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The Relationship Between Prices of Natural Gas and Nitrogen Fertilizer

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INTRODUCTION

The fertilizer market, which had been relatively stable between 1973 and 1998, has become wildly volatile and unpredictable. The cost of nitrogen production is tied directly to the price of commodities before 1993, when natural gas was deregulated. The close correlation between fertilizer prices and the price of commodities continued for a few years, until 1998. Since then, the price of nitrogen has been tied to the price of natural gas. Figure 1 shows the farm price for anhydrous ammonia, the natural gas price, and the index for crop prices received by producers. From 1960 to around 1998, the anhydrous ammonia price was tied to crop prices, indicating that prices were responding to producer's demand for anhydrous ammonia. Higher crop prices suggested greater fertilizer use, because producers would attempt to increase production of

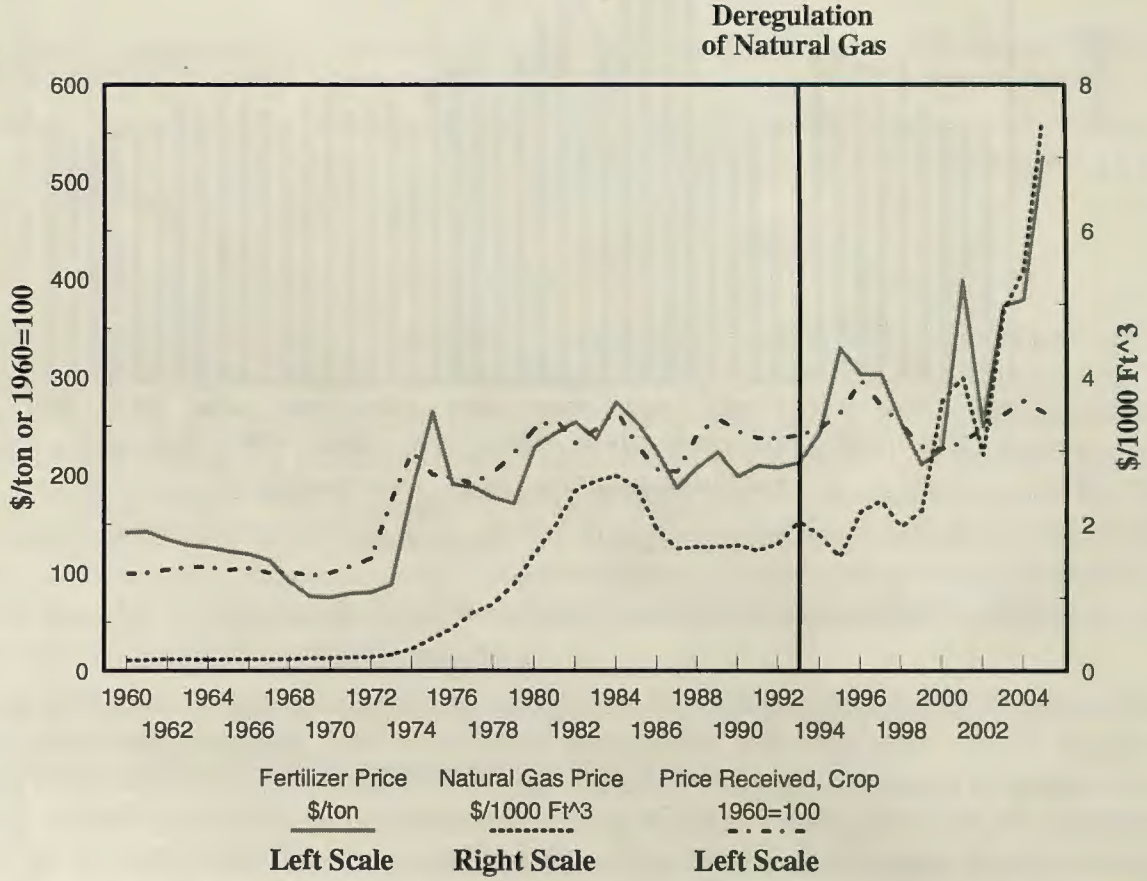

Figure 1. Ammonia Price, Natural Gas Cost, and Prices Received by Farmers, Crops

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commodities at higher prices. Since 1998, the price of natural gas has been volatile and the anhydrous ammonia price has followed natural gas price, indicating that changes in input costs are the driving force in the pricing of nitrogen fertilizer.

Natural gas prices have decreased somewhat in recent months. However, prior to this downturn, natural gas prices increased from \$2.95 per 1000ft^3 in 2002 to \$5.47 per 1000ft^3 in 2004 and \$7.51 per 1000ft^3 in 2005. The price changes for nitrogen have followed the price of natural gas, with about a three to six month lag.

Fertilizer expense has increased from \$1.4 billion in 1960 to \$11.4 billion in 2004, although the percentage of fertilizer costs as a portion of total expense has remained about the same (Figure 2). In 1960, the cost of fertilizer and lime was about 8.3% of producers' total expense. That figure increased to over 15% in 1975 and then steadily decreased until 2003 (7.7%), before rising to 8.4% in 2004. The numbers for 2005 are not available. This history indicates that over the long run, producers' fertilizer expense averaged around 8% of total expense.

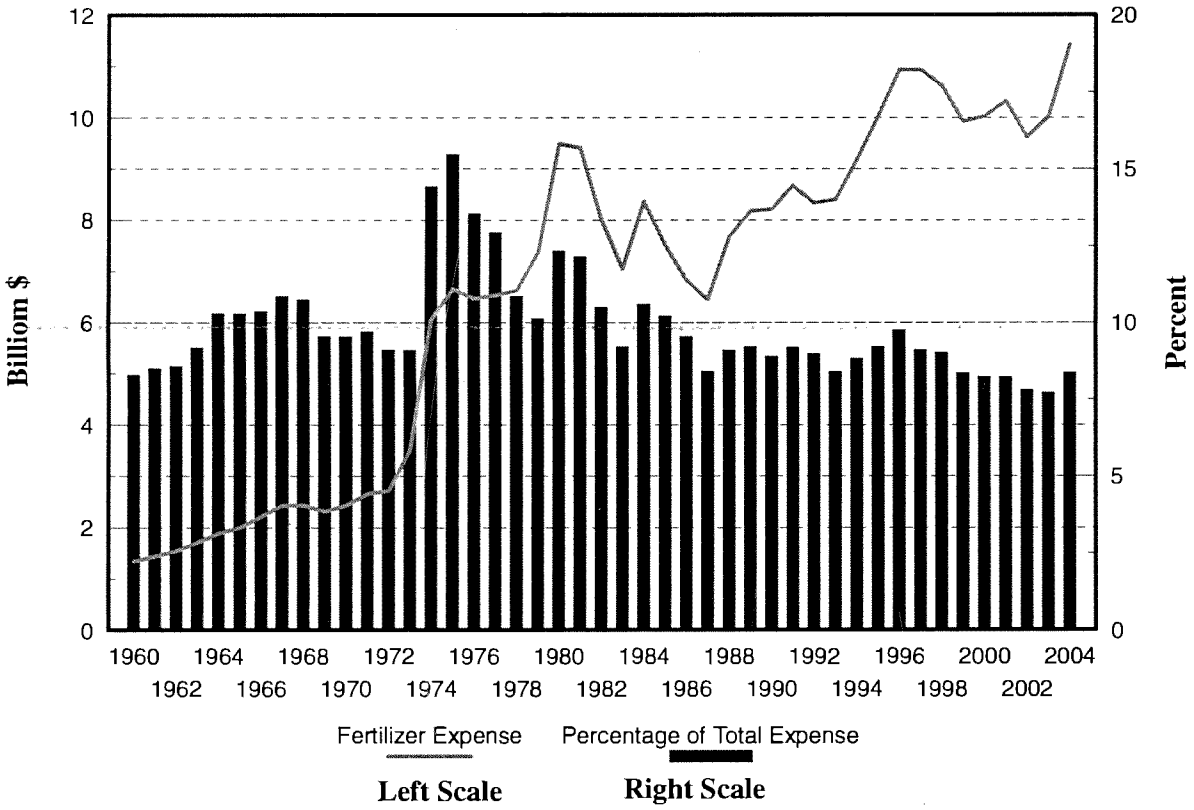

Figure 2. U.S. Fertilizer Expense and Percentage of Total Expense

It is estimated that, currently, about 90% of the cost of anhydrous ammonia is due to the cost of natural gas. A few years ago, that percentage was 75% to 80%. Figure 3 shows the production and net import of ammonia. Until 1990/2000, the United States imported about 2.5 million tons of ammonia. In 2003/04, over 7 million tons of ammonia were imported, almost 44% of total nitrogen fertilizer demand. In addition, the United States imports about 28% of its natural gas consumption. Natural gas is much cheaper overseas. For example, in 2003, natural gas in Venezuela was \$0.50 per MMBtu, compared to \$5.00 per MMBtu[1] in the United States. The current prices in Russia, North Africa, and the Middle East are \$0.70, \$0.40, and \$0.60 MMBtu, respectively.

[1] A MMBtu is 1 million British thermal units, which is similar to 1,000 cubic feet.

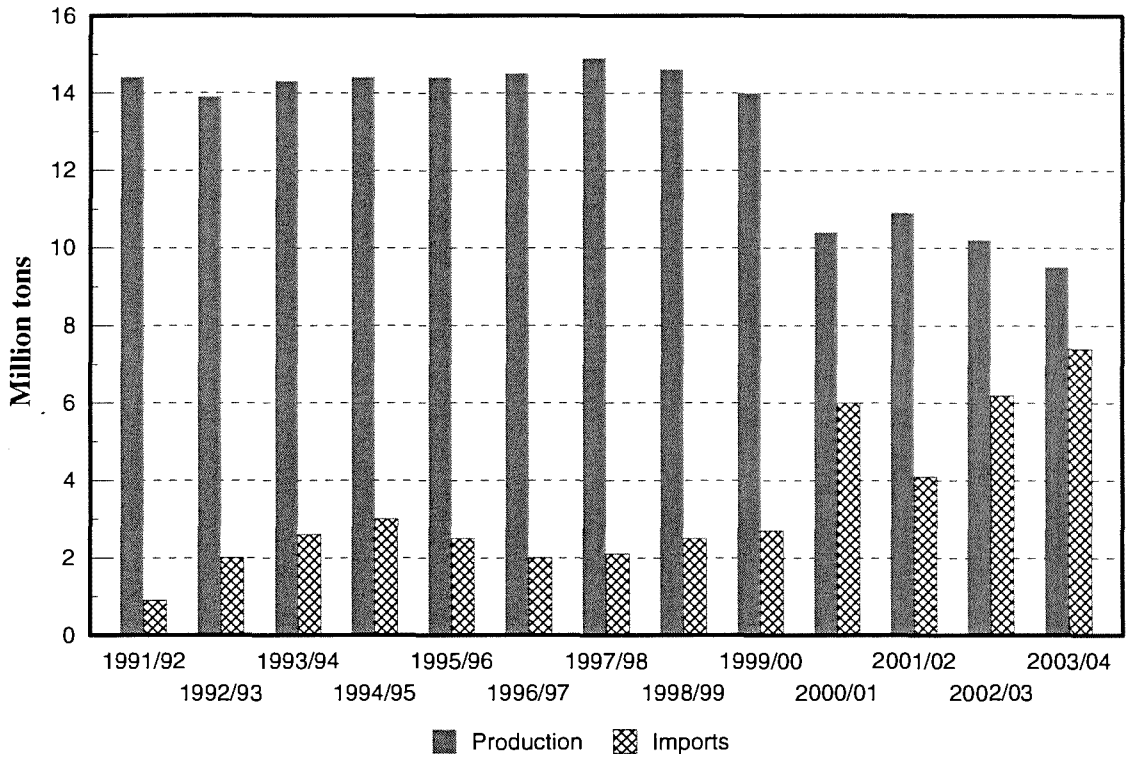

Figure 3. U.S. Ammonia Production and Net Imports

The low prices overseas have reduced U.S. fertilizer production by 36% since 1996. Table 1 shows new urea factories planned to be built abroad in the near future. The United States currently imports 10.36 million tons of nitrogen (44% of consumption), an increase from 6.1 million tons in 1998/99 (Figure 3). With the planned increase in foreign factories, U.S. imports could grow to 20 million tons per year, or about 75% of domestic use.

Methodology

Natural gas is the chief ingredient in the production of nitrogen fertilizer. Currently, 90% of the cost of nitrogen is due to natural gas. Therefore, the price of natural gas should be directly related to the cost of nitrogen fertilizer. Fertilizer price should also be directly related to changes in demand for fertilizer by producers, who respond to changes in commodity prices. When prices are high, producers try to increase the production of those commodities. So, fertilizer demand, and therefore fertilizer price, should be directly related to commodity prices. A dummy variable is included to indicate the year in which natural gas was deregulated. If the year is less than 1993, then D^{93} is equal to 0; otherwise, it is equal to 1. The relationship between nitrogen cost and natural gas price can be expressed as

$$P^N_t = a_1 + a_2 P^G_t + a_3 P^C_t + a_4 D^{93}_t + a_5 \text{Trend}$$

where P^N = price of anhydrous ammonia
P^G = price of natural gas
P^C = crop price index
D^{93} = dummy variable
t = from 1960 to 2005.

Table 1. Additional Worldwide Urea Factories

Start Date	Company	Country	Capacity
2004/05	QafcoIV	Qatar	1.1mmt
2005/06	OMIFCO	Oman	1.6mmt
2006	SABIC	Saudi Arabia	1.1mmt
2006	SPIC	UAE	0.4mmt
2006	KPC	Iran	0.7mmt
2006	NPC	Iran	1.1mmt
2007	AFC	Egypt	0.7mmt
2007/08	EFC II	Egypt	0.6mmt
2008	SIUCI	Oman	1.2mmt
2008	CLICO	Trinidad	0.8mmt
2008	N/A	Egypt	0.6mmt
2008	NPC	Iran	1.1mmt
2008	Petronas	Malaysia	0.5mmt
			Total 11.5mmt

Source: Successful Farming, March 2006

The parameters of this model were estimated with annual data from 1960 to 2005. Since the variables are all trend non-stationary, the trend variable is included in the model. An ordinary least squares estimation is used to estimate the parameters of the model.

Fertilizer price (anhydrous ammonia) data were obtained from USDA-ERS. Natural gas prices were obtained from the Department of Energy-EIA as dollars per 1,000 ft^3, and the index of prices received by producers for crops was obtained from USDA-NASS.

Results

The results are shown in Table 2. All of the coefficients are significant with expected signs. The elasticity of natural gas price is estimated to be 0.28, indicating that a 10% increase in the price of natural gas would increase anhydrous ammonia price by 2.8%, while the elasticity of the crop price index is 0.68, indicating that an increase of 10% in the crop index would increase anhydrous ammonia price by 6.8%. The dummy variable representing deregulation is statistically significant, indicating the price of nitrogen has increased since 1993. The estimated elasticities for crop and

Table 2. Estimated Results for Nitrogen Fertilizer Cost Relationship

	Estimated coefficient	t-value	Elasticity
Constant	41.37	1.27	NA
Natural Gas	43.86	7.85	.28
Crop Prices	0.869	5.18	.68
Dummy Variable	60.19	3.15	NA
Trend	-4.00	-3.19	NA
R^2 0.89			

natural gas prices indicate that the price of nitrogen fertilizer has been influenced more by crop price than the price of natural gas. However, this is no longer true, because during the past few years, natural gas prices have become highly volatile and imports of nitrogen fertilizer increased substantially. Both of these occurrences have changed the fundamental relationship between natural gas price and fertilizer price.

While the estimated equation does not establish the potential lagged effect of natural gas price on the price of nitrogen fertilizer, it is important to recognize that fertilizer delivered for use in the spring is manufactured during the prior fall and winter utilizing natural gas at those seasons' prices. Therefore, there exists a three to six month lag effect of the natural gas price on the price of nitrogen. This indicates that the recent decline in the price of natural gas will lower the price of nitrogen this summer and fall.

Conclusions and Implications

The price of nitrogen fertilizer has changed during the past 40 years. From 1960 to the mid 1990s, the price was related to the demand for fertilizer. After natural gas was deregulated in 1993, its price became volatile. After 1999, the price of nitrogen fertilizer became similarly volatile and followed the price of natural gas. During the 1990s, the United States imported between 12% and 17% of its total nitrogen fertilizer demand. The import share rose to 37% of ammonia demand in 2000 and 44% in 2004. The main reason for the increased level of imports is the lower priced natural gas overseas. While natural gas in the United States is higher than \$5 per 1,000 ft^3, it is less than \$1 per 1,000 ft^3 overseas. Companies in many countries are building fertilizer plants with an annual capacity of over 11 mmt, to provide fertilizer to North America in the future.

Producers have increased fertilizer purchases from \$1.4 billion in 1960 to \$11.4 billion in 2004, although the share of fertilizer as a percentage of total farm expense has remained about the same (8.3%).

A multiple regression model was developed to estimate the relationship between fertilizer price, natural gas price, and the crop price index. Both natural gas price and the crop price index were positively related to fertilizer price. A dummy variable was included to indicate the period in which natural gas was deregulated. The estimated elasticity of natural gas was 0.28, and the elasticity was 0.68 for crop prices. Nitrogen delivered for use in the spring planting season was manufactured during the last fall and winter utilizing natural gas purchased at the price during the period. Therefore, the current price of nitrogen is highly correlated to the price of natural gas three to six months ago. The recent increase in natural gas price, from \$4 per 1,000 per ft^3 in 2004 to over \$11 per 1,000 ft^3 in late 2005, has increased the price of anhydrous ammonia from \$370 per ton in 2004 to over \$500 per ton in the spring of 2006. Natural gas prices had decreased substantially since late 2005, but most of the current spring fertilizer supplies have been manufactured with high-priced natural gas, and fertilizer prices will not fall until they are produced using the new supply of natural gas. The price of nitrogen will most likely decrease during the summer and fall of 2006.

Natural gas price in the United States is higher than the prices in other countries. The United States is not competitive in producing nitrogen fertilizer and will continue to import the fertilizer to meet its domestic demand. This is especially true when the price of natural gas is much higher than the long-term average price, as experienced in the last few years. With a highly

volatile natural gas price in the United States, it maybe necessary to import additional nitrogen fertilizer in order to stabilize the price of nitrogen fertilizer in the United States.

The volatility in the price of nitrogen could cause an additional financial burden and increase uncertainty in producing agricultural goods, and negatively impact net farm income.

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