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The Landscape of Farmland Values: Beyond Income and Interest Rates

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This is the third in a series of three articles evaluating the relationship between farm income, interest rates, and other factors and land values. The first article is available here and the second is available here.

When discussing farmland values, net income and interest rates often take center stage. However, a closer look reveals a complex web of factors influencing land markets, especially in agricultural regions like Iowa. While income and interest rates are important, other forces such as land supply, strong demand for land, proximity to infrastructure, and the growing use of farmland for renewable energy projects—like wind and solar—are playing a significant role in shaping the Midwest's land market.

For example, data from the 2023 Iowa State University Land Value Survey (LVS), along with reports from the Federal Reserve and USDA, show that despite rising interest rates and tightening farm incomes, steady demand for land and limited land supply have helped maintain or even boost land prices in certain areas. Farmland values in south-central Iowa increased by 9.6% in 2023, despite economic pressures and slight decreases in some Northern Iowa counties. This trend underscores the impact of land scarcity and strong demand for land in keeping farmland values high.

Figure 1 outlines the key drivers of land markets in 2023. In addition to factors that directly affect farm income, such as commodity prices, yields, and input costs, several other influences play a critical role. These include limited land supply, strong demand for land, weather uncertainty, and the evolving future of agriculture. In this article, we will briefly explore how each of these factors contributes to the current land market dynamics.

In this issue:

Supply and demand dynamics

Farmland value influences go beyond just profit margins—land supply and demand play a crucial role. In areas like south-central Iowa, stable demand has been a key factor in maintaining high prices. According to the 2023 LVS, land supply was the most frequently cited factor driving up prices across the state with strong demand also listed as a key factor.

The competition for available land is fierce—within Iowa, it is most often between existing farmers, but for other parts in the Midwest, both farmers and investors contend for limited tracts. The 2023 LVS reports that 24% of Iowa farmland sales in 2023 went to investors, with 12% of these buyers being non-local. However, legal restrictions largely determine the players in the market. Presently, 13 US states restrict who can purchase farmland, with Iowa having the strictest regulations in the country that severely limit corporate and foreign ownership. As a result, the influence of investors on the land market varies significantly depending on the state and region. Given that, the investor demand in Iowa, coming from both local and non-local investors, looks different from the investor demand in, say, Illinois. For Iowa, most of the investor demand is concentrated in the southern parts of the state with demand for hunting and recreational ground.

Anecdotally, non-locals investing in farmland not for timber or hunting ground in many cases also represent former Iowa residents who may have moved out of state, and a small portion may be coming from institutional investors. This growing interest from investors though, is part of a broader trend in Iowa where more and more farmland is leased out, rather than owner operated. In 2022, 65% of all Iowa farmland was under some form of lease, with 56% operated under cash-rent leases (table 1).

This goes hand-in-hand with the changes observed in the ownership of farmland, with a total of 51% of Iowa land owned by those who do not farm, and the remaining 49% by part-time or full-time farmers (table 2). Those who do not farm but own farmland are, of course, often leasing it out, explaining the changes described above. Another interesting phenomenon to note about the ownership is that, farmer or not, about 80% of Iowa farmland owners are full-time Iowa residents, while another 6% are part-time residents. So, most of the land ownership remains local (See the appendix).

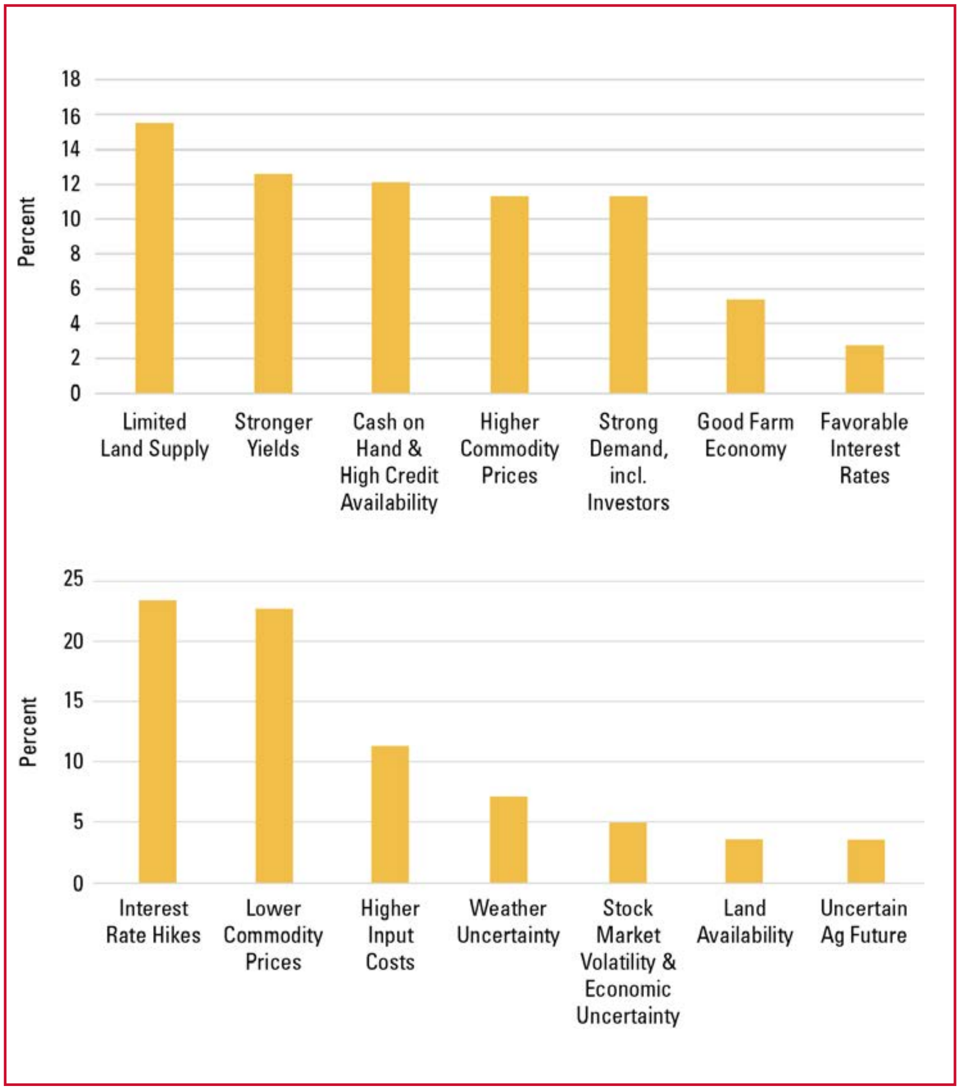

Figure 1. Positive (top) and negative (bottom) factors of the Iowa farmland market, November 2022–November 2023.

Source: 2023 Iowa State University Land Value Survey: Overview (Chandio 2023).

Table 1. Iowa Farmland by Ownership and Operation Type

	1982	1992	2002	2007	2012	2017	2022
Owner-operated	55%	50%	41%	40%	40%	41%	35%
Cash rent lease	21%	27%	40%	46%	46%	49%	56%
Crop share lease	21%	22%	18%	13%	13%	10%	8%
Other type of lease	1%	1%	1%	1%	1%	< 1%	1%

Source: Tong and Zhang (2023).

Climate and weather risks

Climate change is becoming an increasingly significant factor in many sectors of the economy, and farmland is no exception. Shifts in climate and weather patterns directly influence farmland values, particularly through their impact on rainfall and vital transportation systems like the Mississippi River. While rainfall affects yields and farm income, an equally important, yet indirect, consequence of climate change is the decreasing water levels in the Mississippi, a key route for transporting agricultural goods.

The Mississippi River, which facilitates roughly 60% of US grain exports, has faced delays and rising costs as barges struggle with shallower waters caused by prolonged droughts and erratic rainfall—both clear effects of climate change. In 2022 and 2023, reduced water levels led to more than a doubling of barge rates (USDA AMS 2024). These disruptions have a ripple effect on farmers, particularly through the basis—the difference between local cash prices and futures prices on the Chicago Board of Trade (Arita et al. 2022). Higher transportation costs weaken the basis, prompting buyers to lower their cash bids, which further tightens farmers' profit margins.

Table 2. Iowa Farmland Ownership by Residency and Farming Status

	Do not farm		Part-time farmer	Full-time farmer	Total
	Past experience	No experience			
Full-time resident	20%	15%	26%	17%	**79%**
Part-time resident	2%	2%	2%	1%	**6%**
Non-resident	2%	10%	1%	2%	**15%**
Total	**24%**	**27%**	**29%**	**20%**	**100%**

Source: Tong and Zhang (2023).

Increased shipping costs, whether from higher barge rates or more expensive alternative transportation, also contribute to rising input prices. This combination of higher costs and tighter margins can depress farmland values, especially in regions heavily reliant on river transport. In this context, climate change is not just an environmental issue, but a critical economic factor that will shape the future viability and value of farmland.

Infrastructure and proximity

Farmland located near key transportation hubs, markets, and grain elevators often commands higher prices due to the reduced costs and increased efficiency of moving goods to market. For instance, land near major highways or close to processing plants can minimize logistical challenges, driving up competition among buyers even in less favorable market conditions. In states like Iowa, where agricultural infrastructure is well-developed, the added value of proximity can be harder to recognize. However, in regions like the Northern Plains, where distances to grain elevators vary significantly, the impact of proximity on cropland values is more pronounced (Nickerson et al. 2012). Nickerson et al. (2012) find that in North Dakota, the value of cropland within five miles of a grain elevator was at least $1,000 more per acre compared to land farther away. This proximity-value relationship remains a key determinant for farmland prices and varies by location.

Another important factor influencing farmland value is proximity to urban areas. Land near cities or growing industrial regions is often more desirable due to its potential for future development, although this affects only about 23% of agricultural real estate, with the remaining 77% being rural land largely uninfluenced by urbanization (Nickerson et al. 2012).

Interestingly, proximity to electricity transmission lines (TMLs) is also becoming a significant factor in farmland valuations, especially as renewable energy projects expand. A study on the Midwest's farmland and housing markets found that land within 0–2 kilometers of TMLs in high-wind areas was valued 3.1% higher than comparable land in low-wind areas (Lu et al. 2023). This underscores the growing importance of TMLs in land valuation, as they are critical for connecting wind and solar energy projects to the grid. In states like Iowa, where wind energy is abundant, farmland near transmission lines is becoming increasingly valuable. Access to this infrastructure enables landowners to lease their land for energy projects, providing new revenue streams and further enhancing the land's value.

Renewable energy development

Renewable energy development has become a transformative factor in the Midwest's farmland market, beyond just the connection to the electrical grid via TMLs. Wind turbines and solar farms provide landowners with new revenue streams, making land suitable for these projects highly sought after. In Iowa, leasing land for wind turbines can offer a substantial income boost beyond traditional farming operations—this extends to solar energy as well. Recent studies indicate that land near solar projects can see value increases of up to 2.1%, particularly for parcels located within one mile of a solar farm (Kunwar 2024), likely because the proximity highlights their suitability for a similar use. However, this premium tends to decrease with distance, meaning that properties further away may not experience the same financial benefits. These trends make renewable energy projects an appealing opportunity for landowners looking to enhance their land's profitability through energy development.

Looking ahead

The factors shaping land markets today suggest that we may be seeing the beginning of an adjustment. According to the Federal Reserve Bank of Chicago's August Ag Letter, Iowa experienced a 3% decline in the value of "good" farmland between July 1, 2023, and July 1, 2024 (Oppedahl and Kepner 2024). Similarly, the Realtors Land Institute's fall survey reports a 5% drop in Iowa land values from September 2023 to September 2024 (RLI 2024). With Iowa State University's Land Value Survey set for release in December 2024, we will gain further insight into the current state of Iowa's land markets and the specific forces influencing these trends. The future of farmland in the Midwest will depend on how these forces—ranging from economic conditions to renewable energy development—continue to interact, presenting both opportunities and challenges for landowners, farmers, and investors.

References

Arita, S., V. Breneman, S. Meyer, and B. Rippey. 2022. "Low Mississippi River Barge Disruptions: Effects on Grain Barge Movement, Basis, and Fertilizer Prices." Farmdoc Daily: 12(164). Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign. https://farmdocdaily.illinois.edu/2022/11/low-mississippi-river-barge-disruptions-effects-on-grain-barge-movement-basis-and-fertilizer-prices.html.

Chandio, R. 2023. "2023 Iowa State University Land Value Survey: Overview." CARD working paper 23-WP 655. Iowa State University Extension and Outreach and Center for Agricultural and Rural Development, Iowa State University. https://www.card.iastate.edu/products/publications/synopsis/?p=1381.

Nickerson, C., M. Morehart, T. Kuethe, J. Beckman, J. Ifft, and R. Williams. 2012. "Trends in U.S. Farmland Values and Ownership." Publications from USDA-ARS/UNL Faculty, 1598. https://digitalcommons.unl.edu/usdaarsfacpub/1598.

Kunwar, B. 2024. "Impact of Commercial and Utility-Scale Solar Energy on Farmland Price." Master's dissertation, Purdue University Graduate School.

Lu, Q., N. Cheng, W. Zhang, and P. Liu. 2023. "Disamenity or Premium: Do Electricity Transmission Lines Affect Farmland Values and Housing Prices Differently?" Journal of Housing Economics 62:101968. https://doi.org/10.1016/j.jhe.2023.101968.

Oppedahl, D., and E. Kepner. 2024. "AgLetter: August 2024 (No. 2005)." Federal Reserve Bank of Chicago. https://www.chicagofed.org/publications/agletter/2024/august.

Realtors Land Institute – Iowa Chapter (RLI). 2024. "Survey of Farm Land Values in Dollars per Acre [Press release]." https://www.rliiowachapter.com.

Tong, J., and W. Zhang. 2023. "Iowa Farmland Ownership and Tenure Survey 1982–2022: A Forty-Year Perspective." CARD working paper 23-WP 651. Iowa State University Extension and Outreach and Center for Agricultural and Rural Development, Iowa State University. https://www.card.iastate.edu/farmland/ownership/farmland-ownership-tenure-2022.pdf.

United States Department of Agriculture Agricultural Marketing Service (USDA AMS). 2024. *Barge Dashboard*. Accessed September 27, 2024. https://agtransport.usda.gov/stories/s/Barge-Dashboard/965a-yzgy/.

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Appendix

The remaining 15% of non-resident landowners primarily consists of the next generation of landowners who have inherited farmland in Iowa but have since relocated out of state, as well as non-local individual investors. Another factor contributing to this ownership structure is the shift in the primary reason for owning farmland. There has been an increase in ownership driven by family or sentimental reasons rather than for generating income, further supporting the idea that many non-resident landowners are part of the next generation inheriting farmland (figure A1).■

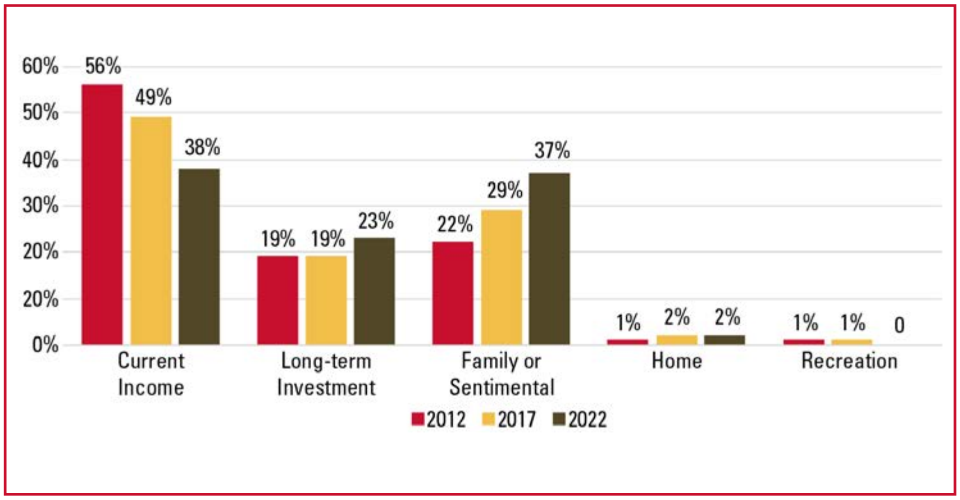

Figure A1. Percentage of Farmland by Primary Reason for Owning Farmland.

Note: In 2022, recreation was <1%.

Waging A Global Trade War Alone: The Cost of Blanket Tariffs on Friend and Foe

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FOR GOOD or bad, not all campaign rhetoric converts to policy once it is examined systematically. We consider a 2024 presidential campaign proposal to escalate US tariffs against all trade partners, with exceptionally high tariffs on Chinese goods. With inevitable retaliation, this creates a trade siege of "fortress America," which disadvantages US exports around the world in favor of trade from other countries. US tariff escalation creates a lucrative set of opportunities for everyone else. For instance, many US manufactured goods would exit European markets as Chinese goods enter, and European consumers and Chinese manufacturers benefit at the expense of US manufacturers. Strengthened trade ties between Europe and China also work in the other direction. China substitutes away from US business services in favor of European service exports. China further entrenches its reliance on agricultural goods from Latin America boosting income in countries like Brazil. Of course, there are costs of the trade war in terms of global efficiency and adverse local impacts on states and agricultural markets.[1] Our new analysis of escalating protection suggests that nearly everyone outside the United States benefits as it moves to isolate itself from global trade. The United States disproportionately bears the global efficiency cost.

We use an advanced model of the global economy to consider a set of scenarios consistent with the proposal to impose a minimum 60% tariff against Chinese imports and blanket minimum 10% tariff against all other US imports. The model's structure, which includes imperfect competition in increasing-returns industries, is documented in Balistreri, Böhringer, and Rutherford (2024). The basis for the tariff rates is a proposal from former President Donald Trump (see Wolff 2024). We consider these scenarios with and without symmetric retaliation by our trade partners. Our central finding is that a global trade war between the United States and the rest of the world at these tariff rates would cost the US economy over $910 billion at a global efficiency loss of $360 billion. Thus, on net, US trade partners gain $550 billion. Canada is the only other country that loses from a US go-it-alone trade war because of its exceptionally close trade relationship with the United States.

We provide context in terms of the current trade conflict, primarily between the United States and China, and enumerate a set of scenarios based on the proposed blanket tariffs. Results suggest the United States is the biggest loser in a comprehensive trade war with the rest of the world. We also consider a potential transatlantic alliance, where Europe joins the United States in tariffs against China. Transatlantic cooperation reduces US losses and leads to sharp losses for China, highlighting the benefits of cooperation relative to the proposed go-it-alone strategy.

State of play

The 2018 US-China trade war was a major economic conflict initiated by the United States that targeted alleged unfair trade practices by China, such as intellectual property theft, forced technology transfers, industrial subsidies, and currency manipulation. The conflict escalated through rounds of tariff impositions, retaliatory measures, and negotiations, significantly affecting global markets and supply chains.

The United States imposed tariffs on over $250 billion worth of Chinese goods, targeting industries like technology, machinery, and consumer products. China responded with tariffs on about $110 billion of US goods, affecting agriculture, automobiles, and other sectors.

Multiple rounds of negotiations occurred between 2018 and 2019. The two countries reached a temporary truce with the "Phase One" trade deal in January 2020, where China agreed to purchase more US goods, particularly agricultural products, and address some intellectual property concerns. China did not, however, meet any of the additional purchase commitments (see Bown 2020). China made some progress toward greater intellectual property protection in certain areas yet continues

1. The Center for Agricultural and Rural Development has been engaged in research on the costs of the current trade war at the country level (see Li, Balistreri, and Zhang 2019) and the specific impacts on Iowa and the agricultural sector (see Balistreri et al. 2018).

to tolerate flagrant intellectual property theft in others (see Krieger 2024). Both economies have suffered from reduced market access and higher costs for businesses and consumers. The conflict also disrupted global supply chains, particularly in consumer technology products, and hit US farmers hard due to China's retaliatory tariffs.

Also, in 2018 the United States imposed a 25% tariff on steel and a 10% tariff on aluminum imports, affecting a wide range of countries, including EU members, South Korea, and Japan. The US administration justified the tariffs on the grounds that a robust domestic steel and aluminum industry was necessary to ensure the availability of critical materials for defense and infrastructure projects despite a memorandum from the Secretary of Defense stating that the "[Department of Defense (DoD)] does not believe that [steel and aluminum imports] impact the ability of DoD programs to acquire the steel and aluminum necessary to meet national defense requirements" (Mattis 2018).

The steel and aluminum tariffs sparked significant backlash, leading to retaliatory tariffs by several countries. Eventually, the United States negotiated managed trade deals with some countries, such as Canada, Mexico, and the EU. Australia escaped relatively unscathed, but other countries were forced to negotiate exemptions or quota systems, such as South Korea, Brazil, and Argentina.

The tariffs increased costs for US manufacturers that rely on imported steel and aluminum, leading to higher prices for US manufacturers, and consumer goods like cars and appliances. US steel and aluminum producers saw benefits in terms of higher domestic prices. The overall effect on jobs was mixed, with some gains in the metal industries but larger losses in sectors reliant on metal imports and in the sectors that were targets of retaliation, namely US agriculture.

In sum, the 2018 trade war generated losses for China and the US economy. The Biden-Harris administration kept the punitive tariffs on China and the steel and aluminum (national-security) tariffs in place, which remains a point of contention in US trade policy.

Recent proposals

In 2024, during his campaign for a second term, former President Donald Trump proposed imposing a 60% tariff against imports from China and a 10% tariff against imports from everyone else in an apparent effort to increase the number of manufacturing jobs in the United States and boost domestic

Table 1. Tariff Scenario Descriptions

Scenario	Description
2018 tariffs	2018 US tariffs (section 301 China tariffs and 232 steel and aluminum tariffs)
USA60	Same as 2018 tariffs with any tariffs below 60% on China brought up to 60%
BOTH60	Same as USA60 with a minimum tariff on US goods into China at 60%
USA6010	Same as USA60 with a minimum US tariff on other countries of 10%
ALL6010	Same as USA6010 with 60% retaliation by China and 10% retaliation by other countries
USEU_v_CHINA	Same as USA60 with EU joining with 25% minimum tariff against China
USEU_V_CHINA_W_ RETALIATION	Same as USEU_v_CHINA with China at 60% retaliatory tariff on US and 25% retaliatory tariff on EU

Table 2. Welfare Effects of Examined Trade Scenarios ($US billions)

	2018	USA60	BOTH60	USA6010	ALL6010	USEU_v_ CHINA	USEU_w_ RET
USA	-81.3	-560.7	-665.4	-511.0	-911.8	-435.6	-436.6
China	-63.3	-70.6	-50.0	-26.2	38.2	-261.3	-464.1
Canada	1.7	8.3	12.2	-14.1	-10.0	9.9	17.3
Mexico	2.9	10.8	12.4	-5.3	9.1	13.8	18.7
S. Korea	8.7	26.9	32.1	24.6	41.0	32.3	48.9
Mercosur	5.8	18.8	22.1	15.1	26.5	23.1	32.3
Other OECD	16.0	65.9	75.1	63.9	93.9	83.4	116.8
Rest of world	23.0	116.2	123.5	74.2	114.4	144.9	201.2
EU	39.8	176.6	193.5	141.8	234.6	103.8	77.8
World	-47	-208	-244	-237	-364	-286	-388

industries. Most economists would agree that tariffs at this scale will backfire by undermining US economic performance.

Below we consider the economic effects of the 2018 tariffs that remain in place today, and then explore potential economic effects of additional trade war scenarios based on proposals by former President Donald Trump (table 1).

Results

The results show both the United States and China suffer losses from the 2018 tariffs, with US losses equivalent to $81.3 billion and $63.3 billion for China (table 2). Imposing a 60% tariff on China and 10% tariff on everyone else unequivocally leads to additional losses for the United States. As a technical note, the economic model evaluates policies based on changes in household welfare, so we can interpret the $81.3 billion loss for the United States as the dollar value of the extra consumption that private households could have had in the absence of the tariffs.

United States

Specifically, with a 60% tariff on China, US losses grow to $560.7 billion; and, if China retaliates, US losses are $665.4 billion. If the United States were to impose the 60% tariff on China and a 10% tariff on everyone else, US losses are $511.0 billion; and, if everyone retaliates in kind, US losses grow to a shocking $911.8 billion (figure 1).

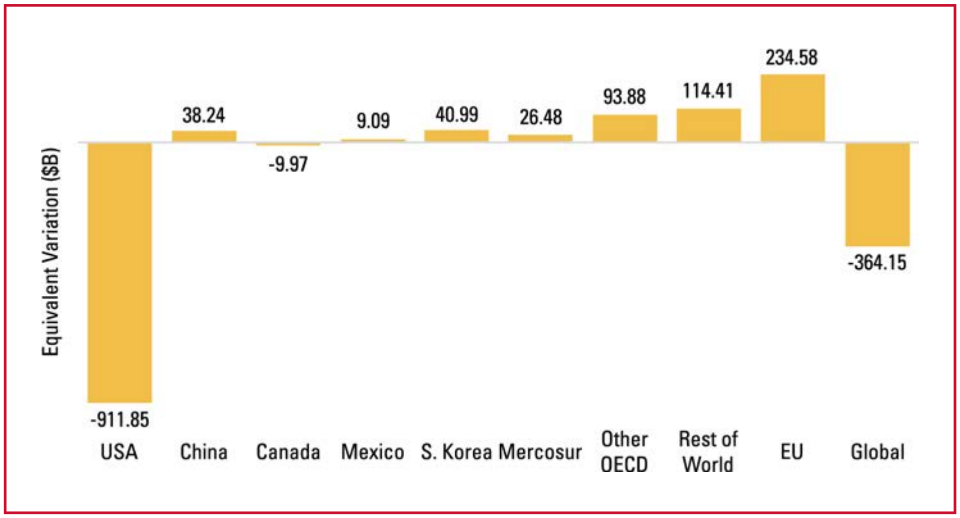

Figure 1. Economic impact of a global trade war.
Source: Authors' calculations. The figures show the effects of the United States imposing a 60% tariff against China, 10% tariff against everyone else, and all countries retaliating in kind (the "ALL6010" scenario).

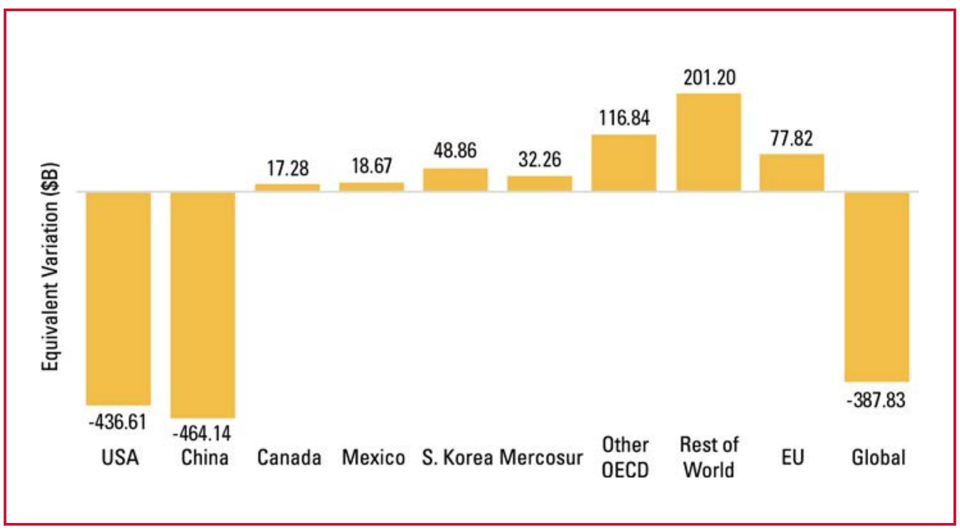

Figure 2. Economic impact of cooperative US-EU retaliation against China.
Source: Authors' calculations. The figures show the effects of the United States imposing a 60% tariff against China, the EU imposing a minimum 25% tariff against China, and China retaliating in kind (the "USEU_V_CHINA_W_ RETALIATION" scenario).

China

China suffers across almost all scenarios, and China's losses are greatest when the United States and EU cooperate. Specifically, if the United States were to impose the 60% tariff on China, China's estimated losses are equivalent to $70.6 billion. But if China retaliates, their losses reduce to $50 billion because the retaliation shifts the terms-of-trade in their favor. As with any large country, tariffs increase export prices relative to (net-of-tariff) import prices. If the United States were to impose the 10% tariff on other countries, China's losses shrink to $26.2 billion, reflecting a further improvement in the terms of trade as European and other goods become relatively less expensive due to less US demand. When everyone retaliates against the United States, the closest scenario here to a US-led go-it-alone global trade war, China actually gains $38.2 billion. As discussed in the introduction, a global trade war between the United States and the rest of the world creates significant opportunities for China in terms of new export opportunities in Europe and less expensive non-US imports. China suffers the most when the United States and EU cooperate. Specifically, welfare losses for China are between $26.2 billion and $70.6 billion when the US pursues a go-it-alone strategy. When the United States and EU cooperate, China's welfare losses reach $261.3 billion to $464.1 billion.

European Union

The EU economy gains from the US-led trade wars mostly because of trade diversion. That is, with the United States and China imposing tariffs on each other, the EU has greater access to lower priced imports from China, and effectively gets preferential treatment for its goods in both the US and Chinese markets. The EU benefits the most ($234.6 billion) when they let the United States go it alone, under the "ALL6010" scenario. In that scenario, the United States imposes tariffs against China and all other countries, and everyone retaliates in kind against the United States, which is the closest scenario to a US-led global trade war. EU importers benefit from lower prices and EU exporters benefit from greater preferential market access.

Other countries

Other countries such as Canada, Mexico, South Korea, and the rest of the world mostly experience net gains from a US-China trade war. Canada and Mexico, however, experience losses when the United States imposes 10% tariffs on all other countries and they retaliate in kind, reflecting the tightly knitted supply chains across North America.

Specifically, Canada and Mexico experience a loss when the United States imposes tariffs on China and all other countries. When other countries retaliate, Mexico goes back to a net gain while Canada continues at a loss. This is attributed to the fact that, although both Mexico and Canada have strong ties to US markets, Canada's trade with the United States is biased toward increasing-returns-to-scale sectors. In this regard, shrinking trade between the United States and Canada implies a greater cost for Canada. South Korea and other OECD countries gain from the US-China trade war scenarios—South Korea's net gains reach $48.9 billion.

US-EU Cooperation

Transatlantic cooperation on tariffs against China, as a punitive measure for intellectual-property violations and other unfair-trade practices, are more effective in terms of greater losses for China and easing the burden on the United States. Specifically, if the United States and EU were to cooperate and impose tariffs against China simultaneously, with the United States imposing 60% tariffs and the EU imposing a minimum of 25% tariffs, US losses reduce to $435.6 billion and China's losses increase to $261.3 billion. If China retaliates against the United States and EU in kind, US losses remain mostly the same, but China's losses increase to $464.1 billion (figure 2).

EU cooperation, however, comes at a cost for the EU's economy. The EU goes from a $234.6 billion gain (in "ALL6010") to a $77.8–$103.8 billion gain in the cooperation scenarios.

These results highlight three important nuances of US-EU cooperation: (*a*) securing EU cooperation eases US economic losses from the trade wars; (*b*) US-EU cooperation sharply increases the net losses to the Chinese economy; and, (*c*) cooperating with the United States comes at a cost for the EU and reduces their net gains from the trade wars.

Conclusion

In conclusion, the analysis presented here reveals that escalating US tariffs, particularly the proposed 60% tariff against China and 10% tariff against all other trade partners, would impose substantial economic costs on the United States. We show that while China and other US trade partners may experience some losses, the United States would bear most of the global efficiency cost, with potential economic losses surpassing $910 billion if all countries retaliate. Interestingly, many of the US's trading partners, including the EU, South Korea, and other OECD countries, stand to benefit from trade diversion as US goods become less competitive globally.

The findings further underscore that transatlantic cooperation in imposing tariffs against China would mitigate some of the US's losses while amplifying the economic pain for China. This cooperation comes at a cost, however, for the EU in terms of the forgone benefits of letting the United States go it alone. Overall, the results highlight the complexities and far-reaching consequences of a "fortress America" protectionist trade policy, where, in the context of a global trade war, the United States stands to lose the most, both in terms of economic welfare and global competitiveness.

References

Balistreri, E.J., C.E. Hart, D.J. Hayes, M. Li, L.L. Schulz, D.A. Swenson, W. Zhang, and J.M. Crespi. 2018. "The Impact of the 2018 Trade Disruptions on the Iowa Economy." Policy brief 18-PB 25. Center for Agricultural and Rural Development, Iowa State University. https://www.card.iastate.edu/products/publications/synopsis/?p=1281.

Balistreri, E.J., C. Böhringer, and T.F. Rutherford. 2024. "Quantifying Disruptive Trade Policies." University of Nebraska—Lincoln, Department of Economics. https://balistreri.createunl.com/Papers/revised.pdf.

Bown, C. 2020. "China Bought None of the Extra $200 Billion of US Exports in Trump's Trade Deal." Petersen Institute for International Economics (PIIE). https://www.piie.com/blogs/realtime-economics/2022/china-bought-none-extra-200-billion-us-exports-trumps-trade-deal.

Krieger, G. 2024. "From 'Made in China' to 'Created in China': Intellectual Property Rights in the People's Republic of China." Joint Force Quarterly 112. National Defense University Press. https://ndupress.ndu.edu/Media/News/News-Article-View/Article/3679322/from-made-in-china-to-created-in-china-intellectual-property-rights-in-the-peop/.

Li, M., E.J. Balistreri, and W. Zhang. 2019. "The U.S.-China Trade War: Tariff Data and General Equilibrium Analysis." Working paper 19-WP 595. Center for Agricultural and Rural Development, Iowa State University. https://www.card.iastate.edu/products/publications/synopsis/?p=1293.

Mattis, J. 2018. "Response to Steel and Aluminum Policy Recommendations." Memorandum for Secretary of Commerce from Secretary of Defense. Department of Defense, Washington, DC. https://www.commerce.gov/sites/default/files/department_of_defense_memo_response_to_steel_and_aluminum_policy_recommendations.pdf.

Wolff, A.Wm. 2024. "Trump's Proposed Blanket Tariffs Would Risk a Global Trade War." Special Project: Election 2024. Peterson Institute for International Economics (PIIE). https://www.piie.com/blogs/realtime-economics/2024/trumps-proposed-blanket-tariffs-would-risk-global-trade-war.

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Argentinean Farmers' Attitudes Toward Collective Management of Herbicide Resistance

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THE 1990S marked a new era in weed management with the introduction of genetically engineered herbicide-tolerant (HT) commercial row crops (Dill 2005). By planting glyphosate-resistant crops, farmers could manage weeds effectively with glyphosate, a broad-spectrum herbicide that effectively eliminated the majority of weeds at that time (Swinton and Van Deynze 2017).

In the United States, HT soybean cultivation grew from 7% of the soybean area in 1996 to over 90% by 2007 (USDA-ERS 2023). In Argentina, HT soybean represented more than 90% of the soybean area just four years after their introduction (Penna and Lema 2003). Nowadays, the United States and Argentina rank as the second- and third-largest soybean producers globally (FAOSTAT 2024).

The widespread use of glyphosate-resistant crops led to a shift in weed management practices, from diverse mechanical, biological, chemical, and cultural methods to primarily relying solely on glyphosate applications (Duke and Powles 2008). However, by repeatedly using glyphosate without alternating modes of action, farmers unintentionally encouraged weeds to develop glyphosate tolerance, reducing the chemical's effectiveness over time. The United States documented its first glyphosate-resistant weed in 2000 (VanGessel 2001), and Argentina reported its first in 2005. Both countries had documented 18 cases of glyphosate-resistant weeds as of 2023 (Heap 2023).

The issue of weed susceptibility to herbicides exhibits features of a public-good problem, necessitating diversified management actions among neighboring farmers—a strategy that may incur short-term costs but ultimately benefits all farmers in the area in the long term (Bagavathiannan et al. 2019). The need for a cooperative approach to curb resistance hinges on the pest's relative mobility (Miranowski and Carlson 1986). Therefore, managing the regional dimension of herbicide-resistant weed populations effectively would require farmers to adopt integrated weed management at the community level (Ervin and Jussaume 2014).

Based on data from farmer focus group meetings and a farmer survey, Jussaume and Dentzman (2016) find that while farmers were aware of the presence of herbicide-resistant weeds (over 90% expressed concern) and knew about various recommendations for controlling resistance, 59% of respondents believed that the likelihood of community-based action to adopt best management practices (BMPs) being effective was either "unlikely" or "neither unlikely nor likely (a 50/50 chance)."

Do the challenges and impacts of herbicide-resistant weeds affect farmers only in the United States?

We collected data from non-US farmers to assess whether the spread and impact of herbicide-resistant weeds, along with the responses to this challenge, mirror those observed in the United States. Specifically, we aim to determine whether the issues, attitudes, and behaviors observed among US farmers are unique or indicative of broader trends at the global level. We focus on Argentina due to its similar adoption rate of HT soybean, its comparable significance of soybean production, and its widespread adoption of no-till farming.

In March and May of 2023, we gathered data from two meetings hosted by AAPRESID (Asociación

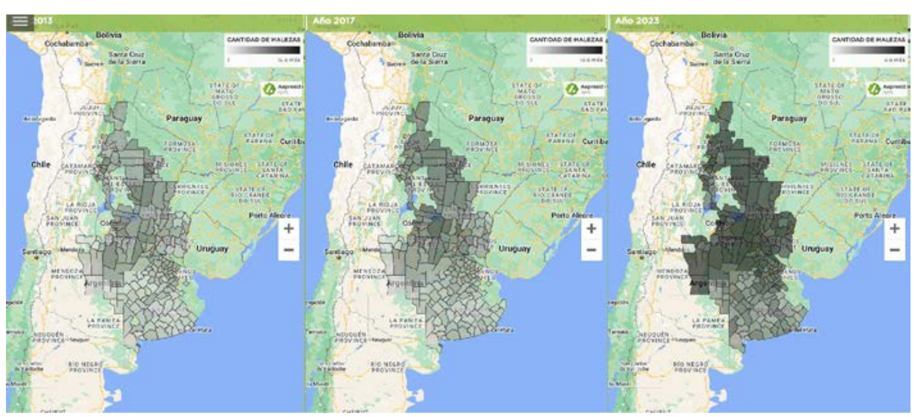

Figure 1. Heatmap depicting the spread of herbicide-resistant weeds in Argentina in 2013, 2017, and 2023.

Source: AAPRESID (Asociación Argentina de Productores en Siembra Directa).

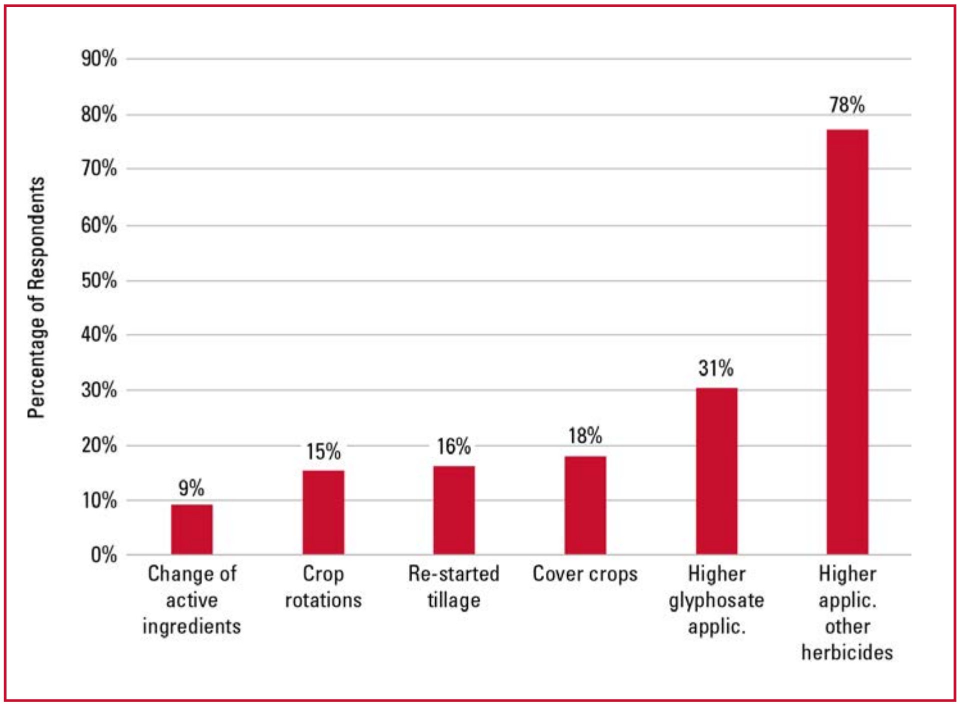

Figure 2. Practices adopted by Argentinean farmers to control herbicide-resistant weeds.

Notes: Total number of responses: 164 (some respondents reported more than one practice).

Source: Authors' collected data and calculations.

Argentina de Productores en Siembra Directa), the Argentinean Association of No-Till Farmers. Many experts credit AAPRESID's advocacy and support for driving the widespread adoption of no-till practices in Argentina. Notably, in the United States there is no national organization with similar characteristics and influence.

We gathered a total of 98 responses from farmers who collectively managed over 1 million acres, with 85% of these located in the province of Buenos Aires. While the sample does not represent all farmers in Argentina, it includes approximately 23% of the area corresponding to farm operations between 25,000 and 50,000 acres and 39% of the area of farm operations exceeding 50,000 acres in the province of Buenos Aires. Therefore, our sample provides valuable insights into the characteristics and behaviors of larger growers, who are likely to be influential industry leaders and trend-setters.

Figure 1, generated from an AAPRESID tool that monitors the distribution of various herbicide-resistant weed species across Argentina, clearly shows a significant rise in the spread of such weeds over the past decade. Our survey data reveals that respondents' average affected area in their operations rose by 12% from 2019/20 to 2021/22, reaching nearly 50% in 2021/22. These data align with the broader trend depicted in figure 1 and underscore the severity of the issue among farmers in our sample.

Our survey found that 54% of individual farms are grappling with four or more species of herbicide-resistant weeds, and 65% of farmers expressed either considerable concern or very high concern about herbicide-resistant weeds in their locations. To address this challenge, farmers have adopted various practices. As figure 2 illustrates, 87% of farmers increased their use of herbicides other than glyphosate. This percentage combines the 78% of farmers who reported increasing the application of alternative herbicides with the 9% who changed the active ingredient they use. Interestingly, this response mirrors the approach taken by US farmers, as documented by Van Deynze, Swinton, and Hennessy (2022).

Figure 2 also reveals that 31% of farmers increased glyphosate application rates, the second-most common response to combat herbicide-resistant weeds. This finding aligns with Dover and Croft's (1986) assertion that pesticide resistance typically leads to heightened chemical use to counter reduced pest susceptibility, thereby exacerbating resistance and associated externalities. Figure 2 further illustrates that cover crops were the third-most adopted strategy among Argentinean farmers to manage herbicide-resistant weeds. However, notably, 16% of farmers returned to tillage to control herbicide-resistant weeds, making it the fourth-most prevalent approach. This shift is significant given that the surveyed farmers were members of AAPRESID, which promotes no-till practices. Consequently, the abandonment of no-till practices is likely more prevalent among other Argentinean farmers. Our survey findings align with those of Livingston et al. (2015), who observed similar responses among US corn and soybean farmers.

Challenges of best management practices and opportunities for collective action

Bagavathiannan et al. (2019) argue that existing BMP standards and research efforts to improve them are a key factor contributing to the ineffective control of weeds. Their contention is that BMPs often focus too narrowly on property-level decisions, overlooking the collective impact of individual actions on landscape-level outcomes. Additionally, they emphasize the potential of collective practices to enhance weed control.

The successful eradication program

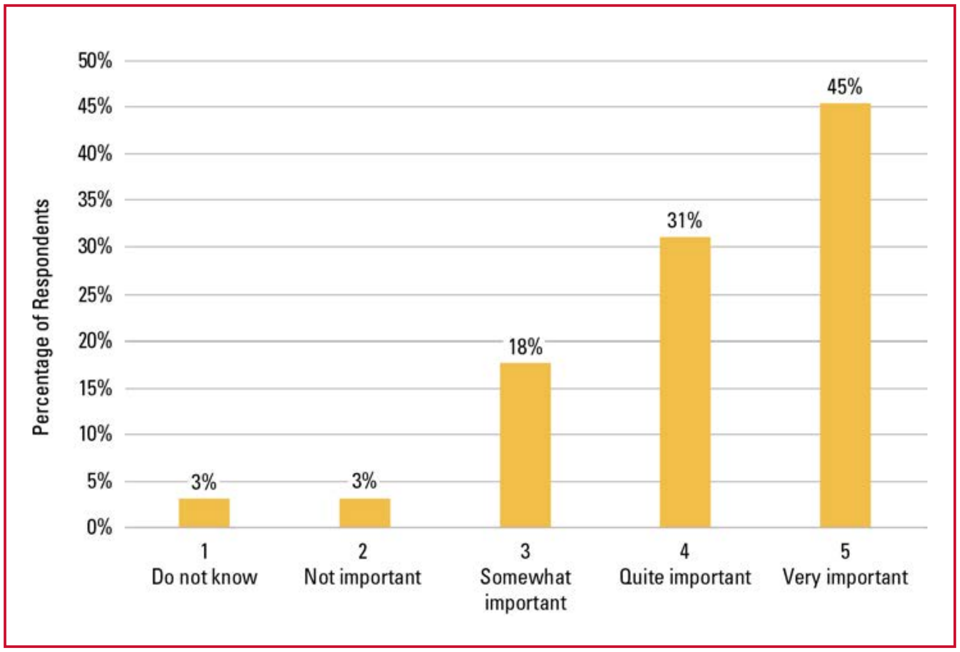

Figure 3. Importance Argentinean farmers assign to attempt controlling herbicide-resistant weeds collectively with neighbors.

Notes: Total number of responses: 97.

Source: Authors' collected data and calculations.

of the cotton boll weevil in the United States serves as a notable example of effective, well-coordinated, area-wide pest management (Ervin and Frisvold 2016). However, in most cases, implementing such programs faces obstacles related to methods, free riding, opposition from the public, and crucially, uncertainty surrounding stakeholder participation (Klassen 2000).

Ervin and Frisvold (2016) suggest a stronger emphasis on supporting collective action is needed, arguing convincingly that the strategy of encouraging farmers to adopt BMPs while offering technical support and industry subsidies has not yielded satisfactory results. To gauge the willingness of Argentinean farmers to participate in collective efforts aimed at managing herbicide-resistant weeds on a landscape scale, we posed such a question to them. According to figure 3, 76% of the farmers surveyed viewed this as either quite important or very important. Moreover, 95% of our sample answered affirmatively when asked if they would coordinate actions with neighboring farmers to address herbicide-resistant weeds. This finding reflects a notable contrast with US farmers regarding their perceptions of the effectiveness of collective action.

Our survey also inquired about farmers' concerns regarding potential barriers to coordinating actions among neighboring farmers for controlling herbicide-resistant weeds. The barriers examined included: (*a*) trusting others to coordinate; (*b*) the effort required for coordination; (*c*) the cost involved in coordination; (*d*) dependency on others for benefits; and, (*e*) program implementation. The results, as presented in table 1, indicate that 61% of respondents were either "quite concerned" or "very concerned" about two specific barriers: trusting others to coordinate and relying on others for benefits. These findings highlight strategic uncertainty as their primary worry, echoing similar observations by Singerman and Useche (2019) in their study on voluntary area-wide pest management efforts against citrus greening disease in Florida. Strategic uncertainty emerged as a key factor contributing to skepticism by both participants and non-participants in the program, and played a pivotal role in the collective action's failure.

Key findings and implications for policy

Our findings indicate that the challenges and impacts posed by herbicide-resistant weeds are not exclusive to US farmers—Argentinean farmers also grapple with similar issues and have adopted practices akin to those used by their US counterparts. Addressing herbicide-resistant weeds may require collective action, but the presence of strategic uncertainty, particularly in voluntary efforts, undermines the trust required for successful action. The central challenge lies in the interdependence of farmers' rewards, which introduces strategic risk. The provision of a public good involves such risks as it requires a critical mass of participants for success—failure to achieve this threshold diminishes rewards for contributors. Interestingly, Argentinean farmers expressed near-unanimous willingness to coordinate actions with neighbors, which suggests a more positive perception of collective action effectiveness compared to US farmers' views (as reported by Jussaume and Dentzman in 2016).

In contexts where coordination is pivotal, public signals play a role in shaping outcomes beyond their informational content by conveying strategic insights into others' beliefs (Morris and Shin 2006). Integrating public research and extension services, alongside appropriate incentives, into initiatives aimed at fostering collective action could potentially bolster trust and mitigate the adverse effects of strategic uncertainty. The recently introduced "coordination frontier," a tool developed by Lence and Singerman (2023), offers a valuable framework to assess conditions under which varying levels of voluntary coordination can succeed, as well as to determine the financial incentives needed for effectiveness. Therefore, the "coordination frontier" holds promise in alleviating concerns related to strategic uncertainty and encouraging collective efforts. Additionally, extension services can play a vital role in reducing strategic uncertainty and promoting collective action by facilitating: (*a*) dialogue among stakeholders to foster cooperation; (*b*) reciprocal cooperation; and, (*c*) enhanced investment returns in public goods.

Table 1. Argentinean Farmers Self-Assessed Potential Barriers to Coordinate Actions among Neighboring Farmers to Control Herbicide-Resistant Weeds

	Not Concerned		Somewhat Concerned		Very Concerned
	1	2	3	4	5
Trusting that others would coordinate	6%	7%	26%	30%	31%
Effort needed to coordinate actions	8%	8%	29%	25%	31%
Cost required to coordinate actions	18%	20%	27%	15%	20%
Depending on others to obtain a benefit	7%	10%	23%	21%	40%
Program implementation	7%	11%	23%	27%	32%

Notes: The number of responses were 91 for all barriers listed except for "Trusting that others would coordinate," which got 89 responses.

Source: Authors' collected data and calculations.

Implementing collective action to address herbicide-resistant weeds may face a nontrivial challenge related to land tenure issues—land renters may prioritize short-term profits, which could make them less inclined to use practices where benefits may not directly accrue to them, including those related to herbicide-resistant management (Norsworthy et al. 2012). If that is the case, this potential barrier could hamper successful collective efforts. However, Frisvold et al. (2020), analyzing national-level data for US corn and soybean from 2010 to 2012, find no statistically significant differences in herbicide use or weed management practices between rented and owned land. Nevertheless, the authors acknowledge that growers now have more experience with herbicide-resistant management and are increasingly concerned about weed resistance to herbicides. If land tenure proves to hinder collective action, providing renters with subsidies could be a viable solution to facilitate collective action practices.

One potential solution to address the challenges presented by herbicide-resistant weeds involves technological innovation. Certain companies are already marketing an artificial intelligence tool designed to be towed behind a tractor, capable of identifying and removing weeds using laser technology. Although this innovation necessitates a substantial initial investment, it reduces herbicide usage and, importantly, mitigates the externalities associated with their applications. However, widespread adoption of such advancements may not occur as swiftly and extensively in other regions as in the United States. In countries like Argentina, where access to credit is limited or available at prohibitively high interest rates, farmers may be hesitant to embrace such technology on a large scale in the near future.

References

Bagavathiannan, M.V., S. Graham, Z. Ma, J.N. Barney, S.R. Coutts, A.L. Caicedo, R. De Clerck-Floate, N.M. West, L. Blank, A.L. Metcalf, M. Lacoste, C.R. Moreno, J.A. Evans, I. Burke, H. Beckie. 2019. "Considering Weed Management as a Social Dilemma Bridges Individual and Collective Interests." Nature Plants 5:343-351. https://doi.org/10.1038/s41477-019-0395-y.

Dill, G.M. 2005. "Glyphosate-Resistant Crops: History, Status and Future." Pest Management Science 61(3):219-224. https://doi.org/10.1002/ps.1008.

Dover, M.J., and B.A. Croft. 1986. "Pesticide Resistance and Public Policy." BioScience 36(2):78-85. https://doi.org/10.2307/1310107.

Duke, S.O., and S.B. Powles. 2008. "Glyphosate: A Once-in-a-Century Herbicide." Pest Management Science 64:319-325. https://doi.org/10.1002/ps.1518.

Ervin, D., and G.B. Frisvold. 2016. "Are Community-Based Approaches to Manage Herbicide Resistance Wisdom or Folly?" Choices 31(4). https://www.choicesmagazine.org/UserFiles/file/cmsarticle_548.pdf.

Ervin, D.E., and R. Jussaume. 2014. "Herbicide Resistance: Integrating Social Science into Understanding and Managing Weed Resistance and Associated Environmental Impacts." Weed Science 62:403-414. http://dx.doi.org/10.1614/WS-D-13-00085.1.

FAOSTAT. 2024. Soybean Producing Countries. Available online: https://www.fao.org/faostat/.

Frisvold, G.B., J. Albright, D.E. Ervin, M.D.K. Owen, J.K. Norsworthy, K.E. Dentzman, T.M. Hurley, R.A. Jussaume, J.L. Gunsolus, and W. Everman. 2020. "Do Farmers Manage Weeds on Owned and Rented Land Differently? Evidence from US Corn and

Soybean Farms." Pest Management Science 76(6):2030-2039. https://doi.org/10.1002/ps.5737.

Heap, I. 2023. "Herbicide Resistant Weeds in Argentina and the United States." The International Herbicide-Resistant Weed Database. Available online: https://www.weedscience.org/.

Jussaume, R., and K. Dentzman. 2016. "Farmers' Perspectives on Management Options for Herbicide-Resistant Weeds." Choices 31(4). https://www.choicesmagazine.org/choices-magazine/theme-articles/herbicide/farmers-perspectives-on-management-options-for-herbicide-resistant-weeds.

Klassen, W. 2000. "Area-Wide Approaches to Insect Pest Management: History and Lessons." In *Proceedings: Area-Wide Control of Fruit Flies and Other Insect Pests*. International Conference on Area-Wide Control of Insect Pests, and the 5th International Symposium on Fruit Flies of Economic Importance, 28 May-5 June 1998, Penang, Malaysia. Pulau Pinang: Penerbit Universiti Sains Malaysia, 21–38.

Lence, S.H., and A. Singerman. 2023. "When Does Voluntary Coordination Work? Evidence from Area-Wide Pest Management." American Journal of Agricultural Economics 105(1):243-264. https://doi.org/10.1111/ajae.12308.

Livingston, M., J. Fernandez-Cornejo, J. Unger, C. Osteen, D. Schimmelpfennig, T. Park, and D.M. Lambert. 2015. "The Economics of Glyphosate Resistance Management in Corn and Soybean Production." Economic research report ERR-184. US Department of Agriculture Economic Research Service, Washington, DC. https://www.ers.usda.gov/webdocs/publications/45354/err-184.pdf?v=8927.3.

Miranowski, J.A., and G.A. Carlson. 1986. "Economic Issues in Public and Private Approaches to Preserving Pest Susceptibility." In Board on Agriculture (ed.) *Pesticide Resistance: Strategies and Tactics for Management*. Washington, DC: National Academy Press, 436-448.

Morris, S., and H.S. Shin. 2006. "Global Games: Theory and Applications." In M. Dewatripont, L.P. Hansen and S.J. Turnovsky (eds). *Advances in Economics and Econometrics*. Cambridge University Press, 56-114.

Norsworthy, J.K., S.M. Ward, D.R. Shaw, R.S. Llewellyn, R.L. Nichols, T.M. Webster, K.W. Bradley, G. Frisvold, S.B. Powles, N.R. Burgos, W.W. Witt, and M. Barrett. 2012. "Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations." Weed Science 60(SP1):31-62. https://doi.org/10.1614/WS-D-11-00155.1.

Penna, J.A., and D. Lema. 2003. "Adoption of Herbicide Tolerant Soybeans in Argentina: An Economic Analysis." In N. Kalaitzandonakes (ed.) *Economic and Environmental Impacts of Agrotechnology*. New York: Kluwer-Plenum, 203-220.

Relevamiento de Tecnología Agrícola Aplicada (ReTAA). 2023. Prácticas Ambientales En La Producción Agrícola Argentina 2021/22. Informe Mensual 65.

Singerman, A., and P. Useche. 2019. "The Role of Strategic Uncertainty in Area-Wide Pest Management Decisions of Florida Citrus Growers." American Journal of Agricultural Economics 101(4):991-1011. https://doi.org/10.1093/ajae/aaz006.

Swinton, S.M., and B. Van Deynze. 2017. "Hoes to Herbicides: Economics of Evolving Weed Management in the United States." The European Journal of Development Research 29:560-574. https://doi.org/10.1057/s41287-017-0077-4.

US Department of Agriculture, Economic Research Service (USDA-ERS). 2023. "Recent Trends in GE Adoption." Adoption of Genetically Engineered Crops in the U.S. https://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-u-s/recent-trends-in-ge-adoption/.

Van Deynze, B., S.M. Swinton, and D.A. Hennessy. 2022. "Are Glyphosate-Resistant Weeds a Threat to Conservation Agriculture? Evidence from Tillage Practices in Soybeans." American Journal Agricultural Economics 104(2):645-672. https://doi.org/10.1111/ajae.12243.

VanGessel, M.J. 2001. "Glyphosate-Resistant Horseweed from Delaware." Weed Science 49(6):703-705. https://www.jstor.org/stable/4046416.

Suggested citation

Singerman, A., and S.H. Lence. 2024. "Argentinean Farmers' Attitudes Toward Collective Management of Herbicide Resistance." Agricultural Policy Review, Fall 2024. Center for Agricultural and Rural Development, Iowa State University. https://agpolicyreview.card.iastate.edu/fall-2024/argentinean-farmers-attitudes-toward-collective-management-herbicide-resistance.■

Production Is Higher Across the Board, Except for Cattle

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USDA'S WORLD Agricultural Supply and Demand Estimates (WASDE) report outlines the current view for agricultural markets over the next 12–18 months. These projections are molded to fit the current events within agriculture. One challenge to monitor this fall will be the impacts of Hurricanes Helene and Milton. Some respondents completed USDA's surveys used for the October update before both hurricanes struck the United States, while other respondents completed surveys in-between the events. Thus, the current outlook does not capture the full extent of the hurricanes' impact—subsequent reports will do that.

In general, US agricultural production continues to set records. The pork and poultry industries are maintaining high production, while beef production declines with fewer cattle across the country. For crops, corn and soybeans are both expected to see record national average yields. US meat demand has been and is expected to be supportive for livestock prices, with the possible exception of hogs. However, the large crop production numbers are overwhelming strong crop usage projections for the 2024 marketing year, leading to lower prices for Iowa crops.

For the livestock sector, some production challenges faded away in 2024, only for some to quickly reappear over the last couple of months. The avian influenza outbreaks over the previous couple of years had limited flock sizes for the poultry markets and luckily, those outbreaks have decreased in both size and intensity. The cattle herd had been shrinking due to the extended drought across the western half of the United States; and, while for the first seven months of 2024, moisture conditions improved greatly over most of the United States, drought has quickly returned over a large swath of the country in September and October. This continues to constrain thoughts of expanding cattle herds, although it is not the only reason—beef prices are high enough to continue to entice cattle producers to place heifers in feedlots. As the 2024 meat production year stands, the beef production estimate continues to edge higher on those heifer feedlot placements. USDA has slightly lowered projected pork and poultry production on lower sow farrowings and slower flock growth. However, expectations are that total meat production in 2024 will reach nearly 108 billion pounds. Given good meat demand across the board, USDA has increased all of the livestock price estimates for 2024, with cattle and broilers leading the way.

For 2025, recent trends are projected to continue. Cattle numbers are projected to decline again, but hog and poultry numbers continue to grow. Beef production will shrink by roughly a billion pounds, but growth in the pork and poultry sectors will more than offset that. Total meat production will exceed 108 billion pounds (table 1). Meat exports, with the exception of beef, are also expected to continue to grow. Combining solid international demand with stable domestic demand, livestock prices in general are heading higher,

Table 1. USDA's Livestock Projections

	2024		2025		
	Forecast	Change from Sept.	Forecast	Change from Sept.	Change from 2024 to 2025
Production			(Billion Pounds)		
Beef	27.00	0.21	25.93	0.30	-1.08
Pork	27.95	-0.11	28.52	0.01	0.57
Broilers	47.08	-0.02	47.83	0.15	0.74
Turkey	5.11	-0.02	5.17	-0.01	0.06
Total Meat	107.88	0.05	108.19	0.45	0.31
Prices			($ per Cwt.)		
Steers	186.18	1.07	186.50	0.25	0.32
Hogs	59.80	0.43	58.00	0.50	-1.80
			(Cents per Pound)		
Broilers	129.10	1.10	129.30	1.50	0.10
Turkey	93.80	0.10	99.80	-3.30	6.00

Source: USDA-WAOB (2024).

with the exception of hogs—even there, recent shifts in demand are improving the price outlook.

The outlook for corn contains a bin-busting national average yield, another 15 billion bushel crop, and usage that continues to churn through a lot of corn (just not enough to keep up with production). After a few years of drought-impacted crops, this year's corn crop showed what a little additional water would do for production. The October estimate for the national average corn yield is a whopping 6.5 bushels above the previous record set last year, soaring well above 180 bushels per acre for the first time. So, as has been the case for the past several years, the corn market will have lots of kernels to feed and fuel users.

Corn usage has also set records over the past couple of years, but those records are still below 15 billion bushels. Feed and residual use increased by over 300 million bushels last year, and USDA expects it to grow slightly in the coming year. Fuel use also increased last year by nearly 300 million bushels and is projected to be steady this year. But there are a couple of sectors where corn usage has slipped. Corn sweetener use has declined within the past five years, down roughly 50 million bushels since 2020. Consumer shifts in beverage choices, mostly a decline in soda consumption, have driven this change. However, the largest shift remains in the export sector. The 2020 marketing year set the record for corn export sales (in bushels), pushed by the COVID-19 recovery surge and the Phase One trade deal with China. Corn exports dropped after that, as rising corn prices, the slowdown after the surge, and the completion of the trade deal limited US competitiveness in global markets. The largest drop came in 2022, as corn exports had fallen by over a billion bushels from the record two years earlier. The drop in corn prices over the past 18 months has translated into more international sales recently, with exports up over 600 million bushels last year. As with feed use, USDA's projections display slight growth over the coming year. The issue is that is still 400 million bushels below sales from 2020.

With production exceeding the record usage, corn stocks have been building. For most of this calendar year,

Table 2. US Corn Supply, Usage, and 2024 Projections from October

		Marketing Year				
		2020	2021	2022	2023	2024
Area Planted	(mil. acres)	90.7	92.9	88.2	94.6	90.7
Yield	(bu./acre)	171.4	176.7	173.4	177.3	183.8
Production	(mil. bu.)	14,111	15,018	13,651	15,341	15,203
Beg. Stocks	(mil. bu.)	1,919	1,235	1,377	1,360	1,760
Imports	(mil. bu.)	24	24	39	28	25
Total Supply	(mil. bu.)	16,055	16,277	15,066	16,729	16,989
Feed & Residual	(mil. bu.)	5,607	5,671	5,486	5,814	5,825
Ethanol	(mil. bu.)	5,028	5,320	5,176	5,471	5,450
Food, Seed, & Other	(mil. bu.)	1,439	1,437	1,382	1,391	1,390
Exports	(mil. bu.)	2,747	2,472	1,662	2,292	2,325
Total Use	(mil. bu.)	14,821	14,900	13,706	14,969	14,990
Ending Stocks	(mil. bu.)	1,235	1,377	1,360	1,760	1,999
Season-Average Price	($/bu.)	4.53	6.00	6.54	4.55	4.10

Note: Marketing Year 2024 = 9/1/24 to 8/31/25.
Source: USDA-WAOB (2024).

Table 3. US Soybean Supply, Usage, and 2024 Projections from October

		Marketing Year				
		2020	2021	2022	2023	2024
Area Planted	(mil. acres)	83.4	87.2	87.5	83.6	87.1
Yield	(bu./acre)	51.0	51.7	49.6	50.6	53.1
Production	(mil. bu.)	4,216	4,464	4,270	4,162	4,582
Beg. Stocks	(mil. bu.)	525	257	274	264	342
Imports	(mil. bu.)	20	16	25	21	15
Total Supply	(mil. bu.)	4,761	4,737	4,569	4,447	4,939
Crush	(mil. bu.)	2,141	2,204	2,212	2,287	2,425
Seed & Residual	(mil. bu.)	97	107	114	123	114
Exports	(mil. bu.)	2,266	2,152	1,980	1,695	1,850
Total Use	(mil. bu.)	4,504	4,463	4,305	4,105	4,389
Ending Stocks	(mil. bu.)	257	274	264	342	550
Season-Average Price	($/bu.)	10.80	13.30	14.20	12.40	10.80

Note: Marketing Year 2024 = 9/1/24 to 8/31/25.
Source: USDA-WAOB (2024).

the projections for corn stocks at the end of the 2024 marketing year have exceeded 2 billion bushels, which is a healthy 240 million bushels above corn stocks for the 2023 marketing year and 640 million bushels above stock levels in 2022. The most recent update lowered the stock estimate to 1.999 billion bushels, showing usage slowly trying to catch up to production (table 2). But as stocks have grown, prices have fallen. The season-average price for corn was $6.54 per bushel for the 2022 crop, which dropped to $4.55 per bushel for 2023. The current projection is $4.10 per bushel for 2024. Current corn futures roughly agree with that outlook, with the futures at the end of the WASDE report day signaling a $4.15 per bushel price.

The combination of a surge in soybean planting this spring and the temporary cessation of drought through most of the growing season has led to record projections for both the national average soybean yield and soybean production. The current yield estimate is 53.1 bushels per acre, besting the record 51.7 bushels per acre from 2021. The previous soybean production record also comes from 2021 at 4.464 billion bushels. The 2024 estimate is 4.582 billion bushels, so there is a lot of beans for the markets to work with this fall.

While corn is capturing record usage, soybean usage is rebounding, but has not quite reached prior levels. The major growth area has been domestic crush, mainly for renewable diesel development. Given USDA's current estimates, crush will consume over 200 million more bushels this year than it did in 2022. The challenge, however, is that growth has not been enough to offset the declines in soybean exports over the past several years. Like corn, soybean exports set their record in 2020. The same factors (higher prices, post-surge slowdown, and completion of Phase One) led to lower exports in 2021, 2022, and 2023. The cumulative drop is roughly 600 million bushels. While 2024 looks like a better export year, USDA's projection leaves soybean exports at 1.85 billion bushels, over 400 million bushels below the 2020 record (table 3).

Thus, soybean stocks are building as well. The 2024 ending stocks estimate is 550 million bushels, more than double the stock level from 2022; and again, as stocks have grown, prices have fallen. The season-average price for soybeans was $14.20 per bushel for the 2022 crop, which dropped to $12.40 per bushel for 2023. The current projection is $10.80 per bushel for 2024. Current soybean futures are not in alignment with that outlook. The market is more pessimistic for soybeans. Futures prices at the end of the WASDE report day imply a $9.80 per bushel price, a full dollar below the USDA estimate.

References

US Department of Agriculture World Agricultural Outlook Board (USDA-WAOB). 2024. "World Agricultural Supply and Demand Estimates." WASDE-653, October 11, 2024. US Department of Agriculture, Washington, DC. https://www.usda.gov/oce/commodity/wasde/wasde1024.pdf.

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Agricultural Tile Drainage in the US Corn Belt: Past, Present, and Future

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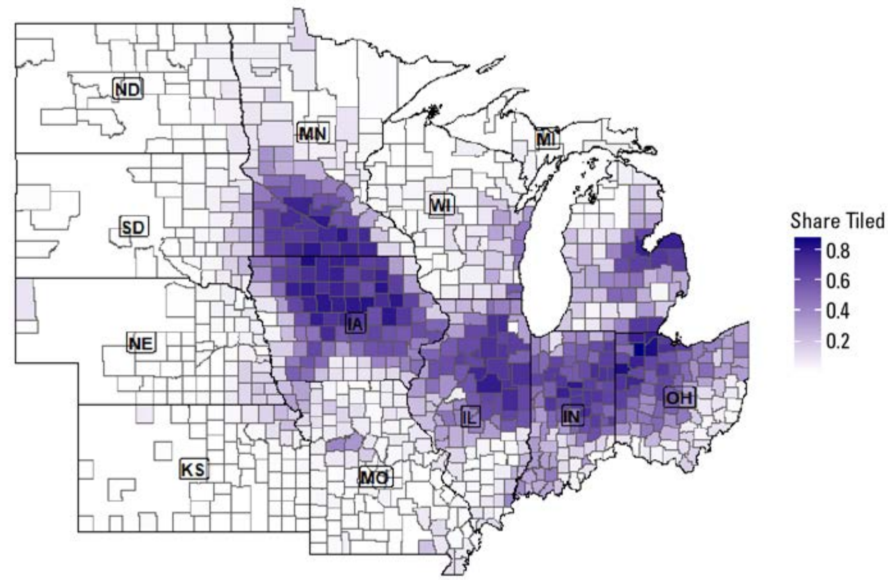

Figure 1. County-level fraction of cropland acres with tile drainage.

VAST NETWORKS of drains, pipes, and tiles that support food production on some of the world's most fertile farmland, such as the US Corn Belt, are in need of expansion and renewal amidst the growing challenges posed by climate change.

What is tile drainage?

Agricultural subsurface drainage systems, or tile drainage, consists of networks of perforated pipes installed beneath croplands to remove excess water. The primary benefits of drainage systems are twofold: (*a*) they protect soil and crop health; and, (*b*) they enable earlier planting (Pavelis 1987). By alleviating waterlogging and enhancing soil aeration, subsurface drainage systems promote stronger root growth and improve nutrient uptake (Castellano et al. 2019), leading to increased crop yields, increased nitrogen use efficiency, and reduced nitrous oxide emissions. Another key advantage of drainage is in allowing for timely field operations, such as planting, which is a strong predictor of yield. This principle has long been recognized, where Cato in *De Agricultura* (200 BCE) advises: "See that you carry out all farm operations betimes, for this is the way with farming: if you are late in doing one thing you will be late in doing everything."

Figure 1 shows the county-level extent of tile drainage as a fraction of cropland in the Midwestern US according to the 2017 US Census of Agriculture.

Figure 2 is a Lorenz curve visualization of the relationship between crop production and the share of county cropland tiled. The curve's convexity and position below the 45-degree line indicate that a disproportionate share of agricultural production (y-axis) comes from counties with higher drainage intensity (x-axis). As we move from counties with little or no drainage to those with higher levels of tiling the cumulative share of production increases rapidly, suggesting that heavily drained counties contribute significantly more to total crop output than do their less drained counterparts, which highlights the importance of tiling in driving agricultural productivity at the county level.

Tile drainage in the context of climate change in the United States

The US Midwest is grappling with growing challenges linked to climate variability. Studies show that the region is experiencing shifting precipitation patterns, including wetter winters, drier summers, and more frequent intense rainfall events (Bowling et al. 2018). Projections from the US Global Climate Change Research Program suggest that climate change will lead to a further increase in intense rainfall events throughout the year, along with prolonged summer droughts during the growing season. Excess precipitation can lead to significant crop losses. Most field crops can endure heavy rainfall without suffering long-term damage as long as the water table drops to six inches below the surface within a day and continues to fall to 18 inches within three days (Hofstrand 2016). This underscores the importance of swiftly draining excess water from fields to maintain the reliability of food production.

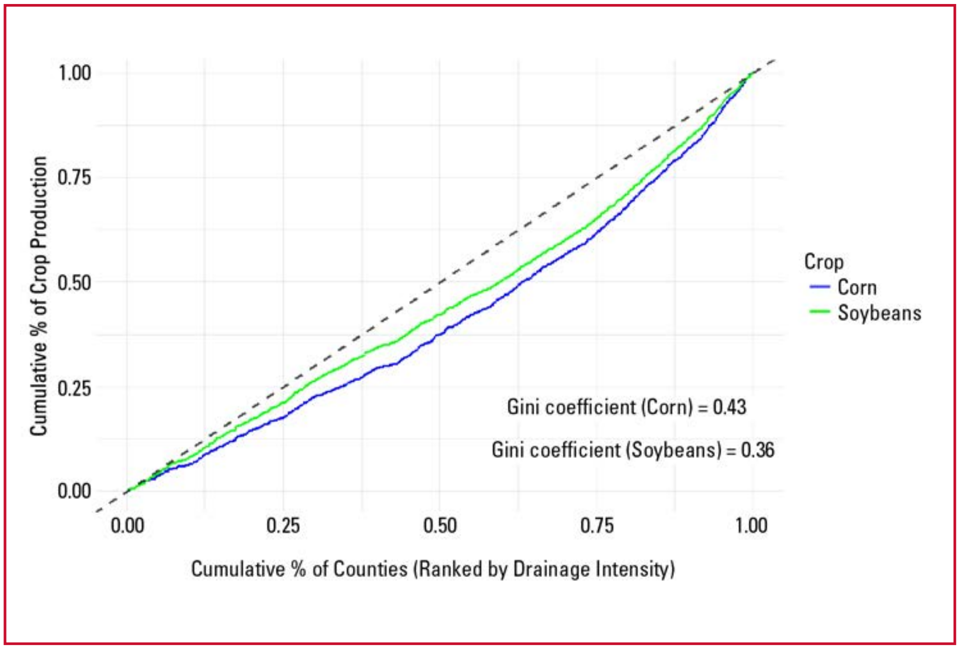

Figure 2. Lorenz curve for corn and soybean production by tile drain intensity.

Note: The Lorenz curve shows the cumulative share of corn and soybean production in the US Corn Belt relative to the cumulative share of counties, ranked by increasing tile drainage intensity (measured as the share of cropland tiled).

Meyer and Keiser (2016) argue that tile drainage is an adaptation tool in regions prone to extreme precipitation, especially in poorly drained areas. Drained croplands, while comprising a small portion of total US farmland, contribute disproportionately to food and feed production. While every state has some drained cropland, more than 50% of cropland acres in the northern Corn Belt are drained. However, states installed much of this infrastructure over a century ago, for a different agricultural era, when pastures and forage crops, which require less drainage than today's grain crops, were more prevalent. These drainage networks need improvement to adapt to modern crop production.

Policy background

Tile drainage in the United States began in the nineteenth century, driven by federal policies like the Swamp Land Acts (1849, 1850, 1860), which transferred wetlands to states for development. At the time, states viewed wetlands as obstacles to land development, often seen as breeding grounds for mosquitoes. The primary objective of the act was to allow states to reclaim these areas by constructing levees, ditches, and drainage systems to make the land more usable. However, inadequate funding led to a shift in responsibility from states to counties and ultimately to private landowners. For landowners, the decision to invest in tile drainage is complex due to coordination challenges (Edwards and Thurman 2022). Drainage systems consist of networks of pipes on individual farms that feed into a shared, community-managed main drain. The effectiveness of this setup depends on both the on-farm infrastructure and the main drain working together to remove excess water. Main drain maintenance and operation rely on collective action, requiring coordination between individual farmers and the community's drainage districts, which can introduce potential sources of friction.

To address coordination challenges in drainage projects, some states established drainage districts—special districts with local taxing authority and the power of eminent domain to facilitate collective investments. In Iowa, for example, following passage of drainage district legislation in 1884 (Sherman 1924) much of Northern Iowa was drained. In Story County, Iowa, drainage districts covered 197,633 acres (58% of all land) by 1920, financing improvements through land taxes (Hewes and Frandson 1952). From a modern governance perspective, drainage districts are a form of special district established with local authority parallel to county and municipal governments but subordinate to state governments. Drainage districts were typically formed through landowner petitions and governed by elected boards, which coordinated drainage investments for public benefit (Prince 2008). Although drainage districts provide legal structure to support coordinated drainage investments, disputes are common as vertical location within the watershed, land quality, tenancy issues, and intended land use create heterogeneous incentives to pay among participants.

Negative externalities and their solutions

Most of the early artificial drainage infrastructure, while beneficial for agricultural productivity, came with significant environmental drawbacks, primarily through depleting wetland and moving nutrients from fields to nearby water systems without benefit of natural filtration processes. For instance, research in northeast Iowa demonstrates that tile drainage was responsible for over 50% of the nitrogen load in watersheds during the growing season (Arenas Amado et al. 2017). Elevated nutrient levels in water bodies contribute to increased phytoplankton growth, which can lead to hypoxic or "dead zones" with low oxygen levels, negatively impacting aquatic ecosystems.

Technological advances aim to mitigate these environmental impacts. Controlled drainage (CD) controls the volume of water leaving the field by using adjustable structures (e.g., weirs or gates) installed in a drainage system outlet. Wang et al. (2020), show CD can increase yields while reducing both outflow and nutrient loss when compared to conventional drainage systems. Denitrification wetlands are an edge-of-field technology that reduces nitrate runoff by naturally filtering drainage water before it enters larger bodies of water. Edge-of-field nutrient-loss reduction practices, which are only applicable to drained acres, are among the most cost-effective methods in terms of dollars per pound of nutrient loss reduced, as well as in terms of percentage reduction in nutrient loss per acre. The Conservation Drainage Network (see https://conservationdrainage.net/), a nationwide collaboration to promote drainage practices that strike a balance between reducing negative environmental impacts and sustaining future crop production, provides resources on how to implement long-term conservation practices, such as denitrification wetlands, bioreactors and saturated buffers.

Farmers and communities face a growing need to modernize and expand drainage systems to protect productivity under climate change. Recent drainage technology developments emphasize both profitability and environmental conservation. These innovative drainage technologies may become increasingly important to agriculture in the upper Midwestern US.

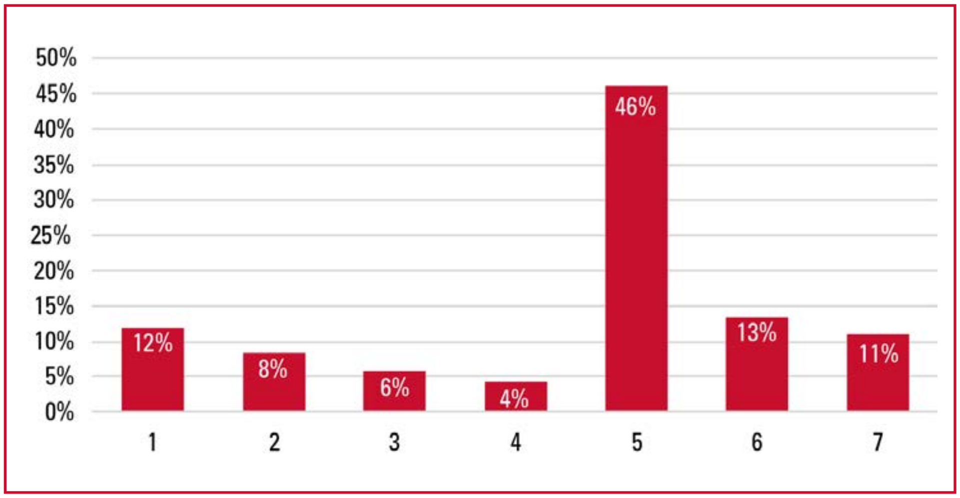

Figure 3. Respondents' most important barriers to drainage investment.

Note: The options were: 1 = Unclear yield effects; 2 = Specifications in rental contract; 3 = Challenges in cooperating with neighbors; 4 = Environmental effects (nutrient loss, flood risk, etc.); 5 = Payback period (time to break even on investment); 6 = Wetland Laws; and, 7 = Other.

Barriers to adoption and potential solutions

The high upfront costs of installing both drainage systems and accompanying innovations like wetland structures can act as a barrier to widespread adoption. In order to delve deeper into farmers' tile drainage adoption behavior, we conducted a farmer survey between March and May 2024 across 870 counties in the US Corn Belt. The study area spanned 12 Midwestern states, focusing on heavily tile-drained regions and neighboring counties with potential for drainage expansion. Out of a sample of 3,000 farm operators, we received a response rate of 20% with 520 usable responses for analysis. Figure 3 depicts respondents' perceived barriers to tile drainage investments. Payback period is reported as the most important factor, indicating that the majority of respondents consider financial impacts, as embodied by the length of time needed to recoup the upfront costs, to be the most significant barrier.

Green bonds, a type of fixed-income security issued to finance projects that have positive environmental or climate benefits, could bridge this gap by providing financing for drainage upgrades that integrate denitrification wetlands. The environmental benefits generated from such projects, such as reduced nitrate levels in runoff, align well with the goals of green bonds, which are often designed to support measurable environmental outcomes. Green bonds could be designed with performance-based incentives—for instance, if the reduction of nitrates in water runoff surpasses a predetermined threshold, the bond issuer (likely a government or cooperative) would pay a lower coupon rate. This creates a financial incentive for all stakeholders, including farmers, investors, and environmental agencies, to prioritize effective water management practices. See https://enviroaccounting.com/green-bonds-and-pay-for-performance/ for more details about green bonds.

Figure 4 offers another key insight—21% of respondents feel that specifications in the rental contract are a significant barrier to investment. This can also relate to concerns regarding payback period. The impact of land tenure on adopting tile drainage depends on the distribution of costs and returns. For non-farming landowners, one strategy is to make the tiling investment and then recover the costs by charging tenants a higher cash rental rate. In contrast, tenants who make the tile drainage investment typically receive the additional net returns without an increase in rent since the landowner

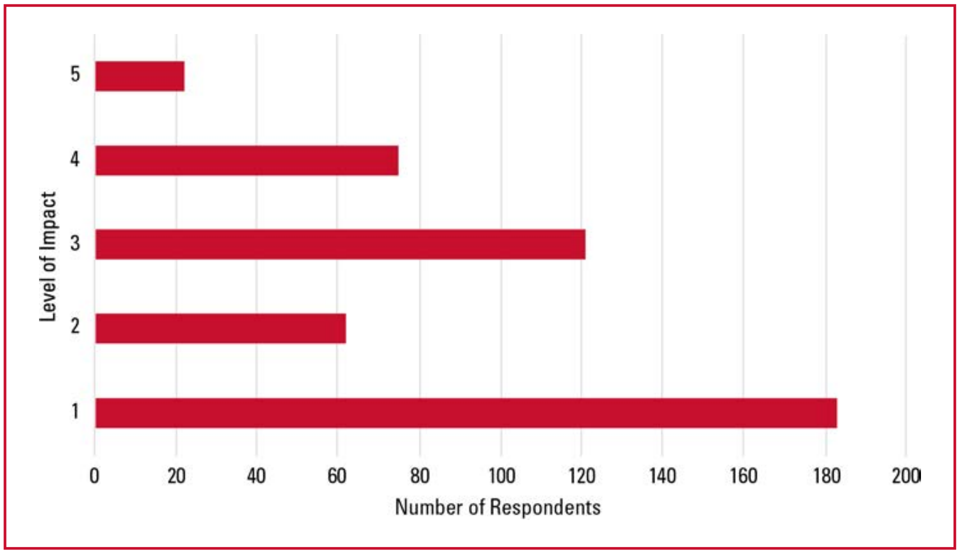

Figure 4. Whether rental contract specifications create barriers to respondents' drainage investment.

Note: Twenty-one percent of respondents (97 of 463) considered rental contract specifications as having either quite a bit of impact or a great impact on drainage investment. 1 = No Impact, 2 = Slight impact, 3 = Some impact, 4 = Quite a bit of impact, 5 = Great impact.

incurs no upfront costs. However, a tenant's major concern is whether they will have access to the land long enough to justify this capital expenditure. Approximately half of the farmland in the Midwest is rented under short-term leases, which can discourage tenants from investing in practices that offer long-term returns. This issue is becoming increasingly prevalent—in 2017, only 37% of farmland in Iowa was owner-operated, a 13 percentage-point decrease since 1982 (Zhang, Plastina, and Sawadgo 2018). One solution is to maintain the standard one-year lease while establishing a separate contract that specifically addresses tile drainage investments. Under this agreement, the tenant would receive a pro-rata buyout from the landowner for their tiling investment if they stop renting the farm before the end of the tile's useful life (Hofstrand 2016). Thus, rental contract terms, including lease length and payment arrangements, are critical in shaping incentives for tile drainage investment.

Our survey also finds that the majority of respondents are unfamiliar with conservation drainage infrastructures like CD and wetlands. This knowledge gap suggests opportunities for problem mitigation. The policy implications are clear—there is a need for more education and outreach to farmers and landowners about these innovative drainage solutions, ensuring they have the knowledge and resources to assess and possibly implement them effectively.

US agriculture's reliance on drainage has expanded from an early focus on productivity to a modern understanding that also includes its environmental implications. Despite the vital role of subsurface drainage in making much of the Midwest's land arable, our survey reveals persistent barriers to wider adoption of modern drainage systems. Key challenges include rental contract terms that discourage long-term investments and a lack of awareness about conservation drainage practices. Addressing these issues may require policy interventions that promote innovative rental agreements, and increased education and outreach. Such efforts will help in enhancing drainage adoption, mitigating environmental impacts, and supporting agricultural resilience in the face of climate change.

References

Arenas Amado, A., K.E. Schilling, C.S. Jones, N. Thomas, and L.J. Weber. 2017. "Estimation of Tile Drainage Contribution to Streamflow and Nutrient Loads at the Watershed Scale Based on Continuously Monitored Data." *Environmental Monitoring and Assessment* 189:1-13. https://doi.org/10.1007/s10661-017-6139-4.

Bowling, L.C., M. Widhalm, K.A. Cherkauer, J. Beckerman, S. Brouder, J. Buzan, O. Doering, J. Dukes, P. Ebner, J. Frankenburger, B. Gramig, E.J. Kladivko, C. Lee, J. Volenec, and C. Weil. 2018. "Indiana's Agriculture in a Changing Climate: A Report from the Indiana Climate Change Impacts Assessment." Purdue University. http://dx.doi.org/10.5703/1288284316778.

Castellano, M.J., S.V. Archontoulis, M.J. Helmers, H.J. Poffenbarger, and J. Six. 2019. "Sustainable Intensification of Agricultural Drainage." Nature Sustainability 2(10):914-921. https://doi.org/10.1038/s41893-019-0393-0.

Edwards, E.C., and W.N. Thurman 2022. "Creating American Farmland: Governance Institutions and Investment in Agricultural Drainage." Working paper 30081. National Bureau of Economic Research. https://doi.org/10.3386/w30081.

Hofstrand, D. 2016. "Economics of Tile Drainage." ISU General Staff Papers. Department of Economics, Iowa State University. https://dr.lib.iastate.edu/handle/20.500.12876/2505.

Hewes, L., and P.E. Frandson. 1952. "Occupying the Wet Prairie: The Role of Artificial Drainage in Story County, Iowa." Annals of the Association of American Geographers 42(1):24-50. https://doi.org/10.1080/00045605209352084.

Meyer, K., and D. Keiser. 2016. "Adapting to Climate Change through Tile Drainage: A Structural Ricardian Analysis." In *2016 Annual Meeting, July 31-August 2, Boston, Massachusetts*, 235932. Agricultural and Applied Economics Association.

Pavelis, G.A. 1987. "Farm Drainage in the United States: History, Status, and Prospects." US Department of Agriculture Economic Research Service. Washington, DC. https://eric.ed.gov/?id=ED295043.

Prince, H. 2008. *Wetlands of the American*

Midwest. University of Chicago Press.
Sherman, J.J. 1924. *Drainage Districts in Iowa: A Study in Local Administration*. University of Iowa.
Wang, Z., G. Shao, J. Lu, K. Zhang, Y. Gao, and J. Ding. 2020. "Effects of Controlled Drainage on Crop Yield, Drainage Water Quantity and Quality: A Meta-analysis." Agricultural Water Management 239:106253. https://doi.org/10.1016/j.agwat.2020.106253.
Zhang, W., A. Plastina, and W. Sawadgo. 2018. "Iowa Farmland Ownership and Tenure Survey 1982-2017: A Thirty-five Year Perspective." PM 1983. Iowa State University Extension and Outreach, Iowa State University. https://store.extension.iastate.edu/product/6492.

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