Economic Impact of Nitrogen Prices on U.S. Corn Producers

Prepared for:

Texas, Missouri, Colorado, Georgia, Illinois,
Indiana, Iowa, Kansas, Kentucky, Maryland,
Michigan, Minnesota, Nebraska, New York,
North Carolina, North Dakota, Ohio, South Carolina, South Dakota,
Tennessee, and Wisconsin Corn Producers Associations and Checkoffs

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This analysis was conducted at the request of the corn grower associations and checkoffs from Texas, Missouri, Colorado, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Michigan, Minnesota, Nebraska, New York, North Carolina, North Dakota, Ohio, South Carolina, South Dakota, Tennessee, and Wisconsin to evaluate the impact of higher nitrogen prices on farms, and, to the extent possible, to determine the factors that are the primary causes of higher prices. AFPC is conducting a separate analysis of the impacts of higher fertilizer prices on our set of 64 representative crop farms, ranches and dairies at the request of a member of Congress. That report should be available by the end of December.

This report is divided into 4 main sections:

- Background
- Historical overview of U.S. nitrogen market
- Do nitrogen prices react to normal supply/demand fundamentals?
- What is the impact of higher nitrogen prices on farms producing corn?

Background

Agricultural producers know three truths: death, taxes, and if commodity prices rise then input prices rise right along with them. Figure 1 illustrates this point using USDA cost of production data for all U.S. farms by comparing the percentage change in annual crop returns with the percentage change in fertilizer and lime, pesticides, and seed expenditures since 1970. Although not occurring 100 percent of the time, it does appear that an increase/decrease in crop returns often coincides with an increase/decrease in input expenditures.

Figure 2 highlights fertilizer and lime expenditures and crop returns. In general, it shows that increases in returns tend to coincide with even higher increases in fertilizer expenditures; however, when crop returns decline, fertilizer expenditures do not tend to decline as much. While the chart suggests input suppliers take advantage of higher returns to increase their returns, many other reasons likely exist.

In testimony submitted to a November 3, 2021 House Agriculture Committee Hearing on "The Immediate Challenges to our Nation's Food Supply Chain" the Fertilizer Institute President and CEO Corey Rosenbusch concluded,

> "Current factors that have most influenced the current market supply of fertilizer include (1) global demand for fertilizer, which is largely driven by crop plantings and prices; (2) recent weather events that disrupted domestic production; (3) COVID-19 related deferral of facility maintenance that is now being undertaken;

(4) international actions, including Belarus and China; (5) transportation costs; and (6) the supply and cost of natural gas.[1]"

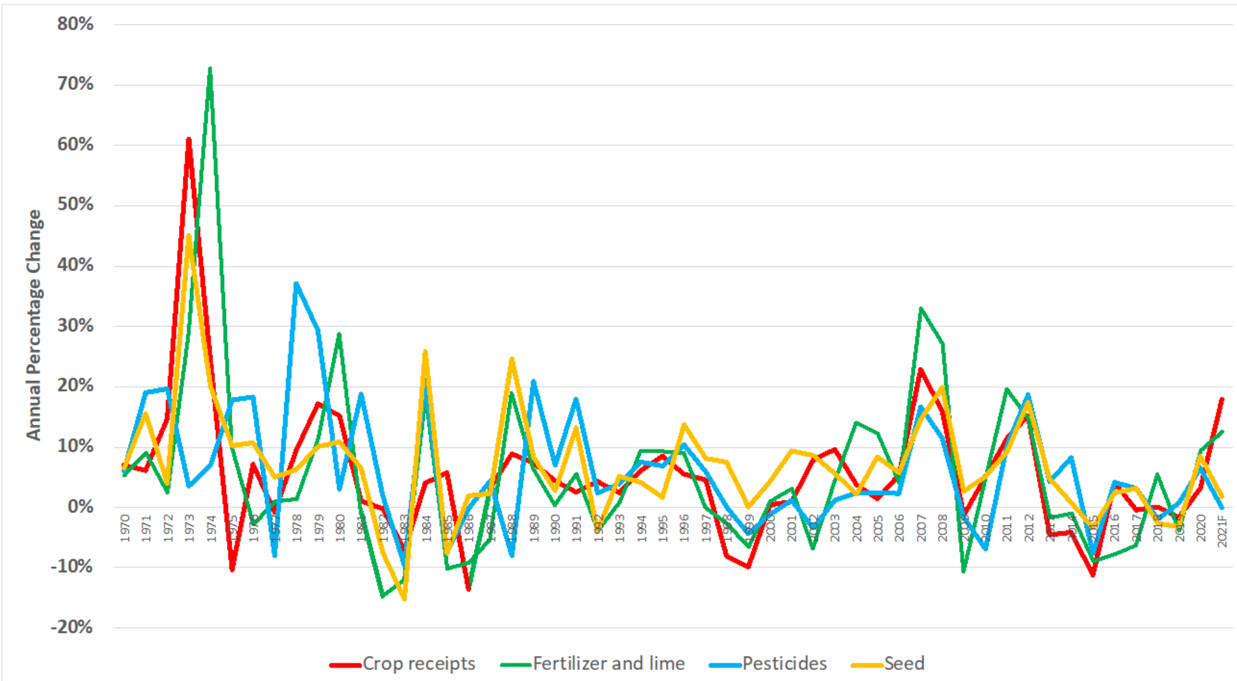

Figure 1. Percentage Change in Annual U.S. Crop Receipts and Percentage Change in Fertilizer and Lime, Pesticides and Seed Expenditures, 1970 to 2021.

1 https://thefertilizerinstitute.sharepoint.com/Govt%20Affairs/Forms/AllItems.aspx?id=%2FGovt%20Affairs%2FTransportation%2FCongressional%20Testimony%20and%20Statements%2FHAC%20Nov%202021%2FTFI%20Statement%20%28final%29%20%2D%20Food%20Supply%20Chain%20%2D%2D%20House%20Ag%20Committee%20110321%2Epdf&parent=%2FGovt%20Affairs%2FTransportation%2FCongressional%20Testimony%20and%20Statements%2FHAC%20Nov%202021&p=true

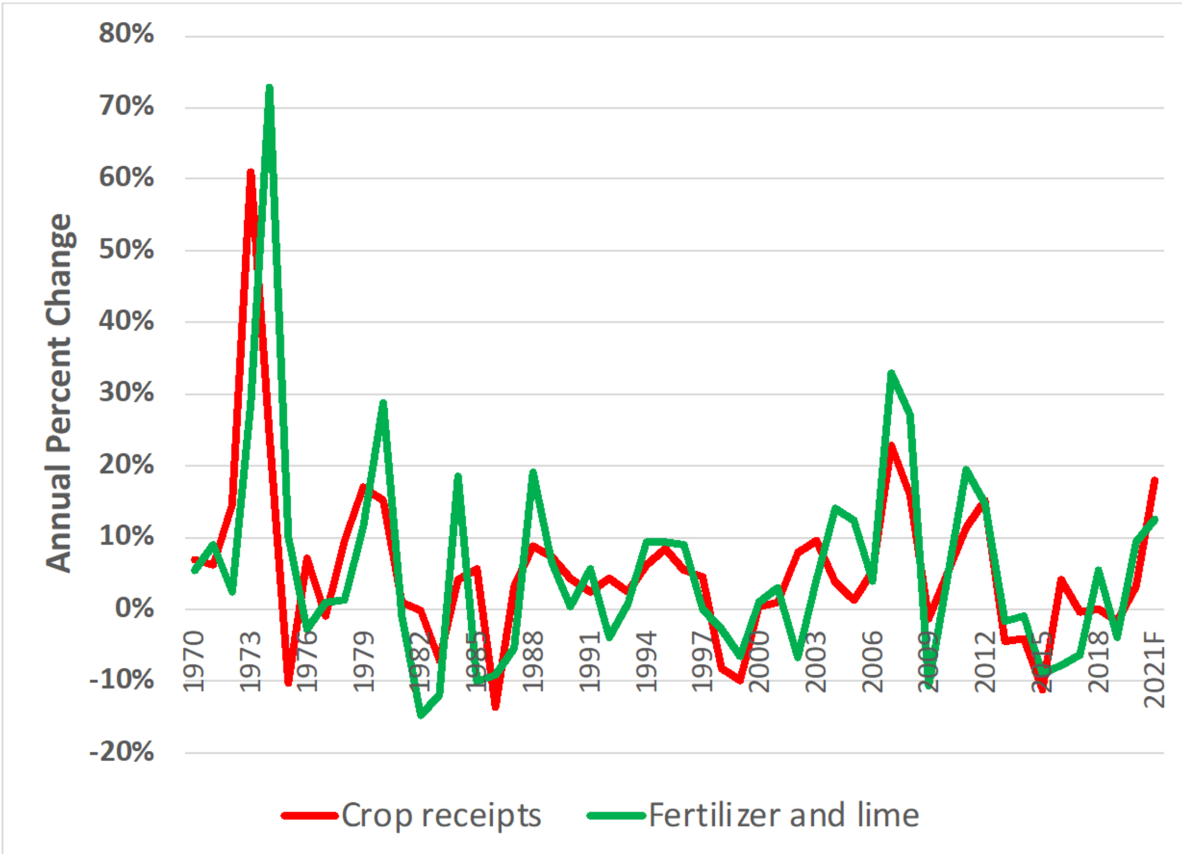

Figure 2. Percentage Change in Annual U.S. Crop Receipts and Percentage Change in Annual Fertilizer and Lime Expenditures, 1970 to 2021.

Source: USDA-ERS Commodity Costs and Returns Data

Fertilizer is an important input in U.S. agricultural production. According to USDA, fertilizer use by U.S. producers peaked in 1981 at 23.7 million tons.[2] Since that time, fertilizer use has experienced annual volatility with no persistent trend. Of the three primary nutrients in commercial fertilizer, nitrogen accounts for more than 50 percent of total use by weight (Figure 3). Recent fertilizer price increases across all three primary nutrients have caused significant concern among producers with particular concern about nitrogen prices due to the amount typically applied. Notice the modest decline in nitrogen, potash and phosphate individually in 2008 results in a significant drop in overall fertilizer use across all products in Figure 3.

[2] https://www.ers.usda.gov/data-products/fertilizer-use-and-price/summary-of-findings/

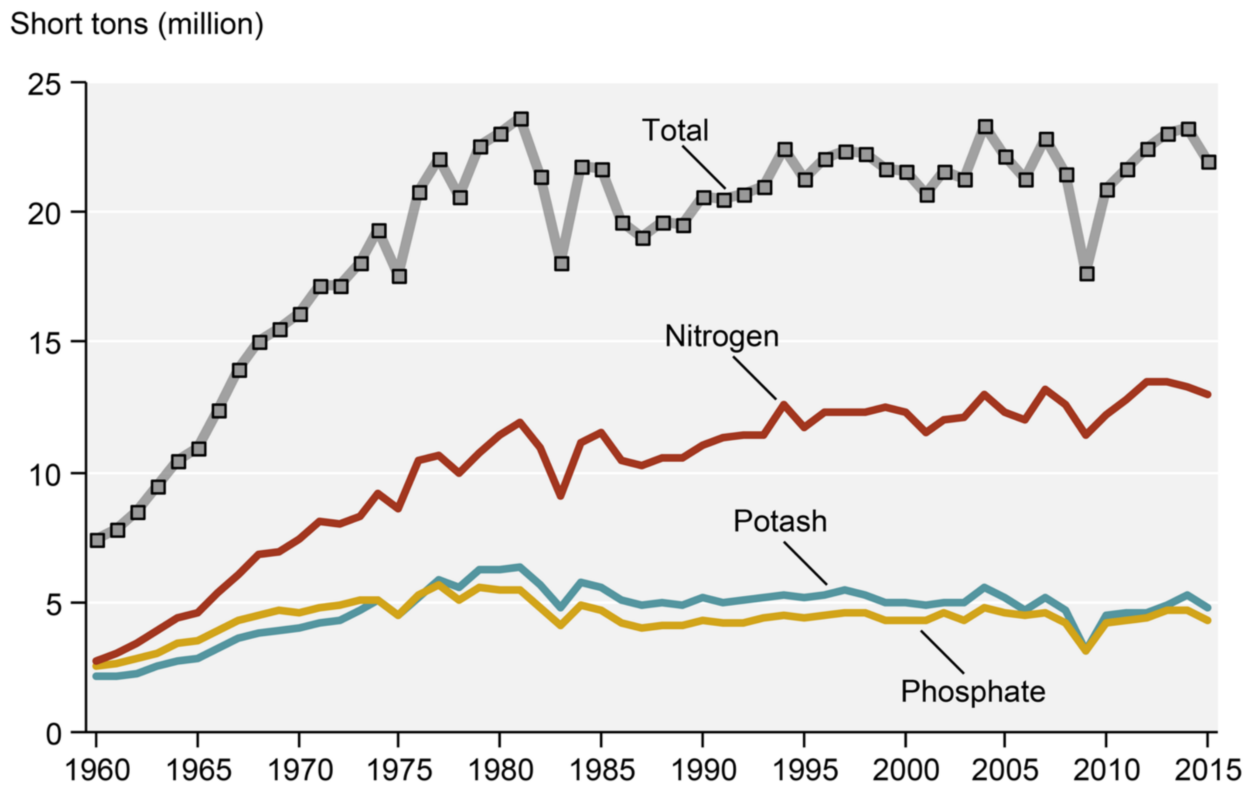

Figure 3. Commercial Fertilizer Use in U.S. Agriculture by Primary Nutrient, 1960 to 2015.

Source: USDA, ERS, Fertilizer Use and Price, https://www.ers.usda.gov/data-products/fertilizer-use-and-price/summary-of-findings/

Over the past year, U.S. nitrogen prices have increased substantially. Figure 4 contains an average of four spot anhydrous ammonia prices (AA) for the Corn Belt, South Central, New Orleans and Southern Plains regions reported on the last trading day of each month by Bloomberg. Two significant price peaks stand out during that period, July 2008 and 2021. U.S. AA prices fell to $226.50/ton in June 2020 before steadily increasing to $432.50/ton in February 2021. In one month (March 2021), AA prices increased 34% to $580/ton. Since that time, prices have steadily risen to $1,022.50/ton by October 2021 – the highest levels since 2008.

Figure 5 provides a near-term look at four different nitrogen products. Most nitrogen fertilizer is produced via the Haber-Bosch process, which generates ammonia nitrate.[3] The other, more stable, nitrogen products are then produced using ammonia nitrate, so it is no surprise that the prices of all nitrogen products closely track one another.

[3] https://www.choicesmagazine.org/choices-magazine/submitted-articles/the-history-consolidation-and-future-of-the-us-nitrogen-fertilizer-production-industry

Figure 4. U.S. Monthly Average Anhydrous Ammonia Prices, January 2019 to October 2021.

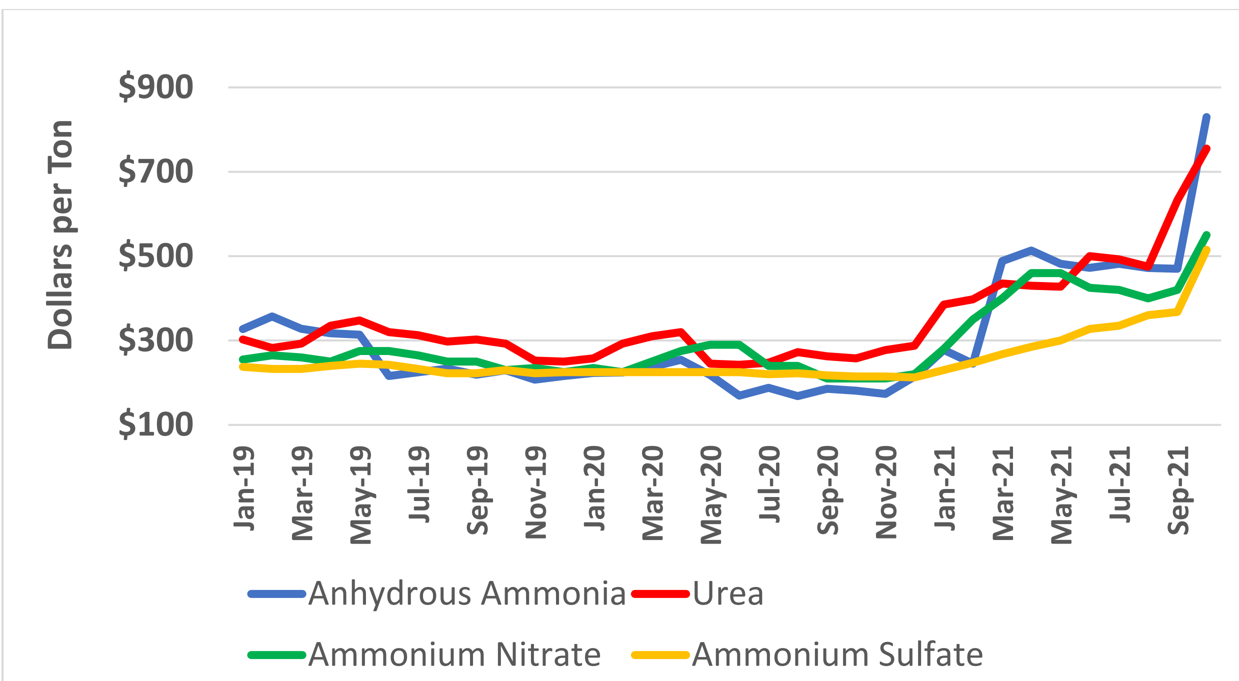

Figure 5. Monthly Nitrogen Prices, January 2019 to October 2021.

Historical Overview of U.S. Nitrogen Market

Nitrogen is the most abundant element in the Earth's atmosphere, making up approximately 78% of the air we breathe, so it is essentially unlimited in elemental form; however, the gaseous element must undergo a transformation called nitrogen fixation to become available to plants. This process, on an industrial scale, is the production of ammonia and is heavily dependent on natural gas as a feedstock. Nitrogen is an essential nutrient for plant growth with no viable substitute. In the U.S., ammonia is applied as nitrogen fertilizer directly as anhydrous ammonia (AA) and indirectly as related products such as urea, ammonium nitrate (AN), nitric acid (NA), ammonium phosphates (AP), and ammonium sulfate (AS) (listed from greatest to least importance).

Most domestic ammonia is produced in the U.S. by international companies and is consumed domestically; however, a portion of the U.S. ammonia demand is met through imports. This dependence on imports has experienced a steady decline over recent years (from 27% in 2016 to an estimated 10% in 2020). Major imported sources of ammonia to the U.S. come from production facilities in Trinidad and Tobago (65 percent of imports over the 2016-2019 period), Canada (30 percent of imports), and Venezuela (3 percent of imports); all other nations combined accounted for the final 2 percent of imports to the U.S.[4] Also noteworthy, a relatively small amount of domestic production is exported. U.S. imports and exports of ammonia may appear minor, especially when compared to domestic production and consumption; however, it is significant on a global scale relative to other ammonia importing and exporting countries.

The U.S. ranked ninth among ammonia exporters in 2019; that same year, the U.S. was the second largest global importer of ammonia. Also in 2019, the U.S. ranked second in the world in urea imports.[5]

Figure 6 illustrates actual U.S. production, imports, exports, ending stocks, and derived consumption of ammonia, 88 percent of which is used for nitrogen fertilizer, from 2016-2019 along with estimated values for 2020. The secondary (right vertical) axis of Figure 6 also indicates the reliance on foreign ammonia for 2016-2020 on a percentage basis.

[4] https://pubs.usgs.gov/periodicals/mcs2021/mcs2021.pdf

[5] https://nutrien-prod-asset.s3.us-east-2.amazonaws.com/s3fs-public/uploads/2020-10/Nutrien%20Fact%20Book%202020.pdf

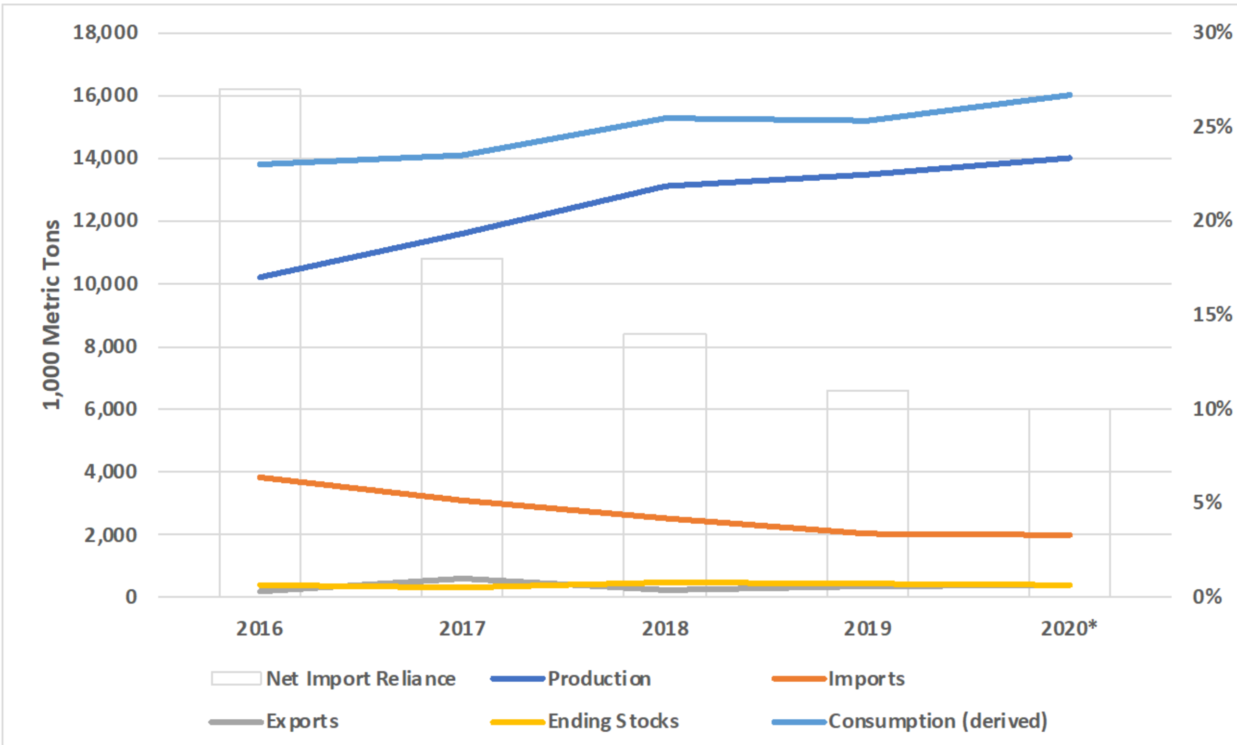

Figure 6. U.S. Ammonia Supply, Use, and Net Import Reliance (2016-2019 actual and 2020 estimated).

Source: https://farmdocdaily.illinois.edu/2021/02/synthetic-nitrogen-fertilizer-in-the-us.html and https://pubs.usgs.gov/periodicals/mcs2021/mcs2021.pdf

Between the 1980s and mid-2000s, declining fertilizer demand and higher fertilizer production input costs led to a contraction in the domestic fertilizer industry, evidenced by the decline from 59 to 22 facilities. The industry also experienced considerable consolidation as the number of firms dropped from 46 to 13.[6]

A few driving factors led to the resurgence in U.S. nitrogen fertilizer production in the mid-2000s. First, the increasing demand for ethanol due in part to the passage of renewable fuels policies amidst record world oil prices increased the demand for corn for use as a feedstock in ethanol production. Increased demand for corn, in turn, led to increased demand for nitrogen fertilizer by corn producers. Additionally, improvements in extraction methods such as hydraulic fracturing technology and horizontal drilling led to a decline in the price of natural gas. Natural gas has, in the past, accounted for as much as 70-90% of variable production costs

[6] https://www.choicesmagazine.org/choices-magazine/submitted-articles/the-history-consolidation-and-future-of-the-us-nitrogen-fertilizer-production-industry

for nitrogen fertilizer. Despite the renewed growth within this sector, market consolidation continued. By 2019, the four-firm concentration ratio was approximately 75% for total domestic nitrogen fertilizer production, indicating that four manufacturers (CF Industries, Nutrien, Koch, and Yara-USA) operating 32 plants in 17 states account for about three-fourths of the domestic nitrogen fertilizer production.

The four-firm concentration ratios for livestock slaughter were compiled from USDA-ERS and USDA-GIPSA reports and summarized by the Institute for Agriculture and Trade Policy; these data demonstrate the magnitude of consolidation in these sectors. Data from 2015, the last year these reports were produced, are displayed in Table 1. Also included in the table are four-firm concentration ratios for proprietary seed sales and nitrogen fertilizer. By 2018, four firms (DowDupont, Chemchina, Bayer and BASF) accounted for over 60 percent of proprietary seed sales around the globe. For corn seed specifically, the largest four firms controlled 85 percent of global sales, with two (DowDupont and Bayer) controlling 78 percent of the corn seed market. A review of the statistics reveals that concentration of market power is evident across many agricultural sectors.

Table 1. Four-firm Concentration Ratios for Various Agricultural Sectors.

Category	Year	Concentration
Livestock Slaughter, Total	2015	68%
Steers & Heifers	2015	85%
Cows & Bulls	2015	57%
Sheep & Lambs	2015	57%
Hogs	2015	66%
Nitrogen Fertilizer	2019	75%
Proprietary Seed	2018	60%
Corn Seed	2018	85%

Sources: https://www.choicesmagazine.org/choices-magazine/submitted-articles/the-history-consolidation-and-future-of-the-us-nitrogen-fertilizer-production-industry, https://civileats.com/2019/01/11/the-sobering-details-behind-the-latest-seed-monopoly-chart/, https://www.iatp.org/sites/default/files/2020-04/03_CBD_Corporate%20Concentration_web_0.pdf

In fact, Bekkerman, Brester and Ripplinger conclude that:

> "In 2018, the industry's Herfindahl–Hirschman Index (HHI) was 2,387. The Department of Justice and Federal Trade Commission consider a market to be moderately concentrated if the sector's HHI is between 1,500 and 2,500, and highly concentrated if an HHI exceeds 2,500 (U.S. Department of Justice, 2010[7])…. The assumption is that highly concentrated industries

[7] U.S. Department of Justice. 2021. Horizontal Merger Guidelines. Available online at https://www.justice.gov/atr/horizontal-merger-guidelines-08192010

are synonymous with the exercise of market power in which output prices are higher than marginal costs of production and are not representative of competitive equilibria."[8]

Do Nitrogen Prices React to Normal Supply/Demand Fundamentals?

As noted earlier, the industry states that natural gas accounts for 70-90% of variable production costs for nitrogen fertilizer. While not perfectly correlated, especially during 2010 to 2015, AA prices (described earlier) and natural gas prices (Henry Hub, Louisiana, spot prices) do tend to move together (Figure 7).

The suggestion that recent increases in the price of natural gas are the primary reason for recent increases in the prices of nitrogen products is highly suspect. For example, the price of AA increased $688 per ton from the end of 2020 through the end of October 2021. However, the increase in the value of the embedded natural gas accounts for only $102 (or 15%) of that increase. Figure 8 indicates that once the value of natural gas in a ton of AA has been subtracted from the AA price, the residual tends to closely track the price of corn, albeit on different scales. This close correspondence could be due to increased demand for nitrogen products as corn prices increase, or could be due to the exercise of market power by nitrogen product manufacturers and extraction of economic rents from corn producers. This residual is also presented in a bar graph in Figure 9. The intent of this brief analysis is to neither prove nor disprove either of those two explanations. But, it does raise serious questions and certainly helps explain the frustration producers are feeling

Figure 10 highlights the U.S. planted acreage to the major field crops (corn, soybeans, wheat, upland cotton, grain sorghum, barley, oats, rice, sunflowers, peanuts, sugar beets, sugar cane) and hay over time. Notice the planted acreage generally stays within a 10 million acre band except for 2019 when there was a significant amount of prevented plantings. The three periods of higher than average planted acreage were 2002, 2008 and 2013 to 2015. There were nitrogen price spikes in 2008 and 2013 to 2015. The planted acres in 2021 are considerably lower than acres that triggered previous nitrogen price increases, even as domestic production of nitrogen products has increased.

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[8] Anton Bekkerman, Gary W. Brester and David Ripplinger. "The History, Consolidation, and Future of the U.S. Nitrogen Fertilizer Production Industry." CHOICES, Vol. 35, Quarter 2, July 8, 2020, pp. 1-7. https://ageconsearch.umn.edu/record/304123?ln=en

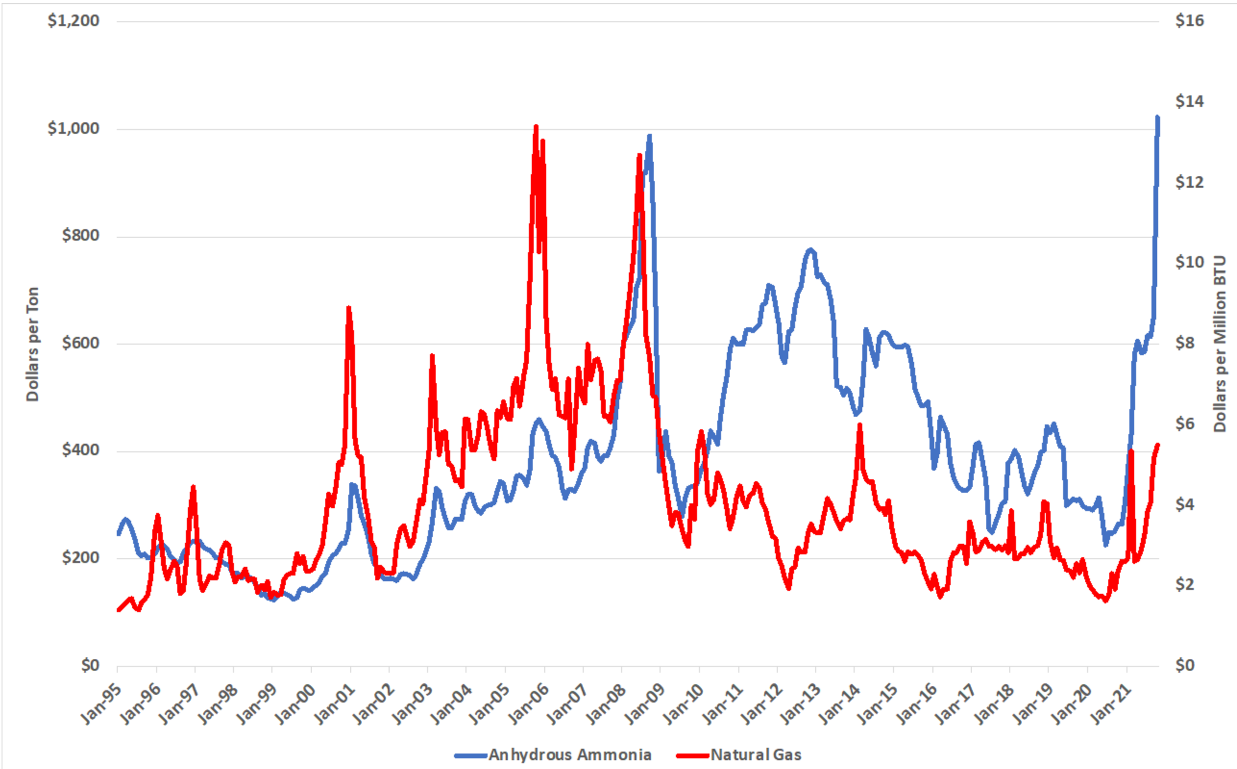

Figure 7. Anhydrous Ammonia and Natural Gas Prices, January 1995 to October 2021.

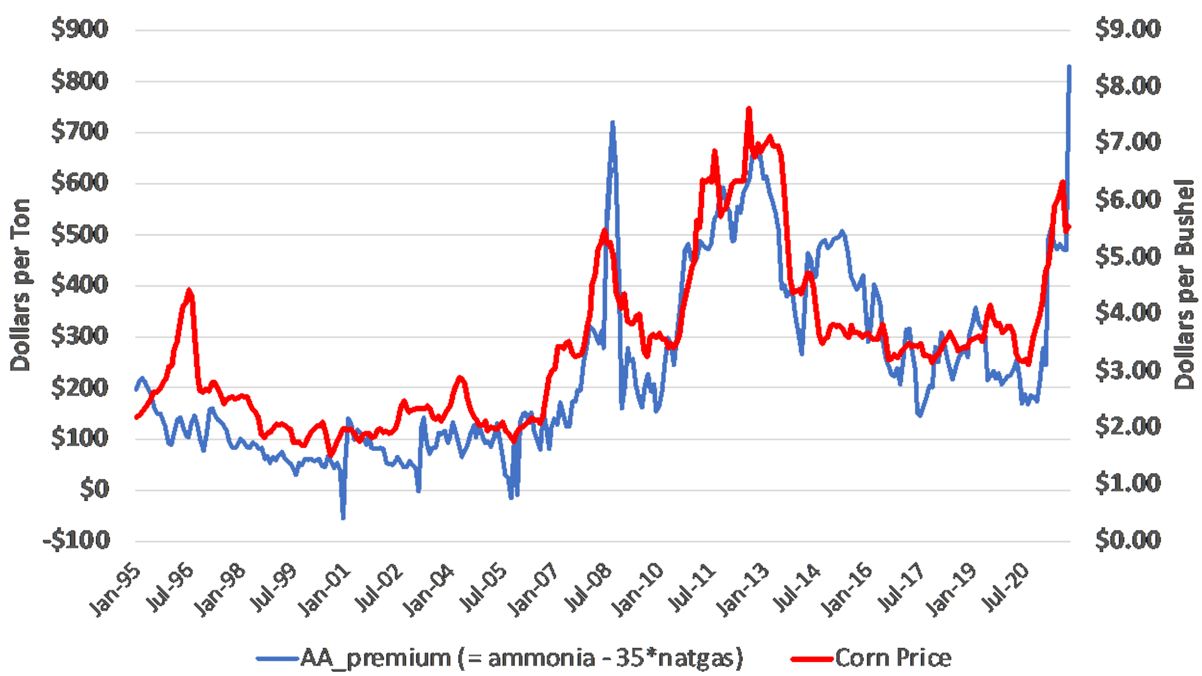

Figure 8. Anhydrous Ammonia price less the value of natural gas and U.S. corn prices, January 1995 to October 2021.

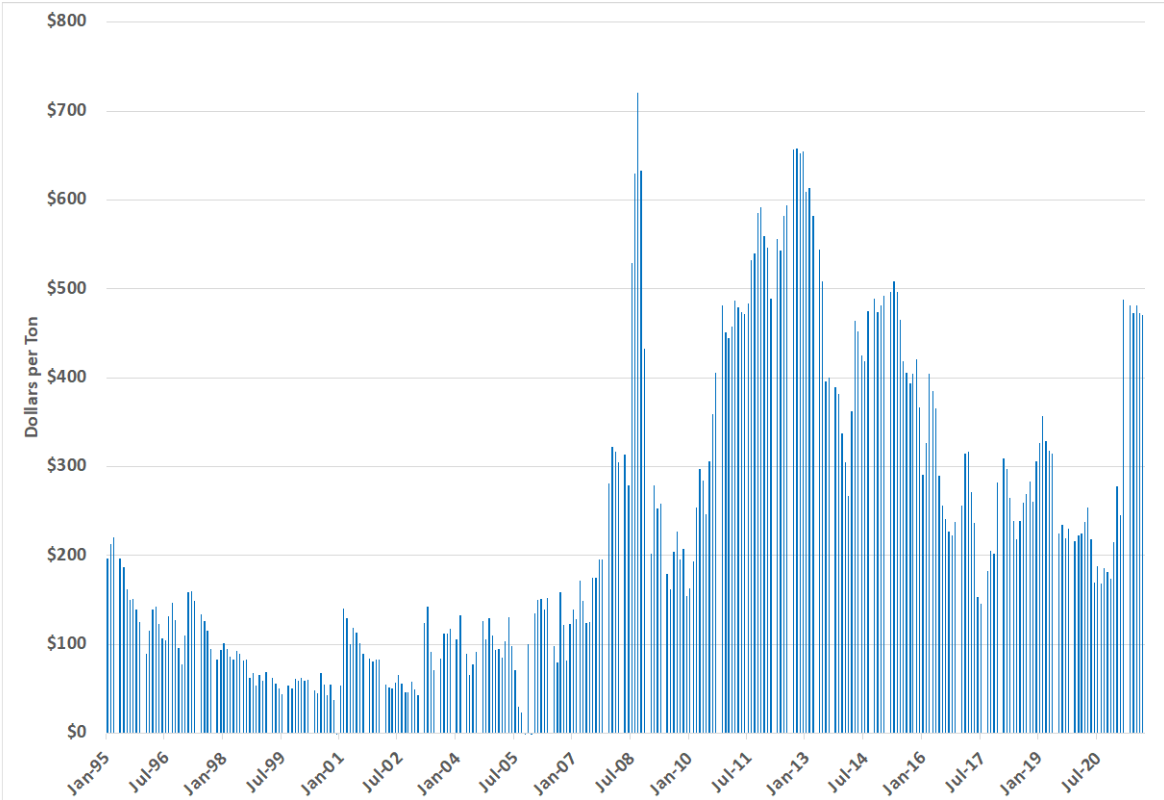

Figure 9. Residual After Subtracting Value of Natural Gas from AA Prices, January 1995 to October 2021.

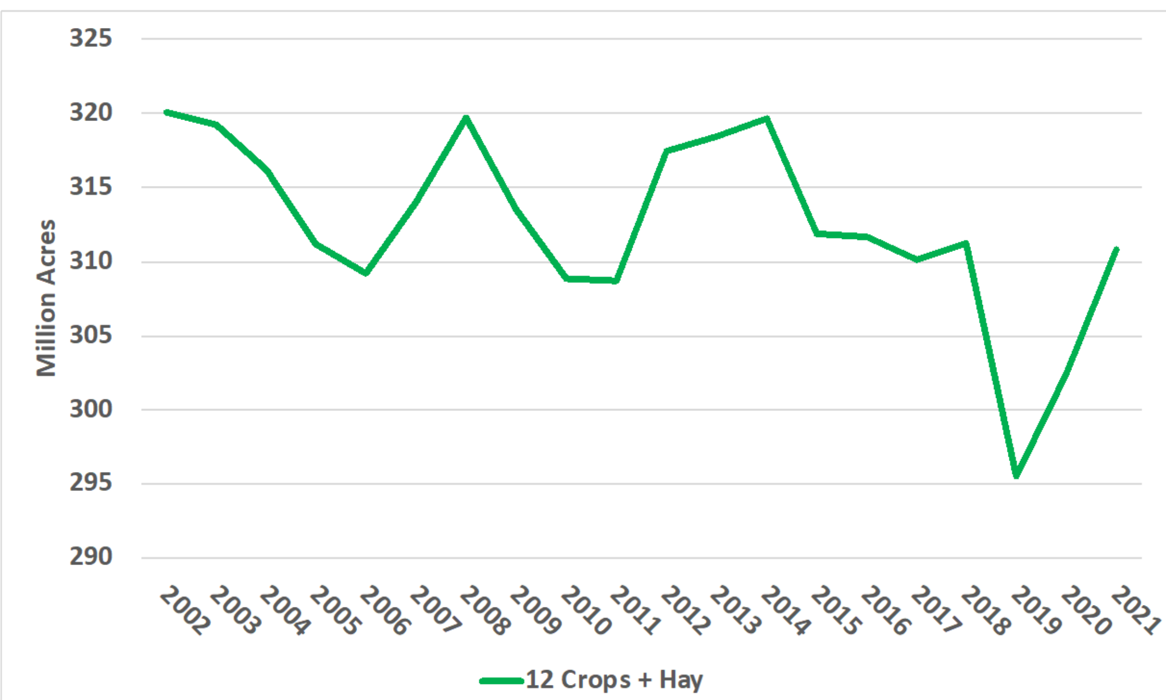

Figure 10. Planted Acres of 12 Primary Row Crops and Hay, 2002 to 2021.

What is the Impact of Higher Nitrogen Prices on Farms Producing Corn?

Fertilizer is a major cost for corn producers with nitrogen accounting for more than 50 percent of the cost. Figure 11 shows the estimated total fertilizer cost per planted acre for nine commodities taken from 2020 USDA cost and returns estimates. Corn has the highest fertilizer cost at $117 per acre followed by rice ($97 per acre) and peanuts and cotton ($68 per acre). The other five crops all spend less than $45 per acre, with soybeans the lowest ($31 per acre) due to little or no nitrogen fertilizer applied.

Fertilizer costs for corn (36%) account for the highest percentage of operating costs across the nine commodities followed by wheat (35%), oats (32%), grain sorghum (30%), and barley (27%). This means that over one-third of corn and wheat operating costs are directly attributed to highly volatile fertilizer prices.

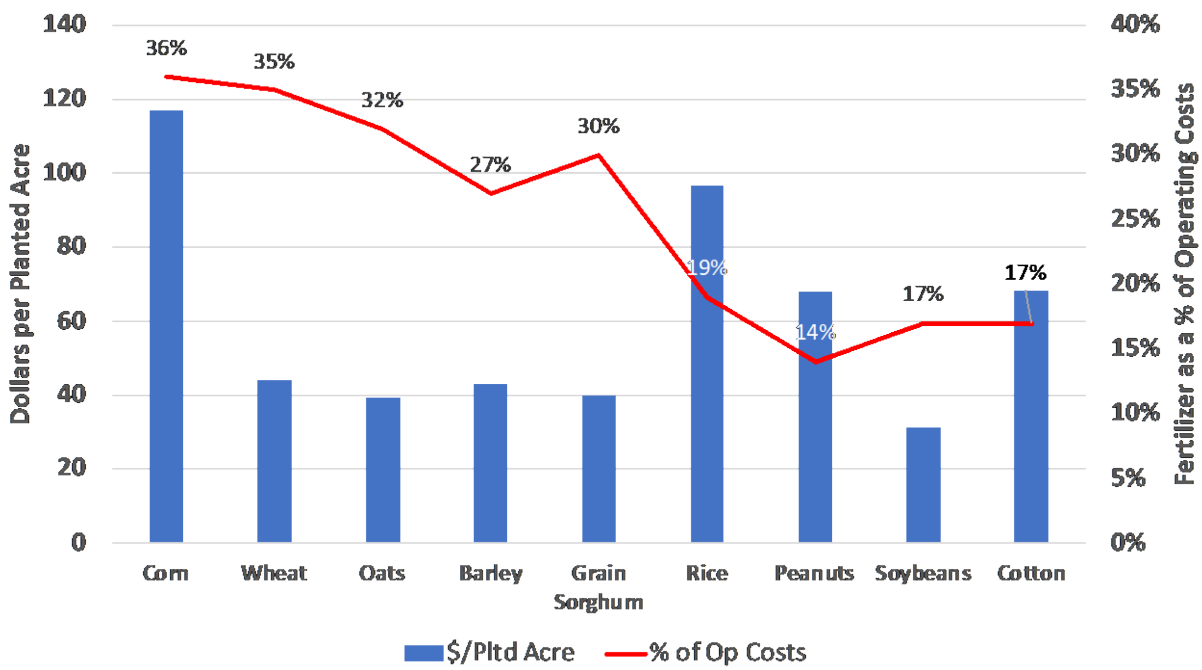

Figure 11. Fertilizer Costs per Planted Acre and Fertilizer Costs as a Percent of Operating Costs for Major U.S. Crops.

Source: USDA-ERS Commodity Costs and Returns data for 2020.

<u>Representative Farm Analysis</u>

As indicated earlier, AFPC has been requested to analyze the impacts of higher nitrogen prices on all 64 representative crop farms by a member of Congress. That analysis will be completed by the end of December, with the results made available to the public after submitting them to the requester. Below is an aggregate look at the impacts of higher nitrogen costs on corn farms.

AFPC has 64 crop farms located in 21 states in our representative farm dataset. Of these, there are 25 feedgrain and oilseed farms, 11 wheat farms, 13 cotton farms, and 15 rice farms categorized by the commodity with the highest gross receipts. In addition to the 25 feedgrain farms that all produce corn, there are 6 wheat farms, 10 cotton farms, and 5 rice farms that also grow corn.

Based on currently available data, the increase in nitrogen prices appears to be 81 percent higher for the 2022 crop than previous estimates. The 46 representative crop farms that grow corn were analyzed using AFPC's simulation model for the 2022 crop year. The results indicate an average increase in nitrogen costs of $52.07 per acre across the 46 farms growing corn. This would translate into roughly $0.32/bushel that corn farmers would need from the market or government to offset the higher nitrogen price.

A reactionary response might be for some to scale back their nitrogen fertilizer application against the backdrop of skyrocketing prices; however, in face-to-face meetings with producers, most have indicated this is simply not feasible. Producers are keenly aware of the yield necessary to break even at current commodity prices. Reducing nitrogen application and expenses, thus directly resulting in lower crop yields, is simply not the prudent management decision for attempting to lower costs of production. This might be a time for producers to look to other nutrient sources (such as manure or other alternatives), to more closely manage and monitor available nutrients already banked in the soil, or to possibly implement variable rate fertilizer (VRF) application methods. Unfortunately, these practices have already been adopted by many, and there is simply no fat left to trim in their nutrient management strategies.

Likely Effects of Import Taxes

In the very highly respected Journal of the Association of Environmental and Resource Economists, UC Berkely economist James Bushnell and UC Davis economist Jacob Humber (2017) investigate the relationship between North American natural gas and AA prices, and how that relationship has evolved over time.[9] They identify a statistically significant structural break in 2010. Before 2010, about 80% of changes in the natural gas price were passed through to the AA price. Since 2010, however, they find no significant pass through. That is, since 2010, natural gas and AA prices have been decoupled. This decoupling has direct implications for the potential effects of an AA import tax. From their paper:

[9] James Bushnell and Jacob Humber, "Rethinking Trade Exposure: The Incidence of Environmental Charges in the Nitrogenous Fertilizer Industry," Journal of the Association of Environmental and Resource Economists, vol. 4, no. 3 (September 2017), pp. 857-894.

> "Two market conditions that would be consistent with a finding of limited pass-through are the presence of binding capacity constraints on domestic production and an increase in market power by domestic suppliers. In both cases, domestic prices would be set by higher cost imported ammonia."

They go on to show that, because in this situation prices are determined on the margin by imports, a carbon tax of $20 per ton of CO2 equivalent ($30.63 per ton of AA) on imported AA would raise domestic prices for AA by that full amount. The motive for the tax is not important here. Any import tax on nitrogen fertilizers would raise prices for both domestically produced and imported fertilizer by the full amount of the tax rate multiplied by the pre-tax price.

The proposed tariffs are ten percent on UAN from Russia and 2 percent on UAN coming from Trinidad & Tobago. The marginal cost of imported and domestically produced nitrogen fertilizers will be set based on the higher rate (10%). Based on prices as of the end of October, a 10% tax on imported UAN would imply an additional increase in prices paid by farmers of $102.25 per ton. At roughly 8 acres per ton, that would translate into an additional $12.78 per acre nitrogen costs for all farmers.