Climate Change and the Cost of the US Federal Crop Insurance Program

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Abstract

Climate change may affect agricultural risk through changes to the yield volatility, the market prices for output, or both. We explore the implications of climate change on the cost of the Federal Crop Insurance Program, which totaled $74 billion between 2008-2017, primarily in the form of premium subsidies. Using a suite of chained biogeophysical, statistical and economic models, we project that climate change will increase both yield risk and output prices. Absent changes to the program, we project that federal expenditures will increase by an average of 31% under a moderate warming scenario, or 65% under a higher warming scenario, by 2080. These increases are mitigated by movement of production into irrigation and out of the worst-affected areas, without which premium subsidy costs would increase even faster.

This paper explores scenarios of change in the cost of Federal Crop Insurance Program (FCIP) subsidies with climate change, using a suite of chained statistical, biogeophysical, and economic models. We begin by modeling the relationship between weather and yields, then project those relationships forward using simulated future weather from climate models. A partial-equilibrium economic model then captures how changing yields will alter patterns of comparative advantage in production, and thereby acreage allocation to crops and production practices. These in turn determine production quantity and price, which allow us to simulate indemnities, payouts, and ultimately the federal government's subsidy expenditures under the FCIP.

1 Production Risk

We model the relationship between yields and weather using a Semiparametric Neural Network (SNN) [1]. SNN's allow us to nest parametric, linear regression models within deep neural networks, combining the efficiency of parametric models specified with domain knowledge together with the power of neural networks to detect complex nonlinear relationships in high-dimensional datasets.

Specifically, we used a fixed-effects regression model regressing crop yields on growing degree-days, time trends and total annual precipitation (following Schlenker and Roberts [2]), to which are added derived regressors that are determined by the neural network, and comprised of nonlinear combinations of daily weather data [3] from throughout the growing season. These fitted models are then used to calibrate the output of a process-based crop model, which provides within-region simulations of differential yields disaggregated by management practice and soil types. We then use downscaled climate model simulations [4, 5, 6] to project expected yields for the future scenarios. Projected changes to yield risk – which we proxy with the inter-annual coefficient of variation – are mapped in figure 1.

2 Producer Response

We model how crop acreage allocation will respond to changing yields using the Regional Environment and Agriculture Programming (REAP) model[7], a partial equilibrium model of the U.S. agricultural sector. In all climate change scenarios and among all crops, irrigated acreage increases relative to baseline values, while dryland acreage declines – especially in corn and soy in the west and south (figure 2). Despite this shift to irrigation, total acreage declines. Meanwhile prices increase, by an inter-model average of 35%, 25% and 7% for corn, soy, and winter wheat respectively under RCP 4.5 (the moderate scenario), and by 65%, 51%, and 11% respectively under RCP 8.5 (the warmer scenario) (figure 3). While irrigation implies higher production costs, the growth in both prices and in irrigation's yield differential is sufficient to drive the modeled movement into this production mode. We note that REAP does not model all types of producer adaptation that may be important in practice, nor can it model global supply and demand changes.

3 The cost of the FCIP

Yield, price, and acreage distribution estimates enable us to simulate the cost of the FCIP, using methods that replicate the procedures used by the USDA Risk Management Agency (RMA), which sets premium rates. Enrolled acres as a share of planted acres and average coverage levels are held constant at the county level; we do not model any demand responses to changed premiums.

Total annual costs of the FCIP are projected to rise to $7.55 or $9.13 billion – under RCP4.5 or 8.5 respectively – from a baseline estimate of $5.77 billion. These results are disaggregated by crop and by climate model in figure 4. Absolute changes are greatest in corn, percentage changes are greatest in soy, and winter wheat changes are modest. There is substantial heterogeneity between climate models.

4 Discussion

We find that climate change will reduce yields, increase their riskiness, and increase the price of agricultural output. As such, we project increases in the cost of the FCIP. We emphasize the further research is needed to explore the implications of relaxing several simplifying assumptions that underpin these projections:

- Demand for insurance is held fixed; there is no response to higher crop insurance premium rates.
- Irrigation water availability and cost are held constant.
- Agricultural technology is static.
- Productivity, yield, price, and demand shocks from outside the U.S. are held constant.
- The structure of the FCIP will remain constant.

In sum, we project higher prices stemming from lower supply, along with increasing yield risk, but mitigated by producer adaptations that include shifts in crop acreage (particularly shifts away from dryland production in riskier regions). Together, these imply higher FCIP subsidy costs. Lower supply is due to a combination of yield and acreage changes, driven by weather that is projected to be less favorable to field crops than a future without climate change, on average over most of the US. While we model some aspects of behavioral adaptation – largely shifts of dryland production into irrigation, and out of production entirely in some parts of the south and west – we are unable to model every potential means by which the agricultural sector might adapt to coming changes.

Figure 1: Projected changes to yield risk – proxied with the interannual yield coefficient of variation – for the period 2060-2099, averaged across all GCMs.

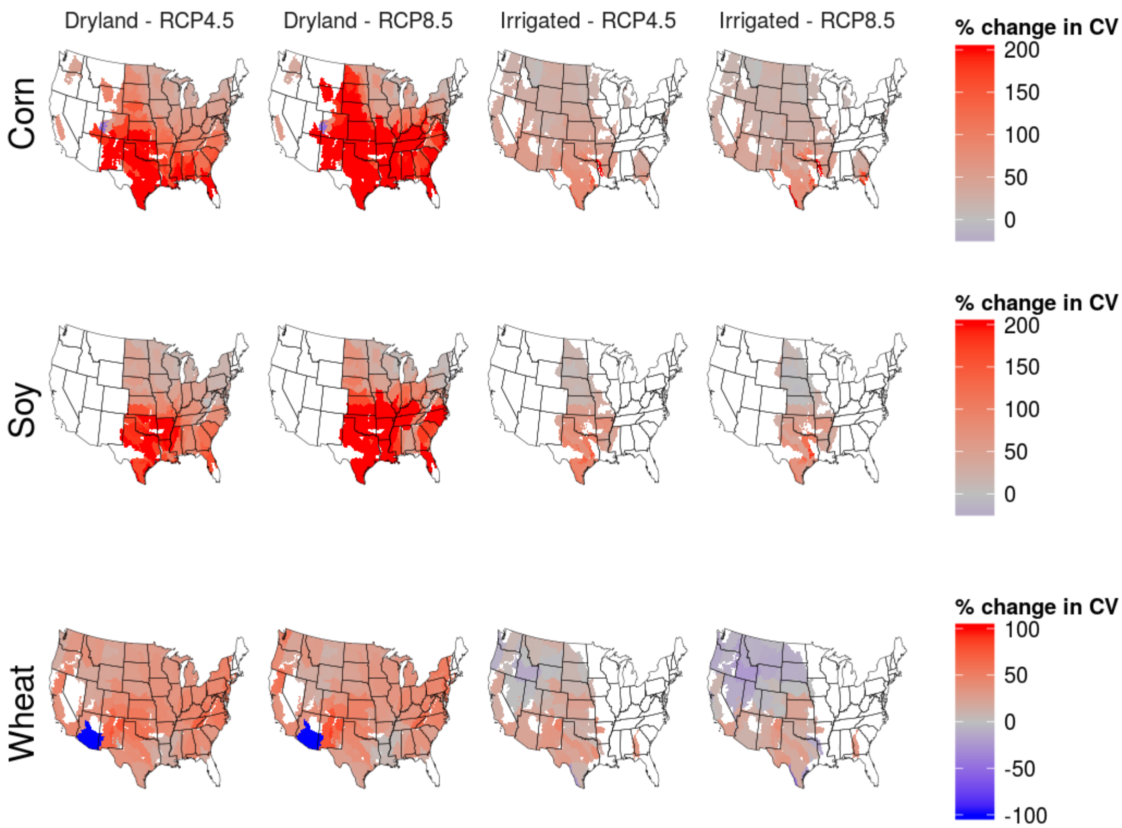


Figure 2: Projected percentage changes to acreage (compared to the baseline scenario with no climate change), averaged across all GCMs. Increases above 100% truncated to 100%.

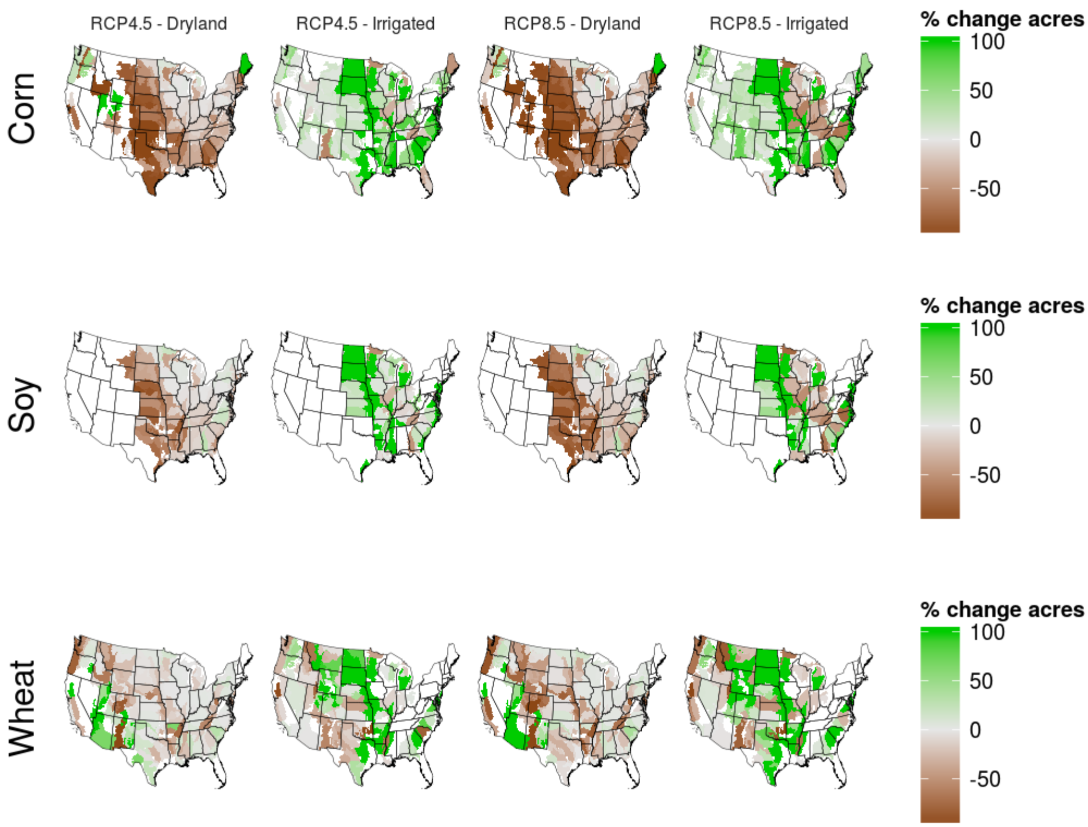


Figure 3: Projected percentage changes to acreage and price, across scenarios. Error bars on price plots indicate projected price standard deviations.

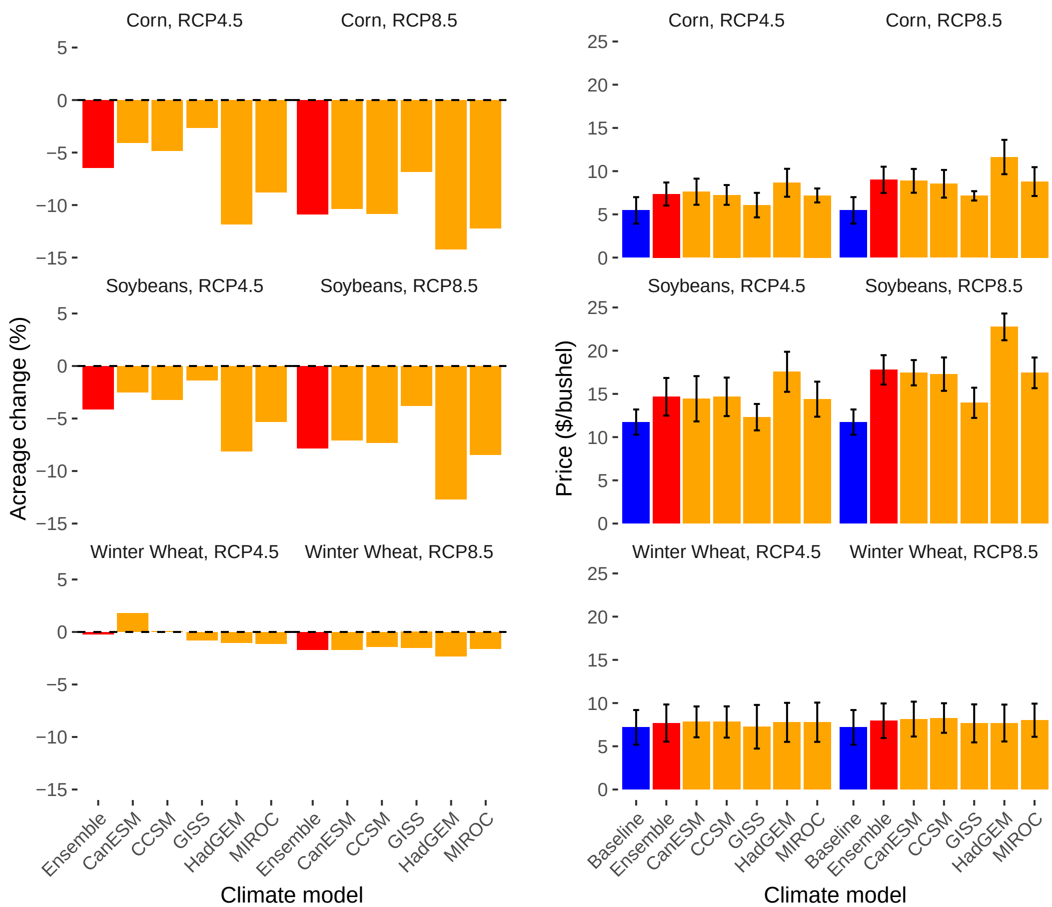
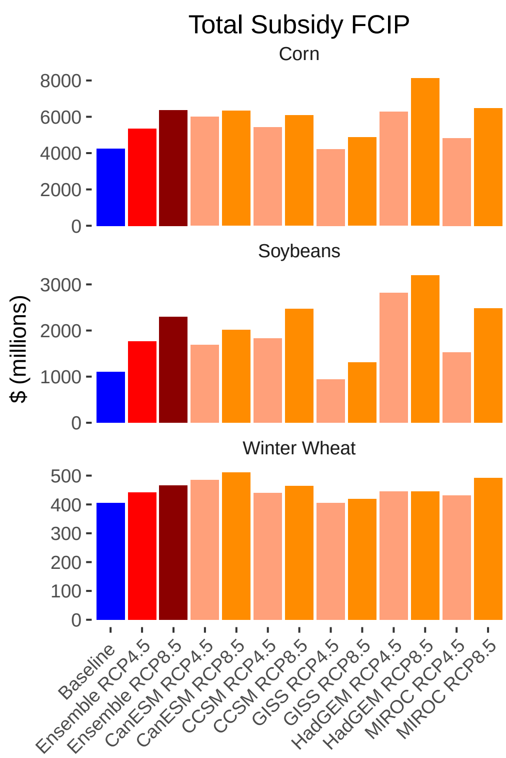


Figure 4: Projected changes to the cost of the FCIP, by crop, climate model, and warming scenario.



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