June 29, 2005

Impacts of Rising Natural Gas Prices on the U.S. Economy and Industries

Executive Summary

Commerce's Economics and Statistics Administration (ESA) prepared this report in response to the Congressional request in the Conference Report accompanying Pub. L. 108-447 (Consolidated Appropriations Act of 2005) directing the Secretary of Commerce, in cooperation with the Secretaries of Energy and Labor, to prepare a study on the economic impacts of rising natural gas prices on energy-intensive industries in the United States.

In preparing this report, ESA sought comments from interested parties through an April 11, 2005 Federal Register Notice. These comments were considered in the drafting of the report and all comments are attached in their entirety in Appendix 1.0 of the report. They may also be found at ESA's web site www.esa.doc.gov/ng.

The following are the primary findings of this study:

- ESA estimates that higher natural gas prices reduced the growth of real U.S. Gross Domestic Product (GDP) by about 0.2 percentage points in both 2000 and 2001. (Estimates derived using the University of Maryland's INFORUM LIFT inter-industry model of the U.S. economy.)

- During 2000-04, higher natural gas prices reduced civilian employment by an average of 489 thousand jobs/year. About 79 thousand of these jobs were in manufacturing industries. (Estimates derived using the INFORUM LIFT model. During 2000-04, U.S. civilian employment averaged about 143 million jobs.)

- The performance of U.S. natural gas intensive industries (as measured by industry shipments, product prices, employment and wages, and capital expenditures) had been suffering *prior* to 2000-04. Higher natural gas prices imposed additional difficulties on these industries. Except in the case of nitrogenous fertilizer manufacturing, however, these higher prices explain only a small portion of the industries' weak economic performance during 2000-04.

- International trade in natural gas intensive industries does not show either decreases in their exports relative to shipments or increases in their imports

relative to consumption that might have been suggestive of deteriorating competitive conditions in the industry.

- Natural gas prices vary across countries, although price movements in the United States tend to track average prices in the 30 industrialized countries of the Organization for Economic Cooperation and Development. During 1999-2003, however, compared with most foreign countries, the United States experienced a slightly larger increase in industrial natural gas prices, so that by 2002 and 2003 natural gas prices here were higher in general than prices overseas.

- The Energy Information Administration anticipates that between 2005 and 2010, natural gas prices will moderate but they are unlikely to return to the lower levels of the 1990s.

This report is organized as follows:

- Section 1 looks at natural gas prices paid by U.S. industries between 1997 and 2004 and compares industrial natural gas prices and price movements in the U.S. to prices paid in foreign countries. Section 1 also looks forward to what lies ahead in natural gas prices through the end of this decade.

- Section 2 examines the macroeconomic impacts of higher natural gas prices across the economy.

- Section 3 examines industry-specific natural gas costs and consumption data to identify natural gas "intensive" industries.

- Section 4 takes a close look at a sample of these natural gas intensive industries and examines the impacts of rising natural gas prices, including effects on domestic performance and international competitiveness.

- Section 5 summarizes the findings of this study.

Section 1. Industrial Natural Gas Prices, 1990-2004

Domestic U.S. Prices for Natural Gas

Natural gas prices were relatively stable through 1999, but then experienced a significant increase in 2000 and a steady climb through 2004. See Table 1.1. The wellhead price of natural gas increased by 151 percent between 1999 and 2004. However, from the perspective of the current study, the industrial price is most relevant. Between 1999 and 2004, industrial natural gas prices rose by 105 percent[1].

Table 1.1. U.S. Average Natural Gas Prices, 1990-2004

Year	Wellhead Price	Industrial Price
	Dollars per thousand cubic feet (mcf)	
1990	1.71	2.90
1991	1.64	2.68
1992	1.74	2.83
1993	2.04	2.97
1994	1.85	2.96
1995	1.55	2.62
1996	2.17	3.35
1997	2.32	3.59
1998	1.96	3.14
1999	2.19	3.12
2000	3.68	4.45
2001	4.00	5.24
2002	2.95	4.02
2003	4.88	5.81
2004	5.49	6.41

Source: Energy Information Administration.

Higher natural gas prices reflected strong demand factors (solid economic growth, large increases in gas-fired electric generating capacity, high oil prices) colliding with limited supply growth in North America (despite very strong drilling efforts). Some of the price strength in 2004 and early 2005 can be attributed to production disruptions in the Gulf of Mexico due to Hurricane Ivan.

What Lies Ahead

In 2004, the average wellhead price for natural gas was $5.49 per mcf and the industrial price was $6.41 per mcf. In the June 2005 *Short-Term Energy Outlook* (STEO) by the Energy Information Administration (EIA), industrial prices are expected to average $7.18

[1] The recorded prices are for volumes of gas purchased from a local distribution company and exclude all volumes purchased elsewhere such as on the spot market. Although limited to a specific portion of industrial gas customers, these prices reflect the overall volatility in natural gas prices since 1999.

per mcf in 2005 and $7.35 per mcf in 2006. Looking forward to 2010, EIA's *Annual Energy Outlook 2005* (AEO2005) forecasts that the wellhead prices of natural gas will decline from current peak levels to $3.64 per mcf in constant 2003 dollars. While this forecast for 2010 may be revised upward, EIA feels that natural gas prices will moderate relative to current high levels, but they are not expected to return to the lower levels during the 1990s.

This view that natural gas prices will *moderate* is based on EIA's assessment in the AEO2005 reference case of three primary factors: *first*, liquefied natural gas (LNG) imports will increase dramatically; *second*, unconventional and offshore gases are expected to increase as well; and *third*, the average cost of imported oil to U.S. refiners in the reference case declines to $25 a barrel by 2010 (constant 2003 dollars) and the movement in price of natural gas, in the long run, follows the movement in price of crude oil[2]. It should be noted that the AEO2005 also includes several cases with substantially higher oil price paths. The reference case oil price scenario is also currently under review for the upcoming AEO2006 and is likely to be higher than reflected in AEO2005. Nevertheless, oil prices are still expected to decline in real terms from their current levels by 2010.[3]

Prices for Natural Gas in Foreign Countries

Unlike crude oil that has virtually a world price, prices paid for natural gas vary significantly between countries. See Table 1.2. In 1999, a majority of foreign countries were paying prices for natural gas greater than prices paid in the U.S. However, the U.S. average annual natural gas price was very similar to prices paid for natural gas in the 30 countries that make up the Organization for Economic Cooperation and Development (OECD).

European countries that belong to the OECD had prices 14 percent higher than the U.S. price in 1999. In 2002 (latest data available), the average price in all OECD countries was only 8 percent above the U.S. price. From 1999 through the latest full year of reporting in 2003, natural gas prices rose steadily for most countries through 2001, declined in 2002 and began to climb again in 2003. In 1999, the price paid for natural gas in most foreign countries was higher than the price paid in the U.S. However, the U.S. experienced a larger increase between 1999 and 2003, so by the end of the period, most foreign countries had lower natural gas prices, with the majority of countries having natural gas prices within 15 percentage points of the U.S. price.[4]

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[2] World oil prices in AEO2005 are defined on the basis of "average refiner acquisition cost" of imported oil to the United States (IRAC). The IRAC price tends to be a few dollars less than the widely cited West Texas Intermediate (WTI) spot price, and in recent months has been as much as $6 per barrel lower than the WTI.

[3] See Appendix 1.1 for a further explanation of EIA's view that these prices will moderate in the future.

[4] See Appendix 1.2 for a more detailed explanation on the movement of U.S. prices on natural gas compared to that of foreign country prices and Appendix Table 1.1 for annual country natural gas price data between 1999 and 2003. Quarterly prices are listed in Appendix Table 1.2.

Table 1.2. Natural Gas Prices in Foreign Countries: Percent Difference from U.S. Price

Country	1999	2003
	Percent Difference from U.S. Price	
OECD Total	7.5	n.a.
OECD Europe	13.7	n.a.
Austria	21.8	n.a.
Canada	-33.1	-14.3
Czech Republic	-13.7	-17.0
Finland	7.8	-35.3
France	13.9	-6.5
Germany	36.0	n.a.
Greece	27.7	-9.7
Hungary	13.6	-3.9
Ireland	38.7	-5.1
Japan	225.0	n.a.
Mexico	-25.6	-16.3
Netherlands	-1.7	-9.3
New Zealand	74.5	6.6
Poland	-22.2	-28.2
Portugal	n.a.	17.3
Slovak Republic	-10.2	-10.0
Spain	10.7	-16.8
Switzerland	81.1	30.4
Turkey	36.8	-6.6
United Kingdom	-13.3	-34.0
Chinese Taipei	109.2	23.1
Indonesia	-69.8	n.a.
Kazakhstan	-97.9	-98.8
South Africa	54.1	n.a.
Thailand	-30.5	n.a.

Note: US $ price per million Btu. Price in selected countries converted to US $ using exchange rates. See Appendix Table 1.2.

Source: International Energy Agency

Section 2. Macroeconomic Impacts of Higher Natural Gas Prices

We used the University of Maryland INFORUM[5] LIFT (Long-term Interindustry Forecasting Tool) model of the U.S. economy to quantify the effects of the natural gas price surge that began in 2000. (See Appendix 2 for the complete report.) To compare historical economic performance to what might have happened if natural gas prices had not increased so dramatically, we conducted a simulation where natural gas prices are 60 percent of the actual natural gas prices for each year from 2000 through 2004. These hypothetical natural gas prices follow the trend of natural gas prices in the 1990s and the price movements after 1999. In other words, the simulation assumes that the "step increase" in natural gas prices in 2000 had not occurred.

In the first two years of higher natural gas price increases, real Gross Domestic Product (GDP) growth is reduced by 0.2 percentage points. See Table 2.1. This shrinkage of growth in the economy disappears over 2002 through 2004, as the aggregate cost of a one-time natural gas price shock dissipates over the long run as the economy adjusts to higher natural gas prices.

Table 2.1. Natural Gas Price Effect on U.S. Real GDP Growth Rate, 2000-2004

Year	Real GDP Growth Rate		Growth Rate Change
	Actual	With Lower Natural Gas Prices	Natural Gas Price Effect
	Percent		Percentage points
2000	3.7	3.9	-0.2
2001	0.8	1.0	-0.2
2002	1.9	1.9	0.0
2003	3.0	3.0	0.0
2004	4.4	4.4	0.0

Source: ESA estimates using the University of Maryland INFORUM LIFT model.

The higher natural gas prices set up a "cost-push" inflationary chain that reverberates throughout the entire economy. For example, the chemical industry uses natural gas relatively intensively. Higher natural gas prices must be accommodated by chemical producers either by a reduction of profit margins or an increase in chemical product prices. In turn, higher prices for chemicals will boost production costs for important down-stream industries such as agriculture, food, textiles, motor vehicles, and so forth.

There are three broad categories of impacts. *First*, higher natural gas prices act like a tax on consumers as higher prices reduce real income. Because they must pay a higher share of their income on heating and cooking, households will have less income left over to spend on other goods and services. *Second*, interest rates increase. Combined with lower

[5] INFORUM is the trade name for the Interindustry Economic Research Fund, Inc. (IERF), a not-for-profit economic research corporation that specializes in economic policy research, economic forecasting, and constructing tools for economic analysis.

profit margins, these higher interest rates act to reduce the demand for nonresidential investment. *Third*, assuming that the run-up in U.S. natural gas prices has outpaced price increases in key trading partners, higher domestic inflation could erode the price competitiveness of the economy. Eventually, the cost-push inflation will run its course, and many negative influences on growth will disappear.

Over a long period of high natural gas prices, we will notice substantial changes in production patterns across industries. Such structural change involves real, albeit transitory, adjustment costs. For instance, layoffs from and capacity obsolescence in retrenching industries impose a cost to the economy. Presumably, this cost disappears once labor and capital resources have been redeployed productively. Changes in industrial structure that emanate from a one-time, permanent, spike in natural gas prices should be durable. Only a reversal in the relative price of gas would remove the disadvantage to natural gas dependent industries.

During the 2000-2004 period, employment effects from rising natural gas prices were broad based and only a fraction of these job losses was in manufacturing. See Table 2.2. On average, between 2001 and 2004, annual total civilian employment was lower by 489,000 jobs because of higher natural gas prices. Manufacturing jobs accounted for about 16 percent of that loss, around 79,000 jobs per year.

In sum, the natural gas price rise in the 2000 through 2004 period had a somewhat mild depressing effect on GDP but a more serious negative effect on employment, especially outside of manufacturing.

Table 2.2 Natural Gas Price Effect on U.S. Total Civilian and Manufacturing Employment, 2000-2004

Year	Total Civilian Employment		Manufacturing Employment	
	Actual	With Lower Natural Gas Prices	Actual	With Lower Natural Gas Prices
		Millions		
2000	144.2	144.5	18.9	18.9
2001	143.7	144.2	17.9	18.0
2002	142.3	142.9	16.7	16.8
2003	141.8	142.3	16.1	16.2
2004	144.6	145.1	16.2	16.3
		Natural Gas Price Effect		
		Thousands		
2000		-306.0		-30.6
2001		-527.1		-78.6
2002		-563.6		-96.6
2003		-528.8		-96.9
2004		-518.2		-90.3
2000-04 Avg.		-488.7		-78.6

Source: ESA estimates using the University of Maryland INFORUM LIFT model.

Section 3. Natural Gas Intensive Industries

Industries most affected by the rise in natural gas prices have been those that have paid the highest amount for natural gas in relation to their overall revenues. See Table 3.1 and Appendix Table 3.1. We call these "natural gas intensive industries." In this report, we estimated the natural gas intensity of 335 goods-producing (manufacturing) industries at the 6-digit NAICS (North American Industry Classification System) level.[6]

Table 3.1. Natural Gas Consumption in Selected U.S. Natural Gas Intensive Manufacturing Industries - 2002

NAICS	Industry	Natural Gas Consumption	Natural Gas Costs Portion of Value of Shipments
		Billion cubic feet	Percent
325311	Nitrogenous fertilizer	542.5	45.3
331311	Alumina refining	n.a.	13.5
325181	Alkalies and chlorine	94.0	12.4
327121	Brick and structural clay	200.0	9.5
327211	Flat glass	51.0	8.4
325182	Carbon black	30.9	8.3
327420	Gypsum products	n.a.	7.0
327213	Glass container	51.0	5.9
325199	All other basic organic chemicals	572.0	5.3
327212	Other pressed and blown glass	n.a.	4.3
325110	Petrochemicals	203.0	4.0
325193	Ethyl alcohol	56.9	3.6
322130	Paperboard mills	183.0	3.5
331111	Iron and steel	406.0	3.5
325211	Plastics	404.0	3.0
327410	Lime	7.0	2.8
325191	Gum and wood chemicals	n.a.	2.1
325188	All other inorganic chemicals	75.0	2.0
322121	Paper (except newsprint) mills	201.0	1.9
322122	Newsprint mills	15.0	1.7
324110	Petroleum refineries	799.0	1.6
325192	Cyclic crude and intermediate	42.0	1.0
327215	Glass products	n.a.	0.6
321113	Sawmills	10.0	0.2

Source: ESA estimates using Census and EIA data.

[6] The 1997 benchmark U.S. Input-Output table published by the Bureau of Economic Analysis was used to determine the share of an industry's value of production attributed to natural gas costs. In this initial selection of industries, we determined the "natural gas intensity"—i.e., natural gas per unit of output—of 423 individual industries in the 1997 benchmark Input-Output table, but focused on the 335 manufacturing industries. See Appendix Table 3.2. Since 1997 was a year when natural gas prices were relatively low and stable, the 2002 Economic Census data from the Bureau of the Census and the 2002 Manufacturing Energy Consumption Survey (MECS) from EIA were used to determine intensity in that year. See Appendix Table 3.1.

The above natural gas intensive manufacturing industries accounted for over half of all natural gas consumed by manufacturing in 2002. These industries accounted for less than 20 percent of all manufacturing GDP and about 2 percent of the total U.S. GDP.

Table 3.1 displays wide variations in natural gas intensities between industries. The nitrogenous fertilizer industry is, by far, the most dependent on natural gas, in terms of cost per unit of output, than any other industry in the U.S. In 2002, the cost of natural gas, both as a fuel and feedstock, accounted for about 45 percent of this industry's value of shipments.[7] The next industry most dependent on natural gas is alumina refining (NAICS 331311) where natural gas accounted for about 14 percent of the value of shipments, about one-third compared to the corresponding percentage for nitrogenous fertilizer.

Competitiveness pressures are felt most acutely in industries most dependent on natural gas inputs, either directly like nitrogenous fertilizer manufacturing, or indirectly, like agriculture. In this assessment, we used the University of Maryland INFORUM LIFT model to determine the direct and indirect impacts of higher natural gas prices on all industries. All other things being equal, the LIFT model determined that higher natural gas prices result in the greatest impacts on the most vulnerable or "directly affected" industries, i.e., those industries that are the most natural gas intensive.

Adding the Costs of Other Gases

Finally, we also looked at the gas intensity of an industry by determining the cost of natural gas *and* liquified petroleum gases (LPGs), such as propane and butane, as a percent of the value of the industry's shipments. LPGs and natural gas are used as feedstocks for petrochemicals, plastics, and all other basic organic chemicals. In the petrochemical industry, natural gas used for heat and power and as a feedstock accounts for 4.0 percent of the industry's value of shipments. Adding the cost of LPG's for this industry raises the share of costs of gas to 28.3 percent. Similarly, the 3.0 percent share of natural gas cost for the plastics industry rises to a 21.4 percent. The 5.3 percent share of natural gas cost for all the other organic chemical industry rises to 16.4 percent of the value of shipments.

Section 4. Impacts on Selected Natural Gas Intensive Industries

This section provides illustrative assessments of the impacts of higher natural gas prices on five of the 24 natural gas intensive industries: nitrogenous fertilizer, petrochemicals,

[7] The Fertilizer Industry, in their comments posted on May 16, 2005, claims that "Natural gas … represents 70 to 90 percent of the production cost of one ton of anhydrous ammonia," the primary product of the Nitrogenous fertilizer industry. In a 2003 report, the General Accountability Office, noted that natural gas accounted for up to 90 percent of fertilizer production costs. Whether the cost of natural gas accounts for 45 percent of shipments (revenue) or 70 to 90 percent of production costs, it is quite clear that this industry would be the most affected by increased prices of natural gas.

all other basic organic chemicals, plastics, and iron and steel. See Table 3.1. Nitrogenous fertilizer manufacturing is, by far, the most natural gas intensive. Petrochemicals, plastics, and all other basic organic chemicals rank right behind nitrogenous fertilizer in terms of "total" gas intensiveness. (See the above paragraph on their use of LPGs as feedstock.) Iron and steel manufacturing was chosen—although its natural gas cost in relation to its revenue is small, 3.5 percent—because this industry consumes a great deal of natural gas, 406 billion cubic feet, the fourth highest consumption among the above 24 industries in Table 3.1.

In our assessments, we first determined the total cost of energy of these industries as a percent of their shipments for 1997 and 2002. This allowed us to assess the total energy cost of these industries in 1997 when gas prices were relatively low and then, again, in 2002 when gas prices were higher. Next, we examined the performance of these industries in two periods, 1997-2000 when natural gas prices were relatively low and more stable and 2000-2004 when prices were higher and much more erratic. During the former period, the economy in general was robust and growing. During the latter period, the economy declined slightly and then recovered.

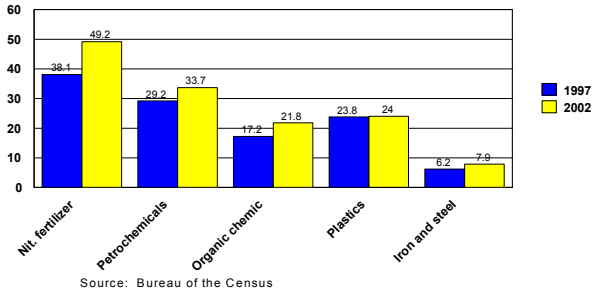
We examined industry performance with respect to (1) changes in shipments and prices, (2) changes in employment and wages, and (3) shifts in exports and imports. We then made some observations regarding their comparative performance while natural gas prices were rising in the latter period.

Finally, we used the LIFT model to estimate the natural gas price impacts on employment in these industries. These impacts allow us to determine what employment in these industries might have been if natural gas prices followed their trend from earlier years up to 1999.

Energy Cost Share of Production, 1997 and 2002

Total energy costs, including natural gas and all other forms of energy (e.g., electricity), were a greater component of the cost structure of natural gas intensive industries in 2002 than in 1997. See Figure 4.1. The nitrogenous fertilizer industry provides the most extreme example. In 1997, total energy costs in this industry were 38 percent of the value of industry shipments. By 2002, total energy cost share had risen 11 percentage

Figure 4.1 Energy Cost As a Percent of Shipments



Source: Bureau of the Census

points to 49 percent of industry shipments. Natural gas costs alone comprised 92 percent of these total energy costs.

Energy cost as a percent of shipments for petrochemicals and all other basic organic chemicals also increased, but not nearly as much as the increase in nitrogenous fertilizer. Each of these industries had about a 4-percentage point increase. In the plastics and iron and steel industries, there were only slight increases. In each case, these changes reflect both the price increases in natural gas as well as changes in the usage of natural gas in production.

Industrial Performance, 1997-2000 and 2000-2004

Production A review of shipments and prices of these natural gas intensive industries in these two time periods reveals that they have not been unduly affected by higher natural gas prices. In the first period, the U.S. economy grew on average over 4 percent per year. With the booming economy, nominal shipments of petrochemicals and plastics showed healthy increases but those of nitrogenous fertilizer, all other basic organic chemicals, and iron and steel declined.

To better understand the movement in shipments, however, it is necessary to separate the price movements in these industries so that we can determine these industries' real shipments. Real shipments—nominal shipments deflated by the sector's producer price index (PPI)—represent volumes or quantities of production. To calculate real *growth* (or decline) in production, we take out the percent change in prices from the percent change in nominal shipments. See Table 4.1 and Appendix Tables 4.1 through 4.5.

Table 4.1. Shipments and Prices of Selected Natural Gas Intensive Industries

Industry	1997-00	2000-04
	Average of Annual Percent Changes	
	Nominal Shipments[1]	
Nitrogenous fertilizer	-6.5	8.0
Petrochemicals	11.4	1.7
All other basic organic chemicals	-0.1	-1.3
Plastics	5.0	-0.4
Iron and steel mills	-2.9	0.6
	Producer Price Index	
Nitrogenous fertilizer	-2.0	11.3
Petrochemicals	n.a.	n.a.
All other basic organic chemicals	n.a.	n.a.
Plastics	2.7	4.3
Iron and steel mills	-2.9	7.8
All Manufacturing Industries	1.6	1.7
	Real Shipments[2]	
Nitrogenous fertilizer	-4.5	-3.3
Petrochemicals	n.a.	n.a.
All other basic organic chemicals	n.a.	n.a.
Plastics	2.3	-4.7
Iron and steel mills	0.0	-7.2

[1]Based on estimated 2004 shipments.

[2]Percent change in nominal shipments less the percent change in producer price index.

Sources: Bureau of the Census and Bureau of Labor Statistics.

During 2000-04 when natural gas prices were rising, real shipments of nitrogenous fertilizer manufacturing experienced an average annual 3.3 percent decline. During, 1997-2000 when natural gas prices were lower, real shipments of this industry declined at even a faster rate, -4.5 percent. During 2000-04, the plastics and iron and steel industries also experienced faster real declines than during the period of more stable and lower prices. Unfortunately, no price data are available to gauge the growth performance of petrochemicals and all other basic organic chemicals.

Table 4.1 also shows that during 2000-04, product prices in the nitrogenous fertilizer, plastics, and iron and steel industries increased on average from 4.3 to 11.3 percent per year, *faster* than the average price rise of 1.7 percent per year for *all* manufacturing industries. This indicates that these natural gas intensive industries may have passed along some part of rising natural gas costs by raising prices.

Employment and Wages Employment in all natural gas intensive industries fell when natural gas prices were relatively low and stable (1997-2000) and also fell—*faster* in all the above industries—when these prices increased rapidly and were unstable (2000-04). See Table 4.2 and Appendix Tables 4.1 to 4.5. However, the rise in natural gas prices

may not be fully culpable in light of the fact that employment in *all* manufacturing—including industries less intensive in natural gas use—also fell 0.3 percent during 1997-2000 and continued falling much more rapidly by 4.8 percent per year during 2000-04. Later in this section of the report, we isolate the employment impact of higher natural gas prices separately from any other factors affecting employment.

Table 4.2. Employment and Wages in Selected Natural Gas Intensive Industries

Industry	1997-00	2000-04
	Average of Annual Percent Changes	
	Employment	
Nitrogenous fertilizer	-3.3	-4.4
Petrochemicals	-2.2	-4.8
All other basic organic chemicals	-3.6	-4.7
Plastics	-1.2	-4.8
Iron and steel mills	-1.6	-8.1
All natural gas intensive industries	-2.2	-5.3
All manufacturing industries	-0.3	-4.8
All private industries	2.5	-0.6
	Wages	
Nitrogenous fertilizer	1.5	4.4
Petrochemicals	3.8	3.1
All other basic organic chemicals	3.1	3.5
Plastics	3.7	2.8
Iron and steel mills	3.7	2.8
All natural gas intensive industries	2.8	3.1
All manufacturing industries	5.1	2.3
All private industries	4.8	2.0

Source: Bureau of Labor Statistics.

Wages in natural gas intensive industries rose in both periods. However, the rise in wages did not tell a consistent story—i.e., faster in some industries but slower in others—between the two periods. Thus, the rise in wages may not be crucial in explaining the consistently faster fall in employment during the later period in all natural gas intensive industries.[8]

Capital Expenditures Finally, a review of capital expenditures by the five natural gas intensive industries indicate that these industries were reducing investment prior to the increase in natural gas prices. See Table 4.3 and Appendix Tables 4.1 to 4.5. In the nitrogenous fertilizer industry, for example, capital expenditures declined by an average 40 percent per year during 1997-2000 and continued to decline although at a slower rate of 6 percent per year during 2000-03.

[8] The growth in wages might be consistent with falling employment since experienced workers with higher wages may be retained while younger workers with lower wages are let go. For this report, however, the reason for the wage/employment relationship was not determined.

Table 4.3. Capital Expenditures of Selected Natural Gas Intensive Industries

Industry	1997-00	2000-03
	Average of Annual Percent Changes	
Nitrogenous fertilizer	-40.4	-6.2
Petrochemicals	-21.4	1.2
All other basic organic chemicals	-5.7	-3.4
Plastics	-4.5	-11.4
Iron and steel mills	-7.2	-7.6
Total nonresidential	8.3	-3.7

Sources: Bureau of the Census and Bureau of Economic Analysis.

Investments Abroad One concern is that higher natural gas prices in this country would force domestic natural gas intensive industries to invest in production facilities abroad where natural gas prices are lower. Bureau of Economic Analysis (BEA) data show that, in 1999, U.S. manufacturing industries invested almost $40 billion abroad, about 20 percent of all of their capital spending. In 2003, these industries invested less abroad than in 1999, about $28 billion and 17 percent of capital spending.

Despite this heavy investment by the manufacturing industry abroad, it is not clear that these investments are necessarily related to the rise in natural gas prices. In fact, BEA data show that investments abroad by the chemical industry declined from $10 billion in 2001 to $6 billion in 2003. In addition, it appears that their foreign investments shifted from Latin American countries—where the prices of natural gas have been significantly lower than prices paid in the U.S.—to Canada and Europe where prices of natural gas have been only marginally lower.

Employment Impacts of Higher Natural Gas Prices

As shown earlier (Table 4.2), employment in all natural gas intensive industries fell when natural gas prices were relatively low and stable (1997-2000) and also fell—faster in all the above industries—when natural gas prices increased rapidly and were unstable (2000-04). In view of this finding, we used the LIFT model to isolate the employment impacts of higher natural gas prices. We then compared the "higher natural gas effect" on employment with the actual annual change in employment in these industries to estimate the share of the employment loss between 1999 and 2004 attributable to higher natural gas prices. See Table 4.4.

Table 4.4. Natural Gas Price Impacts on Employment in Selected Natural Gas Intensive Industries

Employment	2000	2001	2002	2003	2004
		Nitrogenous Fertilizer			
		Annual number of workers			
Actual employment	9,949	9,458	8,977	8,327	8,286
Estimated employment with lower natural gas (NG) prices	9,977	10,140	10,017	9,537	9,476
Job losses due to higher NG prices (no.)	-28	-682	-1,040	-1,210	-1,190
Job losses due to higher NG prices (%)	-0.3	-6.7	-10.4	-12.7	-12.6
		Petrochemicals			
		Annual number of workers			
Actual employment	37,823	36,067	34,199	32,103	31,052
Estimated employment with lower natural gas (NG) prices	38,173	36,963	35,339	33,359	32,220
Job losses due to higher NG prices (no.)	-350	-896	-1,140	-1,256	-1,168
Job losses due to higher NG prices (%)	-0.9	-2.4	-3.2	-3.8	-3.6
		All Other Basic Organic Chemicals			
		Annual number of workers			
Actual employment	40,423	38,088	35,728	34,308	33,279
Estimated employment with lower natural gas (NG) prices	40,761	38,982	36,880	35,542	34,483
Job losses due to higher NG prices (no.)	-338	-894	-1,152	-1,234	-1,204
Job losses due to higher NG prices (%)	-0.8	-2.3	-3.1	-3.5	-3.5
		Plastics			
		Annual number of workers			
Actual employment	70,385	66,031	61,552	60,551	57,658
Estimated employment with lower natural gas (NG) prices	70,556	66,433	62,070	61,104	58,184
Job losses due to higher NG prices (no.)	-171	-402	-518	-553	-526
Job losses due to higher NG prices (%)	-0.2	-0.6	-0.8	-0.9	-0.9
		Iron and Steel Mills			
		Annual number of workers			
Actual employment	130,076	118,188	104,866	99,755	93,821
Estimated employment with lower natural gas (NG) prices	130,202	118,027	104,948	100,073	93,953
Job losses due to higher NG prices (no.)	-126	161	-82	-318	-132
Job losses due to higher NG prices (%)	-0.1	0.1	-0.1	-0.3	-0.1

Sources: Bureau of Labor Statistics and ESA estimates using the University of Maryland INFORUM LIFT model.

Except for the nitrogenous fertilizer industry, higher natural gas prices played a minor role in the employment loss in these industries. For the nitrogenous fertilizer industry, as much as 13 percent of the annual level of employment from 2000 and 2004 were lost due to higher natural gas prices. For the remaining four industries, only 4 percent or less of the jobs from 2000 and 2004 were lost due to the rise in natural gas prices.

International Competitiveness

To gauge international competitiveness, we examined net exports and trade orientation indicators, such as export to shipments ratios and import to domestic consumption ratios.

Among the five natural gas intensive industries under analysis, the nitrogenous fertilizer industry is the only one with a reversal of its trade performance from being a net exporter (2000-02) to becoming a net importer (i.e., having negative net exports during 2003-04). See Table 4.5 and Appendix Tables 4.6 to 4.10. Two industries (all other basic organic chemicals and plastics) have been consistent net exporters while the remaining two industries (petrochemical manufacturing and iron and steel mills) have been consistent net importers during 2000-04.

Table 4.5. Trade Performance of Selected Natural Gas Intensive Industries

Industry	2000	2001	2002	2003	2004
			Exports		
			Million dollars		
Nitrogenous fertilizer	2,316.1	2,118.7	2,118.3	2,359.6	2,638.7
Petrochemicals	615.6	469.2	546.9	646.0	1,089.9
All other basic organic chemicals	16,054.7	15,526.5	14,988.2	17,966.9	21,723.4
Plastics	12,392.1	11,878.0	12,193.8	13,191.9	16,208.7
Iron and steel mills	4,939.3	4,715.4	4,495.4	5,483.6	6,949.7
			Imports		
			Million dollars		
Nitrogenous fertilizer	1,513.9	1,911.1	1,400.1	2,516.6	3,179.4
Petrochemicals	4,285.4	3,497.1	3,992.8	4,882.8	6,993.2
All other basic organic chemicals	13,108.8	13,596.9	12,895.1	14,055.2	16,272.7
Plastics	5,763.8	5,611.2	5,642.2	6,556.7	7,683.0
Iron and steel mills	15,474.7	11,880.3	12,525.1	10,838.0	23,353.4
			Net Exports[1]		
			Million dollars		
Nitrogenous fertilizer	802.2	207.6	718.2	-157.0	-540.7
Petrochemicals	-3,669.8	-3,027.9	-3,445.9	-4,236.8	-5,903.3
All other basic organic chemicals	2,945.9	1,929.5	2,093.1	3,911.7	5,450.7
Plastics	6,628.3	6,266.9	6,551.6	6,635.2	8,525.6
Iron and steel mills	-10,535.4	-7,164.9	-8,029.7	-5,354.5	-16,403.7
			Exports to Shipments Ratio[2]		
			Percent		
Nitrogenous fertilizer	66.6	59.2	59.1	54.9	n.a.
Petrochemicals	2.6	2.4	2.3	2.4	n.a.
All other basic organic chemicals	34.2	35.4	32.8	36.9	n.a.
Plastics	24.1	26.6	26.4	26.8	n.a.
Iron and steel mills	7.7	8.6	8.0	9.9	n.a.
			Imports to Domestic Consumption Ratio[3]		
			Percent		
Nitrogenous fertilizer	56.6	56.7	48.9	56.5	n.a.
Petrochemicals	15.9	15.7	14.8	15.4	n.a.
All other basic organic chemicals	29.8	32.4	29.6	31.4	n.a.
Plastics	12.9	14.6	14.3	15.4	n.a.
Iron and steel mills	20.7	19.2	19.6	17.9	n.a.

[1]Net exports equal exports minus imports.

[2]Using *product* shipments data consistent with *trade* classification.

[3]Imports divided by domestic consumption (shipments plus imports minus exports).

Source: Bureau of the Census.

The nitrogenous fertilizer industry had the strongest trade orientation, exporting 55 to 67 percent of shipments (supplies for domestic and foreign markets) while importing 49 to 57 percent of domestic consumption. All other basic organic chemicals had the next strongest trade orientation, exporting 33 to 37 percent of shipments while importing 30 to 32 percent of domestic consumption. Plastics exported 24 to 27 percent of shipments while importing 13 to 15 percent of domestic consumption. Iron and steel mills had a weaker trade orientation, exporting 8 to 10 percent of shipments while importing 18 to 21 percent of domestic consumption. Finally, petrochemicals had the weakest trade orientation, exporting just about 2.5 percent of shipments and importing 15 to 16 percent of domestic consumption.

As noted above, trade orientation—as measured by the percent share of exports in shipments and by the percent share of imports in domestic consumption—*varies* considerably across industries. However, it is remarkable that these percent shares have been quite *stable* for each industry during the period 2000-04 when U.S. natural gas prices have been rising. This stability indicates that the rise in natural gas prices have not significantly weakened the international competitiveness of these natural gas intensive industries. Within each industry, the largest swings in these ratios are those of nitrogenous fertilizer, but even in this industry, the swings do not appear alarming.

Section 5. Conclusion

We found that higher natural gas prices in the 2000 to 2004 period had a somewhat mild depressing effect on GDP but a more serious negative effect on employment, especially outside of manufacturing. We estimated that in 2000 and 2002 these higher prices reduced real GDP growth by 0.2 percentage points in each of these years. For 2003 and 2004, the growth rate was unaffected. In terms of jobs, total civilian employment was lower by an average 489 thousand jobs in each of those years. Manufacturing employment was lower by an average 79 thousand jobs, about 16 percent of the total civilian jobs lost.

There is no clear evidence, except for nitrogenous fertilizer manufacturing, that higher natural gas prices were the primary reason for the poor economic performance of natural gas intensive industries during 2000 to 2004. These higher prices were certainly an additional burden on these industries, but their performance was already deteriorating prior to the onset of higher gas prices.