese commodity futures, and 13 Indian futures contracts. For each country, the sample period starts with the year in which at least 5 commodity futures exist and ends in June 2015. We include countries that have over 10 commodity futures. The period that each country's data span and more details are reported in Table 1.

[Insert Table 1]

We exclude commodities futures that are delisted during the sample period in the commodity futures markets.[2] To compile the time series of futures returns, we assume that we hold the nearby contract up to the end of the month prior to the maturity month.[3] At the end of that month, we roll our position over to the second nearest-to-maturity contract and hold that contract up to the end of the month prior to maturity. This rolling procedure allows us to minimize the problems related to the lack of liquidity and compute the returns from holding the same contract, instead of switching the contract during the holding month. Futures returns are calculated as the change in the logarithms of the settlement prices in their local currency.[4]

3. Results

[2] We also examine whether including delisted futures contracts changes our results, but the results are qualitatively the same since the delisted futures have rather short period compared to the whole sample period. The reasons why we exclude these delisted futures are that the prices of the nearest contracts do not change for several years before they are delisted and verifying the effective sample period of the contract is rather ambiguous as opposed to the case of delisted stocks. In the literature, many studies use commodity futures data provided by the Commodities Research Bureau (CRB), and Gorton and Rouwenhorst (2006) document that the CRB database contains data primarily for futures contracts that have survived until today.

[3] Some contracts are traded until the end of the maturity month. In these cases, we roll our position at the end of the maturity month.

[4] By defining the return as the change in the logarithms of the prices, returns on any zero investment portfolios are free from the unit of the prices. Though we use prices in the local currency, the main results showing the performance of zero investment portfolios in five countries do not have the different unit problem, thus comparable.

3.1. The existence of momentum in the international commodity futures markets

In this section, we investigate the profitability of momentum strategies in the international commodity futures markets. The literature has documented that momentum strategies are profitable (Asness, 1997; Erb and Harvey, 2006; Miffre and Rallis, 2007) but most of the findings are mainly focused on only a small sample of contracts or markets, such as the US commodity futures market or London Metal Exchange. We extend the study to the international commodity futures markets and further examine what derives the momentum profit in the international commodity futures markets in the subsequent sections.

For momentum strategies, we examine the various combinations of ranking periods (*J*) of 1, 3, 6, and 12 months and holding periods (*K*) of 1, 3, 6, and 12 months. These permutations result in 16 momentum strategies. At the end of each month, futures contracts are sorted into quintiles or terciles based on their average returns over the previous *J*-month-ranking period. For countries with less than 20 commodity futures, which are India, Japan, and UK, we form terciles, and for countries with equal or more than 20 commodity futures, which are US and China, we form quintiles. The futures contracts in each quintile (tercile) are equally weighted. The top quintile (tercile) is assigned as a winner portfolio and the bottom quintile (tercile) is assigned as a loser portfolio. Momentum strategies indicate buying the winner and selling the loser. We hold that portfolio for subsequent *K*-month-holding period. We call the resulting strategy the *J*/*K* momentum strategy.

The return of the momentum strategy is defined as the difference in the returns of the winner and loser portfolios existing in that month. In computing monthly returns of the portfolio, we follow the approach of Jegadeesh and Titman (1993) forming overlapping portfolios. Table 2 reports the monthly returns on the momentum portfolios.

[Insert Table 2]

As well as the momentum strategies in each sample country, we convert all the local currency of the data into US dollar, and construct the global momentum strategies to see whether the momentum phenomenon is observed in the international commodity futures markets.[5] The results show the strong momentum profits in the international markets. The returns on the momentum strategies are insignificant only for the case of 12/6 and 12/12 strategies. Considering that the US stock market indices, S&P 500 composite index and Russell 2000 index, have the annualized Sharpe ratios of 0.236 and 0.222, respectively, and the government indices have negative Sharpe ratios, the Sharpe ratios for the commodity momentum portfolios are substantially large.[6]

Table 2 also presents the results from the individual sample countries. Since the US commodity futures markets have the longest sample period and have the largest number of commodities, the results of the global momentum profits can be driven by the momentum in the US commodity futures markets. The results of the individual countries in Table 2, however, show that the significant momentum profits are observed from the all sample countries though the number of significant strategies is different across countries. In US and China, the momentum profits are large and highly significant. Specifically, 13 of 16 momentum strategies in US and all strategies in China show positively significant profits at the 10% significance level. At the same significance level, 6, 4, and 7 of 16 momentum strategies generate significant returns in UK, Japan, and India commodity futures markets. In terms of the Sharpe ratios, the results of the individual countries also show that the momentum portfolios are highly profitable compared to the other asset indices. The Sharpe ratios for the most of momentum strategies in the commodity futures markets are higher than those for the stock and bond market indices reported in Appendix.

We perform the Fama-MacBeth (1973) cross-sectional regressions to confirm the relation between the past J month returns (J = 1, 3, 6, and 12) and the expected returns. The significant returns on the

[5] At the end of each month, all futures contracts in five sample countries are sorted into quintiles based on their average dollar returns over the previous J-month-ranking period.
[6] We report the annualized Sharpe ratios for stock and bond market indices of each country in Appendix.

momentum strategies mean that the past J month returns have positive relation with the expected returns, thus we examine this relation by the cross-sectional analysis. As in Table 2, we conduct the cross-sectional regressions with the global data in US dollar and with the individual country data in the local currency.

[Insert Table 3]

Table 3 shows consistent results that the momentum phenomenon can be observed in all five sample countries. The results from the global data show that the coefficients on the previous J month returns are positive and significant for all Js. As in Table 2, in US and China, the coefficients on the previous J month returns are highly significant for all Js while in other countries a part of Js show significant coefficients.

Overall, we find that the significant momentum profits in the commodity futures markets are not restricted to only US. They are observed consistently in all five sample countries, and we also confirm that the global momentum portfolios generate significant returns.

3.2. Basis premium and momentum

In this section, we examine whether the basis premium can explain the profitability of the commodity futures momentum strategies as one possible source of the commodity futures momentum. The literature has reported that commodity futures contracts with the larger basis have the higher expected returns, and the commodity futures momentum is closely related to the basis premium. Miffre and Rallis (2007) report that the momentum strategy generates profits by buying high basis contracts and selling low basis contracts (Miffre and Rallis, 2007; Fuertes, et al., 2010; Gorton, et al. 2012; Szymanowska, De Roon, Nijman, and Goorbergh, 2014). Gorton, et al. (2012) suggest the basis and the past futures returns as signals for inventories, so the basis and the past futures returns may contain the common information and the basis premium can be related to the momentum profits. Szymanowska, et al. (2014) report that the returns sorted on the 12-month momentum can be explained by the returns sorted on the basis. The extensive literature shows the possibility that the basis is the source of the commodity futures momentum.

The positive relation between the basis, which is the difference between the spot price and the futures price, and the expected returns on commodity futures has been reported in the body of literature. There are two main theories that explain the positive relation between the basis and the expected returns on futures, the Theory of Normal Backwardation and the Theory of Storage. In the view of the Theory of Normal Backwardation, Keynes (1930) and Hicks (1939) propose that commodity futures prices depend on the net position of hedgers. They hypothesize that a risk premium is accrued to speculators as a reward for accepting the price risk that hedgers sought to transfer. If hedgers are net short, the futures price today has to be a downward-biased estimate of the futures price at maturity. This is to induce speculators to take long positions in commodity futures markets. The increase in the futures price as maturity approaches is referred to as *normal backwardation*. Conversely, if hedgers are net long, then the futures price today is upward-biased and the futures price will decrease as maturity approaches. This is referred to as *contango*. Thus, according to this hypothesis, buying backwardated contracts and selling contangoed contracts can generate profits. The Theory of Storage explains the basis in terms of the interest rates, storage costs, and convenience yields. Fama and French (1987) document that the convenience yield can arise since inventories may have productive value or holding inventories can be a buffer for the unexpected demand shock. Gorton, et al. (2012) also document that convenience yields increase as inventories decrease because of a shortage of goods. Thus, the previous literature predicts the negative relation between inventories and convenience yields, and consequently the negative relation between inventories and the basis.

We define the basis as the difference between the logarithms of the spot price and the futures price. The spot price data, however, are not available for most commodities, thus we employ the price of the nearest futures contract ($F_1(t, T_1)$) maturing at T_1 as the spot price and the price of the second nearest futures contract ($F_2(t, T_2)$) maturing at T_2 as the futures price following Fama and French (1987) and Gorton et al. (2012). Then, the basis is defined as $Basis = \{log(F_1(t, T_1)) - log(F_2(t, T_2))\}/(T_2 - T_1)$. Our definition of the basis is consistent with the definition of '*roll return*' in the literature about the term-structure strategies (Miffre and Rallis, 2007; Fuertes, et al., 2010), so their findings on profits of the term-structure strategies can be interpreted as the basis premium.

Before we investigate the relation between the basis premium and the momentum, we first verify whether the basis premium exists in the international commodity futures markets. The literature has been focused on one commodity futures markets or only a few commodity futures contracts, so the existence of the basis premium in the international commodity futures market should be examined first. We examine the basis premium in two ways: constructing portfolios based on the basis and running the cross-sectional regression. Specifically, first, in each month we sort contracts into quintiles or terciles based on the basis at the end of the previous month and the futures contracts in each quintile (tercile) are equally weighted. We will call the top quintile (tercile) a *Backwardation* portfolio and the bottom quintile (tercile) a *Contango* portfolio. Then, we define basis strategies as buying the backwardation portfolio and selling the contango portfolio. We hold that portfolio for subsequent *K*-month-holding period (*K*=1, 3, 6, and 12 months). In computing monthly returns of the portfolio, we follow the approach of Jegadeesh and Titman (1993) forming overlapping portfolios. Second, we run cross-sectional regressions with the basis. In each month, we regress the expected returns of each commodity futures on its basis. The coefficient of the basis shows the basis premium of the market.

[Insert Table 4]

In Panel A of Table 4, the average monthly returns and the annualized Sharpe ratios of the basis portfolios for K = 1, 3, 6, and 12 months are reported, and in Panel B of it, intercepts and the coefficients of the basis estimated from the cross-sectional regression are reported. In both Panel A and B, the existence of the basis premium in the international commodity futures markets is strongly supported by the results. The global basis portfolios show positive and significant returns (t-statistics = 4.75 to 6.68), and the coefficient of the basis in the cross-sectional regression is also significant (t-statistics = 3.51). The individual country results in both Panel A and B of Table 4 show the existence of the basis premium within all sample countries except Japan. As the momentum, the basis premium in the international commodity futures markets is not solely dominated by the basis premium of the US commodity futures markets.

Based on the findings about the existence of the basis premium, we examine whether the basis premium can explain the momentum in the international commodity futures markets. To investigate the relation between the commodity futures momentum and the basis premium, we take two approaches: a portfolio approach and a regression approach. As the portfolio approach, in each month, we sort commodity futures contracts into two groups based on their basis at first, and then in each basis group we sort contracts into two or three groups based on their previous J month returns (J = 1, 3, 6, and 12 months). In the second sorting procedure, we sort contracts into three groups for US and China and two groups for other countries in the second sorting procedure. For the global portfolio construction, we construct two basis groups first, and then sort contracts into three groups within each of the basis groups. Finally, in each basis group, we construct the winner-minus-loser portfolio by buying the high past return portfolio of the group and selling the low past return portfolio of the group. We compute the monthly return of K month holding strategies for K = 1, 3, 6, and 12 months. Table 5 shows returns on these dependently sorted portfolios.

[Insert Table 5]

Overall results in Table 5 show that the commodity futures momentum cannot be explained by the basis premium. In Panel A, the returns on the global momentum portfolios are significant even after controlling for the basis in general. The results in other panels, however, show rather mixed results. In Panel D and F, the momentum strategies in UK and India show the decrease of the momentum profits. In UK and India, among 32 momentum strategies, only one strategy is significant at the 10% significance level. In Panel B and C, the momentum strategies in US and China generate significant profits even after controlling for the basis. The weak results in Japan are not surprising since we already confirmed that the momentum in the Japanese commodity futures markets is weak in Table 2.

Another interesting feature in Panel A of Table 5 is that the momentum profits and Sharpe ratios in the low basis group are more significant and larger than those in the high basis group in general. This pattern, however, does not seem to be consistent for the individual country cases. If we compare the momentum profits in the low basis group and the high basis group in other panels of Table 5, the pattern observed in Panel A is observed in US, but other countries show the opposite pattern; the momentum in the high basis group generates larger profits than the low basis group.

The US and Chinese commodity futures market data cover the longest period and contain the largest number of commodities, thus the global momentum profits in Panel A of Table 5 can be mainly driven by these two countries. Indeed, in Panel D to F, only one or two of 32 momentum strategies show positive and significant returns at the 10% significance level. Thus, in UK, Japan, and India, the basis premium account for the significant portion of the momentum profits, and the highly significant returns on the global momentum portfolio in Panel A are mainly attributed to the US and Chinese commodity futures markets.

We perform the cross-sectional analysis by regression the expected returns on both the past J month returns and the basis following Fama-MacBeth (1973) methodology. If the basis can explain the momentum, we expect that the coefficients of the past J month returns become insignificant by including the basis to the regression model. We do not report the results in this paper to save the space. The international results show that coefficients of the past *J* month returns are highly significant even after controlling for the basis, but rather the basis become insignificant (*t*-statistics = 1.31) for *J*=12. The results from the individual sample countries appear to be consistent with the results of the portfolio analysis in Table 5. We find the strong relation between the past *J* month returns and the expected return from US and China, but rather weak results from other countries. Among the four variants of *J* (*J* = 1, 3, 6, and 12 months), all cases show significant results in US and China while one or two cases appear to be significant in other countries.

Next, we construct the risk mimicking portfolios for the basis and momentum, respectively, and examine their relation by the time-series regressions. We construct a mimicking portfolio for the basis following Fama and French (1993). In each month, we sort contracts into quintiles or terciles based on the basis at the end of the previous month and the returns on futures contracts in each quintile (tercile) are equally weighted. The top quintile (tercile) is assigned as a backwardation portfolio and the bottom quintile (tercile) is assigned as a contango portfolio. The return difference between the backwardation portfolio and the contango portfolio is defined as *BSS*, the mimicking factor of the basis risk. We run the following regression to verify the explanatory power of the *BSS* factor.

$$WML_{J,t} = \alpha + \beta \times BSS_t + \varepsilon_t \qquad \text{for } J = 1, 3, 6, \text{and } 12 \tag{1}$$

$WML_{J,t}$ indicates the return on winner-minus-loser portfolios based on the previous *J* month returns at month *t*. In Equation (1), if the momentum return can be explained by the basis premium, then the estimated results will show that α, which indicates the part of the momentum returns that are not explained by the basis premium, is not significantly different from zero and β is significantly positive. We test this hypothesis for the four momentum strategies (*J*=1, 3, 6, and 12) globally and within each country. Table 6 shows the estimated results of Equation (1).

[Insert Table 6]

The overall results in Table 6 are consistent with those in Table 5. For the global momentum and the momentum in US, all αs are significant and positive, and for the momentum in China, all αs except the case for *J*=6 are significant. As we confirmed in Table 5, however, the momentum profits are highly reduced in other countries. In UK and Japan, one of four test portfolios have significant α (*t*-statistics = 1.82 and 2.18, respectively), and in India, all test portfolios show insignificant αs. These results suggest that the momentum profits in the Indian commodity futures market can be explained by the basis premium, and in UK and Japanese markets the basis premium seems to have a significant explanatory power since it substantially reduces the momentum profits. Except the case for India, however, the overall results in Table 6 show that the basis premium cannot perfectly explain the momentum which is observed around the world, thus it suggest that the momentum profits are different from the basis premium as opposed to Szymanowska, et al. (2014).

Significant coefficients of BSS_t (β) in all cases only except the case for India with *J*=3, are also noteworthy. Gorton, et al. (2012) document that the time-series variation and cross-sectional variation in the risk premium of the commodity futures are determined by the level of inventories, which can be measured by the basis. Even in Japan, where we find the weak basis premium, Table 6 shows that time-series variation of the momentum profits is significantly affected by the basis premium. Though the basis premium and the momentum profits are not identical risk premiums, their time-variations appear to be closely associated with each other.

To summarize, we examine the relation between the basis premium and the commodity futures momentum, and find that the basis premium cannot fully explain the momentum. We find that the momentum profits are largely reduced by controlling for the basis effects mainly in UK, Japan, and India, but the global momentum and the momentum in US and China show highly significant profits even after controlling for the basis. Considering the time-series movements of the momentum and the basis premium, we find that there are significant and positive relations between them globally and within all sample countries.

3.3. The performance of traditional risk factor models

In this section, we examine whether the momentum returns can be explained by the traditional risk factor models. We focus on three models, Fama and French's (1992) three factor model, Carhart's (1997) four factor model including Fama and French's (1992) three factors and the momentum factor, and Fama and French's (2015) five factor model. For all risk factors of these three models, we use the global factors that can be obtained from the data library of French's website.[7]

We construct the time-series of the monthly returns on momentum portfolios based on the past J month returns (J = 1, 3, 6, and 12)[8], then run the time-series regression for each return series on the risk factors as follows.

$$WML_{J,t} = \alpha + \sum_{k=1}^{K} \beta_k F_{k,t} + \varepsilon_t \quad \text{for } J = 1, 3, 6, \text{and } 12 \tag{2}$$

$WML_{J,t}$ indicates the return on winner-minus-loser portfolios based on the past J month returns at month t, and $F_{k,t}$ indicates the risk factor k at month t. As $F_{k,t}$s in the regression, Fama and French's (1992) three factor model includes the stock market factor (RMRF), size factor (SMB) and growth (or value) factor (HML), and Carhart's (1997) model additionally includes the momentum factor (WML) of

[7] In this section, we use normal returns instead of log returns (see section 2) to make both dependent and independent variables in the same form. And all returns are computed in US dollar because the factors obtained from French's website are computed in US dollar.

[8] As in section 3.1, we assign the top quintile (tercile) as a winner portfolio and the bottom quintile (tercile) as a loser portfolio for the US, China, and global data (UK and Japan data).

the stock market. Fama and French's (2015) model includes RMRF, SMB, HML, profitability factor (RMW), and investment factor (CMA). If the momentum returns in the commodity futures market can be explained by the risk factors, then α should be insignificantly different from zero.

[Insert Table 7]

Table 7 shows the estimates of Equation (2). In Panel A of Table 7, we report the results from the global data, and in other panels, we report the results from the individual countries. First of all, in Panel A, all αs except that of Model 8 are positive and highly significant. These results indicate that all three models fail to explain the momentum profits in the international commodity futures markets. In other panels of Table 7, the momentum profits from the individual country's commodity futures markets also have significant and positive αs in most of the cases. These results support that the international results in Panel A is not driven by one country, and the significant momentum profits are not generally explained by the traditional models in all five sample countries. The only exception among the individual country's results from Panel B to Panel F of Table 7 is the case of UK (Panel D). Most of αs are insignificant for all models, indicating that all three models show successful results in explaining the commodity future momentum. In Table 6, however, we find similar results from UK. With only one factor, the basis factor (BSS), we find that except the commodity futures momentum with J=3 (α=1.183 and t-statistics=1.82), the commodity futures momentum factors show insignificant αs. Moreover, though we do not report the R-squared statistics of regression models in Table 6 and 7, the one-factor (basis factor) model in Table 6 shows larger R-squared value than other multifactor models in Table 7 in most of cases.[9] These results suggest that the basis factor is more important than the traditional risk factors from the stock market in the commodity futures markets.

[9] Indeed, comparing the R-squared values from the basis factor model and the traditional risk factor model can be problematic because the independent variables are different in these two models. But, for the traditional risk factor models, both using log returns and normal returns show similar results.

Though the momentum profits are not explained by the traditional risk factors in general, the relations between the commodity futures momentum returns and the traditional risk factors are noteworthy. First of all, in Panel A, all coefficients of WML factors appear to be significant at the 10% significance level, and these positive relations are consistent with the finding of Pirrong (2005) that the commodity futures momentum and stock momentum are related. More interestingly, the value and significance of coefficients of the WML factor tend to increase as *J* increases in all Panels except Panel F. For example, in Panel B, for the case of *J*=1, the coefficient has the value of 0.127 (*t*-statistics=1.10), but for the case of *J*=12, the coefficient has the value of 0.432 (*t*-statistic=4.02). The longer commodity futures momentum appears to be more associated with the stock momentum.

Other factors of the traditional models show significant coefficients only for few cases, and even the significant coefficients show mixed signs across countries. The SMB and HML factors show positive and marginally significant results for some models in US, but they are significant only in a few models. The SMB and HML factor shows negative results in UK and Japan. Likewise, other risk factors do not show consistent and robust relation with the commodity futures momentum in Table 7.

To summarize, we find that the commodity futures momentum cannot be explained by the traditional risk factor models, Fama and French's three and five factor models and Carhart's four factor model. Though the momentum profits are not fully explained by these models, we find that the commodity futures momentum is significantly and positively related to the stock momentum, consistent with Pirrong (2005).

3.4. Commodity sector momentum

We explore other possible explanations for the commodity futures momentum. Moskowitz and Grinblatt (1999) document that the industry momentum accounts for much of the individual stock momentum in US stock markets. In the spirit of Moskowitz and Grinblatt (1999), we explore the role of the sector momentum in explaining the individual commodity futures momentum.

We categorize commodities into five sectors following Gorton, et al. (2012): *Metals, Softs, Grains, Meats,* and *Energies*. Based on this categorization, we construct the sector momentum, and examine whether the sector momentum accounts for the individual commodity futures momentum. In this analysis, we focus on the international commodity futures momentum, which is constructed by all commodity futures in five sample countries, rather than the commodity futures momentum in each individual country. The sector categorization has some limits in applying to each of the sample countries.[10] First, in each sample country, each category does not span the same sample period. For example, in the Chinese markets, *Metals* category starts from May, 1993 but *Energies* category starts from August, 2004. In the UK markets, *Metals* category starts from February, 2006 while *Softs* category starts from January, 1989. Second, the number of contracts in each category has a big difference in some countries, and some countries do not have any contracts of some categories. In China, futures contract on fuel oil is the only contract of *Energies* category, and there are no *Meats* commodity futures contracts. In UK, while the number of contracts in *Metals* category is seven, that in *Softs* (*Grains*) category is three (one) and there are no *Meats* commodity futures contracts. Thus, we construct the international commodity futures momentum and compare it with the international sector momentum.

Moskowitz and Grinblatt (1999) document that the momentum in returns implies that the correlation between the past period returns and the next period returns is positive. They decompose this correlation into four components, and focus on the serial correlation in industry return component among four components. Applying their idea to the commodity futures momentum, we expect that the serial correlation in sector return component of the commodity futures momentum can be the main driver of it.

[10] We report the composition of the five sectors in each sample country in Table A2 of Appendix.

To construct the sector momentum, we compute the monthly sector return as the equal-weighted average of the monthly returns in each sector. Then, based on the previous J month returns of five sectors, we define the sector momentum portfolio as buying the sector with the highest past returns and selling the sector with the lowest past returns.

We examine four J/K momentum strategies. Following Moskowitz and Grinblatt (1999), we select the strategies with the same lengths of J and K (J and K = 1, 3, 6, and 12).[11] For each strategy, we compute the raw returns (Raw), sector-adjusted returns (Raw – Sector), basis and sector-adjusted returns (Basis-adjusted – Sector), and basis and random sector-adjusted returns. To compute the sector-adjusted returns, in each month, we subtract the return on the sector, which the underlying commodity belongs to, from the individual contract return. The basis and sector-adjusted returns are computed based on the methodology of Daniel, Grinblatt, Titman, and Wermers (1997) and Moskowitz and Grinblatt (1999). To show that the stock momentum is not driven by the size and BE/ME effects, Moskowitz and Grinblatt (1999) match stocks with similar past returns on momentum in addition to adjusting returns for size and BE/ME. Applying their methodology to our case, we first sort contracts by the basis into terciles, and then sort contracts in each basis group into terciles by the past J month returns. We compute the basis-adjusted returns as the return on the individual contract minus the return on the matched portfolio in each month. Then, we subtract the sector return from the basis-adjusted returns as we construct the sector-adjusted returns. Next, we construct the basis and random sector-adjusted returns to investigate the contribution of the sector momentum after controlling for the basis. We replace every true futures contracts in a sector with another contracts that has virtually the same or similar past J month returns and may or may not belong to the same sector.[12] Accordingly, if the sector momentum is the main driver of the commodity

[11] Though we do not report in this paper, we also examine other strategies with different J and K, but results are qualitatively the same.

[12] Following Moskowitz and Grinblatt (1999), we first sort all contracts by the past J month returns, then replace futures contract i's return with contract i-1's return. In other words, we replace each contract with the contract ranked below it. For the first contract, we replace it with the second contract. To control the basis effect, we replace

futures momentum, then the random sector adjusted returns will exhibit the significant momentum while the random sector momentum strategies generate insignificant profits.

[Insert Table 8]

In Table 8, the raw momentum profits (Raw) show significant results up to J=K=6 as we already confirmed in Table 2. The raw sector momentum profits (Raw Sector) show rather weak results. The raw sector momentum is significant only for J=K=1 case (t-statistics=3.24). The raw random sector momentum returns additionally support that the positive raw return for J=K=1 case is generated by the sector characteristics since random sector momentum profit is insignificant for that case. Next, since the sector momentum is significant for short-term, we examine the contribution of the sector momentum on the individual commodity futures momentum. The sector-adjusted profits show reduced returns compared to the raw profits especially for short-term, but they are still significant (t-statistics = 3.41 to 4.18). Comparing these results with the basis and random sector-adjusted returns (Basis-adjusted – Random Sector), adjusting with the true sector shows much larger reduction in the momentum profits than adjusting with the random sector, and these difference may show the contribution of the sector momentum, but the significant basis and sector adjusted returns suggest that the sector momentum is not the main source of the commodity futures momentum.

In sum, we examine whether the sector momentum is the main driver of the individual momentum following the literature about the relation between the stock momentum and the industry momentum. As opposed to the findings of Moskowitz and Grinblatt (1999) in the stock markets, we find that the individual commodity futures momentum shows significant profits even after controlling for the sector

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contract i's basis-adjusted return with the contract i-1's basis-adjusted return, and call the resulting return as the basis-adjusted random sector return.

momentum. Our results show that the contribution of the sector momentum is weak, and also may suggest that the commodity futures momentum is not simply driven by the characteristic of the commodities.

3.5. Prediction with macroeconomic variables

In this section, we investigate whether the commodity futures momentum can be explained by the business cycle as Chordia and Shivakumar (2002) explain the stock momentum. Following Chordia and Shivakumar (2002), we construct the one-month-ahead forecast of the returns using the macroeconomic variables as the following regression.

$$R_{it} = c_{i0} + c_{i1}DIV_{t-1} + c_{i2}YLD_{t-1} + c_{i3}TERM_{t-1} + c_{i4}DEF_{t-1} + e_{it} \tag{3}$$

Chordia and Shivakumar (2002) employ four variables to predict the stock returns: the lagged values of the value-weighted market dividend yield (DIV), default spread (DEF), term spread (TERM), and yield on three-month T-bills (YLD). We employ the same variables to predict the commodity futures returns. DEF is the yield spread between Moody's BAA and AAA corporate bonds, TERM is the yield spread between ten-year government bonds and one-year government bonds, and dividend yield (DIV) on the stock market is defined as the total dividend payments accruing to the CRSP value-weighted index over the previous 12 months divided by the current level of the index. In this analysis, we restrict the sample country to only US because of data availability.

In each month, we estimate the parameters of Equation (3) for each commodity futures contract using the previous 60 months of returns. We restrict this regression to the commodity futures that have at least 24 observations in the estimation period. Then, these estimated parameters of the model are used to compute the one-month ahead predicted return for each commodity futures contract.

To investigate the importance of macroeconomic variables in explaining the momentum, we first sort contracts into two groups based on the predicted returns for the next month. Then, in each group, we sort contracts into terciles based on the past *J* month returns (*J*=1, 3, 6, and 12). We examine whether the winner-minus-loser portfolios in each group generate significant profits. If the commodity futures momentum is attributable to the macroeconomic factors, then we expect that the momentum portfolios in each group may not have significant profits. We present the results in Table 9.

[Insert Table 9]

In Table 9, all panels show that the differences between returns on the low predicted return group and the high predicted return group are positive and significant. These results suggest that a significant part of the next month returns of the commodity futures can be predictable by the macroeconomic variables. The momentum profits, however, remain significant in most of the cases after controlling for the predicted returns. At the 10% significance level, the only exceptions are the high predicted return group for *J*=1 and *J*=6. In the former case, the return difference between the winner and the loser, which is momentum profit, is 0.293 (*t*-statistics = 0.83) while the momentum profit in the low predicted return group is much higher and more significant as 0.763 (*t*-statistics = 2.06). In Panel C, the momentum profit in the high predicted return group is insignificant (*t*-statistics = 0.93), but that in the low predicted return groups is also only marginally significant (*t*-statistic = 1.66). Even in other panels, the common feature is that the momentum profits appear to be larger and more significant in the low predicted return groups than in the high groups for somewhat reason. The predicted returns based on the macroeconomic variables seem to affect the profitability of the momentum, indicating that the part of momentum profit is predictable by the macroeconomic variables, but the significant momentum returns in Table 9 suggest that the unpredictable part of the momentum is also substantial.

3.6. Economic meaning of momentum

In this section, we explore the economic meaning of the commodity futures momentum in the spirit of Liew and Vassalou (2000). Liew and Vassalou (2000) examine whether the size (SMB), book-to-market (HML), and momentum (WML) factors of stock markets have predictive power for the future GDP growth.[13] They document that the performances of these factors should be related to future economic growth to act as state variables according to the hypothesis of Fama and French (1993, 1995) based on Merton's (1973) intertemporal capital asset pricing model.

Since the GDP growth data are provided quarterly, we compute the average of the monthly returns on the commodity futures momentum mimicking factor, WML, for three months to convert the monthly data to quarterly. Then, we run the following time-series regression.

$$GDPgrowth_{t+1,t+hQ} = \alpha + \beta \widetilde{WML}_{J,t} + \varepsilon_t \qquad \text{for } J = 1, 3, 6, \text{and } 12 \text{ and } h = 1, 2, 3, \text{and } 4 \tag{4}$$

$\widetilde{WML}_{J,t}$ indicates the average of the $WML_{J,t}$ factor from month *t*-2 to *t*, and $GDPgrowth_{t+1,t+hQ}$ is the GDP growth from month *t*+1 to month *t*+*h* quarters. We investigate the predictability of $\widetilde{WML}_{J,t}$ for future one to four quarter GDP growth. In addition to the momentum factor ($\widetilde{WML}_{J,t}$), we examine the predictive power of the basis factor ($\widetilde{BSS}_{J,t}$) to compare the results.

[Insert Table 10]

In Table 10, Panel A to E show the results of US, China, UK, Japan, and India, respectively. First of all, overall results in Table 10 support the negative relation between the commodity futures momentum and the future GDP growth. The length of the predictive period for the GDP growth and the length of the

[13] The GDP growth data for five sample countries can be obtained from the Organization for Economic Co-operation and Development (OECD). The data periods for US, China, UK, Japan, and India are 1969:01 – 2015:10, 2011:01 – 2015:10, 1969:01 – 2015:10, 1969:01 – 2015:10, and 1996:07 – 2015:10, respectively.

past periods for measuring momentum (J) having the significant relation are different across countries, but the common feature is that the coefficients of $\widetilde{WML}_{J,t}$ are negative for almost all significant cases. There is only one positive and significant coefficient in Panel B (t-value = 1.88). Otherwise, all significant coefficients are negative. These negative relations between the momentum and the future GDP growth do not seem to be driven by a few countries. These relations appear be strongest in US and weakest in India, but all five countries show significant and negative relations for at least one model even after controlling for $\widetilde{BSS}_{J,t}$. Among the various choices for measuring momentum, Panel A shows that the long term momentum (J=12) seems to be the most powerful predictor for the GDP growth since its coefficients are highly significant for one to four quarter GDP growth, while Panel C and D show that the short term momentum (J=1) is stronger than other in predicting the future GDP growth. In addition, as opposed to the momentum factor, the basis factor shows much weaker and insignificant relations with the future GDP growth in all five countries.

Next, we investigate the relation between the momentum factor and the future GDP growth further with the macroeconomic variables. We employ the default yield spread (DEF), the term yield spread (TERM), and the variable CAY.[14] DEF and TERM are defined as in Table 9, and CAY is a detrended wealth variable computed by Lettau and Ludvigson (2000). The literature has documented that these variables are closely associated with the business cycle (Lettau and Ludvigson, 2000; Chordia and Shivakumar, 2002; and Vassalou, 2003). As in section 3.5, we restrict this analysis to the US market because of the data availability. Thus, we examine whether if these variables are included to the regression (Equation (4)), then the explanatory power of the momentum factors is subsumed by them. In this analysis, we restrict the sample country to only US because of data availability.

[Insert Table 11]

[14] For predicting the GDP growth from month t+1 to $t+hQ$ as in Equation (4), we employ DEF and TERM at month t and CAY at the previous quarter, which is from month t-2 to month t.

Table 11 shows that the negative coefficients of the momentum factor remain significant even after controlling for effects of the three macroeconomic variables. Though DEF shows weak predictability, CAY and TERM are significantly related to the future GDP growth from one to four quarters as literature. In all regression models in Table 11, the predictability of the momentum factor appears to be significant (*t*-values = -1.83 to -3.33) but for the next one quarter GDP growth the momentum factor shows the most significant results.

Overall, we find that the commodity futures momentum negatively predicts the future GDP growth from one quarter to a year. The basis factor, which is generally compared with the momentum as the factor containing some common information, does not show significant predictability. Comparing with other macroeconomic variables, the predictability of the commodity futures momentum is independent from their effects.

4. Conclusion

In this paper, we investigate the profitability of the momentum in the international commodity futures markets in various ways. We find that the momentum are largely reduced by controlling for the basis effects mainly in UK, Japan, and India, but the global momentum and the momentum in US and China show highly significant profits even after controlling for the basis. Though the profits of the momentum strategies are not fully explained by the basis premium, we find the worldwide evidence of a significant comovement in the basis premium and the momentum profits. We also examine other possible explanations, such as the traditional risk factor models, the commodity sector's characteristics, or macroeconomic variable model, but find that they cannot fully account for the momentum. Based on those failures on explaining the commodity futures momentum, we regard the momentum as a risk factor of the commodity futures market and show that it predicts the future GDP growth, indicating its possible role as a state variable.

Though we find the substantial explanatory power of the basis premium, especially in UK, Japan, and India, there are still unexplained significant profits of the momentum strategies. Moreover, the different predictability of the basis factor and the momentum factor for the future GDP growth suggests that the basis premium and the momentum do not contain the same information though they are significantly related to each other. Considering the relation between the stock momentum and the commodity futures momentum, they appear to have the positive relation but they do not seem to be qualitatively the same for two reasons. First, the stock momentum factor fails to explain the commodity futures momentum. Second, Liew and Vassalou (2000) report that the stock momentum factor in the US stock markets cannot predict the future GDP growth, but we find that the commodity futures momentum negatively predicts the future GDP growth and this predictability appears to be even robust to other macroeconomic variables. The implications of our findings seem to be interesting, but unexplored yet, thus we expect the further research for the unexplained part of the commodity future momentum and the differences between the stock momentum and the commodity futures momentum.

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Appendix

To compare the Sharpe Ratios for commodity futures strategies with those of other assets, we compute the Sharpe Ratios for the representative stock and government indices for each country. Except the bond indices of US, other indices and commodity futures in each country have the same sample period. For US, China, UK, and Japan, we use *Datastream*'s average government indices with maturities 1 to 3 years (Gov. Bond1), 3 to 5 years (Gov. Bond2), 5 to 7 years (Gov. Bond3), 7 to 10 years (Gov. Bond4), and over 10 years (Gov. Bond5). For India, we use Barclays emerging market bond index of India (Gov. Bond). As stock market indices, we use S&P 500 composite index and Russell 2000 index for US stock markets, Shanghai composite index and Shenzen composite index for Chinese stock markets, Financial Times Stock Exchange (FTSE) 100 index and FTSE small-cap index for UK stock markets, Nikkei 225 index and Nikkei JASDAQ average index for Japanese stock markets, and CNX 500 index and CNX mid-cap index for Indian stock markets. To compute the excess returns of stock and bond market indices, we employ three month Treasury-bill rate of US and UK, three month central bank-bill rate of China, one month Gensaki Treasury-bill rate of Japan, and 3 month Mumbai interbank rate of India as a risk-free rate of the country.

[Insert Table A1]

Table A1 shows the Sharpe ratios for stock and bond market indices during the sample period for each country.

Table 1. The list of commodity futures contracts

This table describes the commodity futures contracts of US, China, United Kingdom, Japan, and India and the sample period that each country's dataset spans. We exclude commodities whose futures are delisted during the sample period in the commodity futures markets, and the sample period is set to start from the year in which at least 5 commodity futures exist.

Country	Commodity futures	Period
US	32 futures (butter, feeder cattle, live cattle, corn, dry whey, ethanol, lean hogs, lumber, milk, oats, rough rice, soybeans, soybean meal, No. 2 red wheat, hard red spring wheat, cocoa, coffee 'C', cotton seed, orange juice, sugar No. 11, coal, brent crude oil, light sweet crude oil, heating oil, gasoline, electricity, copper, gold 100 oz, palladium, platinum, silver 5000 oz, and natural gas)	197901-201506
China	20 futures (aluminum, copper, fuel oil, gold, natural rubber, rebar steel, wire rod steel, zinc, lead, corn, LLDPE, No. 1 soybeans, No. 2 soybeans, palm oil, PVC, soybean meal, soybean oil, No. 1 cotton, white sugar, and pure terephthalic acid)	200501-201506
UK	16 futures (cocoa No.7, coffee, white sugar, wheat, brent crude oil, sour crude oil, gas oil heating oil, gasoline, aluminum, aluminum alloy, copper, lead, nickel, tin, and zinc)	200301-201506
Japan	16 futures (crude oil, gasoline, gold, kerosene, palladium, platinum, rubber, silver, Chukyo gasoline, Chukyo kerosene, azuki (red bean), corn, soybeans, frozen shrimp, raw sugar, and rice)	199001-201506
India	13 futures (aluminum, cardamom, copper, crude oil, gold, gold guinea, gold petal, kapas, lead, menthe oil, nickel, silver, and zinc)	200501-201506

Table 2. Profitability of momentum strategies

This table shows the average monthly return on the momentum portfolios. At the end of each month, futures contracts are sorted into quintiles or terciles based on their returns over the previous *J*-month-ranking period. Momentum strategies buy the top quintile (tercile) and sell the bottom quintile (tercile). That portfolio is held for subsequent *K*-month-holding period. The rows assigned SR indicates the annualized Sharpe ratio of each strategy. The numbers in parenthesis are *t*-statistics.

		J=1				*J*=3				*J*=6				*J*=12			
		K=1	*K*=3	*K*=6	*K*=12	*K*=1	*K*=3	*K*=6	*K*=12	*K*=1	*K*=3	*K*=6	*K*=12	*K*=1	*K*=3	*K*=6	*K*=12
Global	Return	1.427	0.760	0.595	0.578	1.241	0.706	0.538	0.577	1.055	0.770	0.813	0.451	1.279	0.731	0.313	-0.035
		(4.38)	(3.44)	(3.54)	(4.80)	(3.62)	(2.42)	(2.35)	(3.35)	(3.11)	(2.53)	(3.10)	(2.06)	(3.77)	(2.39)	(1.11)	(-0.14)
	SR	0.727	0.570	0.588	0.797	0.602	0.402	0.391	0.558	0.519	0.423	0.517	0.343	0.634	0.401	0.186	-0.023
US	Return	1.436	0.732	0.576	0.564	1.347	0.726	0.458	0.521	1.038	0.675	0.663	0.347	1.270	0.597	0.107	-0.166
		(3.91)	(3.15)	(3.23)	(4.33)	(3.58)	(2.33)	(1.86)	(2.81)	(2.87)	(2.06)	(2.32)	(1.47)	(3.46)	(1.79)	(0.35)	(-0.60)
	SR	0.649	0.523	0.535	0.718	0.596	0.388	0.309	0.468	0.479	0.343	0.387	0.246	0.582	0.301	0.058	-0.101
China	Return	1.947	1.252	1.006	1.047	1.512	0.955	0.863	0.955	1.303	1.181	1.306	1.306	2.132	1.457	1.243	0.899
		(3.73)	(3.83)	(3.66)	(4.64)	(3.23)	(2.14)	(2.12)	(3.04)	(2.54)	(2.35)	(2.80)	(3.07)	(4.04)	(3.00)	(2.60)	(2.02)
	SR	1.160	1.191	1.138	1.444	1.012	0.672	0.666	0.954	0.808	0.746	0.890	0.975	1.316	0.976	0.848	0.658
UK	Return	0.973	0.698	0.678	0.569	1.592	1.267	0.788	0.541	1.279	0.608	0.318	0.000	0.228	-0.229	-0.561	-0.663
		(1.51)	(1.79)	(2.19)	(2.16)	(2.38)	(2.19)	(1.61)	(1.25)	(1.91)	(1.04)	(0.58)	(0.00)	(0.36)	(-0.39)	(-1.01)	(-1.41)
	SR	0.430	0.509	0.623	0.614	0.683	0.628	0.461	0.360	0.552	0.301	0.169	0.000	0.107	-0.115	-0.298	-0.416
Japan	Return	0.632	0.309	0.082	0.299	0.613	0.089	-0.007	0.338	-0.045	-0.148	0.200	0.297	0.872	0.359	0.250	0.138
		(1.68)	(1.22)	(0.43)	(2.17)	(1.64)	(0.30)	(-0.03)	(1.88)	(-0.12)	(-0.44)	(0.70)	(1.32)	(2.28)	(1.02)	(0.79)	(0.48)
	SR	0.335	0.243	0.086	0.432	0.328	0.059	-0.006	0.374	-0.024	-0.089	0.141	0.265	0.461	0.206	0.161	0.097
India	Return	1.709	0.174	0.407	0.135	1.045	0.481	0.948	0.480	2.116	1.174	0.835	0.700	1.060	0.761	0.755	0.311
		(2.37)	(0.39)	(1.31)	(0.68)	(1.63)	(0.91)	(2.21)	(1.66)	(2.66)	(2.01)	(1.68)	(1.87)	(1.59)	(1.21)	(1.36)	(0.62)

SR	0.737	0.122	0.407	0.210	0.512	0.286	0.692	0.520	0.845	0.639	0.534	0.594	0.517	0.393	0.444	0.202

Table 3. Cross-sectional regression with past returns

This table shows the cross-sectional results with the past *J* month returns (*J*=1, 3, 6, and 12) following Fama-MacBeth (1973) methodology. We report only the coefficients of the past *J* month returns in this table for each regression model. The numbers in parenthesis are *t*-statistics.

	J=1		*J*=3		*J*=6		*J*=12	
Global	0.086	(5.31)	0.037	(4.44)	0.020	(3.71)	0.016	(3.95)
US	0.083	(4.57)	0.042	(4.40)	0.020	(3.45)	0.015	(3.35)
China	0.153	(4.77)	0.072	(4.11)	0.051	(3.74)	0.033	(3.44)
UK	0.053	(0.97)	0.075	(2.56)	0.034	(1.92)	0.014	(1.46)
Japan	0.060	(2.03)	0.023	(1.46)	0.008	(0.70)	0.018	(2.31)
India	0.120	(2.85)	0.015	(0.67)	0.043	(2.48)	0.019	(1.67)

Table 4. Existence of the basis premium

This table shows the returns on the basis portfolios (Panel A) and the cross-sectional results (Panel B). At the end of each month, futures contracts are sorted into quintiles or terciles based on their basis. The *basis* portfolio buys the top quintile (tercile) and sells the bottom quintile (tercile), and it is held for subsequent *K*-month-holding period. In Panel A, the average and *t*-statistics of the monthly returns, and the annualized Sharpe ratio (SR) are reported. In Panel B, intercepts and the coefficients of the basis (*Basis*) estimated from the cross-sectional regression are reported. The numbers in parenthesis are *t*-statistics.

Panel A. Returns on Basis Portfolios					
		K=1	*K*=3	*K*=6	*K*=12
Global	Return	1.406	1.404	1.232	0.806
		(5.21)	(6.54)	(6.68)	(4.75)
	SR	0.863	1.083	1.107	0.788
US	Return	1.283	1.373	1.250	0.823
		(4.00)	(5.69)	(6.13)	(4.40)
	SR	0.664	0.942	1.015	0.729
China	Return	1.607	1.636	1.235	0.944
		(2.81)	(4.57)	(3.75)	(3.21)
	SR	0.870	1.417	1.160	0.993
UK	Return	0.987	0.747	0.793	0.123
		(1.84)	(1.71)	(1.96)	(0.31)
	SR	0.521	0.484	0.557	0.087
Japan	Return	0.254	0.295	0.187	0.284
		(0.78)	(1.20)	(0.85)	(1.57)
	SR	0.154	0.238	0.169	0.312
India	Return	2.571	2.224	1.635	1.079
		(3.66)	(3.99)	(3.74)	(3.18)
	SR	1.133	1.235	1.159	0.986

Panel B. Cross-sectional Results				
	intercept		*Basis*	
Global	-0.069	(-0.35)	0.174	(3.51)
US	-0.054	(-0.29)	0.172	(3.16)
China	-0.065	(-0.15)	0.270	(2.95)
UK	0.269	(0.46)	0.551	(1.91)
Japan	0.056	(0.19)	0.064	(0.61)
India	0.347	(0.67)	0.495	(2.13)

Table 5. The basis premium and momentum

This table shows the average monthly return on the two-way sorted portfolios. At the end of each month, we sort commodity futures contracts into two groups based on their basis at first, and then each basis group we sort contracts into two or three groups based on their past *J* month returns (*J* = 1, 3, 6, and 12 months). In each basis group, we construct the winner-minus-loser portfolio by buying the high past return portfolio of the group and selling the low past return portfolio of the group. We compute the monthly holding return of *K* month holding strategies for *K* = 1, 3, 6, and 12 months. Panel A shows the returns on the international portfolios and other panels show the returns on the portfolio constructed within each individual country. The rows assigned SR indicates the annualized Sharpe ratio of each strategy. The numbers in parenthesis are *t*-statistics.

		J=1				*J*=3				*J*=6				*J*=12			
Basis		*K*=1	*K*=3	*K*=6	*K*=12	*K*=1	*K*=3	*K*=6	*K*=12	*K*=1	*K*=3	*K*=6	*K*=12	*K*=1	*K*=3	*K*=6	*K*=12
Panel A. Global																	
Low	Return	0.870	0.476	0.378	0.439	1.290	0.713	0.394	0.418	0.909	0.367	0.347	0.201	0.872	0.281	-0.123	-0.271
		(2.88)	(2.57)	(2.71)	(4.06)	(4.04)	(2.76)	(1.88)	(2.60)	(2.96)	(1.35)	(1.49)	(1.09)	(2.73)	(1.01)	(-0.50)	(-1.28)
	SR	0.477	0.427	0.449	0.673	0.672	0.460	0.312	0.433	0.493	0.226	0.248	0.182	0.458	0.170	-0.084	-0.215
High	Return	0.815	0.283	0.130	0.184	0.539	0.297	0.232	0.321	0.451	0.330	0.466	0.254	0.639	0.433	0.206	-0.074
		(2.59)	(1.39)	(0.85)	(1.82)	(1.63)	(1.21)	(1.23)	(2.35)	(1.40)	(1.26)	(2.17)	(1.45)	(2.09)	(1.75)	(0.90)	(-0.37)
	SR	0.430	0.231	0.142	0.302	0.271	0.202	0.205	0.391	0.234	0.211	0.361	0.242	0.352	0.294	0.152	-0.061
Panel B. US																	
Low	Return	0.682	0.465	0.316	0.358	1.224	0.610	0.301	0.339	0.863	0.322	0.292	0.117	0.743	0.233	-0.175	-0.342
		(1.99)	(2.31)	(2.12)	(3.09)	(3.50)	(2.14)	(1.31)	(1.93)	(2.53)	(1.06)	(1.12)	(0.58)	(2.06)	(0.74)	(-0.63)	(-1.48)
	SR	0.330	0.383	0.351	0.513	0.581	0.357	0.217	0.320	0.422	0.177	0.187	0.097	0.346	0.124	-0.106	-0.249
High	Return	0.735	0.244	0.167	0.233	0.648	0.408	0.251	0.345	0.586	0.326	0.403	0.230	0.438	0.367	0.087	-0.077
		(2.08)	(1.15)	(1.05)	(2.18)	(1.82)	(1.57)	(1.26)	(2.39)	(1.67)	(1.18)	(1.79)	(1.25)	(1.30)	(1.39)	(0.36)	(-0.36)
	SR	0.346	0.190	0.174	0.362	0.303	0.261	0.209	0.398	0.279	0.198	0.299	0.209	0.218	0.233	0.060	-0.060
Panel C. China																	
Low	Return	0.929	0.668	0.432	0.496	0.960	0.694	0.367	0.481	0.673	0.691	0.533	0.707	0.821	0.199	0.247	0.270
		(1.97)	(2.35)	(1.74)	(2.71)	(1.96)	(1.65)	(0.94)	(1.59)	(1.28)	(1.41)	(1.13)	(1.63)	(1.49)	(0.42)	(0.63)	(0.79)
	SR	0.613	0.731	0.541	0.843	0.616	0.519	0.294	0.498	0.405	0.446	0.359	0.517	0.484	0.137	0.205	0.258
High	Return	1.692	0.623	0.589	0.625	1.021	0.553	0.693	0.739	0.784	0.801	1.064	1.106	0.969	1.092	1.056	0.886
		(2.73)	(1.76)	(2.04)	(2.56)	(1.93)	(1.29)	(1.82)	(2.23)	(1.37)	(1.75)	(2.46)	(2.77)	(1.62)	(2.05)	(2.14)	(1.91)
	SR	0.848	0.547	0.635	0.796	0.605	0.406	0.569	0.700	0.434	0.555	0.782	0.881	0.527	0.667	0.696	0.622
Panel D. UK																	

Low	Return	-0.404	0.052	0.040	0.139	0.733	0.393	0.078	0.040	-0.311	-0.506	-0.307	-0.111	-0.435	-0.493	-0.764	-0.362
		(-0.76)	(0.17)	(0.18)	(0.80)	(1.30)	(1.03)	(0.28)	(0.19)	(-0.60)	(-1.25)	(-0.88)	(-0.43)	(-0.87)	(-1.15)	(-2.06)	(-1.25)
	SR	-0.223	0.050	0.052	0.234	0.383	0.302	0.083	0.056	-0.180	-0.373	-0.262	-0.128	-0.266	-0.350	-0.629	-0.382
High	Return	0.783	0.438	0.252	0.090	1.041	0.517	0.267	0.328	0.778	0.363	0.179	-0.106	0.660	0.191	0.232	-0.221
		(1.24)	(1.41)	(1.24)	(0.60)	(1.71)	(1.08)	(0.64)	(0.92)	(1.22)	(0.67)	(0.37)	(-0.26)	(1.12)	(0.39)	(0.52)	(-0.62)
	SR	0.354	0.401	0.354	0.171	0.491	0.310	0.184	0.265	0.354	0.193	0.107	-0.075	0.330	0.116	0.155	-0.182
Panel E. Japan																	
Low	Return	0.392	0.168	-0.199	0.122	0.411	-0.394	-0.270	0.136	-0.345	-0.338	0.143	0.159	0.698	0.247	0.129	0.104
		(0.94)	(0.67)	(-1.09)	(0.99)	(0.99)	(-1.35)	(-1.23)	(0.93)	(-0.79)	(-1.10)	(0.60)	(0.81)	(1.67)	(0.82)	(0.49)	(0.44)
	SR	0.186	0.134	-0.216	0.198	0.197	-0.270	-0.245	0.186	-0.158	-0.220	0.121	0.161	0.337	0.166	0.100	0.089
High	Return	0.726	0.204	0.080	0.090	0.044	0.066	-0.138	0.092	0.079	-0.079	0.041	0.157	0.518	0.309	0.210	0.100
		(2.07)	(0.93)	(0.50)	(0.81)	(0.14)	(0.29)	(-0.78)	(0.68)	(0.24)	(-0.31)	(0.19)	(0.94)	(1.48)	(1.11)	(0.88)	(0.49)
	SR	0.410	0.185	0.099	0.162	0.027	0.057	-0.155	0.135	0.047	-0.061	0.038	0.187	0.300	0.224	0.179	0.100
Panel F. India																	
Low	Return	1.114	0.074	-0.186	-0.001	0.263	-0.406	-0.035	-0.015	0.668	-0.276	-0.013	0.084	-1.037	-0.164	0.026	0.090
		(1.40)	(0.16)	(-0.70)	(-0.01)	(0.34)	(-0.74)	(-0.09)	(-0.05)	(0.74)	(-0.52)	(-0.03)	(0.25)	(-1.40)	(-0.30)	(0.05)	(0.21)
	SR	0.437	0.051	-0.217	-0.002	0.107	-0.233	-0.028	-0.015	0.237	-0.165	-0.009	0.080	-0.463	-0.099	0.017	0.071
High	Return	1.064	0.200	0.404	0.290	0.114	0.186	0.369	0.253	0.566	0.114	0.053	0.361	0.476	0.351	0.265	0.061
		(1.67)	(0.56)	(1.48)	(1.51)	(0.20)	(0.44)	(1.22)	(1.14)	(0.95)	(0.25)	(0.14)	(1.31)	(0.81)	(0.78)	(0.66)	(0.18)
	SR	0.520	0.175	0.460	0.471	0.062	0.139	0.382	0.356	0.301	0.078	0.044	0.415	0.265	0.254	0.216	0.058

Table 6. Time-series regression with the mimicking portfolio for the basis risk

This table shows the estimated results of Equation (1). At the end of each month, futures contracts are sorted into quintiles or terciles based on their returns over the previous *J*-month-ranking period. Momentum strategies buy the top quintile (tercile) and sell the bottom quintile (tercile). The numbers in parenthesis are *t*-statistics.

		J=1	*J*=3	*J*=6	*J*=12
Global	α	1.190	0.996	0.752	0.962
		(3.58)	(2.85)	(2.18)	(2.80)
	β	0.170	0.178	0.217	0.238
		(2.97)	(2.95)	(3.62)	(3.89)
US	α	1.188	1.046	0.774	0.990
		(3.22)	(2.79)	(2.14)	(2.71)
	β	0.196	0.239	0.207	0.232
		(3.62)	(4.34)	(3.88)	(4.24)
China	α	1.513	0.879	0.697	1.303
		(2.93)	(2.05)	(1.48)	(2.93)
	β	0.267	0.387	0.405	0.531
		(3.41)	(5.87)	(5.48)	(7.59)
UK	α	0.758	1.183	0.704	-0.112
		(1.18)	(1.82)	(1.10)	(-0.18)
	β	0.213	0.361	0.448	0.282
		(2.20)	(3.68)	(4.63)	(2.79)
Japan	α	0.597	0.575	-0.108	0.805
		(1.60)	(1.56)	(-0.30)	(2.18)
	β	0.150	0.204	0.344	0.325
		(2.28)	(3.14)	(5.45)	(4.88)
India	α	1.128	0.785	1.080	0.256
		(1.52)	(1.18)	(1.39)	(0.39)
	β	0.231	0.109	0.414	0.343
		(2.56)	(1.33)	(4.42)	(4.25)

Table 7. Time-series regression with traditional factor models

This table shows the time-series results with the three risk models, Fama and French's (1992) three factor model, Carhart's (1997) four factor model including Fama and French's (1992) three factors and the momentum factor, and Fama and French's (2015) five factor model. As the dependent variables, WML*J* indicates the return on winner-minus-loser portfolios based on the past *J* month returns at month *t*, For each WML*J*, we test three risk models. Panel A shows the returns on the international portfolios and other panels show the returns on the portfolio constructed within each individual country. The numbers in parenthesis are *t*-statistics.

	WML1			WML3			WML6			WML12		
	1	2	3	4	5	6	7	8	9	10	11	12
						Panel A. Global						
α	1.238	1.087	1.290	1.389	1.246	1.458	0.784	0.427	0.735	1.414	0.983	1.267
	(3.58)	(3.07)	(3.48)	(3.86)	(3.37)	(3.79)	(2.20)	(1.20)	(1.93)	(4.02)	(2.84)	(3.37)
RMRF	-0.141	-0.101	-0.157	-0.155	-0.116	-0.171	-0.142	-0.046	-0.099	-0.029	0.086	0.048
	(-1.75)	(-1.21)	(-1.50)	(-1.85)	(-1.34)	(-1.57)	(-1.72)	(-0.55)	(-0.92)	(-0.36)	(1.06)	(0.45)
SMB	0.057	0.018	0.030	0.153	0.115	0.116	0.177	0.083	0.197	0.105	-0.008	0.175
	(0.34)	(0.11)	(0.17)	(0.87)	(0.66)	(0.62)	(1.02)	(0.49)	(1.07)	(0.61)	(-0.05)	(0.96)
HML	-0.223	-0.146	-0.241	-0.063	0.010	-0.122	-0.157	0.026	-0.309	-0.206	0.014	-0.344
	(-1.48)	(-0.94)	(-1.06)	(-0.40)	(0.06)	(-0.52)	(-1.01)	(0.16)	(-1.32)	(-1.35)	(0.09)	(-1.49)
WML		0.169			0.161			0.402			0.483	
		(1.82)			(1.67)			(4.31)			(5.33)	
RMW			-0.133			-0.195			0.042			0.282
			(-0.49)			(-0.69)			(0.15)			(1.03)
CMA			0.047			0.125			0.261			0.211
			(0.16)			(0.42)			(0.87)			(0.71)
						Panel B. US						
α	1.097	0.984	1.266	1.452	1.253	1.514	0.607	0.285	0.510	1.198	0.814	1.031
	(2.55)	(2.22)	(2.76)	(3.40)	(2.87)	(3.32)	(1.52)	(0.71)	(1.19)	(2.93)	(1.98)	(2.36)
RMRF	-0.048	-0.017	-0.105	-0.068	-0.014	-0.082	-0.093	-0.007	-0.040	0.035	0.138	0.119

	(-0.48)	(-0.17)	(-0.80)	(-0.69)	(-0.14)	(-0.63)	(-1.01)	(-0.07)	(-0.33)	(0.37)	(1.44)	(0.97)
SMB	0.407	0.378	0.320	0.324	0.272	0.291	0.312	0.228	0.359	0.263	0.162	0.343
	(1.95)	(1.79)	(1.44)	(1.56)	(1.31)	(1.31)	(1.61)	(1.19)	(1.73)	(1.32)	(0.83)	(1.62)
HML	-0.002	0.055	-0.043	0.321	0.423	0.265	0.082	0.247	-0.022	0.105	0.302	-0.034
	(-0.01)	(0.29)	(-0.15)	(1.73)	(2.21)	(0.95)	(0.47)	(1.40)	(-0.09)	(0.59)	(1.68)	(-0.13)
WML		0.127			0.223			0.362			0.432	
		(1.10)			(1.95)			(3.43)			(4.02)	
RMW			-0.426			-0.176			0.182			0.331
			(-1.27)			(-0.53)			(0.58)			(1.03)
CMA			0.119			0.117			0.164			0.206
			(0.33)			(0.33)			(0.49)			(0.60)
Panel C. China												
α	1.804	1.727	1.655	1.486	1.418	1.361	1.116	1.012	0.876	2.270	2.149	2.185
	(3.24)	(3.08)	(2.71)	(2.94)	(2.79)	(2.46)	(1.97)	(1.78)	(1.42)	(4.23)	(4.02)	(3.71)
RMRF	-0.081	-0.043	-0.027	0.156	0.190	0.174	0.095	0.146	0.152	0.043	0.102	0.048
	(-0.66)	(-0.34)	(-0.17)	(1.40)	(1.65)	(1.18)	(0.76)	(1.14)	(0.93)	(0.36)	(0.84)	(0.31)
SMB	-0.333	-0.315	-0.269	-0.245	-0.229	-0.192	-0.599	-0.575	-0.496	-0.546	-0.518	-0.510
	(-0.87)	(-0.83)	(-0.67)	(-0.71)	(-0.66)	(-0.53)	(-1.55)	(-1.49)	(-1.23)	(-1.49)	(-1.42)	(-1.33)
HML	-0.501	-0.362	-0.464	-0.251	-0.126	-0.051	-0.228	-0.038	0.015	-0.229	-0.010	-0.049
	(-1.40)	(-0.96)	(-1.00)	(-0.77)	(-0.37)	(-0.12)	(-0.63)	(-0.10)	(0.03)	(-0.66)	(-0.03)	(-0.11)
WML		0.192			0.173			0.262			0.302	
		(1.13)			(1.11)			(1.52)			(1.85)	
RMW			0.375			0.513			0.820			0.398
			(0.58)			(0.87)			(1.25)			(0.63)
CMA			0.194			-0.073			0.056			-0.113
			(0.34)			(-0.14)			(0.10)			(-0.21)
Panel D. UK												
α	0.889	0.759	0.678	1.155	1.019	0.774	0.949	0.730	0.459	0.121	-0.350	-0.730

	(1.44)	(1.21)	(0.99)	(1.81)	(1.57)	(1.11)	(1.39)	(1.06)	(0.62)	(0.18)	(-0.55)	(-1.02)
RMRF	-0.006	0.034	0.088	-0.075	-0.033	0.027	-0.073	-0.005	0.034	0.009	0.154	0.327
	(-0.04)	(0.23)	(0.47)	(-0.50)	(-0.21)	(0.14)	(-0.45)	(-0.03)	(0.17)	(0.06)	(1.01)	(1.67)
SMB	-0.226	-0.252	-0.157	-0.311	-0.339	-0.233	-0.135	-0.179	-0.050	0.241	0.147	0.479
	(-0.54)	(-0.60)	(-0.36)	(-0.72)	(-0.78)	(-0.53)	(-0.29)	(-0.39)	(-0.11)	(0.53)	(0.34)	(1.06)
HML	-0.760	-0.630	-0.821	-0.452	-0.316	-0.280	-0.058	0.161	0.261	0.046	0.516	0.050
	(-1.83)	(-1.46)	(-1.65)	(-1.06)	(-0.71)	(-0.55)	(-0.13)	(0.34)	(0.48)	(0.10)	(1.18)	(0.10)
WML		0.219			0.230			0.369			0.793	
		(1.11)			(1.14)			(1.72)			(3.96)	
RMW			0.411			0.959			1.308			1.852
			(0.61)			(1.39)			(1.78)			(2.63)
CMA			0.434			0.221			0.088			1.250
			(0.67)			(0.33)			(0.13)			(1.86)
Panel E. Japan												
α	0.829	0.550	0.753	0.855	0.666	0.918	0.142	-0.107	0.025	0.772	0.364	0.743
	(2.14)	(1.39)	(1.82)	(2.25)	(1.72)	(2.27)	(0.38)	(-0.28)	(0.06)	(1.94)	(0.91)	(1.75)
RMRF	-0.121	-0.048	-0.050	-0.130	-0.080	-0.135	-0.046	0.019	0.002	0.166	0.273	0.166
	(-1.35)	(-0.52)	(-0.43)	(-1.48)	(-0.89)	(-1.18)	(-0.54)	(0.21)	(0.01)	(1.80)	(2.94)	(1.38)
SMB	-0.360	-0.430	-0.336	-0.232	-0.279	-0.271	-0.233	-0.295	-0.173	0.020	-0.082	0.039
	(-1.92)	(-2.30)	(-1.68)	(-1.26)	(-1.51)	(-1.39)	(-1.29)	(-1.64)	(-0.90)	(0.10)	(-0.43)	(0.19)
HML	-0.301	-0.161	-0.581	-0.290	-0.195	-0.414	-0.412	-0.288	-0.433	-0.233	-0.029	-0.161
	(-1.79)	(-0.94)	(-2.27)	(-1.77)	(-1.15)	(-1.65)	(-2.56)	(-1.74)	(-1.76)	(-1.35)	(-0.16)	(-0.61)
WML		0.303			0.205			0.270			0.444	
		(2.95)			(2.02)			(2.73)			(4.27)	
RMW			0.019			-0.231			0.277			0.116
			(0.06)			(-0.78)			(0.95)			(0.37)
CMA			0.489			0.244			0.006			-0.139
			(1.48)			(0.76)			(0.02)			(-0.41)

Panel F. India												
α	1.913	1.981	2.096	1.484	1.481	1.272	2.289	2.312	2.573	1.065	1.028	0.627
	(2.66)	(2.73)	(2.68)	(2.29)	(2.26)	(1.79)	(3.00)	(2.99)	(3.07)	(1.68)	(1.61)	(0.92)
RMRF	-0.141	-0.174	-0.313	-0.285	-0.283	-0.226	-0.331	-0.343	-0.466	-0.138	-0.120	-0.028
	(-0.89)	(-1.06)	(-1.51)	(-2.00)	(-1.91)	(-1.19)	(-1.98)	(-1.96)	(-2.09)	(-1.00)	(-0.83)	(-0.16)
SMB	0.342	0.326	0.261	0.134	0.134	0.225	0.393	0.388	0.269	0.046	0.055	0.234
	(0.69)	(0.66)	(0.51)	(0.30)	(0.30)	(0.48)	(0.75)	(0.74)	(0.49)	(0.11)	(0.13)	(0.53)
HML	-0.499	-0.623	0.122	-0.393	-0.389	-0.232	-0.439	-0.480	-0.309	-0.676	-0.609	-0.269
	(-1.08)	(-1.27)	(0.21)	(-0.94)	(-0.88)	(-0.43)	(-0.89)	(-0.92)	(-0.49)	(-1.66)	(-1.41)	(-0.52)
WML		-0.170			0.006			-0.058			0.092	
		(-0.77)			(0.03)			(-0.24)			(0.47)	
RMW			0.313			0.660			-0.485			1.451
			(0.38)			(0.87)			(-0.54)			(2.00)
CMA			-1.180			0.123			-0.655			0.153
			(-1.64)			(0.19)			(-0.85)			(0.24)

Table 8. Sector momentum

This table shows the performance of the commodity sector momentum and its explanatory power for the individual commodity futures momentum following Moskowitz and Grinblatt (1999). The (*J/K*) column indicates that the momentum portfolios are formed based on the past *J* month returns and be held for the subsequent *K* months. The numbers in parenthesis are *t*-statistics.

(*J/K*)	Raw		Raw - Sector		Basis-adjusted - Sector		Basis-adjusted - Random Sector		Raw Sector		Raw Random Sector	
	Mean	(*t*-stat)	Mean	(*t*-stat)	Mean	(*t*-stat)	Mean	(*t*-stat)	Mean	(*t*-stat)	Mean	(*t*-stat)
(1/1)	1.427	(4.38)	0.750	(3.81)	0.381	(2.18)	0.967	(3.72)	1.470	(3.24)	0.379	(1.53)
(3/3)	0.706	(2.42)	0.571	(3.41)	0.229	(1.60)	0.728	(3.69)	0.482	(1.26)	0.185	(0.91)
(6/6)	0.813	(3.10)	0.647	(4.18)	0.306	(2.24)	0.258	(1.44)	0.114	(0.34)	0.087	(0.44)
(12/12)	-0.035	(-0.14)	0.194	(1.25)	-0.046	(-0.35)	0.694	(3.96)	-0.350	(-1.05)	0.477	(2.80)

Table 9. Predicted returns and momentum

This table shows the momentum profits after controlling for the predicted returns based on Equation (3). Following Chordia and Shivakumar (2002), in each month, we compute the one month ahead predicted return for each commodity futures contract based on the estimates of Equation (3). We first sort contracts into two groups based on the predicted returns for the next month, and then in each group, we sort contracts into terciles based on the past *J* month returns (*J*=1, 3, 6, and 12). We report the winner-minus-loser portfolios of each predicted return group. The numbers in parenthesis are *t*-statistics.

Panel A. *J*=1						
		Raw returns				
		1(low)	2	3(high)	Differences	
Predicted returns	1 (low)	-0.882	-0.363	-0.119	0.763	(2.06)
	2 (high)	0.229	0.164	0.523	0.293	(0.83)
	differences	1.112	0.527	0.641		
		(3.33)	(2.01)	(1.95)		
Panel B. *J*=3						
		Raw returns				
		1(low)	2	3(high)	Differences	
Predicted returns	1 (low)	-0.941	-0.600	0.156	1.097	(3.26)
	2 (high)	-0.001	0.170	0.756	0.757	(2.23)
	differences	0.940	0.770	0.600		
		(2.91)	(2.99)	(1.79)		
Panel C. *J*=6						
		Raw returns				
		1(low)	2	3(high)	Differences	
Predicted returns	1 (low)	-0.878	-0.224	-0.325	0.553	(1.66)
	2 (high)	0.199	0.241	0.511	0.312	(0.93)
	differences	1.077	0.464	0.837		
		(3.14)	(1.77)	(2.67)		
Panel D. *J*=12						
		Raw returns				
		1(low)	2	3(high)	Differences	
Predicted returns	1 (low)	-0.940	-0.505	0.046	0.985	(2.69)
	2 (high)	-0.188	0.370	0.713	0.901	(2.89)
	differences	0.752	0.875	0.667		
		(2.22)	(3.58)	(2.00)		

Table 10. Predictive power for future GDP growth

This table shows the estimated results of Equation (4). We examine the GDP growth from t+1 to t+h quarters (h=1, 2, 3, and 4), and the values of h are noted as 1Q, 2Q, 3Q, and 4Q. For explanatory variables, BSS indicates the basis factor ($\widetilde{BSS}_{J,t}$) and WML indicates the momentum factor ($\widetilde{WML}_{J,t}$). The numbers in parenthesis are t-statistics.

GDP growth	Variable		*J*=1		*J*=3		*J*=6		*J*=12	
		1	2	3	4	5	6	7	8	9
Panel A. US										
1Q	BSS	-0.026		-0.021		-0.023		-0.021		0.000
		(-1.34)		(-1.16)		(-1.05)		(-1.02)		(0.00)
	WML		-0.033	-0.029	-0.022	-0.018	-0.033	-0.030	-0.038	-0.038
			(-2.31)	(-2.04)	(-1.44)	(-1.09)	(-2.62)	(-2.22)	(-3.06)	(-2.95)
2Q	BSS	-0.041		-0.036		-0.037		-0.035		-0.003
		(-1.48)		(-1.32)		(-1.22)		(-1.19)		(-0.12)
	WML		-0.039	-0.033	-0.037	-0.031	-0.050	-0.045	-0.060	-0.060
			(-1.30)	(-1.10)	(-1.74)	(-1.38)	(-2.50)	(-2.36)	(-2.41)	(-2.35)
3Q	BSS	-0.054		-0.046		-0.046		-0.037		-0.010
		(-1.59)		(-1.40)		(-1.30)		(-1.12)		(-0.32)
	WML		-0.066	-0.058	-0.066	-0.057	-0.087	-0.082	-0.082	-0.080
			(-1.92)	(-1.71)	(-2.62)	(-2.34)	(-2.93)	(-2.83)	(-2.34)	(-2.28)
4Q	BSS	-0.036		-0.027		-0.031		-0.020		0.001
		(-0.83)		(-0.62)		(-0.70)		(-0.46)		(0.01)
	WML		-0.071	-0.066	-0.076	-0.070	-0.101	-0.098	-0.093	-0.093
			(-1.77)	(-1.66)	(-2.52)	(-2.44)	(-2.76)	(-2.73)	(-2.06)	(-2.11)
Panel B. China										
1Q	BSS	0.018		0.031		0.011		0.016		0.013
		(0.42)		(0.71)		(0.27)		(0.37)		(0.31)

	WML		0.021	0.028	0.031	0.028	0.025	0.023	0.019	0.015
			(1.23)	(1.88)	(1.03)	(1.14)	(1.01)	(0.86)	(0.86)	(0.85)
2Q	BSS	0.116		0.109		0.160		0.156		0.171
		(1.20)		(1.26)		(1.43)		(1.58)		(1.56)
	WML		-0.090	-0.085	-0.016	-0.082	-0.039	-0.088	-0.013	-0.078
			(-2.11)	(-2.26)	(-0.24)	(-1.27)	(-0.93)	(-1.82)	(-0.21)	(-1.43)
3Q	BSS	0.138		0.132		0.175		0.183		0.211
		(1.61)		(1.56)		(1.66)		(2.01)		(2.00)
	WML		-0.078	-0.072	0.002	-0.070	-0.041	-0.099	-0.023	-0.104
			(-1.49)	(-1.95)	(0.04)	(-1.20)	(-1.25)	(-2.54)	(-0.51)	(-2.51)
4Q	BSS	0.111		0.107		0.130		0.145		0.178
		(1.36)		(1.24)		(1.41)		(1.62)		(1.73)
	WML		-0.064	-0.059	0.019	-0.034	-0.029	-0.076	-0.027	-0.095
			(-1.64)	(-1.85)	(0.28)	(-0.57)	(-0.82)	(-2.22)	(-0.75)	(-3.08)
Panel C. UK										
1Q	BSS	-0.034		-0.026		-0.022		-0.024		-0.047
		(-1.88)		(-1.61)		(-0.91)		(-1.02)		(-2.08)
	WML		-0.034	-0.031	-0.031	-0.027	-0.016	-0.011	-0.001	0.005
			(-1.62)	(-1.56)	(-1.44)	(-1.24)	(-0.91)	(-0.57)	(-0.04)	(0.24)
2Q	BSS	-0.054		-0.032		-0.016		-0.020		-0.067
		(-1.73)		(-1.12)		(-0.39)		(-0.45)		(-1.87)
	WML		-0.071	-0.064	-0.065	-0.061	-0.039	-0.033	-0.012	0.001
			(-1.87)	(-1.74)	(-1.73)	(-1.55)	(-0.98)	(-0.75)	(-0.25)	(0.01)
3Q	BSS	-0.040		-0.007		0.026		0.032		-0.017
		(-0.91)		(-0.16)		(0.50)		(0.57)		(-0.32)
	WML		-0.096	-0.094	-0.090	-0.096	-0.056	-0.066	-0.043	-0.040
			(-1.95)	(-1.86)	(-1.70)	(-1.74)	(-0.93)	(-0.99)	(-0.56)	(-0.52)

4Q	BSS	-0.009		0.033		0.085		0.099		0.049
		(-0.17)		(0.55)		(1.32)		(1.26)		(0.71)
	WML		-0.111	-0.118	-0.108	-0.128	-0.069	-0.098	-0.079	-0.088
			(-1.87)	(-1.81)	(-1.61)	(-1.86)	(-0.92)	(-1.16)	(-0.90)	(-0.94)
Panel D. Japan										
1Q	BSS	-0.005		0.004		0.005		0.007		0.002
		(-0.19)		(0.13)		(0.17)		(0.19)		(0.08)
	WML		-0.072	-0.073	-0.071	-0.072	-0.028	-0.031	0.005	0.005
			(-1.86)	(-1.80)	(-1.59)	(-1.50)	(-0.96)	(-0.81)	(0.18)	(0.15)
2Q	BSS	-0.029		-0.016		-0.015		-0.009		-0.014
		(-0.87)		(-0.51)		(-0.48)		(-0.27)		(-0.38)
	WML		-0.104	-0.102	-0.092	-0.089	-0.067	-0.064	-0.035	-0.030
			(-2.58)	(-2.60)	(-1.78)	(-1.72)	(-1.84)	(-1.73)	(-0.87)	(-0.72)
3Q	BSS	-0.068		-0.053		-0.059		-0.065		-0.053
		(-1.47)		(-1.16)		(-1.26)		(-1.28)		(-1.05)
	WML		-0.121	-0.114	-0.068	-0.055	-0.058	-0.034	-0.070	-0.052
			(-2.18)	(-2.07)	(-1.01)	(-0.80)	(-0.99)	(-0.58)	(-1.65)	(-1.31)
4Q	BSS	-0.079		-0.067		-0.073		-0.090		-0.063
		(-1.29)		(-1.10)		(-1.15)		(-1.29)		(-0.94)
	WML		-0.095	-0.086	-0.051	-0.036	-0.021	0.012	-0.069	-0.048
			(-1.77)	(-1.62)	(-0.64)	(-0.44)	(-0.27)	(0.15)	(-1.25)	(-0.92)
Panel E. India										
1Q	BSS	-0.046		-0.049		-0.039		-0.040		-0.031
		(-2.01)		(-2.20)		(-1.69)		(-1.06)		(-0.99)
	WML		-0.004	0.009	-0.044	-0.029	-0.039	-0.021	-0.089	-0.078
			(-0.14)	(0.37)	(-0.68)	(-0.44)	(-0.86)	(-0.37)	(-1.88)	(-1.64)
2Q	BSS	-0.042		-0.043		-0.046		-0.060		-0.078

		(-1.04)		(-1.04)		(-0.91)		(-1.21)		(-1.44)
	WML		-0.004	0.007	0.002	0.018	-0.001	0.024	-0.035	-0.007
			(-0.08)	(0.15)	(0.02)	(0.24)	(-0.03)	(0.50)	(-0.62)	(-0.12)
3Q	BSS	-0.072		-0.074		-0.081		-0.065		-0.103
		(-1.19)		(-1.35)		(-1.20)		(-1.19)		(-1.42)
	WML		-0.010	0.008	0.013	0.041	-0.051	-0.023	-0.101	-0.064
			(-0.13)	(0.12)	(0.14)	(0.45)	(-0.68)	(-0.31)	(-1.85)	(-1.53)
4Q	BSS	0.037		0.024		0.033		0.046		0.030
		(0.70)		(0.45)		(0.51)		(0.64)		(0.37)
	WML		0.055	0.049	0.028	0.017	-0.018	-0.038	-0.057	-0.068
			(0.84)	(0.73)	(0.28)	(0.14)	(-0.29)	(-0.49)	(-1.38)	(-1.47)

Table 11. Predictive power for future GDP growth with economic factors

This table shows the relation between the momentum factor and the future GDP growth further with the macroeconomic variables. Three macroeconomic variables, CAY, DEF, and TERM, are added to Equation (4). DEF is the yield spread between Moody's BAA and AAA corporate bonds, TERM is the yield spread between ten-year government bonds and one-year government bonds, and CAY is a detrended wealth variable computed by Lettau and Ludvigson (2000). BSS indicates the basis factor ($\widetilde{BSS}_{J,t}$) and WML indicates the momentum factor ($\widetilde{WML}_{J,t}$).We examine the GDP growth from t+1 to t+h quarters (h=1, 2, 3, and 4), and the values of h are noted as 1Q, 2Q, 3Q, and 4Q, respectively. The numbers in parenthesis are t-statistics.

GDP growth	Variables		J=1		J=3		J=6		J=12	
		1	2	3	4	5	6	7	8	9
1Q	BSS	-0.010		-0.005		0.001		-0.003		0.003
		(-0.67)		(-0.33)		(0.07)		(-0.21)		(0.20)
	WML		-0.031	-0.030	-0.035	-0.035	-0.034	-0.033	-0.037	-0.038
			(-2.55)	(-2.40)	(-3.15)	(-3.33)	(-3.14)	(-3.28)	(-2.99)	(-3.03)
	CAY	5.00	5.65	5.51	5.33	5.35	5.28	5.20	5.21	5.28
		(1.84)	(2.13)	(2.08)	(1.98)	(1.98)	(1.93)	(1.89)	(1.96)	(1.97)
	DEF	-0.284	-0.251	-0.248	-0.267	-0.267	-0.265	-0.264	-0.323	-0.325
		(-1.33)	(-1.24)	(-1.22)	(-1.33)	(-1.32)	(-1.27)	(-1.25)	(-1.66)	(-1.66)
	TERM	0.082	0.074	0.074	0.073	0.073	0.068	0.068	0.068	0.067
		(1.94)	(1.80)	(1.83)	(1.86)	(1.87)	(1.61)	(1.64)	(1.71)	(1.71)
2Q	BSS	-0.017		-0.010		-0.005		-0.010		0.002
		(-0.74)		(-0.45)		(-0.22)		(-0.45)		(0.12)
	WML		-0.046	-0.045	-0.044	-0.043	-0.038	-0.036	-0.061	-0.061
			(-1.92)	(-1.83)	(-2.29)	(-2.31)	(-2.01)	(-2.07)	(-2.46)	(-2.50)
	CAY	12.59	13.37	13.05	12.89	12.75	12.96	12.67	12.60	12.67
		(2.27)	(2.40)	(2.41)	(2.30)	(2.32)	(2.29)	(2.27)	(2.28)	(2.33)
	DEF	-0.350	-0.300	-0.295	-0.329	-0.327	-0.332	-0.326	-0.415	-0.417

		(-0.83)	(-0.74)	(-0.72)	(-0.81)	(-0.80)	(-0.80)	(-0.78)	(-1.09)	(-1.09)
	TERM	0.160	0.147	0.148	0.148	0.149	0.143	0.145	0.137	0.137
		(1.84)	(1.75)	(1.78)	(1.78)	(1.80)	(1.64)	(1.68)	(1.66)	(1.67)
3Q	BSS	-0.039		-0.029		-0.021		-0.028		-0.016
		(-1.31)		(-1.02)		(-0.81)		(-1.05)		(-0.66)
	WML		-0.067	-0.062	-0.067	-0.061	-0.058	-0.052	-0.075	-0.072
			(-2.22)	(-2.04)	(-2.67)	(-2.65)	(-2.28)	(-2.32)	(-2.27)	(-2.24)
	CAY	19.00	20.57	19.65	19.86	19.24	19.97	19.12	19.56	19.10
		(2.48)	(2.69)	(2.61)	(2.60)	(2.53)	(2.59)	(2.49)	(2.60)	(2.55)
	DEF	-0.212	-0.149	-0.136	-0.190	-0.180	-0.194	-0.179	-0.305	-0.291
		(-0.34)	(-0.25)	(-0.22)	(-0.32)	(-0.30)	(-0.31)	(-0.29)	(-0.53)	(-0.50)
	TERM	0.232	0.212	0.216	0.212	0.216	0.205	0.210	0.202	0.205
		(1.71)	(1.61)	(1.65)	(1.63)	(1.66)	(1.52)	(1.57)	(1.55)	(1.57)
4Q	BSS	-0.043		-0.031		-0.021		-0.030		-0.017
		(-1.16)		(-0.88)		(-0.64)		(-0.89)		(-0.58)
	WML		-0.080	-0.075	-0.082	-0.077	-0.071	-0.065	-0.085	-0.080
			(-2.21)	(-2.06)	(-2.75)	(-2.76)	(-2.30)	(-2.37)	(-2.13)	(-2.15)
	CAY	26.81	28.58	27.58	27.72	27.10	27.85	26.95	27.42	26.92
		(2.70)	(2.83)	(2.81)	(2.75)	(2.74)	(2.75)	(2.70)	(2.76)	(2.76)
	DEF	0.091	0.167	0.182	0.121	0.131	0.117	0.132	-0.014	0.002
		(0.11)	(0.21)	(0.22)	(0.15)	(0.16)	(0.14)	(0.16)	(-0.02)	(0.00)
	TERM	0.308	0.285	0.289	0.285	0.288	0.275	0.280	0.275	0.278
		(1.64)	(1.57)	(1.58)	(1.58)	(1.58)	(1.51)	(1.53)	(1.52)	(1.53)

Table A1. Sharpe ratios for stock and bond market indices

This table shows the annualized Sharpe ratios for each country's stock and bond market indices. Gov. Bonds indicate the government bond indices with various maturities and other two indices are the representative stock market indices of each country. The last column shows the sample period of each index.

Country	Asset	Sharpe Ratio	Sample period
US	Gov. Bond1	-1.531	198001-201506
	Gov. Bond2	-0.748	
	Gov. Bond3	-0.520	
	Gov. Bond4	-0.388	
	Gov. Bond5	-0.215	
	S&P 500	0.236	197901-201506
	Russell 2000	0.222	
China	Gov. Bond1	-0.911	200501-201506
	Gov. Bond2	-0.482	
	Gov. Bond3	-0.249	
	Gov. Bond4	-0.118	
	Gov. Bond5	-0.170	
	Shanghai composite	0.267	
	Shenzen composite	0.475	
UK	Gov. Bond1	-2.719	200301-201506
	Gov. Bond2	-1.801	
	Gov. Bond3	-1.219	
	Gov. Bond4	-0.769	
	Gov. Bond5	-0.378	
	FTSE100	-0.055	
	FTSE Small Cap	0.125	
Japan	Gov. Bond1	-1.105	199001-201506
	Gov. Bond2	-0.326	
	Gov. Bond3	0.017	
	Gov. Bond4	0.256	
	Gov. Bond5	0.253	
	Nikkei 225	0.149	
	JASDAQ	0.024	
India	Gov. Bond	-0.173	200501-201506
	CNX 500	0.436	
	CNX mid-cap	0.416	

Table A2. Commodity sectors

This table shows the composition of the commodity sectors in each sample countries. We categorize commodities into five sectors, *Metals*, *Softs*, *Grains*, *Meats*, and *Energies*.

Nation	Commodity Sector	Commodity
US	*Metals*	Copper, gold, palladium, platinum, and silver
	Softs	Ethanol, lumber, cocoa, coffee, cotton seed, orange juice, and sugar
	Grains	Corn, oats, rough rice, soybeans, soybean meal, No.2 red wheat, and hard red spring wheat
	Meats	Butter, feeder cattle, live cattle, dry whey, lean hogs, and milk
	Energies	Coal, brent crude oil, light sweet crude oil, heating oil, gasoline, electricity, natural gas
China	*Metals*	Aluminum, copper, gold, rebar steel, wire rod steel, zinc, and lead
	Softs	Natural Rubber, LLDPE, PVC, cotton, sugar, and pure terephthalic acid
	Grains	Corn, No.1 soybeans, No.2 soybeans, palm oil, soybean meal, and soybean oil
	Energies	Fuel Oil
UK	*Metals*	Aluminum, aluminum alloy, copper, lead, nickel, tin, and zinc
	Softs	Cocoa, coffee, and sugar
	Grains	Wheat
	Energies	Brent Crude Oil, sour crude oil, gas oil, heating oil, and gasoline
Japan	*Metals*	Gold, palladium, platinum, and silver
	Softs	Rubber, and raw sugar
	Grains	Azuki (Red Bean), corn, soybeans, and rice
	Meats	Frozen Shrimp
	Energies	Crude Oil, gasoline, kerosene, Chukyo gasoline, and Chukyo kerosene
India	*Metals*	Aluminum, copper, gold, gold guinea, gold petal, lead, nickel, silver, and zinc
	Softs	Cardamom, kapas, and menthe oil
	Energies	Crude Oil