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Weather and crops.

Farm Programs and Climate Change

J.K. Lewandrowski and R.J. Brazee

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The authors are economists with the Resources and Technology Division of ERS.

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Abstract

By encouraging or discouraging adaptations to new environmental conditions, farm programs could greatly affect the costs of climate change. On balance, today's programs seem susceptible to climate change driven cost increases. Some policy tools and program changes, however, would facilitate adaptation and so could help lower the costs.

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Government Farm Programs and Climate Change

The confirmation that 1990 was the hottest year in over a century means that 6 of the 7 warmest years on record have now occurred since 1981. While few scientists are willing to conclude that this string of historically high temperatures is the greenhouse effect, those involved with agriculture have more reason to be concerned. By its nature, agricultural production is largely defined by the climate. The choices of inputs, outputs, and methods of production all reflect farmers' expectations concerning upcoming temperature, precipitation, growing season, and soil moisture patterns. These are also the variables whose means and variances, many believe, will change as a result of the increasing levels of greenhouse gases in the atmosphere. A changing climate, then, could dramatically shift the current map of agriculture by altering regional (as well as international) comparative advantages in the production of commercially important crops and livestock.

Recently, economists have started to consider the potential costs and benefits relating to agriculture from possible climate change (Dudek, 1989; Adams et al. 1988; Arthur and Abizadeh, 1988). With respect to U.S. agriculture, the general conclusion has been that the aggregate impact will probably be quite small; some regional effects, however, are likely to be significant. One omission in the work to date is the role government farm programs might play in the process of adapting to climate change.

In this paper we use the standard portfolio model to develop a framework for discussing how farm programs might affect the costs of climate change. The paper is a first step and so our objectives are simply to outline the nature of the relationship and to discuss the issues involved.

Farm Programs and the Costs of Climate Change:

It is widely believed that the farm sector could do much to adapt to all but the most pessimistic climate change scenarios. Losses that might now be incurred under warmer and/or drier growing conditions could be offset through the use of alternative crops, different cultivars, more efficient irrigation technology, and minimum tillage practices . Unfavorable late summer weather could be avoided by earlier plantings and harvests. Longer growing seasons might allow for multiple plantings. Increases in weed growth, insect threats, plant disease threats, and the demand for soil nutrients could be addressed with heavier applications of various agro-chemicals. Farmers could also adapt to climate change by entry and exit; leaving the industry where conditions become unfavorable for agriculture and entering it where conditions improve.

To help conceptualize how farm programs might affect the process of adaptation to climate change, we utilize the standard portfolio model (Fama, 1976). At the start of each growing season, a farmer allocates a given level of wealth among n possible investments. Let one investment be perfectly safe. The n-1 alternatives each contain some risk and a subset of these are crops. Denote the return to investment i as r_i and define it

$$r_i = \mu_i + \varepsilon_i \qquad \text{where: } \varepsilon_i \sim (0, \sigma_i^2).$$

Letting s_i stand for the share of wealth allocated to investment i, the return to portfolio p is

$$R_p = \Sigma_i s_i r_i \qquad \text{where: } \Sigma s_i = 1.$$

Because the returns to the n-1 risky investments are uncertain, the farmer must allocate resources based on expectations. For investment i and portfolio p, the expected returns are

$$E(r_i) = \mu_i, \quad \text{and,} \quad E(Rp) = \Sigma_i s_i \mu_i.$$

To compensate for the possibility that the returns to farming will fall short of the return to the risk free investment, risk averse farmers require a premium to induce them to grow crops. That is, the expected returns to crop production must exceed the certain return to the risk free investment. For a given crop and a given farmer, the level of risk premium required will be a positive function of the probability of the crop's return falling below that of the completely safe investment. This implies risk reduction has a value and that there is a price schedule that risk averse farmers would be willing to pay for given reductions in risk. Of course, farmers are mainly concerned with the expected return and risk associated with their entire portfolio. Defining the risk associated with an investment in terms of the variance of its return, allows the risk associated with portfolio p to be written

$$\sigma_p^2 = \Sigma_i(\Sigma_j \; s_j\sigma_{i,j}) = \Sigma_i cov(r_i, R_p).$$

In any given year then, the farmer's problem is to maximize the expected returns to the portfolio subject to total portfolio risk equalling some desired level σ_p^{2*} and the sum of the investment shares equalling one. Formally,

$$(1) \qquad Max_{s_i} \; L = \Sigma_i \; s_i E(r_i) + \lambda_1(\; \sigma_p^{2*} - \Sigma_i(\Sigma_j \; s_j\sigma_{i,j})) + \lambda_2(1 - \Sigma_i s_i).$$

The first order conditions with respect to the s_i's are

$$(2) \qquad L'_{si} = \mu_i - 2\lambda_1\Sigma_i s_i\sigma_{i,j}^2 - \lambda_2 = 0.$$

Solving for s_i yields

$$(3) \qquad s_i = (\mu_i - 2\lambda_1\Sigma_{j\neq i}s_j\sigma_{j,i}^2 - \lambda_2) \;/\; 2\lambda_1\sigma_{i,i}^2.$$

Equation (3) provides a simple framework for assessing how farm programs might impact the social costs of climate change. It says that risk averse farmers will allocate more resources to crop i when the expected returns to crop i increase, the risks associated with growing crop i decrease, or the covariance between the returns to crop i and the returns to another asset in the portfolio becomes more negative. Through their influence on these factors, farm programs could either encourage or discourage farm sector adaptations to climate change. Most of today's programs have elements that would do both and so we focus on the individual tools of farm policy. Table 1 groups these tools according to whether their primary effect is to reduce farmer risk, control aggregate supply, lower production costs, or protect the environment.

In the framework of equation (3), today's farm programs appear susceptible to climate change driven cost increases in several respects. The most costly scenarios are those that include more variable weather patterns. Increased weather variability would make agriculture more risky. Given more frequent droughts, severe storms, and periods of heat above critical crop tolerance levels, farmers would face an increased probability of incurring large production losses. Additionally, in years when these extreme weather events did not occur, conditions for growing crops would be very good (slightly warmer, more precipitation, higher atmospheric carbon). This could mean more frequent bumper crops and a higher probability of years with low agricultural prices. As can be seen in Table 1, many tools of farm policy are designed to reduce farmer risk. Through these tools, the agricultural sector could transfer much of any climate change related increase in risk to society.

Disaster payments and crop insurance would protect farmers from large crop losses. Target prices, deficiency payments, nonrecourse loans, government purchases of surplus production, and (for cotton) producer protection would protect farmers against the negative economic impacts of large surpluses. By shielding farmers from the risks associated with climate change, society would remove the incentive for farmers to engage in other risk reducing behavior. The cost of footing this bill could be quite large. In 1990, a good year for agriculture, crop disaster payments were estimated to be $6 million (USDA, 1990). On the other hand, 1988 was a year of severe drought in much of the United States. Disaster payments related to the 1988 drought were about $3.4 billion in 1989 (USDA, 1990).

The structure of today's commodity programs could also aggravate the social costs of climate change if agriculture becomes more risky. These programs, which account for the bulk of USDA outlays (see Table 2), strongly discourage participants from altering their output mix. Switching crops is generally viewed as one of the most obvious and least costly adaptations farmers could make should climate change alter regional weather patterns. Some evidence suggests that climate change would favor regional shifts in the production of many program crops. Higher levels of atmospheric CO_2 will enable crops in the C3 plant group to increase biomass more than crops in the C4 plant group; on the other hand, C4 plants will improve their water use efficiency relative to C3 plants (Hillel and Rosenzweig, 1989). Commercially important C3 crops include wheat, rice, soybeans, legumes, and root crops; important C4 crops include corn, sorghum, and sugarcane. In terms of comparative advantage then, we might expect climate change to favor shifts to C4 crops where conditions get drier, and to C3 crops where water availability stays constant or increases. Additionally, historical evidence suggests that wheat is particularly susceptible to extreme heat (Rosenberg, 1989). Hence, we might also expect wheat production to decrease in much of the South.

While regional shifts in crop production could help reduce the social costs of climate change, present commodity programs would make these benefits difficult to realize. A farm's allowable acreage for a given program crop is usually based on the average acreage it has allocated to that crop over the last few years. Hence, it takes time to build program acreage in new crops; additionally, farmers are penalized for several years for any major reduction in one year's program acreage. Should climate change increase the relative riskiness of producing nonprogram crops, more farmers will opt for program participation. To the extent farm programs discourage the production of crops best suited to local conditions, the social costs of climate change will increase.

A third area in which farm policy is susceptible to climate change driven cost increases relates to the provision of federally subsidized irrigation water to western farmers. These subsidies lower the private costs of production enabling otherwise uncompetitive firms to enter the industry. The irrigation water program is particularly important because it is one area where today's actions could significantly affect the costs of adapting to climate change. Historically, this water has been provided under long-term contracts (typically around 40 years). Many contracts are now expiring and western farmers are pushing to have them renewed. At the same time, population growth is greatly increasing non-agricultural demand for water in much of the West (particularly in southern California, and around Denver, Salt Lake City, and Sparks-Reno). These demand shifts will become more pronounced if the West becomes hotter and/or drier. Large outward shifts in the non-farm demand for water would greatly increase the opportunity cost of selling federally controlled water to farmers at prices fixed well below current market values. The potential magnitude of the cost increases can be appreciated by considering that in some areas, non-farm users are already willing to pay $200-$300 per acre foot for water the government sells to agriculture for less than $50 (Moore, forthcoming).

Finally, within the structure of current farm policy, the social costs of climate change could be aggravated by the more frequent use of import restrictions. Domestic sugar producers can compete in the in the U.S. market only because the government limits the quantity of imported sugar. The costs of this protection are largely incurred in the form of higher consumer prices (2 to 3 times the world average). Global Climate Model (GCM) simulations suggest a similar situation could arise in other important agricultural markets given climate change. GCM simulations predict that the effects of climate change will be minimal in Argentina, Brazil, and Australia; in Canada the impacts will be substantial but favorable to agriculture. If crop production costs in the United States rise relative to these other countries, U.S. farmers may become less competitive in other important commodities. As with sugar today, we may be technically able to meet domestic demand but not able to do so at a lower cost than foreign producers. The temptation to protect domestic farmers with import quotas and the implied higher consumer costs are obvious.

While many of today's farm policy tools appear to leave society vulnerable to climate change driven cost increases, others could have a mitigating effect. If agricultural production becomes subject to more frequent booms and busts then, in the absence of more of government intervention, agricultural prices will exhibit more year to year volatility. Government storage programs could reduce this instability by smoothing the market supply of agricultural products between poor and abundant harvests. There also seems to be the potential for storage programs to reduce farm sector risk without large resource transfers from society. Farmers, for example, could be given program production limits (defined, say, as their share of national production). Output above this level would be put in storage until a bust year when it would be returned to the farmer. If producers were not paid for their surplus production (as they are now) then the only costs to society would be for transportation and storage. In 1989 the USDA spent about $1.5 billion storing and transporting surplus production. Given the alternative of highly unstable agricultural markets, a 2 to 3 fold increase in these outlays may be socially justifiable.

In addition to government stockpiles, the system of publicly financed research and extension could help mitigate the costs of climate change. So far, we have been careful not to include technological breakthroughs in the list of possible farm sector adaptations to climate change. This is because of the uncertainty of results from experimental research. Still, given the recent advances in biotechnology, it seems reasonable to assume the some technological advances will help agriculture adapt to hotter and/or drier environments. Given the potential social costs of climate change, and the likelihood that the social returns to climate change research will exceed the private returns, a case can be made for expanding publicly funded research.

We have considered how climate change might impact the social costs of maintaining the current set of farm programs. Two other types of costs are also relevant to this discussion; though they are really opposite sides of the same coin. First, given a changing climate, how could present farm programs be modified to achieve their goals at a lower cost? Second, how costly might climate change inspired modifications to farm policy be if, in fact, climate remains constant?

The numerous uncertainties regarding the impacts of climate change on agriculture argue against undertaking expensive remedial measures at present. Not knowing what form the impacts will take, makes it difficult to know what types of mitigation or adaptations would be desirable. Additionally, almost any farm sector adaptation one can think of could be accomplished in 1 to 2 years; by most estimates, the impacts of climate change will not become apparent for at least 2 decades. Still, some modifications to today's programs might be worth considering that would facilitate adjustments to climate change. These are modifications that could either be accomplished at a low cost or which have more immediate justifications. In addition to the already mentioned expansion of public research, possible modifications include implementing flexibility in the commodity programs, encouraging investments in more efficient irrigation equipment, and tying disaster payments to a moving average of recent yields.

Implementing flexibility in the commodity programs would remove their rigid output restrictions and allow participants to choose from a range of crops without directly affecting their level of support. Flexibility has several potential environmental benefits, including protecting groundwater supplies (McCormick and Algozin, 1989). Should climate change become a reality, farmers would have more incentive to shift to crops that are better suited to the new environmental conditions.

A second possible adjustment to farm policy is helping farmers in water scarce areas acquire more technically efficient irrigation equipment. This equipment is expensive; a center pivot sprinkler system that can irrigate 320 acres costs about $90,000 (Ward et al., 1989). Farmers who have access to adequate water supplies are unlikely to undertake this investment themselves. Where these supplies are publicly subsidized, or, where water withdrawals now exceed natural replacement, there may be benefits to reducing irrigation water use that would accrue to people outside agriculture. Such benefits could justify helping farmers obtain the irrigation equipment and would put them in a better position to adapt to climate change should it occur.

Finally, we might consider tying disaster payments to average yields over the last several growing seasons. It is generally believed that the effects of climate change will show up slowly over a period of years. This means that the growing conditions for important commercial crops could gradually deteriorate. Relative to today, we might observe a series of crop failures before recognizing that the cause was climate change. This modification would act as a check against making a string a disaster payments when, in fact, yields are average given the new environmental conditions. Additionally, the change would be inexpensive to implement and would cost nothing if climate remained constant.

Conclusions:

The social costs of climate change may well depend on how fast agriculture adapts to new environmental conditions. Farm programs could greatly influence the rate at which this adaptation process occurs. Because these programs are resource intensive and have proven to be very durable, now maybe the time to start considering how they could affect the costs of adapting to climate change.

Depending on the accumulation of scientific evidence, it could become increasingly necessary for policy makers to account for climate change when developing and implementing farm programs. On balance, today's programs appear susceptible to large climate change driven cost increases. With the exception of not renewing long-term water contracts in the West, however, it seems too early to make expensive modifications to farm policy specifically aimed at climate change. Some changes to present farm programs that would encourage adaptation to climate change might warrant consideration for other reasons. These changes include implementing flexibility in the commodity programs, assisting farmers in some water scarce regions to acquire water efficient irrigation equipment, expanding agricultural research related to climate change, and tying disaster payments to an average of recent yields.

Table 1: Grouping Farm Policy Tools by Main Effect

A. Reduce risk to farmers:

1. Price supports:
   a. nonrecourse loans
   b. market purchases of surplus production
2. Income supports:
   a. target prices
   b. deficiency payments
3. Disaster payments
4. Crop insurance
5. Producer protection (cotton program)
6. Subsidized credit (other than crop insurance)
7. Milk indemnity plan

B. Maintain output prices:

1. Government stockpiles
2. Acreage restrictions
   a. program acreage limits
   b. acreage reduction programs
3. Production/marketing quotas
4. Import restrictions
5. Export restrictions

C. Reduce production costs:

1. Subsidized water sales
2. Agricultural research and extension
3. Marketing loans

D. Reduce environmental damage:

1. Conservation Reserve Program
2. Swampbuster provisions
3. Sodbuster provisions

Table 2: Funding of Selected Agricultural Price/Income Support Activities of the Commodity Credit Corporation for 1989 (in 1,000's of dollars):

Commodity purchases and related inventory acquisitions	2,146,384
Storage, transportation, and other obligations not included above	988,831
Producer storage payments	481,794
Direct producer payments:	
Feed grains	5,034,964
Wheat	626,725
Rice	482,136
Cotton	356,382
Dairy	168,240
Crop disaster payments	3,385,946
Livestock assistance	532,579

Source: U.S. Dept. of Agric. (1990). Budget Estimates for the United States Department of Agriculture for the Fiscal Year Ending September 30, 1991.

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