Factor Structure in Commodity Futures Return and Volatility

by

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The Financialization of Commodities

Sample period: 2004 – 2014

Investment Strategies

- long only (index fund)
- harvesting risk premia
- "arbitrage" along the term structure, momentum trading, etc.

Basic Questions

- How do returns behave?
- How does volatility behave?
- Portfolio aspects of both questions
- Commodities as part of the "market portfolio"
- Tail behavior (lognormal??, threshold correlations)
- How much do these characteristics vary over time?

This paper generates a tremendous amount of new information

Selects 15 of most important futures markets, in 5 major categories (energy, metals, grains, "softs", livestock)

Uses real time intraday data

Examines means, volatilities, and correlations (plus tail behavior)

"Realized volatility" includes "jumps" and overnight returns, with data problems moderated by overlapping 5-minute intervals

Explores interactions among markets with clever use of principal components

- search for common factor(s) [Does a commodities market portfolio make sense?]
- explores connections between individual commodities and the S&P 500
- applies general method to measure market integration (Pukthuanthong and Roll (2009)

Results

Fact #1: Daily realized commodity futures volatility has extremely high persistence.

Fact #2: The logarithm of realized commodity futures volatility is close to normally distributed.

Fact #3: There is some evidence of a factor structure in daily commodity futures returns excluding livestock.

Fact #4: The factor structure in daily commodity futures volatility is much stronger than the factor structure in returns.

Fact #5: There is little evidence of a time-trend in the degree of integration across commodity futures markets during the 2004-2014 period.

Fact #6: The strong common factor in commodity volatility is largely driven by stock market volatility.

Fact #7: Commodity betas with the stock market were high during 2008-2010 but have since returned to a level close to zero.

Fact #8: Commodity futures returns standardized by expected realized volatility are closer to normally distributed than the returns themselves but still display leptokurtosis.

Special Features of Commodities

The paper addresses these questions as an econometrics exercise.

"Investment" in commodities is through futures markets

- highly levered – encourages ~~gambling~~ ~~speculation~~ information trading
- zero-sum game – for every buyer there is a seller who thinks he/she has a good reason to sell.
- The "representative agent" does not trade futures.

Pricing follows two different equilibrium models, depending on the nature of the underlying

1. The "Cost of Carry" Model – for storable commodities, based on arbitrage (buy spot-sell futures)

$$\mathbf{F_0(T) = S_0\, e^{rT} + \text{physical storage costs} - \text{cash/dividend payout}}$$

2. The "Expectations" Model – for things that can't be carried from today until futures maturity

$$\mathbf{F_0(T) = E_0[S_T] \pm \text{risk premium}}$$

Special Features of Commodities

The valuation model appropriate for a given commodity determines how we should interpret the answers to the paper's questions.

Futures for some underlying commodities clearly follow the classic Cost of Carry model.

- gold
- S&P 500 index

Other futures clearly must be based on expectations, not arbitrage.

- live animals
- weather
- VIX index

Many futures have features of both models:

- **oil (storage in tankers vs underground; impact of international political events)**
- **natural gas (frakking affects future supply)**
- **grains and other agricultural products (cost of carry only until next harvest)**
- **copper (future prices affect both supply—mining—and demand)**

Special Features of Commodities

1. The "Cost of Carry" Model – for storable commodities, based on arbitrage

$$F_0(T) = S_0\, e^{rT} + \text{physical storage costs} - \text{cash/dividend payout}$$

- futures dynamics dominated by spot price dynamics
- ...even if spot price movements are nonrandom (e.g., seasonal patterns)
- acquire exposure without funding (facilitates price variability; e.g., S&P futures are more volatile than spot index)
- effect of interest rates: small but affects all cost of carry markets simultaneously
- no risk premium in futures price
- expected future supply and demand affect futures only if the spot is affected

2. The "Expectations" Model – for things that can't be carried from today until futures maturity

$$F_0(T) = E_0[S_T] \pm \text{risk premium}$$

- no arbitrage that connects futures and spot markets
- futures dynamics dominated by expectations
- prices will reflect variation in risk premia and expected future supply and demand (speculation)
- future exchange rates will be impounded in prices for commodities traded in international markets

Results Reconsidered

Fact #1: Daily realized commodity futures volatility has extremely high persistence.

<more than the stock market; commodities are more directly tied to the real economy>

Fact #2: The logarithm of realized commodity futures volatility is close to normally distributed.

<stochastic volatility models can have Gaussian shocks>

Fact #3: There is some evidence of a factor structure in daily commodity futures returns excluding livestock. <interest rates affect all Cost of Carry futures; risk premia may vary for all expectations model futures but changes in expected values may well be more independent>

Fact #4: The factor structure in daily commodity futures volatility is much stronger than the factor structure in returns. <interesting result; relevant for risk assessment and options modeling>

Fact #5: There is little evidence of a time-trend in the degree of integration across commodity futures markets during the 2004-2014 period.

<very interesting; should financialization of commodities increase market integration?>

Fact #6: The strong common factor in commodity volatility is largely driven by stock market volatility.

<"driven"? The test is designed to maximize apparent influence of S&P index.

Is the S&P 500 <u>really</u> the world market portfolio?>

Fact #7: Commodity betas with the stock market were high during 2008-2010 but have since returned to a level close to zero.

<strong evidence of time variation in interactions among markets>

Fact #8: Commodity futures returns standardized by expected realized volatility are closer to normally distributed than the returns themselves but still display leptokurtosis.

<nice! lognormal plus risk adjustment; volatility expectations errors fatten tails>

Facts 9 and 10??: Should we expect left tail asymmetry, like stocks? What about intraday patterns?

Bottom Line

Great paper!

It puts a lot of new and important stylized facts on the table.