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The Potential for Moral Hazard Behavior in Irrigation Decisions under Crop Insurance

Background: The Federal Crop Insurance Corporation provides one of the most widely adopted risk mitigation tools used by crop producers across the United States. In 2018, over 90% of corn and soybean acres were insured in most of the Great Plains and Midwestern United States (Farm Bureau, 2019). As with all insurance, there are questions of whether moral hazard behavior occurs with insurance enrollment. In economics, *moral hazard* refers to cases where someone makes riskier decisions when he or she is protected from the full cost of doing so. For example, someone with fire insurance on their home may be less careful about checking and replacing smoke alarms than someone without fire insurance. With crop insurance, moral hazard occurs if a producer makes riskier operating decisions because of the loss protection provided by insurance.

In a recent project, we combined information about the federal crop insurance program with parameterized crop-water production function information to determine if there is an incentive for moral hazard in irrigation decisions under crop insurance. A naïve approach suggests that a producer would deliberately reduce irrigation with crop insurance since he can save the cost of irrigation and receive an indemnity for lost revenue. However, this naïve statement ignores many of the realities of the crop insurance program. Recent work (Mieno et al., 2018) suggests that when the dynamics of crop insurance are incorporated, moral hazard may either decrease or increase input use since the benefits of higher yield accrue for multiple years. In our work, we asked the following questions: 1) Is there an economic incentive to change irrigation management under crop insurance when realistic features of the crop insurance program are included?, and 2) How does the economic incentive change if important features of crop insurance program design are modified?

We used simulation analysis with realistic parameters from the existing crop insurance program, agronomic crop-water production function information, historical weather conditions, and current prices to determine if there is an incentive to change irrigation use under crop insurance (relative to the no-insurance case). Our results showed that under the existing crop insurance policy design with current input and output prices, there is no incentive to adjust irrigation use, and optimal irrigation use is the same with or without crop insurance. We also found that if irrigation costs increase significantly, it may become financially beneficial to reduce irrigation application.

Our analysis accounts explicitly for the fact that insurance premiums and benefits are a function of Actual Production History (APH). In its simplest form, APH is an average of the 10 most recent yields in one's cropping history. Since input use affects APH for the next 10 years, the use of production history introduces temporal dynamics into farmers' input use decision making. Deliberately using low levels of inputs to take advantage of crop insurance (i.e., moral hazard) will reduce APH for the next 10 years. Consequently, the dynamics help alleviate the moral hazard problem. Importantly, the crop insurance program design includes more complex rules that can modify APH, and we examine yield adjustment[1].

In the case of unexpected catastrophic yield-damaging events (e.g., drought, hail, flood), a producer can elect to substitute 60% of a county's T-yield for his yield in the APH calculation with *yield adjustment* (YA). A

[1] We also examine trend adjustment in the full article. Results can be found in the full article.

County's T-yield value is based on the historical average yield. For example, the T-yield for irrigated corn in 2018 for Chase County, Nebraska, was 185 bushels per acre. Consider someone who has produced 200 bushels per acre for the past nine years. If hail wipes out his crop (no yield), the yield is zero in the tenth year. Without YA, his APH would be 180 (calculated as [200×9+0×1]/10). With YA, he can substitute 60% of the county T-yield (0.6×185 = 111) for the zero, which results in an APH of 191 (calculated as [200×9+111]/10). We examine various levels of YA to understand the potential impact on irrigation usage.

Modeling Approach: Our analysis used USDA-RMA actuary parameters for Chase County, Nebraska for the 2017 production season. Chase County is in southwestern Nebraska in the Republican River Basin. Irrigation in the region is primarily from the Ogallala Aquifer. While concerns about the long-term sustainability of groundwater use throughout the Ogallala Aquifer are significant, this region also has short-term needs to limit groundwater use.

Estimating the impact of crop insurance on farmer's water-use decisions requires understanding the response of crop yields to irrigation inputs, and how this response varies under different growing season weather conditions. We estimated the crop-water production function for corn in Chase County using AquaCrop-OS. AquaCrop-OS is a free, open-source version of AquaCrop, a crop water productivity model developed by the Food and Agriculture Organization of the United Nations (Foster et al., 2017). AquaCrop-OS relates crop yield and total seasonal applied water to a soil moisture target and weather conditions. Our approach allowed the soil moisture target to vary intra-seasonally by crop growth stage, reflecting differing crop sensitivity to water stress throughout the season. All simulations used crop parameters that have previously been calibrated for typical corn hybrids grown in the U.S. and assume that irrigation is applied using a center-pivot irrigation system (the common technology used in the study region) with an application efficiency of 90%. Figure 1 shows the distribution of generated yields. We created a representative sample of weather scenarios for our study region by using observed time-series data for the study area from a weather station in Champion, Nebraska.

We solve the dynamic optimization problem under various combinations of irrigation costs and YA ratios. Insurance costs are dynamically updated each year to reflect yield history. We include irrigation costs of $6, $10, $14, and $18 per acre-inch. We include YA ratios of 0, 0.2, 0.4, 0.6 (status quo), 0.8, and 1. A YA ratio of 0.4 means that a producer can substitute 40% of the county T-yield for actual yield in the APH calculation. A ratio of 0 is equivalent to not allowing any yield adjustment, and a ratio of 1 means that a producer can fully substitute the county T-yield without penalty.

Results: Table 1 compares the average optimal irrigation use with and without insurance at the different levels of irrigation cost and adjustment ratio. At lower irrigation costs ($6 and $10), there is no incentive for moral hazard at any YA ratio. For costs of $14/acre-inch and $18/acre-inch, increasing the adjustment ratio from the status quo has a sizable impact on moral hazard incentives. Allowing full replacement (ratio = 1.0) with the county T-yield reduces irrigation applied by 2.03 and 4.30 acre-inches relative to no insurance when costs are $14 and $18 per acre-inch, respectively. This is a net reduction of 0.93 (2.03−1.10 = 0.93) and 2.30 (4.30−2.00 = 2.30) acre-inches, relative to the status quo. In contrast, lowering the adjustment ratio has a much smaller effect on applied irrigation. An adjustment ratio of 0.0 is equivalent to not allowing YA. Adjusting the crop insurance program to not allow YA is expected to increase applied irrigation by 0.24 (10.38–10.14) and 0.68 (8.9-8.22) at costs of $14 and $18, relative to the status quo, respectively.

Our results show that at high costs, there are substantial differences between the insured and non-insured optimal irrigation application rates. One possible explanation for this result is the presence of a moral hazard cycle, where periods of full irrigation are followed by periods of little or no irrigation (this was found in previous work by Vercammen and van Kooten, 1994). If insurance rules that require the application of sufficient irrigation to meet crop water requirements are enforced, then it may not be *practically possible* for farmers to adopt this approach. We test this by imposing a requirement that farmers only choose soil moisture target strategies with an expected level of

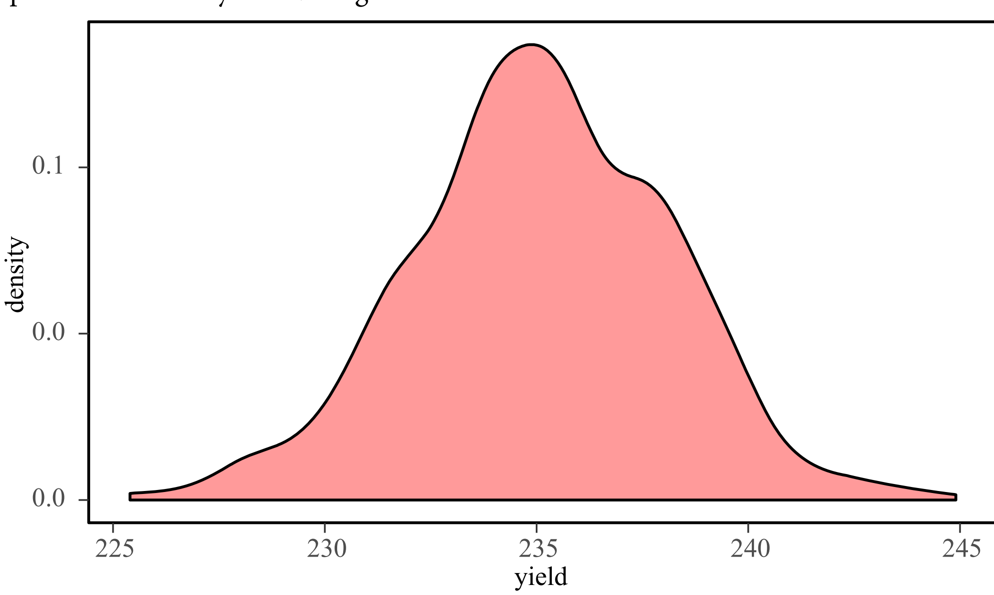

Figure 1: Generated Distribution of Yield

irrigation of at least 5 acre-inches. The results are in Table 2, which compares the expected level of irrigation based on policy enforcement. Results show that when a zero-irrigation strategy is not feasible (i.e., the requirement is enforced), the incentive for moral hazard is nearly eliminated at all irrigation costs.

Table 1: The Impact of Yield Adjustment on Optimal Irrigation

		Mean Irrigation (inches)		
Irrigation Cost	Yield Adjustment Ratio	With Insurance	No Insurance	Difference
6	0.0 - 1.0	12.51	12.50	0.01
10	0.0 - 1.0	11.44	11.44	0.00
14	0.0	10.38	11.24	-0.86
	0.2	10.33		-0.91
	0.4	10.25		-0.99
	0.6	10.14		-1.10
	0.8	9.79		-1.45
	1.0	9.21		-2.03
18	0.0	8.9	10.22	-1.32
	0.2	8.84		-1.38
	0.4	8.69		-1.53
	0.6	8.22		-2.00
	0.8	7.58		-2.65
	1.0	5.92		-4.31

Note: This table presents the mean optimal irrigation amount under various irrigation costs and YA ratios. "With Insurance" and "No Insurance" columns present optimal irrigation with and without crop insurance, respectively. "Difference" compares the two cases. All adjustment ratios are estimated for $6 and $10 independently with identical results.

Table 2: The Impact of the Sufficient Irrigation Requirement on Optimal Irrigation

		Mean Irrigation (inches)		
Irrigation Cost	Irrigation Requirement Enforced	With Insurance	No Insueance	Difference
6	Yes/No	12.51	12.50	0.01
10	Yes/No	11.44	11.44	0.00
14	Yes	11.08	11.24	-0.15
	No	10.14		-1.10
18	Yes	10.23	10.22	0.01
	No	8.22		-2.00

Note: Results are based on the status quo yield adjustment ratio of 0.6.

Discussion and Conclusion: Our results show that under the current policy design and at current irrigation costs, there is little incentive to adjust irrigation use due to crop insurance. However, if both the YA ratio and the cost increase, that incentive increases significantly. These results are driven almost entirely by a moral hazard cycle, where producers switch between irrigation and no irrigation. Enforcement that eliminates the zero-irrigation option nearly eliminates these effects. When enforcement is not fully feasible, policies to increase the cost of irrigation to reduce water use (e.g., water tax) may inadvertently affect insurance incentives. In most cases, the policies shift water use in the same direction. A higher water tax reduces irrigation use directly via the tax, and indirectly via an insurance incentive. However, there are cases where the policies work in opposite directions.

While the results provide important insight about crop insurance policy design, it is important to keep in mind that the outcomes are based on simulations and not on empirical data. Our results are determined by an optimization procedure that incorporates risk aversion but does not incorporate other behavioral factors. The results show that if a producer chooses to do so, incentives to adjust irrigation exist in certain cases but does not suggest that producers are doing this in practice.

For more information on this project, refer to: Suchato, P., Mieno, T., Schoengold, K., & Foster, T. The potential for moral hazard behavior in irrigation decisions under crop insurance. *Agricultural Economics*. 2021. 1-17. https://doi.org/10.1111/agec.12676

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