Macroeconomic determinants of international commodity prices

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What drives commodity prices?

- Individual commodities are of course influenced by individual micro causes.
  - E.g., why did cobalt prices quadruple in 2017-18?
    - Rising EV battery demand;
    - Congo-concentrated supply hit by instability & sanctions.
What drives commodity prices?

• Individual micro causes.
  – Why did soybean prices fall by 20% in June-July, 2018?
  – Chinese retaliation against Trump tariffs.

Source: Business Insider, 8/7/2018
What drives commodity prices?

- **Individual micro causes.**
  - Why did oil prices rise in June?
  - In part, US sanctions on Iran after withdrawing from JCPA.

**Crude Oil Price: WTI** – Cushing, OK, Daily

Source: U.S. Energy Information Administration

FRED, Aug. 8, 2018
What drives commodity prices?

• But the extent to which prices of different commodities move together is striking.

• There are direct microeconomic linkages among some of them, to be sure.

• But the correlation is broader than that.
Fig. 1: Commodity prices are (i) volatile & (ii) correlated.

Commodity price indexes, annual

Source: Commodity Markets Outlook, World Bank Group, Oct. 2017
Some macroeconomic factors influence commodity prices jointly.

1. Economic Activity: GDP


3. What about exchange rates?

4. Other determinants of net convenience yield
   - Inventories
   - Risk premium

The “carry trade” model.
1. First macro factor: overall economic activity

- as measured by US GDP or a global counterpart.
  - Probably China’s growth rate has mattered more for global commodity demand than that of other countries,
    - e.g., Kilian & Hicks (2013).

- Some of the big price swings since 2000 can be explained by GDP.

- But there is more going on.
2. Second macro factor: monetary policy

- The claim: An increase in the real interest rate $r$, has a negative effect on real commodity prices, even controlling for GDP.

- E.g., why did commodity prices:
  - (i) continue to rise sharply mid-2007 – mid-2008?
  - (ii) fall sharply in mid-2014?
    - The end of QE in 2014.

- I have been making this case for over 30 years.
    - effect of $r$ on real commodity prices.
    - add in also convenience yield & its determinants.
High real interest rates reduce the price of storable commodities through 4 channels:

• by increasing the incentive for extraction today
  – rather than tomorrow.
  – Think of rates at which oil is pumped, copper mined, or forests logged.

• by decreasing firms' desire to carry inventories.
  – Think of oil inventories held in tanks or cattle in feed lots.

• by encouraging speculators to shift out of spot commodity contracts, and into treasury bills.
  – Think of the “financialization” of commodities.

• by appreciating the domestic currency
  – and so reducing the price of internationally traded commodities in domestic terms,
  – even if the price hasn't fallen in terms of foreign currency.
The relationship can be derived from 2 simple assumptions.

- **1st assumption:** “regressive expectations.”

- Let:
  \[ s \equiv \text{the log of the spot price of the commodity}, \]
  \[ p \equiv \text{the (log of the) economy-wide price index}, \]
  \[ q \equiv s - p, \text{the (log) real price of the commodity}, \]
  and
  \[ \bar{q} \equiv \text{the long run equilibrium (log) real price of the commodity}. \]

- Market participants observe the real commodity price \( q \) today lying either above or below its long-run equilibrium value \( \bar{q} \). They expect it to return to equilibrium over time, at an annual rate proportionate to the gap:

- \( E[\Delta q] \equiv E[\Delta(s - p)] = -\theta (q - \bar{q}) \quad (1) \)
  or \( E(\Delta s) = -\theta (q - \bar{q}) + E(\Delta p). \quad (2) \)
\[ E(\Delta s) = -\theta (q-\bar{q}) + E(\Delta p) \]  

\( + \) 2\textsuperscript{nd} assumption, speculative arbitrage:

\[ E(\Delta s) + c = i, \]  

where \( c \equiv \text{net convenience yield}. \)

\[ => -\theta (q-\bar{q}) + E(\Delta p) + c = i \]

\[ => q - \bar{q} = -(1/\theta)(r - c) \]

• So \( q \) responds negatively to the real interest rate, \( r \equiv i - E(\Delta p), \)
  – holding \( \bar{q} \) & \( c \) constant.

\* \( c \equiv cy - sc - rp \equiv \text{convenience yield} - \text{storage cost} - \text{risk premium}. \)
The overshooting equation: $q = \bar{q} - \frac{1}{\vartheta}(r-c)$

$q$ is negatively related to the real interest rate $r$.
The real commodity price index is negatively related to the real interest rate.

Thanks to Shruti Lakhtakia
# OLS estimates of the overshooting equation

Regression of real commodity price indices against real interest rate (1950-2012)

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Dependent variable: log of commodity price index, deflated by US CPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>VARIABLES</td>
<td>CRB index</td>
</tr>
<tr>
<td>Real interest rate</td>
<td>-0.041***</td>
</tr>
<tr>
<td>Constant</td>
<td>0.900***</td>
</tr>
<tr>
<td>Standard errors (in parentheses)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>Observations</td>
<td>739</td>
</tr>
<tr>
<td>R²</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*** p<0.01 (Standard errors in parentheses.)

Frankel (2014)
### Updated estimates of overshooting model

Commodity price indices are significantly negatively correlated with real interest rates.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Dependent variable: Log of Real Commodity Price Index</td>
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<tr>
<td><strong>VARIABLES</strong></td>
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</tr>
<tr>
<td>CRB (BLS) Foods Price Index</td>
<td><strong>-0.026</strong>*</td>
<td><strong>-0.026</strong>*</td>
<td><strong>-0.088</strong>*</td>
<td><strong>-0.071</strong>*</td>
</tr>
<tr>
<td>Dow Jones-AIG Commodity Price Index</td>
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<tr>
<td>Moody's Commodity Price Index</td>
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<tr>
<td>Goldman Sachs Commodity Price Index</td>
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<td></td>
</tr>
<tr>
<td>Real Interest Rate</td>
<td><strong>0.847</strong>*</td>
<td><strong>0.043</strong></td>
<td><strong>2.594</strong>*</td>
<td><strong>0.713</strong>*</td>
</tr>
<tr>
<td>Constant</td>
<td>(0.017)</td>
<td>(0.017)</td>
<td>(0.013)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>Observations</td>
<td>807</td>
<td>757</td>
<td>807</td>
<td>581</td>
</tr>
<tr>
<td>R²</td>
<td>0.018</td>
<td>0.022</td>
<td>0.295</td>
<td>0.172</td>
</tr>
</tbody>
</table>

*** p<0.01, ** p<0.05.  (Heteroskedastic robust standard errors in parentheses.)

- **REAL INTEREST RATE** (Month X, YEAR T) = [ 3-TBILL(Month X, YEAR T)/100 - INFLATION (Month X-1, YEAR T) ]*100 for months (Feb-Dec); for Jan we take INFLATION (Month X-1, YEAR T-1).
- **INFLATION** (Month X, Year T) =Log CPI (Month X, Year T) – Log CPI (Month X, Year T-1).
- Source for 3-month treasury bill rates: FRB of St. Louis.  Source for Commodity Price Indexes: Global Financial Data

Thanks to S.Lakhtakia
3. What about exchange rates and commodity prices in other currencies?

• The limiting case of a small country in an integrated global commodity market:
  – a 1% exchange rate change translates into an immediate 1% commodity price change expressed in terms of local currency.

• Even for the US, $ depreciation => commodity price ↑
  – though smaller & slower than for other countries.

• Regardless the country, the exchange rate is endogenous.

• Real interest differentials move real exchange rates,
  – & so move local-currency real commodity prices,
  – relative to the real $ commodity price.
Determining commodity prices in non-$ currencies.

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Australia</td>
<td>-0.023*</td>
<td>-0.076*</td>
<td>-0.057*</td>
<td>-0.067*</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.003)</td>
<td>(0.005)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Brazil</td>
<td>-0.024*</td>
<td>-0.006*</td>
<td>-0.161*</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.002)</td>
<td>(0.019)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Canada</td>
<td>-0.047*</td>
<td>-0.065*</td>
<td>-0.073*</td>
<td>-0.076*</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>Chile</td>
<td>-0.063*</td>
<td>-0.021*</td>
<td>-0.092*</td>
<td>-0.018*</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.004)</td>
<td>(0.014)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.055*</td>
<td>-0.017*</td>
<td>0.047*</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.002)</td>
<td>(0.011)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>NZ</td>
<td>0.001</td>
<td>-0.067*</td>
<td>-0.081*</td>
<td>-0.075*</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.004)</td>
<td>(0.006)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.034*</td>
<td>-0.054*</td>
<td>-0.171*</td>
<td>-0.095*</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.009)</td>
<td>(0.013)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>UK</td>
<td>-0.053*</td>
<td>-0.086*</td>
<td>-0.106*</td>
<td>-0.023*</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.007)</td>
<td>(0.007)</td>
<td>(0.006)</td>
</tr>
</tbody>
</table>

* indicates coefficient significant at the 5% level of significance. (Robust standard errors.)

Frankel (2008)
Now, complete the “carry trade” equation.

There is no reason for the net convenience yield, \( c \), to be constant.

\[
q - \bar{q} = - \left( \frac{1}{\theta} \right) (r - c) \tag{4}
\]

\[c \equiv cy - sc - rp\]

Substituting into (4),

\[
q = \bar{q} - \left( \frac{1}{\theta} \right) r + \left( \frac{1}{\theta} \right) cy - \left( \frac{1}{\theta} \right) sc - \left( \frac{1}{\theta} \right) rp \tag{5}
\]
Complete “carry trade” equation for price determination, continued

\[ q = q - (1/\theta) r + (1/\theta) cy - (1/\theta) sc - (1/\theta) rp \] (5)

Hypothesized effects:

- Real interest rate: *negative*
- Convenience yield: *positive*
  - <= Economic activity
  - <= Risk of disruption
- Storage costs: *negative*
  - \( sc = \Phi (INVENTORIES) \).
- Risk premium \( rp \)
  - Measured directly: \( (\Delta s^e)-(f-s) \)
  - Or as determined by volatility (*ambiguous sign*)
    - measured by actual volatility
    - or by option-implied subjective volatility.
Estimation of the carry-trade equation.

• My 2014 paper estimated for the period 1950-2012 the complete equation that included the micro variables:
  – commodity-specific data on inventories, volatility,
  – and survey expectations of future price changes.

• I found the real interest rate had particularly strong negative effects on the prices of copper, cattle, hogs, oats & soybeans.

• Inventories had a particularly strong negative effect on the prices of copper, oats, & platinum.

• For a complete panel across the 11 commodities where all data were available, all four variables of interest appeared significant: real interest rate, global business cycle, inventories, and volatility.
  – When the equation was estimated on first differences, significance was lost, in particular, for inventories & volatility.
The positive risk premium seemed to have disappeared after 2005 ($\hat{E}\Delta s$ measured by survey data), despite no decline in volatility. Consistent with Hamilton & Wu’s (2013) interpretation of the financialization hypothesis: Investors in commodity indices took the long side of the futures market after 2005.

From Frankel (2014)
5. Updated tests

• There is some negative correlation between perceived volatility as measured by the VIX and the commodity price index.
  – E.g., prices high in 2006, when VIX low (“risk on”),
  – & prices low in 2009, when VIX high (“risk off”).

• But the VIX is not a significant determinant
  – when controlling for $r$ and GDP.
VIX-implied volatility appears negatively correlated with real commodity price index.

Thanks to S.Lakhtakia
Updated tests for real commodity price index show significant negative effect of $r$ and positive effect of GDP.

<table>
<thead>
<tr>
<th>Dependent variable: Real Commodity Price Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Interest Rate</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
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<tr>
<td>Real Commd PI trend</td>
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<tr>
<td>-1.627</td>
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<tr>
<td>Lagged</td>
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<td>3</td>
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<tr>
<td>Real US GDP</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Constant</td>
</tr>
<tr>
<td>Observations</td>
</tr>
<tr>
<td>47</td>
</tr>
<tr>
<td>R²</td>
</tr>
<tr>
<td>0.150</td>
</tr>
<tr>
<td>*** p&lt;0.01, ** p&lt;0.05, * p&lt;0.1</td>
</tr>
</tbody>
</table>

(Robust standard errors in parentheses.)

Thanks to S. Lakhtakia
Consider four components of price index

In regressions for the four price indices, \( r \) has a negative sign for all variations. It is most consistently significant in the case of industrial metals prices.
### Stylized macro effects on commodity prices

<table>
<thead>
<tr>
<th>Period</th>
<th>GDP growth</th>
<th>Monetary ease</th>
<th>$ r $</th>
<th>Value of $</th>
<th>$ commodity prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-07</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>2007-08</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
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</tr>
<tr>
<td>2008-09</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
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<tr>
<td>2010-11</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
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<tr>
<td>2014-16</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Forecast (My guess, as of 2018)</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>
Some references by the author on macroeconomic determination of commodity prices.

The overshooting model: Real interest rates influence real commodity prices.

Determinants of commodity prices in non-$ currencies

The “carry trade” model: Determinants of convenience yield matter too.
Short-term interest rates: Jan. 2000 – July 2018
Macroeconomic determinants of commodity prices

Jeffrey Frankel

https://scholar.harvard.edu/frankel
www.project-syndicate.org/columnist/jeffrey-frankel