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

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**Presentation at the annual meetings of the Southern Agricultural Economics Association**
**Mobil, Alabama, February 3-6, 2007**

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

The presenter would like to thank Charlie Hallahan, a mathematician with ERS, from whom the presenter has learned analytical methods and Eview used in the analysis.

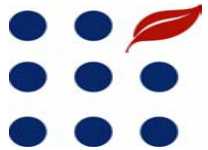
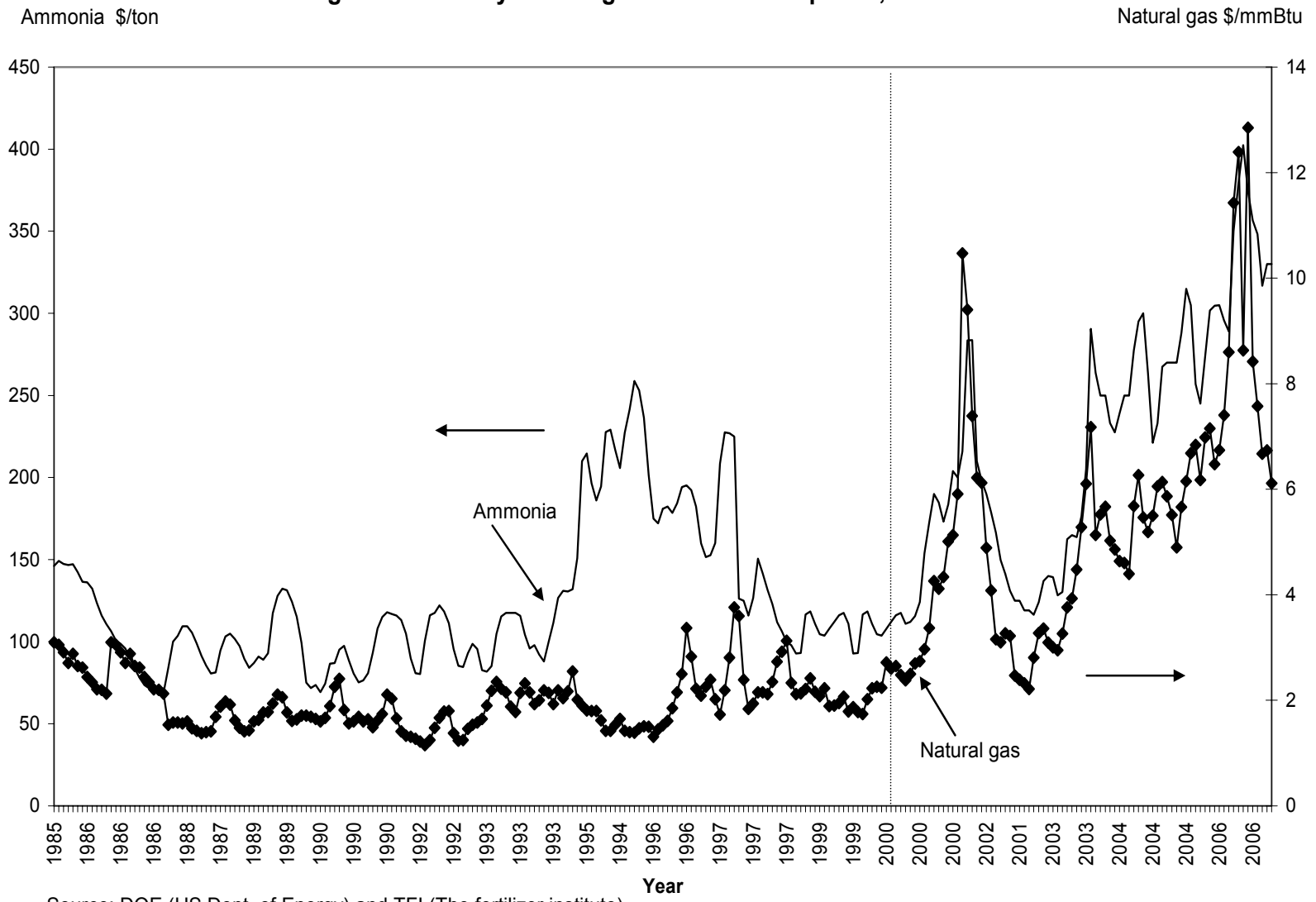


**Figure 1. Monthly natural gas and ammonia prices, 1985-2006**




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

# Background

- 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**

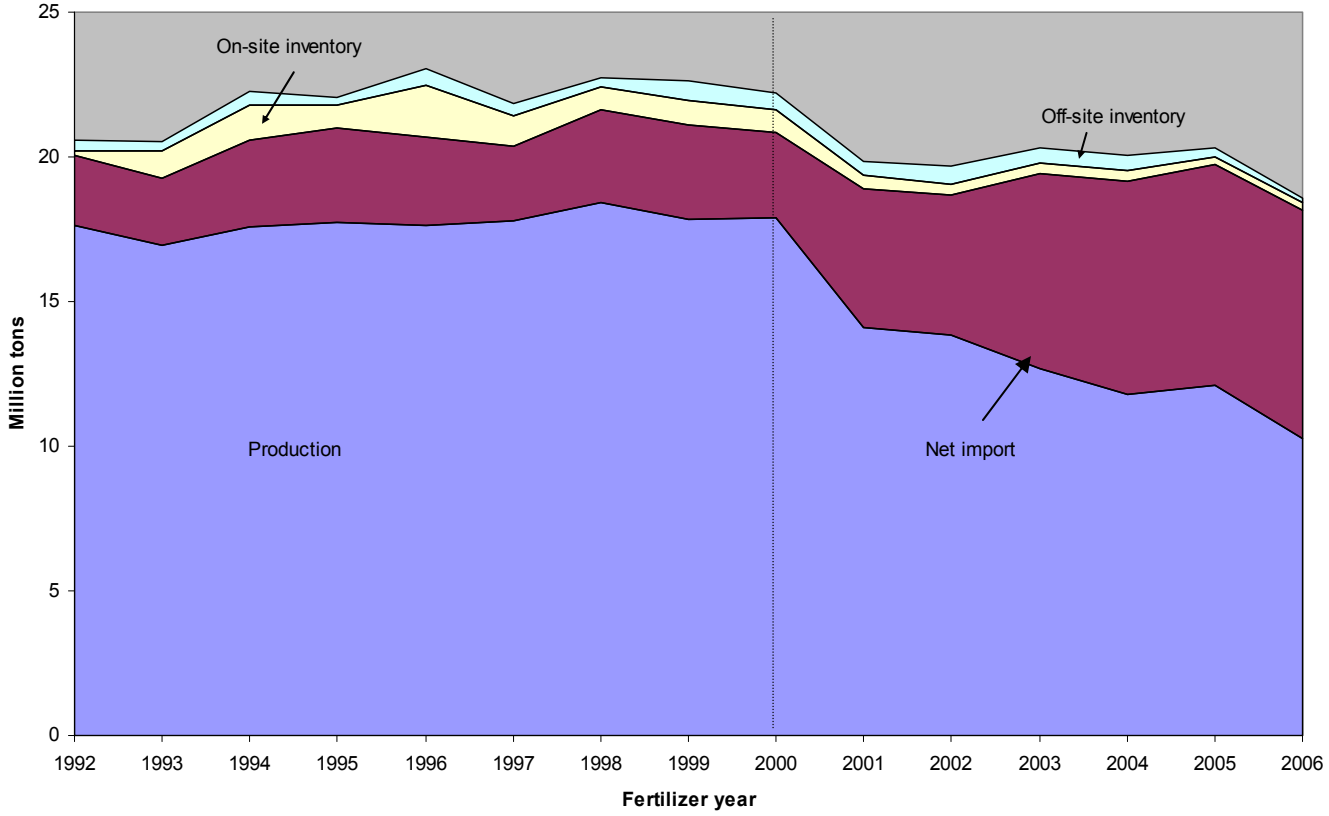


**Figure 3. Ammonia production capacity and production in U.S. 1990-2006**

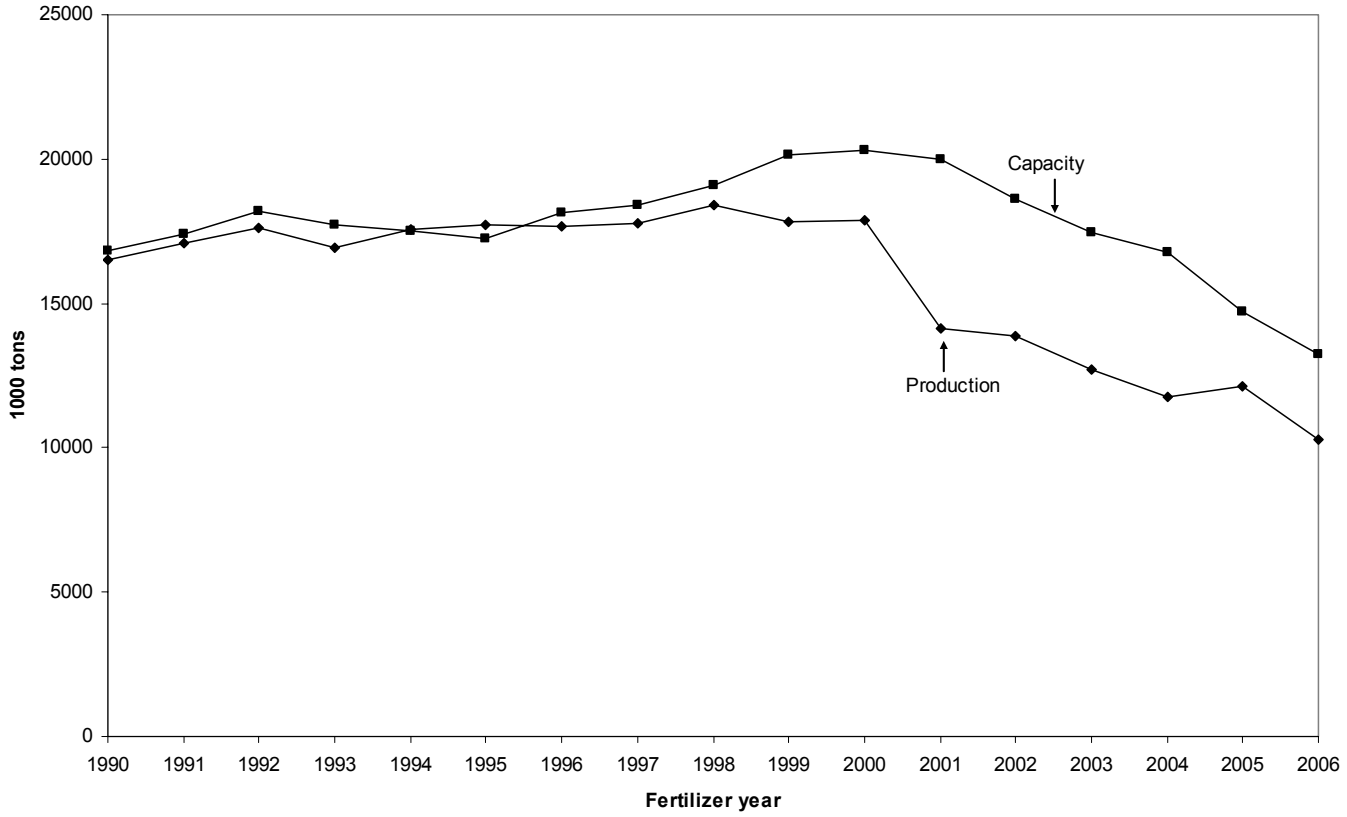
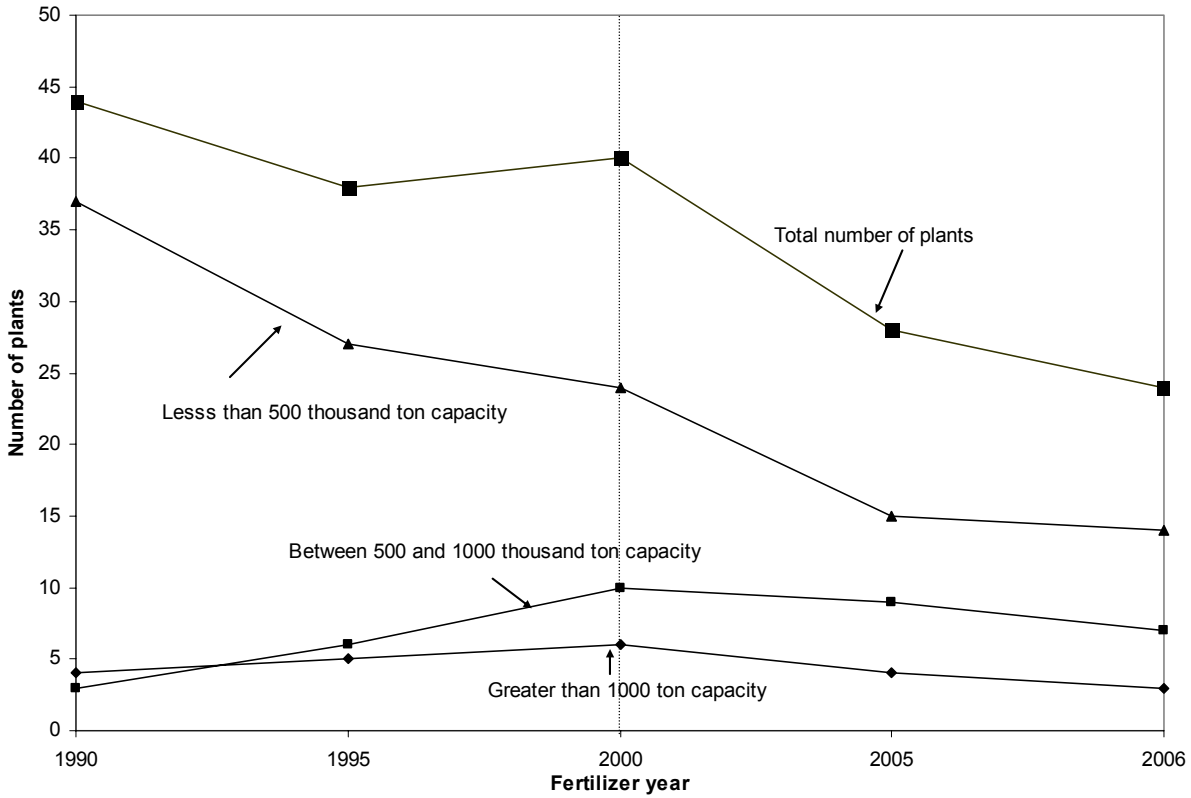


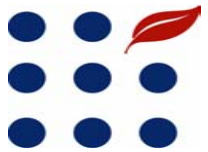
**Figure 4. Number of ammonia plants in three ranges of production capacity, 1990-2006**




Source: IFDC

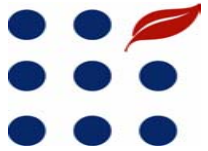
# Factors Affecting Ammonia Demand

- 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



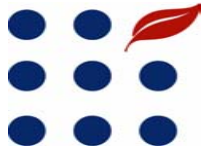
## Factors Affecting Ammonia Supply

- 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.

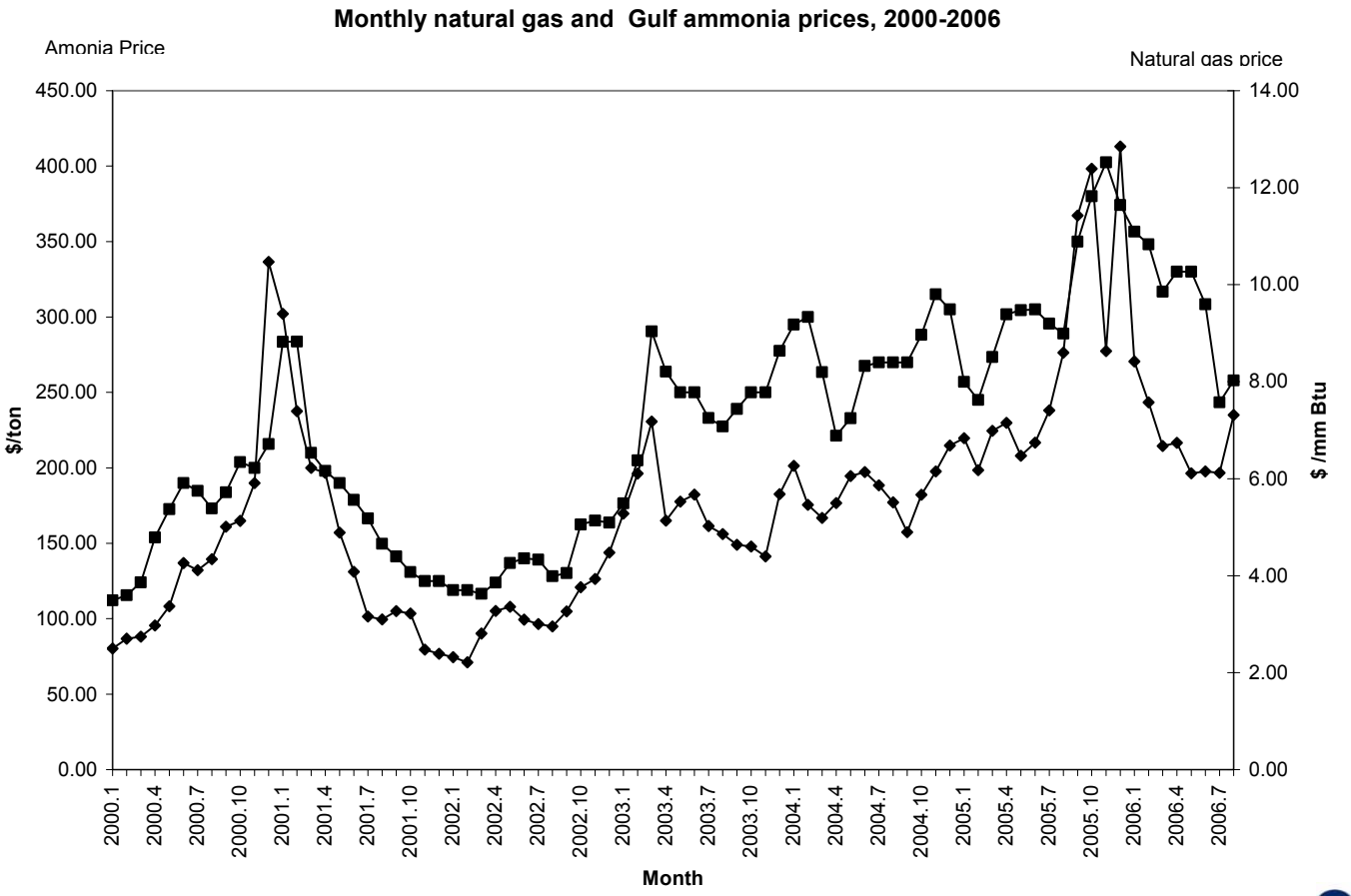
$$D Y_t = \theta_1 D Y_{t-1} + \theta_2 D X_t + \theta_3 D X_{t-1} + \alpha (\beta_1 Y_t - \beta_2 X_t - \beta_0)_{t-1} + u_t$$

Short-run effect | Long-run equilibrium

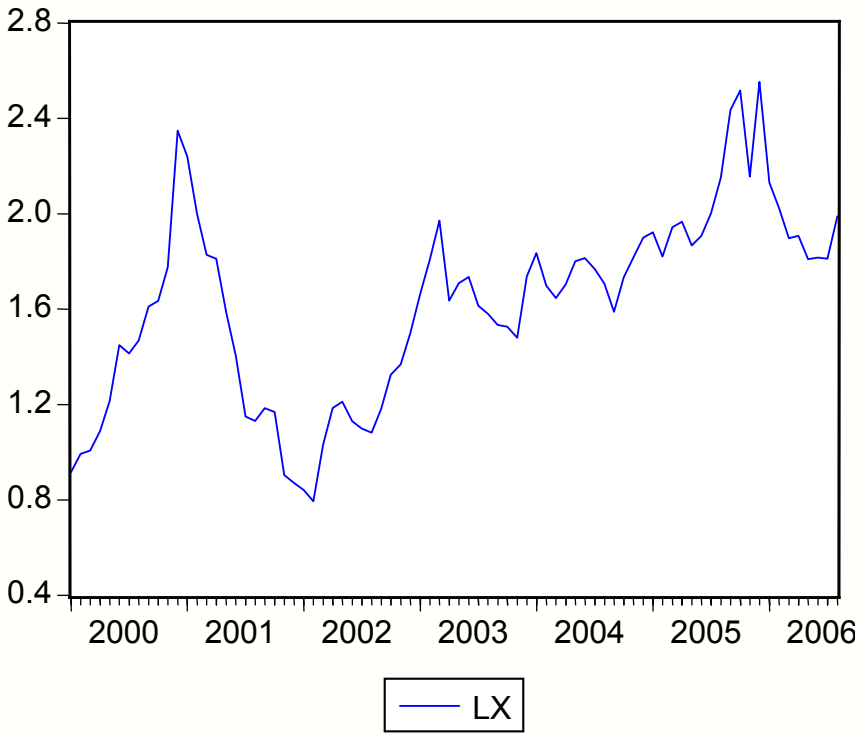
$\alpha$ = Speed of adjustment

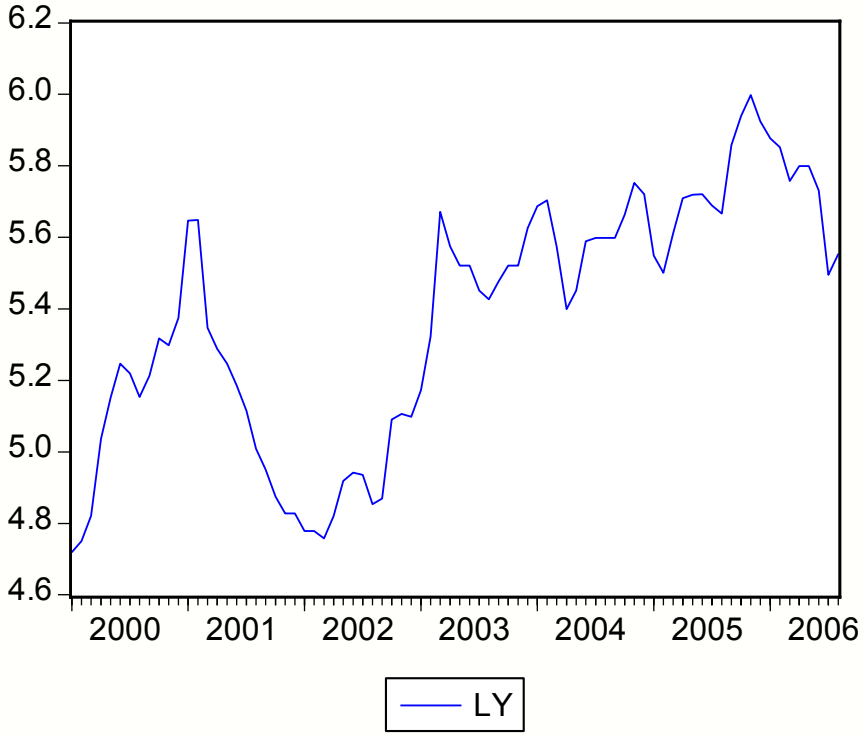
$D Y_t = Y_t - Y_{t-1}$

# Estimation Results



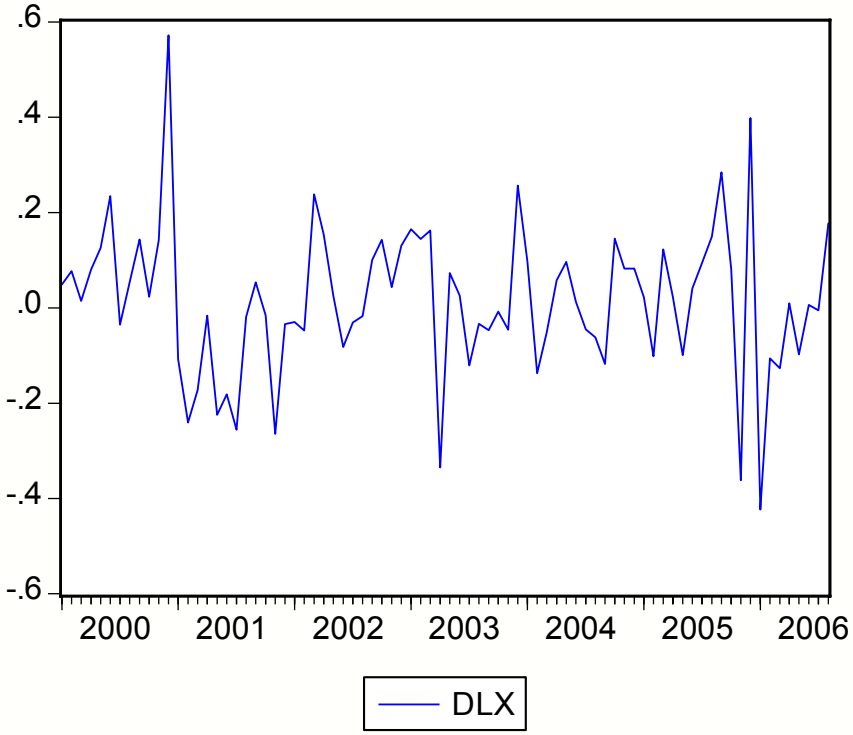

► **Non-stationary time series**

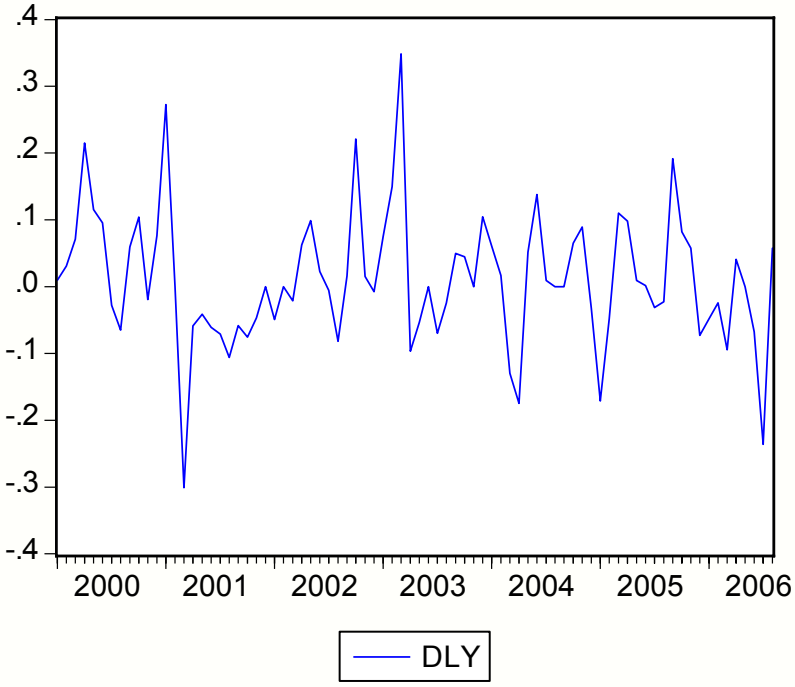



► **LX and LY are X and Y in log scale**

► **Non-stationary time series**




- **DLX = $LX_t$ - $LX_{t-1}$**
- **Stationary time series (Augment Dickey-Fuller Unit Root Test)**

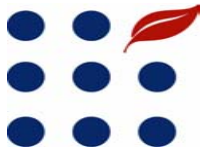
## ► Johansen Co-integration Test

**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**

**Unrestricted Cointegration Rank Test (Trace)**

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None | 0.165770 | 19.57728 | 20.26184 | 0.0619 |
| At most 1 | 0.061498 | 5.077636 | 9.164546 | 0.2750 |

**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

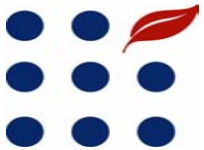
Dependent Variable: DLY
Method: Least Squares
Date: 12/20/06 Time: 09:02

Included observations: 80

DLY = C(1)*DLY(-1) +C (2)*DLX +C(3)*DLX(-1) +C(4)*(LY(-1) +C (5) + C(6)*LX(-1))

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C(1) | 0.215459 | 0.093385 | 2.307211 | 0.0238 |
| C(2) | 0.251516 | 0.057984 | 4.337700 | 0.0000 |
| C(3) | 0.141671 | 0.070070 | 2.021836 | 0.0468 |
| C(4) | -0.229730 | 0.066292 | -3.465409 | 0.0009 |
| C(5) | -4.112831 | 0.160902 | -25.56104 | 0.0000 |
| C(6) | -0.789601 | 0.096906 | -8.148134 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.453489 | Mean dependent var | 0.010543 |
| Adjusted R-squared | 0.416563 | S.D. dependent var | 0.101829 |
| S.E. of regression | 0.077780 | Akaike info criterion | -2.197830 |
| Sum squared resid | 0.447678 | Schwarz criterion | -2.019178 |
| Log likelihood | 93.91319 | Durbin-Watson stat | 1.896165 |



# ► Residue Tests

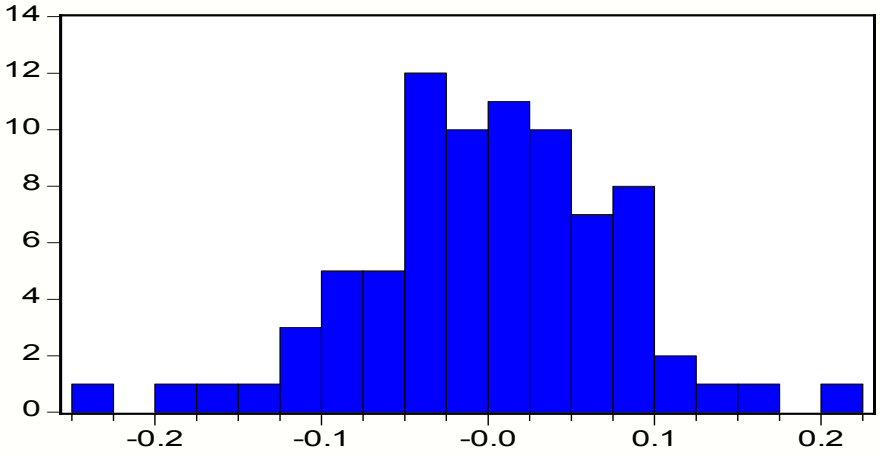
## ► Breusch-Godfrey Serial Correlation LM Test:

| | | | |
|---|---|---|---|
| F-statistic | 1.009765 | Prob. F(4,70) | 0.408411 |
| Obs*R-squared | 4.364248 | Prob. Chi-Square(4) | 0.358949 |

## ► ARCH LM Heteroscedasticity Test

| | | | |
|---|---|---|---|
| F-statistic | 0.944164 | Prob. F(2,75) | 0.393579 |
| Obs*R-squared | 1.915630 | Prob. Chi-Square(2) | 0.383730 |

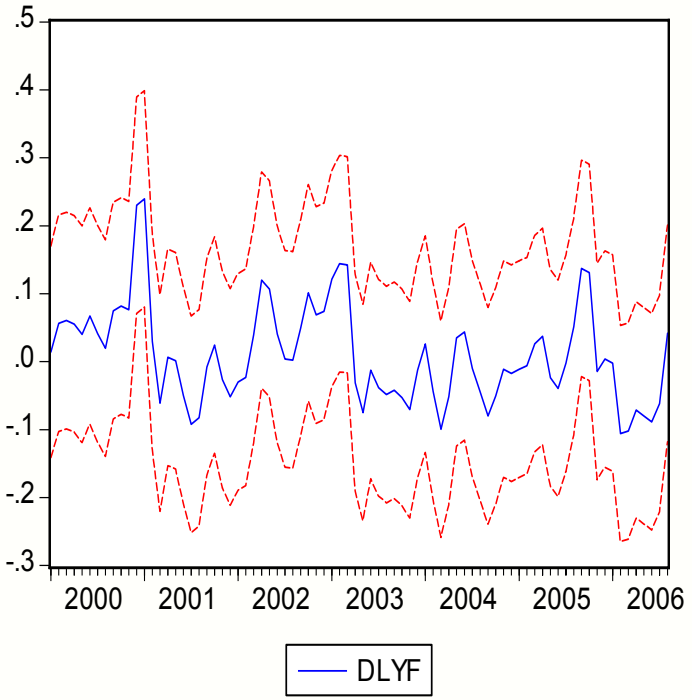
## ► Normality Test




Series: Residuals
Sample 2000M01 2006M08
Observations 80

| | |
|---|---|
| Mean | -9.57e-13 |
| Median | 0.001926 |
| Maximum | 0.204998 |
| Minimum | -0.233859 |
| Std. Dev. | 0.075278 |
| Skewness | -0.277154 |
| Kurtosis | 3.689465 |
| Jarque-Bera | 2.608730 |
| Probability | 0.271345 |

## ► 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 ($LY_t / LY_{t-1} = 0.011$) same as natural gas prices.
- Ammonia and Natural gas prices have a stable long-run relationship.
- The long-run ammonia price elasticity $((\partial Y_t / Y_t)/( (\partial X_t / X_t ) )$ 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:
  - $[\partial (Y_t / Y_{t-1})/(Y_t / Y_{t-1})] / [\partial (Y_{t-1} / Y_{t-2}) / ( Y_{t-1} / Y_{t-2} )] = 0.21$.
  - $[\partial (Y_t / Y_{t-1})/(Y_t / Y_{t-1})] / [\partial (X_t / X_{t-1}) / ( X_t / X_{t-1})] = 0.25$.
  - $[\partial (Y_t / Y_{t-1})/(Y_t / Y_{t-1})] / [\partial (X_{t-1} / X_{t-2}) /(X_{t-1}/ X_{t-2})] = 0.14$.