A Model of Financialization of Commodities

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- A sharp increase in the popularity of commodity investing; large inflows of money from pension funds, endowments, and other institutional investors
  - Institutional holdings went up from $15 billion in 2003 to over $200 billion in 2008
- Unprecedented booms and busts in commodity prices
- Sharp increase in correlations among commodities
- Increase in equity-commodity correlations
- ... and especially so for commodities included in commodity indices
Commodity Futures Prices

Source: Tang and Xiong (2012)
Correlations Have Gone Up Significantly

Figure 3: Average Correlations of Indexed and Off-index Commodities
This figure depicts average return correlations of commodities in the SP-GSCI and DJ-UBS indices and commodities off these indices. We separate the samples of indexed and off-index commodities. In each sample, we construct an equal-weighted return index for each commodity sector. A commodity is not included into the index until its average daily futures trading volume in a certain calendar year is larger than 20 million dollars. Then, for both indexed and off-index commodities, we compute equal-weighted average of one-year rolling return correlations of all sector pairs.

Figure 4: Open Interest of Commodity Futures Contracts
This figure depicts the total open interest of futures contracts with maturities less than one year of five commodities, oil, soybeans, cotton, live cattle, and copper, since January 1991. We normalize the open interest of each commodity in January 1991 to be 100.

Source: Tang and Xiong (2012)
Our Work

- Main question: How do institutional investors affect commodity futures prices, volatilities, and their comovement?

- A theoretical model of financialization of commodity futures markets
  - Disentangles how much of price rise can be attributed to financialization and how much to rising demand for commodities

- Features institutional investors alongside traditional market participants
  - Institutions care about their performance relative to a commodity market index
  - Otherwise, a conventional asset pricing model
Effects of Financialization: Our Main Results

- Commodity futures prices:
  - all go up, index futures rise by more
  - news about index commodity fundamentals spill over to all other commodities

- Volatilities of all futures go up, but those of index futures increase by more

- Correlations:
  - cross-commodity correlations rise
  - equity-commodity correlations rise
  - rise more for index commodities

- Financialization accounts for 11% to 17% of commodity futures prices and the rest is attributable to fundamentals
Related Literature

- Empirical evidence directly supporting our findings:
  Tang and Xiong (2012), Singleton (2013)

- Evidence from other markets (equity):
  - index effects:
    Harris and Gurel (1986), Shleifer (1986) and others
  - asset class effects:
    Barberis, Shleifer, and Wurgler (2005), Boyer (2011)

- An alternative view of financialization:
  Fattouh, Kilian, and Mahadeva (2012), Hamilton and Wu (2012)

- Modeling of institutional investors:
  Basak and Pavlova (2013)
The Model

- **$K$ commodities.** Supply news of commodity $k$:
  \[
  dD_{kt} = D_{kt} [\mu_k dt + \sigma_k d\omega_{kt}] \quad \text{GBM}
  \]

- **Generic good 0**, with supply news:
  \[
  dD_t = D_t [\mu dt + \sigma d\omega_{0t}] \quad \text{GBM}
  \]
  - the numeraire
  - supply news uncorrelated across commodities

- Prices of commodities are $p_{kt}$
The Model

- **K futures contracts**; one for each commodity $k$:
  - Maturity $T$, payoff at maturity $p_{kT}$, futures price $f_{kt}$

  $$df_{kt} = f_{kt}[\mu_{f_{kt}} dt + \sigma_{f_{kt}} d\omega_t]$$

- **Commodity index** includes $L < K$ commodities

  $$l_t = \prod_{i=1}^{L} f_{it}^{1/L}$$

  - geometrically-weighted, as S&P Commodity Index

- **Stock market**: claim to time-$T$ aggregate output:

  $$D_T + \sum_{k=1}^{K} p_{kT} D_{kT}$$

  $$dS_t = S_t[\mu_{St} dt + \sigma_{St} d\omega_t]$$

- **Risk-free bond**
Investors

- “Normal” investor $\mathcal{N}$
  \[
  u_\mathcal{N}(W_{\mathcal{N}T}) = \log(W_{\mathcal{N}T})
  \]

- “Institutional” investor $\mathcal{I}$
  \[
  u_\mathcal{I}(W_{\mathcal{I}T}) = (a + bl_T) \log(W_{\mathcal{I}T}), \quad a, b > 0
  \]
  - Dislikes to perform poorly when benchmark does well
  - Less concerned about performance when ahead of the benchmark
  - Formally, marginal utility is increasing in index level

- Cobb-Douglas consumption index (real wealth)
  \[
  W_n = C_{n_0}^{\alpha_0} C_{n_1}^{\alpha_1} \cdots C_{n_K}^{\alpha_K}, \quad n \in \{\mathcal{N}, \mathcal{I}\}
  \]

- Institution’s endowment $\lambda S_0$, normal investor’s $(1 - \lambda)S_0$
Price of commodity $k$:

$$ p_{kT} = \bar{p}_{kT} = \frac{\alpha_k}{\alpha_0} \frac{D_T}{D_{kT}} $$

-$\bar{p}_{kT}$ price in benchmark economy with no institutions

Supply $D_k$ ➔ Aggregate output $D$ ➔ Demand $\alpha_k$ ➔

<table>
<thead>
<tr>
<th></th>
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<td>Price $p_{kT}$</td>
<td>$-$</td>
<td>$+$</td>
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Commodity index $I_T$ inherits properties of $p_{1T}, \ldots, p_{LT}$
Discount Factor $M_{0,T}$ (from $f_{kt} = E_t[M_{t,T} p_{kT}]$)

- Benchmark with no institutions: $\overline{M}_{0,T} = \frac{e^{(\mu - \sigma^2)T}D_0}{D_T}$
- With institutions: $M_{0,T} = \overline{M}_{0,T} \left(1 + \frac{b \lambda (I_T - E[I_T])}{a + b E[I_T]}\right)$

States with high payoffs of commodity index are priced higher than in benchmark economy.
Commodity Futures Prices

- Equilibrium futures prices in benchmark economy:

\[ \overline{f}_{kt} = \frac{\alpha_k}{\alpha_0} e^{(\mu - \mu_k - \sigma^2)(T-t)} \frac{D_t}{D_{kt}} \]

- In the economy with institutions:

\[ f_{kt} = \frac{\overline{f}_{kt}}{\frac{\text{Const} + b \lambda e^{1\{k \leq L\}} \sigma_k^2 (T-t)/L} \cdot \frac{D_t}{\text{Const} + b \lambda e^{-\sigma^2(T-t)} \cdot D_t \prod_{i=1}^{L} (g_i(t)/D_{it})^{1/L}}} \]

\[ > 1 \]

with \( g_i(t) = \frac{\alpha_i}{\alpha_0} e^{(\mu - \mu_i + (1/L-1)\sigma_i^2/2)(T-t)} \)

- Futures prices are higher than in benchmark
- Index futures prices rise more than nonindex ones
Why?

- Institutions care about the index
- Their marginal utility is increasing in index level
- They value assets that pay off more in states when index does well
- Hence, they value index futures more than nonindex
Supply News and Commodity Futures Prices

- $f_{kt}$
  - index
  - nonindex
  - benchmark

$D_{it}$ – index commodity supply news

- If a commodity is included in the index, its supply news affect all other commodities

- If not, its supply news affect just that commodity alone

$D_{\ell t}$ – nonindex commodity supply news
Demand Shifts and Commodity Futures Prices

\[ f_{kt} \]

\[ \alpha_{it} \] – index commodity demand shift

\[ \alpha_{\ell t} \] – nonindex commodity demand shift

- If a commodity is included in the index, its demand shifts affect all other commodities
- If not, its demand shifts affect just that commodity alone
Commodity Futures Volatilities

- Recall: \( df_{kt} = f_{kt}[\mu_{f_k}dt + \sigma_{f_k}d\omega_t] \)

- Equilibrium loadings on sources of risk of
  - index commodity futures:
    \[
    \sigma_{f_k} = \bar{\sigma}_{f_k} + h_{kt} \sigma_{lt}, \quad h_{kt} > 0
    \]
  - nonindex commodity futures:
    \[
    \sigma_{f_k} = \bar{\sigma}_{f_k} + h_t \sigma_{lt}, \quad h_t > 0
    \]
  - \( \bar{\sigma}_{f_k} \) (constant) loadings in benchmark economy
  - \( \sigma_{lt} \) loadings on (expected) index
  - \( h_{kt} > h_t \)

- Volatilities of all futures prices, \( ||\sigma_{f_k}|| \), are higher than in benchmark economy

- Volatilities of index futures rise more than those of nonindex
Commodity Futures Volatilities

- Index commodities supply news $D_i$ emerge as new sources of risk
- Aggregate output news $D_t$ is amplified
- Hence, volatilities go up
Commodity Futures Comovement

- Covariances and correlations among all commodity futures rise
- Covariances and correlations among index commodities rise more than nonindex – an asset class effect
Commodity Futures Correlations

- All futures load on a new common factor: commodity index
- Factor loadings are all positive
- Hence, covariances go up

\[ corr_t(i, k) \]

\[ D_{it} \] – index commodity supply news

\[ D_t \] – aggregate output news
Transmission to Stock Market

- Stock market value

\[ S_t = \overline{S}_t \frac{\text{Const} + b \lambda D_t \prod_{i=1}^{L} (g_i(t)/D_{it})^{1/L}}{\text{Const} + b \lambda e^{-\sigma^2(T-t)} D_t \prod_{i=1}^{L} (g_i(t)/D_{it})^{1/L}} > 1 \]

with \( \overline{S}_t = \sum_{k=0}^{K} \frac{\alpha_k}{\alpha_0} e^{(\mu-\sigma^2)(T-t)} D_t \)

- Stock market volatility components

\[ \sigma_{St} = \overline{\sigma}_S + h_{St} \sigma_{It}, \quad h_{St} > 0 \]

with \( \overline{\sigma}_S = \sigma \)

- Stock market value is higher than in benchmark economy

- Stock market volatility is higher than in benchmark economy
Stock is valued using the same discount factor $M_{t,T}$ as other assets

Stocks and commodity futures load on the new (common) factor: the index

$D_{it}$ – index commodity supply news

$D_t$ – aggregate output news

Equity-Commodity Correlations
Quantitative Implications

- Calibrate the model with supply and demand shocks

- Commodity 1 represents energy

- Demand shocks = stochastic energy expenditure share $\alpha_1$

  in

  $$W = C_0^{\alpha_0} C_1^{\alpha_1} \cdots C_K^{\alpha_K}$$

  - $\alpha_1$ is increasing with aggregate output
Demand Shocks and Energy Futures Prices

- Demand shocks – additional source of risk affecting index
- As demand increases, financialization accounts for a bigger fraction of futures prices
### Energy futures:

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### Non-energy futures:

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Summary: Effects of Financialization

- Prices of all commodity futures go up, but those of index futures rise by more

- If a commodity is in index, news about its fundamentals affect all other commodities

- Volatilities of both index and nonindex futures go up, but those of index futures increase by more

- Correlations among index commodities rise more than nonindex – an asset class effect

- Equity-commodity correlations go up, and especially so for index commodities

- Financialization accounts for 11% to 17% of commodity futures prices and the rest is attributable to fundamentals
Commodity Spot Prices

- The model pins down time-$T$ commodity spot prices but not time $t < T$. Need a model with intermediate consumption.

- Let us extrapolate from our model. Assume that
  - commodities are storable
  - one can freely buy or sell commodities at any time $t \leq T$
  - convenience yield/storage costs are constant fraction $\delta_k$ of price

- Then

$$f_{kt} = p_{kt} e^{\delta_k (T - t)}$$

- A great question to explore in future research!