# Anatomizing commodity risk premium factors[1]


## Abstract

**Strategy Framework: This report constructs 5 categories of 13 CTA risk premium factors from the perspective of commodity fundamentals, statistical features, and macroeconomics.** Based on commodity fundamentals, we can construct factor types such as commodity inventory, term structure, and positions. Based on statistical features of volume and price, volume and price factors can be constructed to describe movement pattern. In addition, macro correlation factors can be constructed from the perspective of commodity futures prices and macroeconomic correlations.

**Backtesting Methodology: Use group backtesting method** to check the validity of CTA factors. Calculate the factor value at the end of the holding period. Sort factor value from small to large 5 groups, buy (sell) the first 20% (G1) of the products according to the signal direction, and sell (buy) the 20% (G5) of the products. With 100% margin ratio and equal weight allocation, we constructed a long-short portfolio, and judged the effectiveness of the factor based on the indicators such as Sharpe ratio.

**Parameter Optimization:** Mainly involve two types of parameters, **the factor construction window period R and the holding period H**. We test the annualized returns, Sharpe ratio and other indicators under different parameter groups and select the factor signals under the optimal parameter group to observe out of sample.

**Conclusions:** Among commodity fundamentals, **inventory and term structural factors perform best.** In the volume-price factors, **momentum and coefficient of variation perform well.** However, macro factors such as CPI_Beta and RMB Beta don't show excess returns. By comprehensively comparing the major categories of factors, we find that CTA factor mining still needs to **stick to economic logic**. Inventory and term structural factors have mature academic support and excellent returns in China and abroad. The statistical characteristic factors (momentum, coefficient of variation) are also more effective, but the factors (idiosyncratic volatility, etc.) derived from overfitting of statistical characteristics hardly harvest excess returns in Chinese market.


## 1. Backtesting Methodology

In recent years, with the development and improvement of China's futures market, the variety of commodity futures has gradually increased. Currently, the number of commodity futures listed on the SSE, CZCE and DCE has exceeded 50 varieties, ranging from precious metals, non-ferrous metals, agricultural products, chemicals, Black to other breed categories. In addition, under the environment of diversified asset allocation needs, the value of the allocation of commodities has become increasingly prominent, and funds have gradually paid attention to the layout of commodity futures funds. The approval of the commodity future ETFs will increase the liquidity of commodity futures and provide investors with more allocation tools.

[1] For more，see https://github.com/evelynpurse/CTA_summary

This report considers the actual conditions of the Chinese futures market and constructed a framework of 5 categories such as inventory, term structure, positions, volume and price, and macro. According to the definition of factors and economic logic, the direction of setting the profit forecast is shown in following table:

| Main class | Categories | Factor | Definition | Direction |
|---|---|---|---|---|
| **Commodity Fundamentals** | **Inventory** | Warehouse Receipt change | Percent change in warehouse receipts during R days | - |
| | | Inventory level | Current warehouse receipt / average warehouse receipt level of the previous 12 months | - |
| | **Term Structure** | Roll return | The log difference of price of the nearest month and the second nearest month contract | + |
| | | Basis | The arithmetic difference of the nearest month and the second nearest month contract | + |
| | | Basis Momentum | The difference of log return of the nearest month and the second nearest month contract | + |
| | **Open Interest** | Open Interest Change | Change rate of the previous R day open interest | + |
| **Statistical Feature** | **Price and Volume** | Momentum | Return of the previous R days | + |
| | | Skewness | Skewness of the previous R days daily return | - |
| | | Liquidity | Liquidity of dominant contract before R-day | - |
| | | Volatility | Variation coefficient of daily return of the previous R days | + |
| | | Idiosyncratic Volatility | Standard deviation of residual from regression on momentum return, the basis return, and the market return | - |
| **Macro economics** | **Macro economics** | CPI Beta | Regression coefficient of daily returns in the previous R days to the growth rate of CPI | + |
| | | RMB Beta | Regression coefficient of daily returns of the previous R days to the CNY index | - |

**Table: Factor definition**

## 2. Commodity fundamentals

### 2.1. Inventory

The cost of carry model implies that the futures price equals

$$F_t^n = S_t\left(1 + r_f\right)^n (1 + U) - C_{t+n}$$

Where $F_t^n$ denotes the futures price for delivery at time t + n, $S_t$ denotes the spot price of the underlying commodity, $r_f$ denotes risk-free interest rate, $U$ denotes physical storage costs, $C_{t+n}$ is the equivalent cash payment from convenience yield.

In terms of cost of carry model, futures price is affected by storage level. More specifically, when inventory levels rises, futures price would rise. Here we define 2 factors to describe this pattern, which are warehouse receipt change and inventory level.

**Warehouse receipt change**

$$\text{Signal}_t = I_t / I_{t-R}$$

Where $I_{t-R}$ is the warehouse receipt at day t-R

**Inventory level**

$$\text{Inv\_level}_t = I_t / I^*$$

Where $I^*$ is the rolling mean of past R days' warehouse receipts

## 2.2. Term Structure

Term structures captures the return coming from time value of risk free interest rates. When approaching maturity, the price of futures and underlying assets would converge eventually. Based on this logic, we define roll return, basis and basis momentum factors.

**Roll return**

$$\text{roll return signal} = \left(\ln\left(f_{t,front}\right) - \ln\left(f_{t,second}\right)\right) \times \frac{365}{D_{second} - D_{front}}$$

where $f_{t,front}$ is the price of the nearest month contract. $f_{t,second}$ is the price of the second nearest month contract.

**Basis**

$$\text{Basis} = 365 \times \left(\frac{f_{t,front}}{f_{t,second}} - 1\right) / \left(D_{second} - D_{front}\right)$$

where $f_{t,front}$ is the price of the nearest month contract. $f_{t,second}$ is the price of the second nearest month contract.

**Basis momentum**

$$BM_t = \prod_{s=t-R}^{t} \left(1 + R_{s,front}\right) - \prod_{s=t-R}^{t} \left(1 + R_{s,second}\right)$$

Where $R_{s,front}$ is the daily return of front contract, $R_{s,second}$ denotes the daily return of second contracts.

## 2.3. Open Interest

Open interest is the total number of outstanding contracts. When open interest change gets positively

larger, it implies that investors get higher bullish sentiment.

$$\text{Open Interest Change} = \frac{\sum H_t}{\sum H_{t-R}}$$

Where H denotes the open interest of a futures variety.

## 3. Statistical features

Here we summarized several frequently used factors based on statistical features of price and volume.

### 3.1. Momentum

Momentum effects are observed almost in every asset classes. Here we define momentum as the percentage change of dominant contract price.

### 3.2. Skewness

Based on the pattern of mean reversion of returns, we constructed a portfolio which exposes long position on the most negatively skewed varieties and short position on the most positively skewed varieties.

$$\text{Skewness} = \frac{\frac{1}{R}\sum_{d=1}^{R}(r_d - \mu)^3}{\sigma^3}$$

Where $r_d$ is the daily return.

### 3.3. Liquidity

Literature shows that illiquid varieties are given a return compensation. Here we define liquidity factor as the rolling average of trading volume to absolute daily return.

$$\text{LR} = \frac{1}{R}\sum_{t=1}^{R}\frac{volume_t}{|R_t|}$$

### 3.4. Volatility

Dhume(2011), Gorton et al. (2012) and Szymanowska et al. (2014) showed that varieties with higher volatility generates higher returns due to the risk premium of higher variation and the higher correlation with the macro economics. Here we use coefficient of variation to describe the variation of a commodity futures variety, considering the different scales of returns.

$$\text{coefficient of variation} = \frac{\sigma^2}{\mu}$$

### 3.5. Idiosyncratic Volatility

We regress daily return on market return, momentum return and basis return. Then idiosyncratic volatility is defined as the standard deviation of residuals.

$$r_{i,d} = \alpha_i + \boldsymbol{\beta_i f_d} + \varepsilon_{i,d}$$
$$\text{d} = 1,2,3 \ldots \text{R}$$

Where $\boldsymbol{f_d}$ is the vector of market beta factor return, momentum factor return and basis factor return.

## 4. Macro economics

### 4.1. CPI Beta

Commodity prices rise when inflation rate rises. Therefore we define CPI Beta as the coefficient of daily returns in the previous R days to the growth rate of CPI.

$$r_{i,m} = \alpha_i + \boldsymbol{\beta_i CPI\_g_m} + \varepsilon_{i,m}$$
$$\mathrm{m} = 1,2,3 \ldots \mathrm{R} \times 12$$

### 4.2. RMB Beta

Commodity futures prices are also related to FX market. Futures prices tend to rise when CNY appreciates. Therefore we define RMB Beta as regression coefficient of daily returns of the previous R days to the CNY index.

$$r_{i,m} = \alpha_i + \boldsymbol{\beta_i RMB\_g_m} + \varepsilon_{i,m}$$
$$\mathrm{m} = 1,2,3 \ldots \mathrm{R} \times 12$$

## 5. Key Conclusions and Investment Recommendations

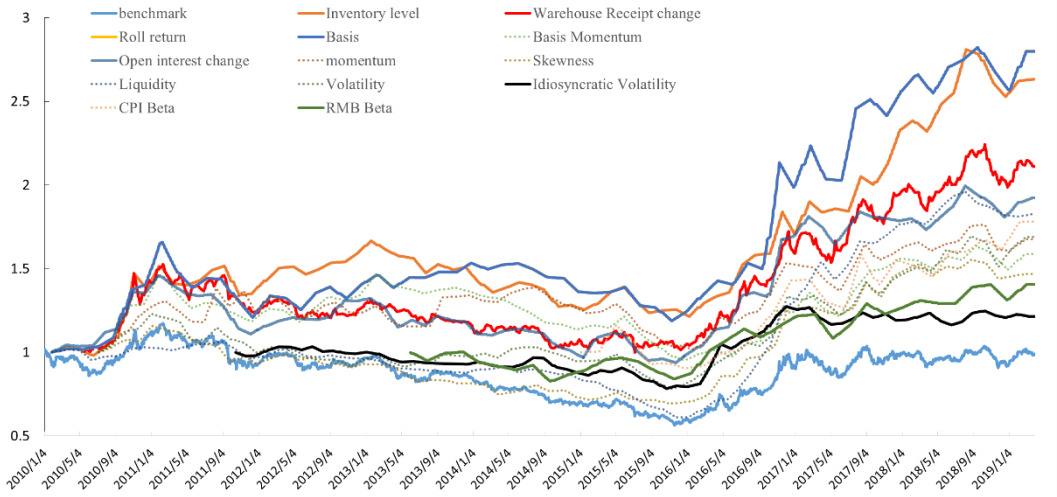


**Figure: Factor performance since 2010**

This report sorts out the relevant theories of commodity futures and backtests 13 factors in five categories: inventory, term structure, position correlation, volume and price factors, and macro correlation. Observing the effect of backtesting of each factor, we can find that **the inventory and term structure factors perform best**. **Momentum factors perform moderately, while the remaining factors can barely outperform the market.** Inventory and maturity structure factors are supported by mature economic theories, while the remaining factors are only statistically significant in foreign markets and may not be applicable in the Chinese market.

We propose the following outlook for future research:

**Firstly, take the characteristics of the term structure of different varieties into consideration.** The term structure of 'black' varieties, agricultural products, chemical industry, and precious metals often shows different characteristics. For example, the term structure of agricultural soybean futures,

yellow soybeans, tends to be backwardation. It is obviously very unreasonable to use only the characteristics of the contract prices of the nearest month and the second nearest month to describe the term structure of the symbol.

**Secondly, inventory and fundamental factors combined with timing indicators.** The essence of commodity futures factors is to conduct cross-section screening of commodity futures from the perspective of factors, but there is not enough research on single varieties.

**Thirdly, precious metal futures (gold and silver) have a safe-haven nature and are often favored by safe-haven funds when the economic and political situation is volatile.** The research on precious metal varieties needs to consider the US dollar exchange rate, macro indicators (Ted spreads, government bond yields), political events (war, elections, etc.), gold and silver ratios and other indicators.

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