V. The Chinese Commodities Futures Markets

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Outline

- the relationship between spot prices and futures prices
- market efficiency for Chinese commodity futures markets
- dynamic spillover analysis between the Chinese and US commodity futures markets
- hedging in Chinese commodity futures markets
The relationship between spot and futures

- for non-dividend paying assets: $F_0 = Se^{rT}$
- for dividend-paying assets: $F_0 = Se^{(r-q)T}$ or $F_0 = (S - I)e^{rT}$
- for commodity futures with storage cost: $F_0 = (S + U)e^{rT}$
- in general we have $F_0 = E[S_T]$ so futures market is ideal market to examine price discovery
Market efficiency

- long run efficiency

\[ s_t = \rho + \gamma f_{t-\tau} + u_t \]

where \( s_t \) and \( f_t \) are log prices and \( u_t \) is the pricing errors
- \( \gamma \) represents combined effect of risk premium and trading costs
- if \( \gamma = 1 \) the market is long run efficient; if \( \rho = 0 \) and \( \gamma = 1 \), futures price is an efficient and unbiased predictor of the spot level
- taking \( s_{t-\tau} \) from both sides we have

\[ s_t - s_{t-\tau} = \rho + f_{t-\tau} - s_{t-\tau} + u_t \]

- if this holds the market is short run efficient and hence long-run efficiency is a precondition of the short-run efficiency
- \( u_t \) needs to be serially uncorrelated
to minimize residual autocorrelation, the test of short-run efficiency is performed

\[ s_t - s_{t-\tau} = \alpha + \beta(f_{t-\tau} - s_{t-\tau}) + \sum_{i=1}^{k} \lambda_i(s_{t-i} - s_{t-\tau-i}) + \sum_{i=1}^{k} \gamma_i(f_{t-i} - f_{t-\tau-i}) + u_t \]

short run efficiency is obtained by \( \gamma_1 = \cdots = \gamma_k = 0 \) and \( \lambda_1 = \cdots = \lambda_k = 0 \)
any significant lag is a violation of the short run efficiency but it does not tell us how (in)efficient a market is
relative efficiency is measured by the forecasting errors in the fitted short-run regression and long-run forecast

\[ \Phi_c = \frac{(n - 2k - 2)^{-1} \sum_{t=1}^{n} \hat{u}_t^2}{(n - 1)^{-1} \sum_{t=1}^{n} \left( (s_t - f_{t-\tau}) - (s_t - f_{t-\tau}) \right)^2} \]
Commodity futures written on copper, aluminium, soybeans and wheat.

Copper and aluminium futures are traded in Shanghai futures exchange; soybeans are traded in Dalian and wheat in Zhengzhou.

Sample periods from late 1993 or early 1994 to March 2006.

All samples are also divided into two sub-samples around 2000 as there is a market re-structuring in Sept 1999 when all markets are merged into 3 exchanges and rules and regulations were properly followed to avoid price squeezes and manipulation.

Copper and aluminium have monthly deliveries while soybeans and wheat have bi-monthly contracts (Jan, March, etc).
Market efficiency

- For long run efficiency tests, for the whole sample period, all contracts are long-run efficient ($\gamma = 1$ cannot be rejected) except copper futures with 1-month delivery.

- For test of unbiasedness, it tends to be rejected for contracts with 1-month and 2-month to delivery ($\gamma = 1$ and $\rho = 0$ rejected) and not rejected for contracts with 1-week and 2-week to delivery, hence longer horizon contracts may contain enlarged risk premium.

- For short run efficiency test, we choose the lag containing most information by the Akaike Information Criterion (AIC) with the null hypothesis that $\gamma_1 = \cdots = \gamma_k = 0$.

- For copper the fitted 10 lags is significant while for aluminium the fitted 4 lags is significant hence both of them are short-run inefficient; for the two agricultural products they are short-run efficient with no significant lag.

- For relative efficiency, it’s 82% for copper, 92% for aluminium, and 100% for soybeans and wheat; overall, agricultural commodity futures markets seem more efficient.
Market efficiency

- breaking the sample into two sub-samples, the effect of regulation is ambiguous
- copper futures at 1-month horizon is long run efficient and unbiased in the first sub-sample but not so in the second; 1-month aluminium is long run efficient and unbiased in both sub-samples, etc
- mixed results for short run efficiency and unbiasedness tests
- relative efficiency also mixed: 1-month copper 100% dropped to 84%; aluminium raised from 85% to 100% etc
Spillover effect

- The main research questions: (1) Are the Chinese commodity futures and US commodity exchanges affect the return and volatilities of each other; and (2) are these effects the same over the entire contract life even though there is a time-dependent margin rates in China?

- See Tables 1 and 2 for examples of time-dependent margin rates; adopted to avoid over-speculation and price squeezes towards the end of contract life.

- However, it has severe effect on the trading volume, hence liquidity, of the Chinese commodity futures markets.
### Spillover effect

#### soybeans

<table>
<thead>
<tr>
<th>Time to Maturity</th>
<th>Margin rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>From the first listing day</td>
<td>5%</td>
</tr>
<tr>
<td>From the first trading day of one month before delivery month</td>
<td>10%</td>
</tr>
<tr>
<td>From the sixth trading day of one month before delivery month</td>
<td>15%</td>
</tr>
<tr>
<td>From the eleventh trading day of one month before delivery month</td>
<td>20%</td>
</tr>
<tr>
<td>From the sixteenth trading day of one month before delivery month</td>
<td>25%</td>
</tr>
<tr>
<td>From the first trading day of delivery month</td>
<td>30%</td>
</tr>
</tbody>
</table>

#### copper

<table>
<thead>
<tr>
<th>Time to Maturity</th>
<th>Margin rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>From the first listing day</td>
<td>5%</td>
</tr>
<tr>
<td>From the tenth trading day of the second month before delivery month</td>
<td>7%</td>
</tr>
<tr>
<td>From the first trading day of the first month before delivery month</td>
<td>10%</td>
</tr>
<tr>
<td>From the tenth trading day of the first month before delivery month</td>
<td>15%</td>
</tr>
<tr>
<td>From the first trading day of delivery</td>
<td>20%</td>
</tr>
<tr>
<td>From the second trading day before the last trading day</td>
<td>30%</td>
</tr>
</tbody>
</table>
the model used is an asymmetric dynamic conditional correlation model (ADCC)
equations for conditional means

\[ r_{c,t} = \alpha_c + \beta_{c1} r_{c,t-1} + \beta_{c2} r_{u,t-1} + \gamma_c (p_{c,t-1} - p_{u,t-1}) + \varepsilon_{c,t} \]
\[ r_{u,t} = \alpha_u + \beta_{u1} r_{u,t-1} + \beta_{u2} r_{c,t-1} + \gamma_u (p_{u,t-1} - p_{c,t-1}) + \varepsilon_{u,t} \]
equations for conditional variances

\[ h_{c,t} = \phi_c + \eta_c \varepsilon_{c,t-1}^2 + \Phi_c h_{c,t-1} + \lambda_c \varepsilon_{u,t-1}^2 + \delta_c l_{t-1} \varepsilon_{c,t-1}^2 \]
\[ h_{u,t} = \phi_u + \eta_u \varepsilon_{u,t-1}^2 + \Phi_u h_{u,t-1} + \lambda_u \varepsilon_{c,t-1}^2 + \delta_u l_{t-1} \varepsilon_{u,t-1}^2 \]
with \( l_t = 1 \) if \( \varepsilon_t < 0 \) and 0 otherwise
Spillover effect

- investigate two commodities: soybeans (DCE and CBOT) and copper (SHFE and NYMEX)
- three types of samples: whole sample, maturity data, and prior-to-margin data
- for soybeans, in the whole sample, the cross country lag return $\beta_2$ is significant but higher for the US (0.14 vs. 0.08) hence return spillover is bi-directional with the US take the lead; the cross country term for volatility $\lambda$ is significant only for the US so volatility spillover is one-directional
- for maturity data, same pattern for return and volatility spillover
- for prior-to-margin sample, return spillover more significant with larger coefficients; volatility spillover bi-directional, too
- more consistent story for copper: for whole sample, maturity data, and prior-to-margin data, return spillover and volatility spillover are all bi-directional and significant
data suggests regime changes (structural breaks) for all 6 sample series

- two regimes for soybeans with a change roughly around mid-2003; three regimes for copper, first around Oct 2001 and second around January 2004 with the last regime corresponding to a period with growing copper demand in China

- the return and volatility spillover effect for these sub-samples are very strong and bi-directional even for maturity data; in a number of cases, Chinese market is the more dominant force
this paper compares a number of methods to obtain an optimal hedge ratio that can minimize variance of a hedged portfolio with 1 share of the underlying commodities and $HR_t$ amount of commodity futures.

- the expected return of the portfolio is

$$E_t(r_{p,t+1}) = E_t(r_{s,t+1} - HR_tr_{f,t+1})$$

- the variance of the portfolio return is

$$\text{var}_t(r_{p,t+1}) = \text{var}_t(r_{s,t+1}) + HR_t^2 \text{var}_t(r_{f,t+1}) - 2HR_t \text{cov}_t(r_{s,t+1}, r_{f,t+1})$$

- and the optimal hedge ratio is

$$HR_t = \frac{\text{cov}_t(r_{s,t+1}, r_{f,t+1})}{\sigma^2_f,t+1}$$
methodology includes

1. the OLS regression
2. DCC method where t-distribution is assumed for return distributions of the spot and futures
3. Gaussian copula function which does not have tail dependence
4. Gumbel copula function with upper tail dependence
5. Clayton copula function with lower tail dependence
6. survival copula \( \tilde{c}_{x,y}(u, v) = c_{x,y}(1 - u, 1 - v) \) is also used with the original copula to obtain a mixture of copula functions
   \[
   c_m(u, v | \alpha, \tilde{\alpha}, w) = wc(u, v | \alpha) + (1 - w)\tilde{c}(1 - u, 1 - v | \tilde{\alpha})
   \]
7. time-varying copula functions in which copula parameters are assumed to follow a quasi-ARMA(1,1) process
the performance of these methods are judged by two criteria:

1. statistical variance reduction

\[ e = 1 - \frac{\text{var}(P)}{\text{var}(U)} \]

2. economic benefits: assume \( E_t U(r_{p,t+1}) = E_t(r_{p,t+1}) - \kappa \sigma_t^2(r_{p,t+1}) \)

where \( \kappa \) is the degree of risk aversion, the utility of a hedging strategy should be greater than the utility value of benchmark hedging strategy plus transaction cost

actual transaction cost is used: 0.15% per contract for soybeans and 0.02% for copper
Hedging in the Chinese commodity futures markets

- the joint distributions are non-normal
- for in-sample tests
  soybeans: 3-month OLS, 5-month time-varying mixture Gumbel, 7-month time-varying mixture Gumbel
copper: 2-month mixture Gumbel, 3-month mixture Gumbel, 4-month mixture Gumbel, 5-month time-varying Gumbel
- for out-of-sample tests
  soybeans: 3-month DCC, 5-month time-varying mixture Gumbel, 7-month Gumbel
copper: 2-month mixture Gumbel, 3-month mixture Gumbel, 4-month mixture Gumbel, 5-month OLS
- in terms of hedging horizon, 4 to 5 months to maturity is best for soybeans and 2 months to maturity is best for copper