

Concentration and Competition in the U.S. Fertilizer Industry

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Between September 2021 and April 2022, anhydrous ammonia prices in the United States more than doubled, topping out at a record-high \$1,300/ton. At the time, Senator John Boozman, Ranking Member of the Senate Committee on Agriculture, Nutrition, and Forestry, asked the Agricultural & Food Policy Center (AFPC) at Texas A&M University to analyze the impact of significant increases in input costs – particularly fertilizer costs – on farms and ranches across the United States.¹ While cost has since abated somewhat for most inputs, the spike in prices in 2022 renewed concerns about competition (or the lack thereof) in the fertilizer industry. As a result, Senators John Thune (R-SD) and Amy Klobuchar (D-MN) asked AFPC to provide an updated analysis of trends in the correlation between fertilizer costs and commodity prices, an overview of fertilizer price transparency, and the outlook for domestic fertilizer production capacity. The Senators also requested updated information about concentration levels in the fertilizer industry and policy considerations that could increase competition. This report was prepared in response to their request.

Overview of U.S. Nitrogen Market

Nitrogen is an essential nutrient for plant growth with no viable substitute. Elemental nitrogen is the most abundant element in the Earth’s atmosphere; however, it must undergo a transformation called nitrogen fixation to become available to plants. The industrial process of fixing nitrogen with hydrogen to produce ammonia, known as the Haber-Bosch process, is heavily dependent on natural gas as a feedstock.² Because of this, the price of nitrogen fertilizers is highly correlated to the price of natural gas. In the U.S., ammonia (as a nitrogen fertilizer) is directly applied as anhydrous ammonia and indirectly as derivative products such as urea, ammonium nitrate, nitric acid, ammonium phosphates, and ammonium sulfate (listed from most to least commonly used domestic nitrogen fertilizer products).

Most domestically consumed ammonia is produced in the U.S. by international companies; however, a portion of the annual U.S. ammonia demand is typically met through imports. The net reliance on imports has experienced a steady decline over recent years (from 30 percent in 2015 to an estimated 9 percent in 2022). The countries exporting ammonia to the U.S. and their relative importance as exporters to the U.S. have also shifted over the last few years. Production facilities in Trinidad and Tobago provided 58 percent of ammonia exports to the U.S. over the most recently reported 2018-2021 period (down from 66 percent of exports over the 2014-2017 period). Canada accounted for 40 percent of ammonia exports to the United States over the 2018-2021 timeframe (up from 23 percent of exports over the 2014-2017 period). In this most recent 2018-2021 period, Venezuela accounted for a mere one percent of ammonia exports to the United States (down from 4 percent over the 2014-2017 period). Over the 2014-2017 period, Russia also accounted for 4 percent of U.S. ammonia imports; however,

¹ For more information, see: <https://afpc.tamu.edu/research/publications/files/716/BP-22-06.pdf>.

² For more information, see: <https://www.choicesmagazine.org/choices-magazine/submitted-articles/the-history-consolidation-and-future-of-the-us-nitrogen-fertilizer-production-industry>.

from 2018-2021, all other nations combined (including Russia) accounted for only one percent of U.S. ammonia imports.³

Also noteworthy, a relatively small amount of domestic production is exported. At a glance, U.S. imports and exports of ammonia may appear minor, especially when compared to domestic production and consumption; however, the magnitude becomes more apparent when examined alongside other ammonia importing and exporting countries. The U.S. did not rank in the top 10 ammonia exporters in 2021, but, in that same year, the U.S. did surpass India as the largest global importer of ammonia. The U.S. also ranked third in the world in urea imports in 2021.⁴ Figure 1 illustrates actual U.S. production, imports, exports, ending stocks, and derived consumption of ammonia, 88 percent of which is typically annually used for nitrogen fertilizer, from 2014-2021 along with estimated values for 2022. The secondary (right) vertical axis of Figure 1 also indicates the reliance on foreign ammonia for 2014-2022 (on a percentage basis).

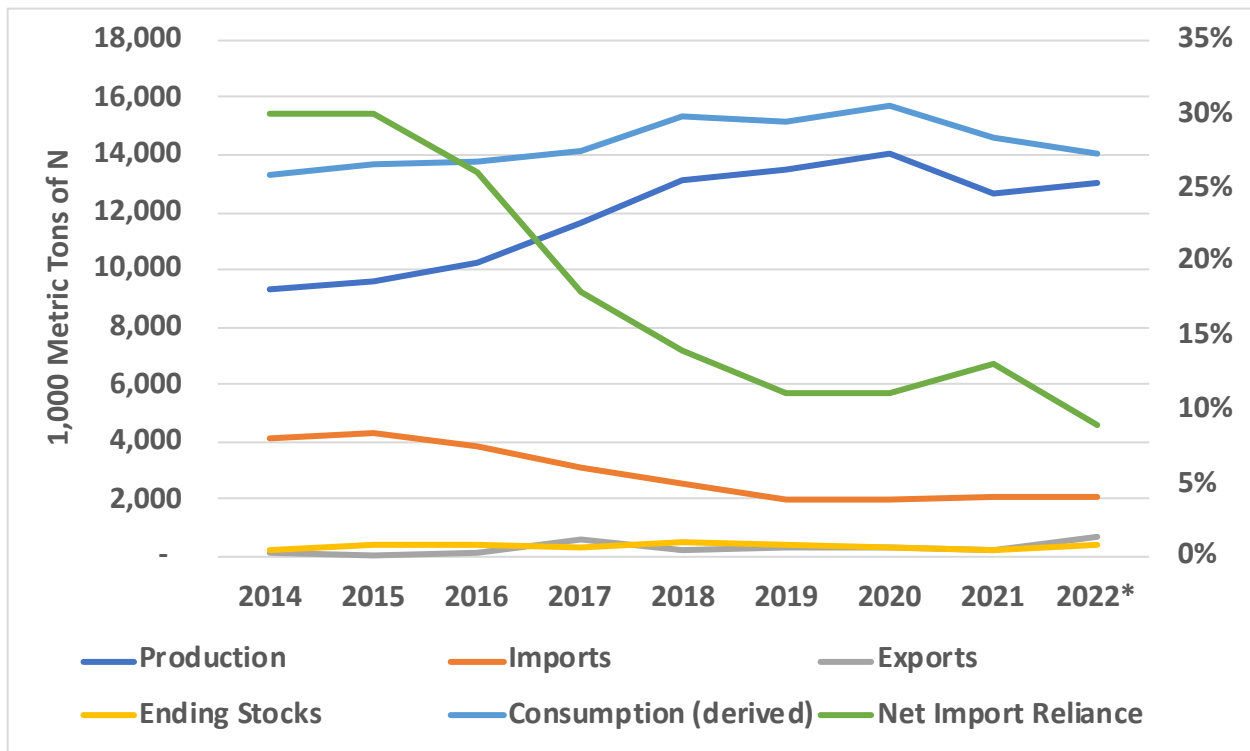


Figure 1. U.S. Ammonia Supply, Use, and Net Import Reliance (2015-2021 actual and 2022 estimated).

³ For more information, see: <https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-nitrogen.pdf>.

⁴ For more information, see: <https://nutrien-prod-asset.s3.us-east-2.amazonaws.com/s3fs-public/uploads/2022-06/Nutrien%202022%20Fact%20Book.pdf>.

Recent Trends

Over the past two years, U.S. nitrogen prices have experienced tremendous volatility. Figure 2 contains an average of select regional spot anhydrous ammonia prices reported on the last trading day of each month by Bloomberg. Also included are average regional monthly spot prices for urea, ammonium nitrate, and ammonium sulfate. As previously mentioned, almost all nitrogen fertilizer is produced via the Haber-Bosch process, which yields ammonia. The other, more stable nitrogen fertilizer products are then produced from ammonia, so it is no surprise that the prices of major nitrogen fertilizer products closely track one another, especially if adjusted based on nitrogen content (not shown). Because of corresponding movements between nitrogen fertilizer products, anhydrous ammonia prices will be the focus of the following discussion.

Two significant price peaks stand out during the study period: July 2008 and April 2022. U.S. anhydrous ammonia prices fell to \$226.50/ton in June 2020 before steadily increasing to \$650.75/ton in September 2021. In one month (October 2021), anhydrous ammonia prices increased another 57% to \$1,022.50/ton. Monthly prices continued to rise before reaching an all-time high of over \$1,300/ton in April 2022. Since that time, prices have shown a slow but steady return to more “normal” levels, dipping just below \$300/ton in June 2023. Bloomberg market data reveals an increase back to \$345/ton for anhydrous in July 2023, a level still over 50 percent higher than typical prices paid just three years earlier.

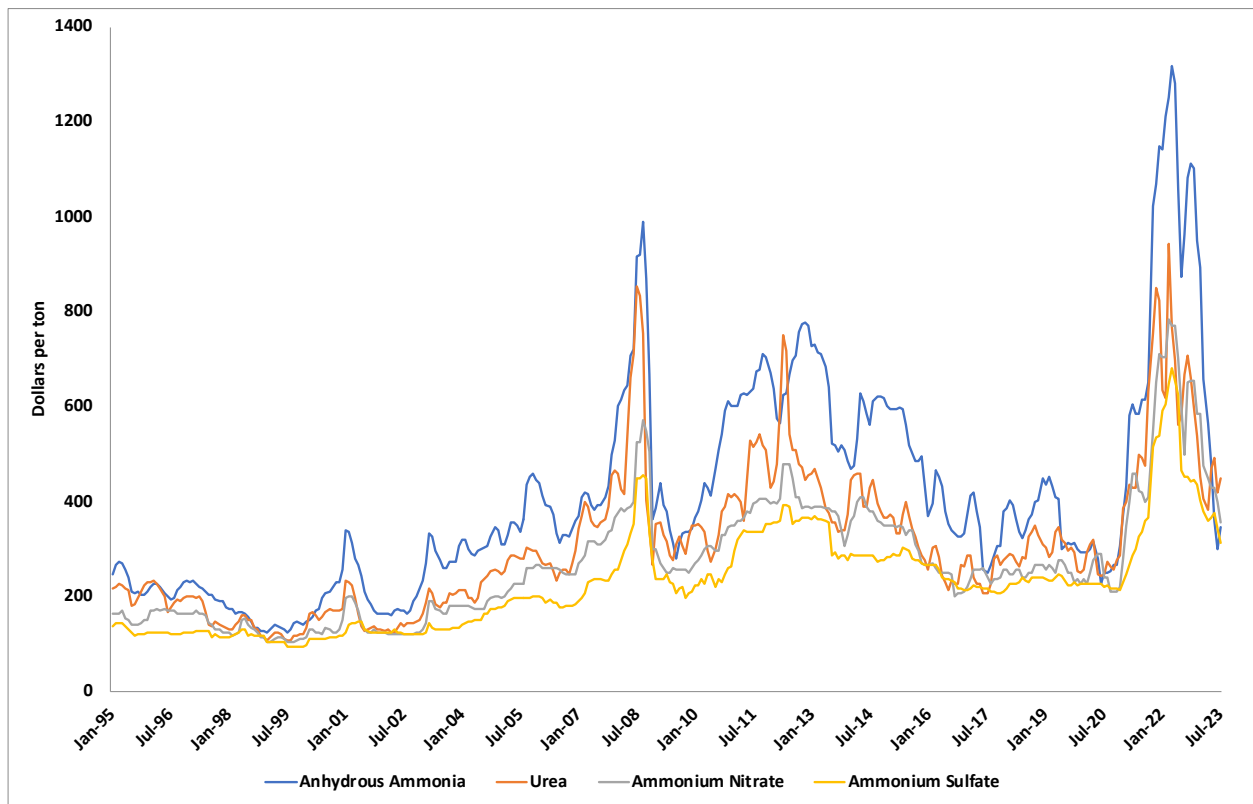


Figure 2. Monthly Prices for Select Nitrogen Fertilizer Products, January 1995 to July 2023.

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, particularly as observed over the 2010 to 2015 period, anhydrous ammonia prices (described earlier) and natural gas prices (Henry Hub, Louisiana, spot prices) do generally tend to move together (Figure 3).

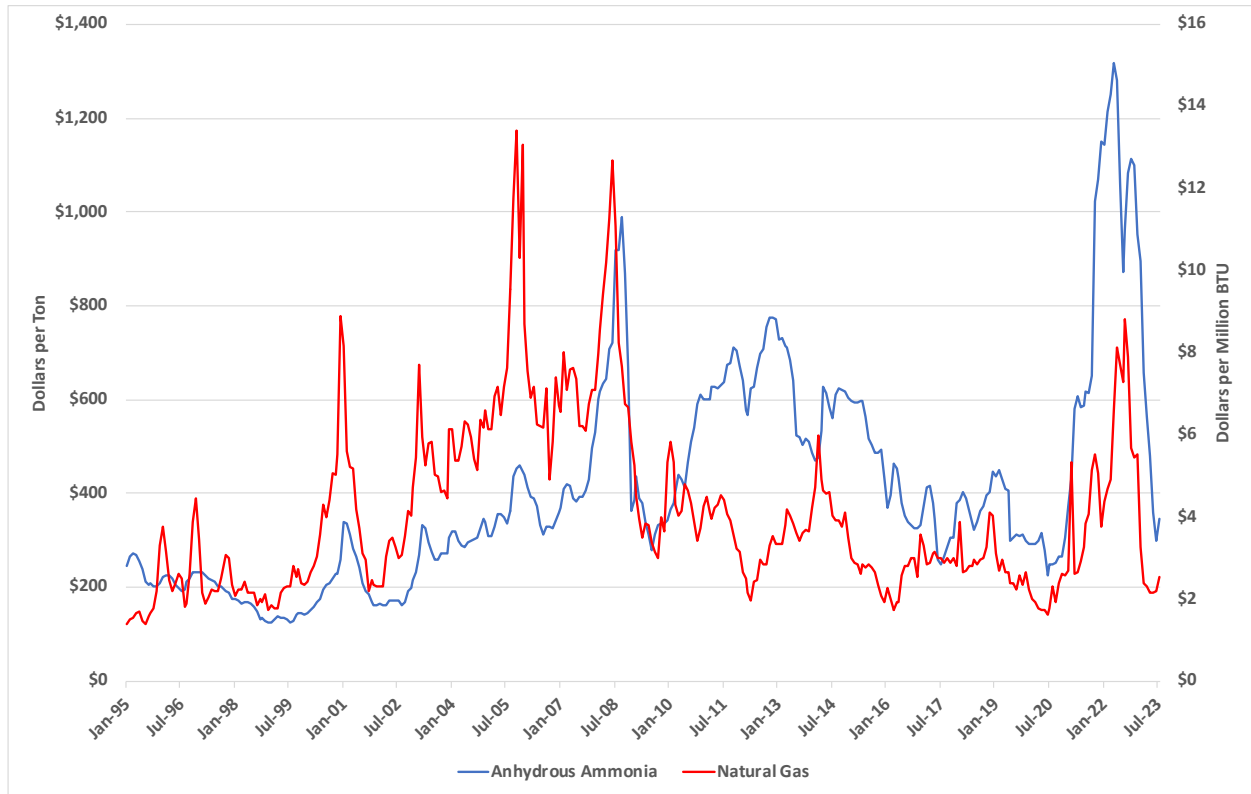


Figure 3. Anhydrous Ammonia and Natural Gas Prices, January 1995 to July 2023.

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 likely only part of the story. For example, the price of anhydrous ammonia increased over \$700 per ton from April 2021 to the same month in 2022 (a 118% increase); however, the increase in the value of the embedded natural gas accounts for only \$138 (19%) of that increase as the Henry Hub Natural Gas Spot Price increased from \$2.66 to \$6.60 (a 148% increase) over the same time horizon. Figure 4 indicates that once the value of natural gas in a ton of anhydrous ammonia has been subtracted from the anhydrous ammonia price, the residual tends to closely track the price of corn, albeit on different scales. These corresponding movements 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 crop producers. This residual is also presented in a bar graph in Figure 5. The intent of this brief analysis is to neither support nor refute either of those two explanations, as fertilizer markets are complex and have

many moving parts beyond the scope of this paper. However, breaking down the share of cost increases attributable to natural gas price changes does raise questions and certainly helps validate the frustration producers have felt during this tumultuous ride.

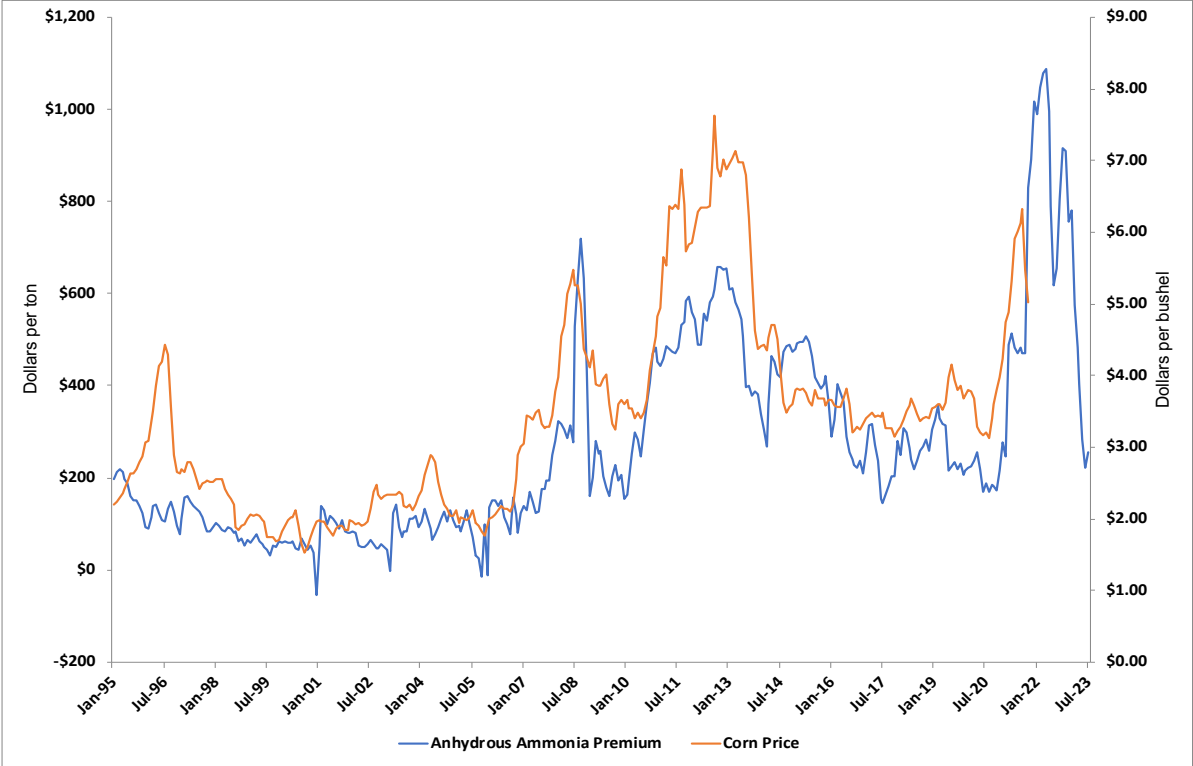


Figure 4. Anhydrous Ammonia price less the value of natural gas and U.S. corn prices, January 1995 to July 2023.

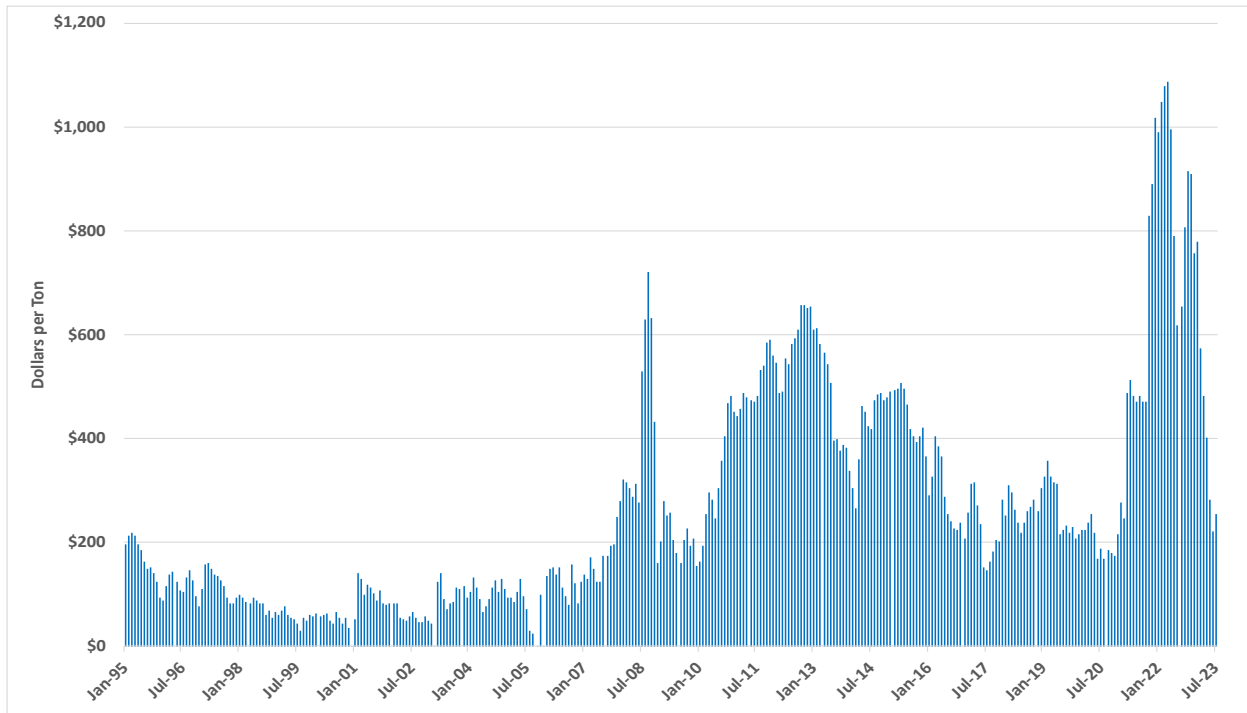


Figure 5. Residual After Subtracting Value of Natural Gas from Anhydrous Ammonia Prices, January 1995 to July 2023.

Figure 6 highlights the U.S. annual planted acreage to the major field crops (corn, soybeans, wheat, upland cotton, grain sorghum, barley, oats, rice, sunflowers, peanuts, and sugar beets) and harvested acreage of sugarcane 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 2003, 2008 and 2012 to 2014. Corresponding nitrogen price spikes were observed in 2008 and at least through part of the 2012 to 2014 period. The planted acres in 2021 are considerably lower than acres that corresponded with previous nitrogen price increases, especially considering that domestic production of nitrogen products has increased.

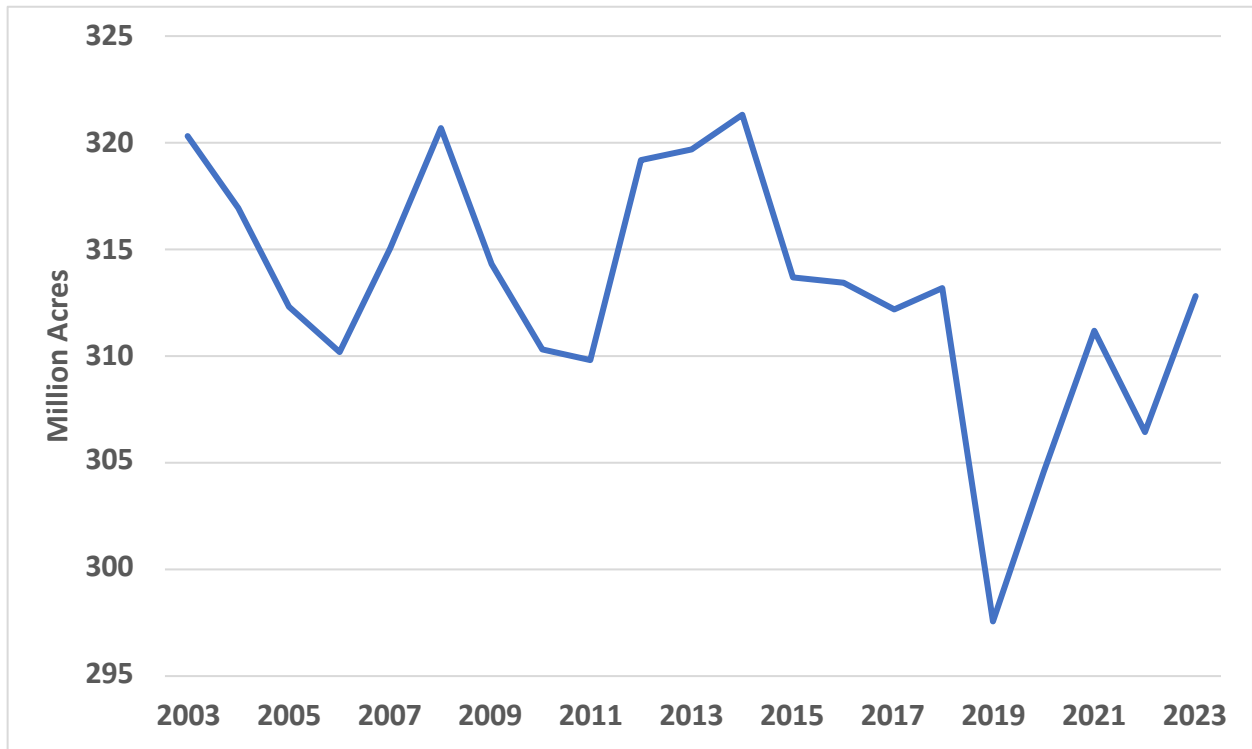


Figure 6. Planted Acres of 12 Primary Row Crops and Hay, 2003 to 2022 and 2023 estimated).

Policy Considerations

As noted above, factors like the price of natural gas – a significant input in the production of nitrogen fertilizer – appear to offer little by way of explaining the drastic increase in fertilizer prices in 2021 and 2022. Also, research has shown a significant level of concentration in the production of fertilizer, raising concerns about the potential for certain producers to exert market power. In addition, while price data exists, much of it is behind a paywall and the granular data needed to do the analysis to either refute or confirm claims of market power is not publicly available. These topics/concerns are discussed further in this section.

Concentration

There has long been concern about growing concentration in the agricultural input markets.^{5,6} Table 1 summarizes the four-firm concentration ratios for several different sectors in the agricultural industry. Livestock slaughter data were compiled from USDA Economic Research

⁵ <https://www.ers.usda.gov/amber-waves/2012/december/rising-concentration-in-agricultural-input-industries-influences-new-technologies/#:~:text=Consequences%20of%20Concentration%20For%20Agricultural,drive%20growth%20in%20agricultural%20productivity.>

⁶ Much of this section summarizing previous research was taken directly from “Economic Impact of Nitrogen Prices on U.S. Corn Producers” which was prepared by AFPC staff at the request of several state-level corn grower organizations.

Service (ERS) and the Grain Inspection, Packers and Stockyards Administration (GIPSA) reports and summarized by the Institute for Agriculture and Trade Policy; these data demonstrate the magnitude of consolidation in these sectors. 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 accounted for 85 percent of global sales, with two (DowDupont and Bayer) controlling 78 percent of the corn seed market. While Table 1 illustrates that the fertilizer industry is not unique in terms of market concentration, it is not immune either. For example, as noted in Table 1, the four-firm concentration ratio for total domestic nitrogen fertilizer production was approximately 75% by 2019, indicating that four manufacturers (CF Industries, Nutrien, Koch, and Yara-USA), operating 32 plants in 17 states, accounted for about three-fourths of the domestic nitrogen fertilizer production in the United States.

Table 1. Four-firm Concentration in 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%

Source: compiled from <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/>; and https://www.iatp.org/sites/default/files/2020-04/03_CBD_Corporate%20Concentration_web_0.pdf.

In fact, Bekkerman, Brester and Ripplinger concluded 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, 2010⁷).... The assumption is that highly concentrated industries 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

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

⁸ Anton Bekkerman, Gary W. Brester and David Ripplinger. “The History, Consolidation, and Future of the U.S. Nitrogen Fertilizer Production Industry.” Available at: <https://ageconsearch.umn.edu/record/304123?ln=en>.

AFPC was asked to provide a more updated picture on market concentration. The analysis that follows relies on Bloomberg Green Markets data, subscription-based data that provides a comprehensive accounting of virtually all firm and plant level fertilizer capacity in the United States and across the Globe – over 30 fertilizer firms (100+ plants) in the United States and 1000+ firms globally (1500+ plants). With this data, two measures of concentration were calculated:

- 1) Herfindahl-Hirschman Index (HHIs)—calculated as the summation of the square of each firm’s capacity share.
- 2) Four-firm Concentration (CR4)—calculated as the contribution of the top 4 firms’ capacities to the total.

Tables 2 and 3 summarize the concentration measures:

Table 2. Herfindahl-Hirschman Index (HHI) measure for Fertilizers by Geographic Scope

Geographic Scope	United States	North America	World
Potash	3,455	4,255	1,011
Nitrogen	2,382	2,242	368
Phosphate	4,553	4,533	152

Table 3. Four-firm concentration (CR4) measure for Fertilizers by Geographic Scope

Geographic Scope	United States	North America	World
Potash	100%	99%	84%
Nitrogen	77%	77%	13%
Phosphate	100%	100%	25%

Measures of concentration are sensitive to how geographic scope is defined. Fertilizers are a globally integrated market, with an estimated 44% of all fertilizer produced being traded. Fertilizer production is highly concentrated both within country (very few firms) and across countries (only a handful of countries dominating production). Given these factors, concentration measures were calculated according to different levels of geographic scope. Concentration measures are found to be very high when only including firms located in the United States. CR4 measures are as high as 100% for potash and phosphate and 77% for nitrogen. The country level geographic scope almost certainly gives the impression of less competitive pressure than exists because it ignores supply through trade. For instance, for phosphates, the U.S. CR4 only includes U.S. based Mosaic, Nutrien, JR Simplot, and Rafos, but does not include many of the large foreign firms like Moroccan OCP, which was an important supplier for the U.S. market (until countervailing duties were imposed).

When using the total amount of firms reported across all countries, the concentration measures are generally lower (CR4 measures below 25% for phosphate and nitrogen). Relying solely on globally-based measures is likely to give the impression of greater competitive

pressure than actually exists for several reasons. First, many countries that produce fertilizers do not export to the United States (due to non-competitiveness, shipping costs, tariffs, sanctions, etc.). Second, even for countries that do export to the United States, many of their firms are not engaged in trade. For instance, there are over 700 nitrogen fertilizer producing firms in China, but none supply the United States. Finally, the estimates of concentration do not include potential associations, partnerships, or other overlap between companies, so effective levels of concentration are likely higher.

Admittedly, this is a rough measure of concentration. Ideally the concentration measure would be adjusted according to trade activity. However, due to lack of availability of firm-level import data on fertilizers, trade data utilized is at the country level. This is illustrative in revealing the countries in which the respective products originate; however, there is a lack of detail regarding which companies within these countries are sourcing the products. Further, global trade is extremely volatile. For instance, the OCP (Morocco) supply of phosphates was eliminated due to the imposition of countervailing duties. Trade flows are generally quite volatile in response to supply and demand fluctuations and shifting across markets at both the country and firm level. Thus, attempting to identify which companies are supplying the U.S. while accounting for which periods they leave and enter would be very difficult, particularly on a sufficiently comprehensive level necessary to construct concentration measures. Finally, another added layer of complexity is the role of foreign affiliates. Mosaic, CF industries, and Nutrien have plants located all over the world. Many of these phosphate or nitrogen plants are set up abroad specifically to serve those regional markets.

Overall, the high levels of the HHI and CR4 measures for the United States and low levels for the world imply a high degree of sensitivity of fertilizer market performance (defined loosely as the extent to which market prices reflect production costs) to trade policy. Specific trade barriers may be warranted and prudent, but trade policy taken as a whole will influence the extent to which the United States benefits from lower global concentration.

Figures 7 and 8 provide the HHI and CR4 measures for fertilizers by geographic scope by year.

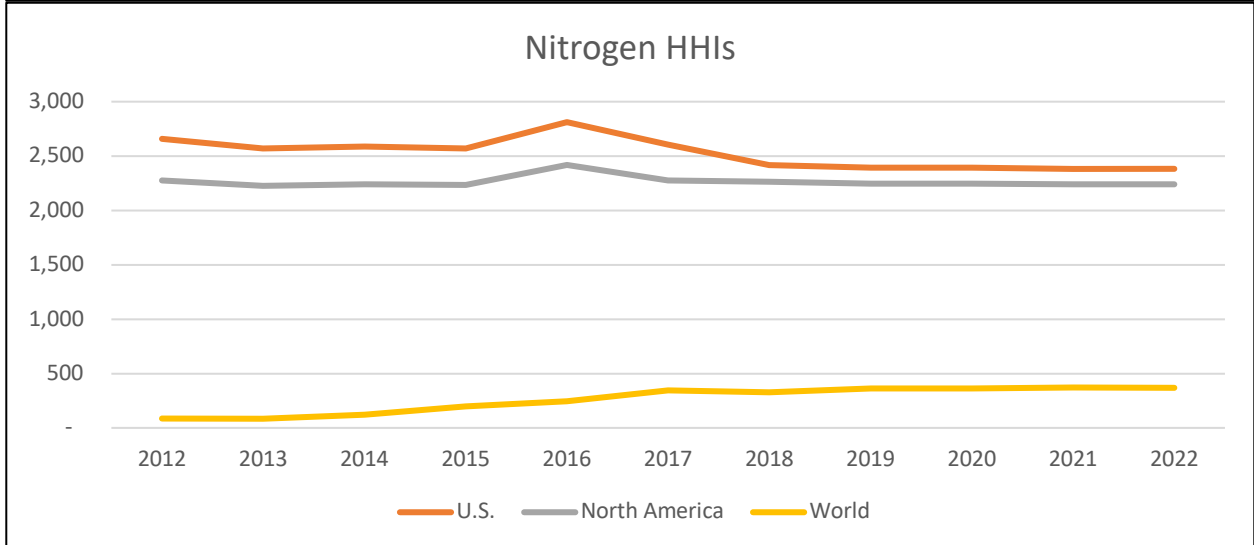
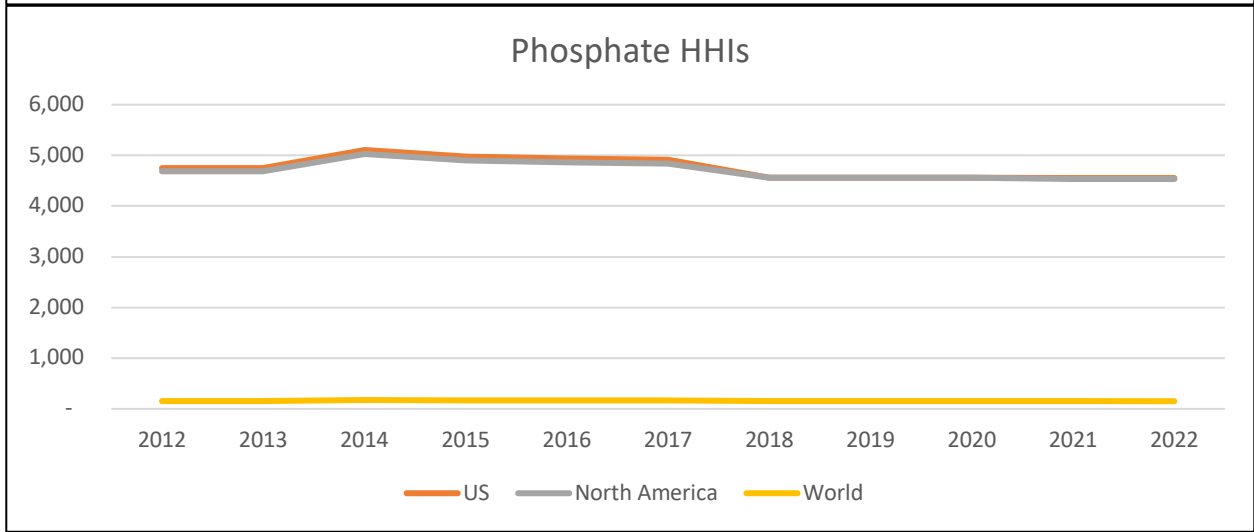
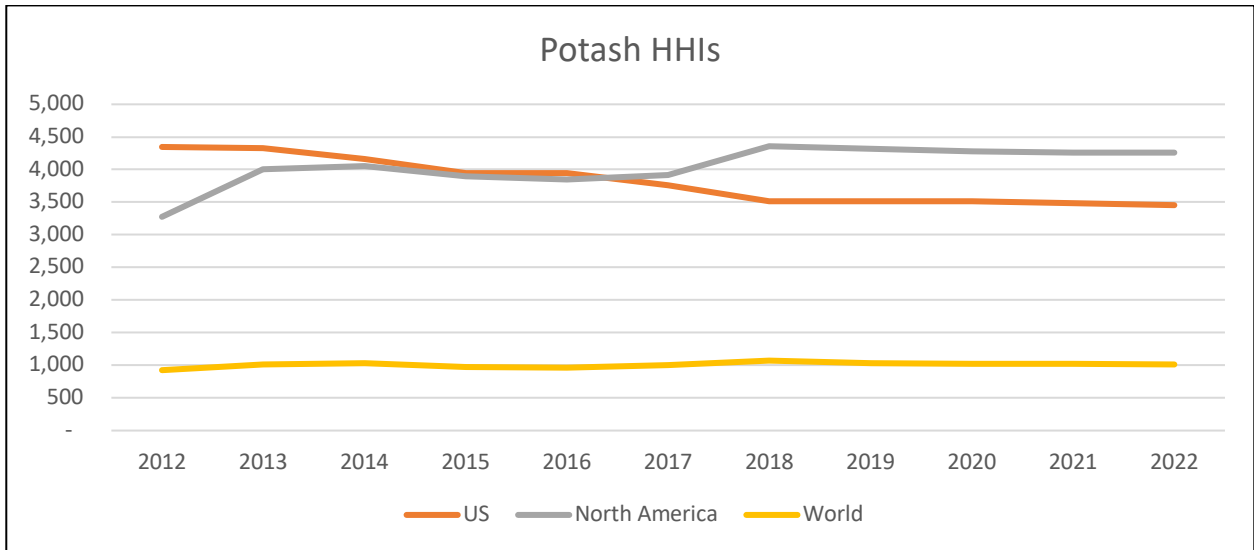


Figure 7. HHI Measures for Fertilizers by Geographic Scope by Year

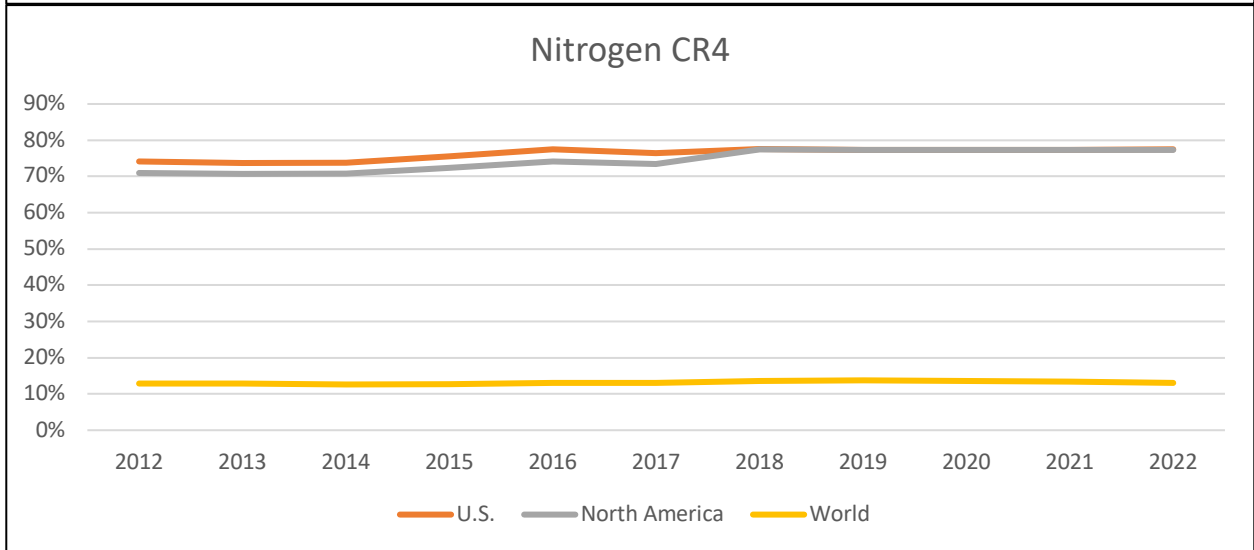
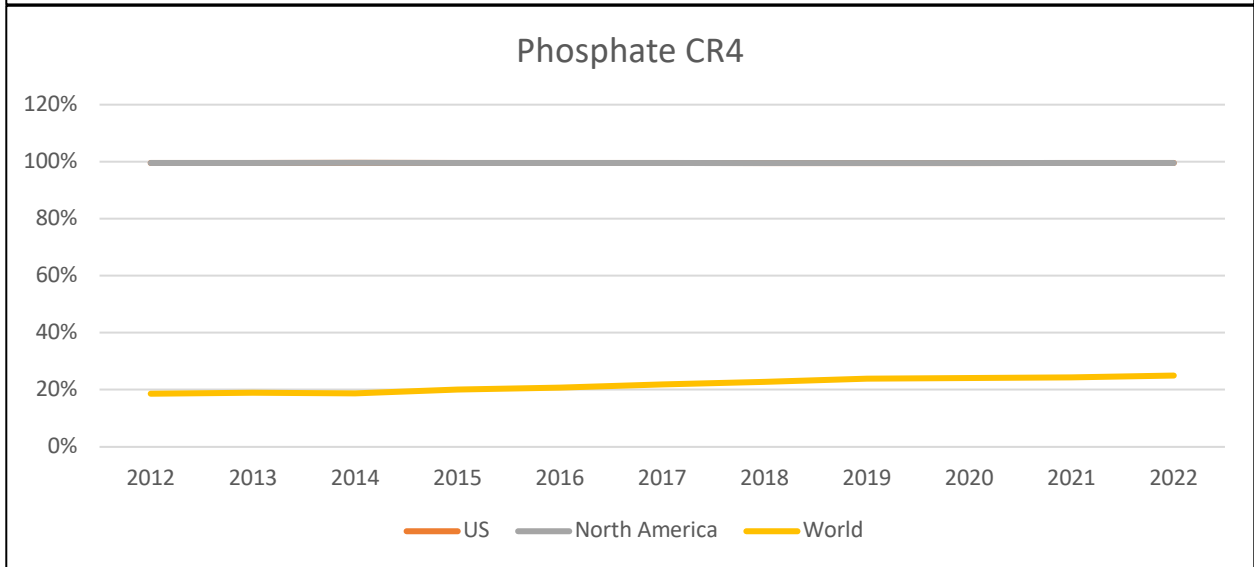
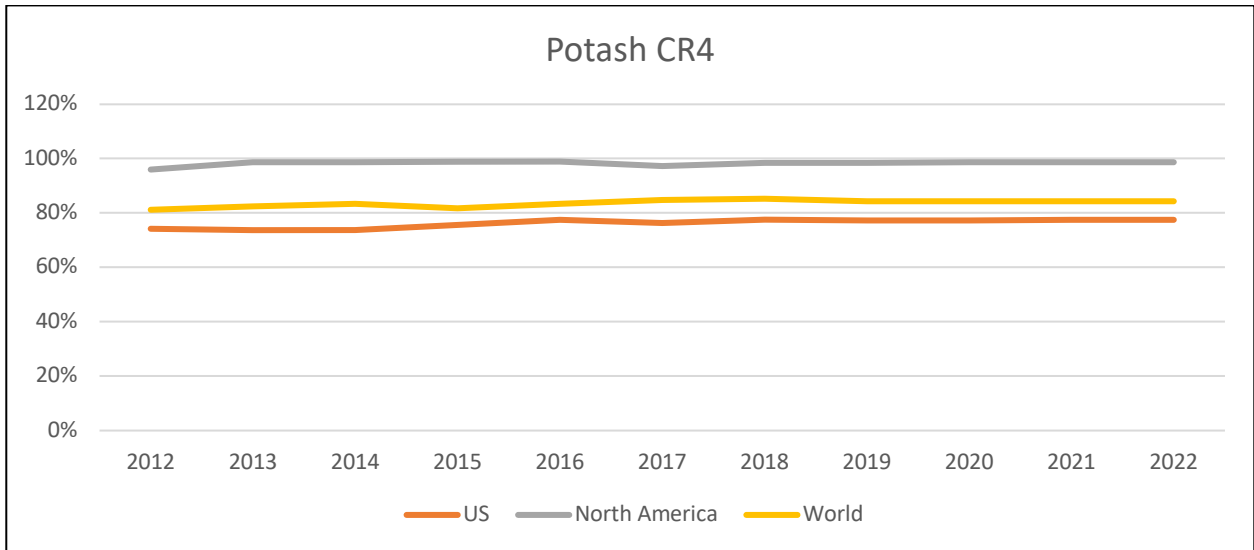


Figure 8. CR4 Measure for Fertilizers by Geographic Scope by Year

Competition & Pricing

While concentration provides an indicator of market power, quantifying the market power exerted by particular companies (or groups of companies) is considerably more difficult and data intensive. If Congress wanted to provide more transparency in the fertilizer markets, there are examples to which it can look, including mandatory price reporting for livestock:

“The U.S. Department of Agriculture’s (USDA) Agricultural Marketing Service (AMS) collects livestock and meat price data and related market information from meat packers under the authority of the Agricultural Marketing Act of 1946 (7 U.S.C. §1621 et seq.). This information was collected on a voluntary basis until 2001, when most of it became mandatory. As the livestock industry became increasingly concentrated in the 1990s, fewer animals were sold through negotiated (cash or “spot”) purchases and with increasing frequency were sold under alternative marketing arrangements that were not publicly disclosed under voluntary reporting. Some livestock producers, believing such arrangements made it difficult to impossible for them to assess “fair” market prices for livestock going to slaughter, called for livestock mandatory reporting (LMR) for packers who purchase livestock, process them, and market the meat. In response, Congress passed the Livestock Mandatory Reporting Act of 1999 (P.L. 106-78) that mandated price reporting for cattle, boxed beef, and swine and allowed USDA to establish mandatory price reporting for lamb purchases. USDA issued a final rule that included lamb reporting in December 2000 and took effect in April 2001. Since then, the law has been amended to include more detail on swine reporting and has added wholesale pork as a covered product. The act has been reauthorized four times, and most recently the Agriculture Reauthorizations Act of 2015 (P.L. 114-54) reauthorized LMR through September 30, 2020.”⁹

If Congress were to implement the same requirements for the fertilizer industry, there are a few issues it may wish to consider, including:

- **Availability of data.** While there is a considerable amount of publicly available fertilizer price data, much of it is behind some type of paywall. Beyond availability, as noted above, to do robust analysis, firm-level import volume data would need to be disclosed as well.
- **Global dynamics.** Advocates for the industry will highlight that fertilizer is a global industry meeting a global demand. While true, it is also important to consider that those global companies have subsidiaries in the United States. As noted in figures 7 and 8, concentration in the United States is considerably higher than in the overall global marketplace.

⁹ For more information, see: <https://crsreports.congress.gov/product/pdf/R/R45777>.

- **Independent Analysis.** Simply disclosing more prices to USDA will not necessarily leave producers satisfied, because much of it will remain out of public view over confidentiality concerns. If more data is collected, Congress may wish to require USDA to contract for outside analysis that could protect the confidentiality of the data. This is consistent with a recommendation AFPC made on mandatory price reporting for livestock:¹⁰

“With that said, if Congress and/or USDA wish to make even more informed decisions, then additional research is in order. While Congress could certainly revisit confidentiality requirements in the context of reauthorizing LMR – for example, making more data publicly available for analysis – there are legitimate reasons for making sure confidential business data is protected. On the other hand, USDA has collected enormous volumes of data via LMR over the last two decades, much of which has never been independently analyzed. As such, in lieu of relaxing confidentiality requirements, Congress may wish to consider requiring USDA to contract for additional analysis but in a manner that protects business-sensitive information. There are a number of analytical tools that could be brought to bear, but so far, independent analysis is limited to a small subset of data that is made publicly available.”

Other Considerations

On March 12, 2022, the Biden Administration announced a request for “comments and information from the public to assist the U.S. Department of Agriculture (USDA) in identifying relevant difficulties, including competition concerns, and potential policy solutions for the fertilizer market.”¹¹ The following question from the request for comments is of particular relevance to this report:

“(13) Please comment on the availability and accessibility of market information and data for fertilizers. Which public or private sources do you rely on to receive information on fertilizer prices and other related markets? Are you able to access timely, accurate, and comprehensive information on spot prices of fertilizers in local, regional, and national markets? If not, how can USDA further facilitate price reporting information and transparency for market participants? Beyond price reporting, what other market related information would be helpful that is currently limited or not accessible?”

Unfortunately, of the 1,504 comments received as of publication, our cursory review revealed that fewer than 20 of the comments directly addressed this question.¹² It remains to be seen what USDA will glean from the exercise.

¹⁰ For more information, see: <https://www.afpc.tamu.edu/research/publications/710/cattle.pdf>.

¹¹ For more information, see: <https://www.govinfo.gov/content/pkg/FR-2022-03-17/pdf/2022-05670.pdf>.

¹² For more information, see: <https://www.regulations.gov/docket/AMS-AMS-22-0027>.

Conclusions

Record high fertilizer prices in 2021 and 2022 led to renewed concerns among agricultural producers and policymakers about concentration in the fertilizer industry and the impact on competition. Our work found that increases in the cost of natural gas prices explained less than 20% of the increase in fertilizer prices paid by producers in 2022. Our work also confirmed earlier research which found that the fertilizer industry in the United States is moderately to highly concentrated. To refine those estimates and to thoroughly analyze the industry's ability to exert market power, additional research is needed. Importantly, to carry about that research, additional data – both price and volume – are needed. Mandatory price reporting is one tool that Congress has at its disposal to compel the disclosure of that data. If Congress were to go that route, it may also wish to ensure that USDA contracts for independent analysis of the data.