Influence of the Natural Gas Price on the Ammonia Price, 2000 to 2006

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The views expressed in this presentation are those of the presenter and do not necessarily reflect the views of the USDA.

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Figure 1. Monthly natural gas and ammonia prices, 1985-2006

Source: DOE (US Dept. of Energy) and TFI (The fertilizer institute)

- Price correlations
  - from 1985 to 1999: 0.17
  - from 2000 to 2006: 0.81
Objectives

► Background of Ammonia Supply
► Factors affecting ammonia demand and supply
► Co-integration Analysis
► Estimation Results
► Implications
Natural gas is the main input to produce ammonia. Accounts for 72-85 percent of the ammonia production cost. Contains 82 percent of N. The source for all nitrogen fertilizers. Declining supply.

Figure 2. Ammonia supply from all sources in the U.S., 1992-2006.
Figure 3. Ammonia production capacity and production in U.S. 1990-2006
Figure 4. Number of ammonia plants in three ranges of production capacity, 1990-2006

Source: IFDC
Factors Affecting Ammonia Demand

► Demand for nitrogen fertilizers--acres planted, percent of acres treated, the application rate, and crop rotations
► Crop prices and the nitrogen fertilizer prices
► The land price and the opportunity cost of labor
► Risk perception
► Changes in crop production technologies
Factors Affecting Ammonia Supply

- Ammonia prices
- Contract prices of natural gas
- Opportunity costs of using natural gas to produce ammonia
- Ammonia production and inventory
- Production technology and capacity
- Global competition: ammonia imports and exports
Co-integration Analysis

► Two variables are co-integrated if
  
  ► They are unit root processes
  ► A stationary linear combination of them can be found

► If the price of natural gas, $X_t$, and the price of ammonia, $Y_t$ are co-integrated, then

  ► $\beta_1 Y_t - \beta_2 X_t - \beta_0 = u_t$ ; $u_t \sim I(0) N(0, \sigma^2)$
The Equilibrium Error-Correction Model

► Co-integration is necessary and sufficient to establish an equilibrium error-correction model.

► The model expresses changes in ammonia prices as a function of short-run (the contemporaneous) and long-run (the equilibrium) effects, as well as the speed of adjustment from disruptions to the long-run equilibrium.

\[ D Y_t = \theta_1 D Y_{t-1} + \theta_2 D X_t + \theta_3 D X_{t-1} + \alpha (\beta_1 Y_t - \beta_2 X_t - \beta_0)_{t-1} + u_t \]

|____________________|            |______________|
|Short-run effect                             Long-run equilibrium|

\[ \alpha = \text{Speed of adjustment} \]

\[ D Y_t = Y_t - Y_{t-1} \]
Estimation Results

Non-stationary time series

Monthly natural gas and Gulf ammonia prices, 2000-2006
LX and LY are X and Y in log scale

Non-stationary time series
DLX = LX_t - LX_{t-1}

Stationary time series (Augment Dickey-Fuller Unit Root Test)
### Johansen Co-integration Test

Date: 01/23/07   Time: 13:49  
Sample: 2000M01 2006M08  
Included observations: 80  
Trend assumption: No deterministic trend (restricted constant)  
Series: LX LY  
Lags interval (in first differences): 1 to 1

<table>
<thead>
<tr>
<th>Hypothesized</th>
<th>Trace</th>
<th>Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.165770</td>
<td>19.57728</td>
<td>20.26184</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.061498</td>
<td>5.077636</td>
<td>9.164546</td>
</tr>
</tbody>
</table>

Trace test indicates no cointegration at the 0.05 level  
* denotes rejection of the hypothesis at the 0.05 level  
**MacKinnon-Haug-Michelis (1999) p-values
Estimation Result

Dependent Variable: DLY
Method: Least Squares
Date: 12/20/06   Time: 09:02

Included observations: 80

\[ DLY = C(1)\cdot DLY(-1) + C(2)\cdot DLX + C(3)\cdot DLX(-1) + C(4)\cdot LY(-1) + C(5) + C(6)\cdot LX(-1) \]

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(1)</td>
<td>0.215459</td>
<td>2.307211</td>
</tr>
<tr>
<td>C(2)</td>
<td>0.251516</td>
<td>4.337700</td>
</tr>
<tr>
<td>C(3)</td>
<td>0.141671</td>
<td>2.021836</td>
</tr>
<tr>
<td>C(4)</td>
<td>-0.229730</td>
<td>-3.465409</td>
</tr>
<tr>
<td>C(5)</td>
<td>-4.112831</td>
<td>-25.56104</td>
</tr>
<tr>
<td>C(6)</td>
<td>-0.789601</td>
<td>-8.148134</td>
</tr>
</tbody>
</table>

R-squared    : 0.453489
Mean dependent var  : 0.010543
Adjusted R-squared : 0.416563
S.D. dependent var  : 0.010543
S.E. of regression  : 0.077780
Akaike info criterion : -2.197830
Schwarz criterion   : -2.019178
Durbin-Watson stat   : 1.896165

Log likelihood  : 93.91319
Residue Tests

Breusch-Godfrey Serial Correlation LM Test:

<table>
<thead>
<tr>
<th>F-statistic</th>
<th>Prob. F(4,70)</th>
<th>Obs*R-squared</th>
<th>Prob. Chi-Square(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.009765</td>
<td>0.408411</td>
<td>4.364248</td>
<td>0.358949</td>
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</tbody>
</table>

ARCH LM Heteroscedasticity Test

<table>
<thead>
<tr>
<th>F-statistic</th>
<th>Prob. F(2,75)</th>
<th>Obs*R-squared</th>
<th>Prob. Chi-Square(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.944164</td>
<td>0.393579</td>
<td>1.915630</td>
<td>0.383730</td>
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</tbody>
</table>

Normality Test

Series: Residuals
Sample 2000M01 2006M08
Observations 80

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-9.57e-13</td>
</tr>
<tr>
<td>Median</td>
<td>0.001926</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.204998</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.233859</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.075278</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.277154</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>3.689465</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>2.608730</td>
</tr>
<tr>
<td>Probability</td>
<td>0.271345</td>
</tr>
</tbody>
</table>
Forecast

Forecast: DLYF
Actual: DLY
Forecast sample: 2000M01 2006M08
Included observations: 80

Root Mean Squared Error 0.076953
Mean Absolute Error 0.060499
Mean Abs. Percent Error 190.1224
Theil Inequality Coefficient 0.441308
Bias Proportion 0.000001
Variance Proportion 0.145289
Covariance Proportion 0.854711
Implications

- Monthly ammonia prices have been growing at the rate 
  \( \frac{LY_t}{LY_{t-1}} = 0.011 \) same as natural gas prices.
- Ammonia and Natural gas prices have a stable long-run relationship.
- The long-run ammonia price elasticity 
  \( \left( \frac{\partial Y_t}{Y_t} / \left( \frac{\partial X_t}{X_t} \right) \right) \)
  with respect to natural gas prices is 0.79.
- About 23 percent of a disruption from the long-run equilibrium 
  will be recovered in the following period (month).
- The short-run relationships are:
  - \( \left[ \frac{\partial (Y_t / Y_{t-1})}{(Y_t / Y_{t-1})} \right] / \left[ \frac{\partial (Y_{t-1} / Y_{t-2})}{(Y_{t-1} / Y_{t-2})} \right] = 0.21. \)
  - \( \left[ \frac{\partial (Y_t / Y_{t-1})}{(Y_t / Y_{t-1})} \right] / \left[ \frac{\partial (X_t / X_{t-1})}{(X_t / X_{t-1})} \right] = 0.25. \)
  - \( \left[ \frac{\partial (Y_t / Y_{t-1})}{(Y_t / Y_{t-1})} \right] / \left[ \frac{\partial (X_{t-1} / X_{t-2})}{(X_{t-1} / X_{t-2})} \right] = 0.14. \)