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THE ENVIRONMENTAL IMPACTS OF SUBSIDIZED CROP INSURANCE

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Abstract

A partial equilibrium model of stochastic crop production is used to analyze the environmental impacts of popular subsidized crop insurance programs. If a perfectly seperating, actuarially fair equilibrium exists, crop insurance does not effect land utilization. However, in the more practically feasible pooling equilibrium, additional acres are cultivated in the short-run. In particular, crop insurance results in the employment of land with a minimum quality that is strictly lower than the minimum quality without insurance. Therefore, if economically marginal land is also environmentally marginal, crop insurance contributes to the degradation of the environment.

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Introduction

Subsidized crop insurance as a federal farm policy tool has been increasing in scope and scale for the past decade. An important economic question is the impact of crop insurance in general, and subsidized crop insurance in particular, on the level of environmental degradation due to expansion of the extensive margin in agricultural production. A large literature exists on the impacts of crop insurance on variable input use and the intensive margin. Notable theoretical studies include Nelson and Loehman (1987), Chambers (1989) and Quiggin (1993). Notable empirical studies include Horowitz and Lichtenberg (1994), Smith and Goodwin (1996) and Babcock and Hennessy (1996). Surprisingly, however, less has been written on the impacts of subsidized crop insurance on the extensive margin. Only recently has a simulation and empirical literature arisen. Gardner and Kramer (1986), Goodwin, Smith and Hammond (1999), Keeton, Skess and Long (1999), and Young, Schnepf, Skees and Lin (1999) all conclude that subsidized crop insurance results in the additional employment of marginal acreage.[1] But, to the authors' knowledge, a formal economic theory that underpins this research does not yet exist.

This paper develops a partial equilibrium model to analyze this question. The model presented is stylized, yet captures the essence of the economic forces at work in federal crop insurance. This requires several ingredients. The supply curve is positively sloped in the "short-run", while there are constant returns to scale in the "long-run." Individual units of land are distinguished by a qualitative index that jointly measures the impact of higher land quality on the mean and variance of crop yields and on environmental degradation. In particular, higher land quality is associated with an increase in the mean and a decrease in the variance of crop yields, while the level of environmental degradation decreases with an increase in land quality, *ceteris paribus*. Variable inputs are committed to production prior to the realization of a random event that influences the actual yield. Land is a quasi-fixed input. A unit of higher quality land earns a greater internal rate of return than an equivalent size unit of lower quality land. Thus, the long-run equilibrium market price of land increases with land quality. There are simultaneously land qualities that are infra-marginal, marginal, and at the extensive margin of crop production.

We find that without any crop insurance program, all land of a critical quality and higher will be in production. The addition of a crop insurance program that is characterized by a *perfectly separating equilibrium* and an actuarially fair premium for each quality does not change input use or land allocation. However, with risk neutral farmers and actuarially fair premiums, all farmers are indifferent between the purchase and not pur-

[1] Similarly, Williams (1988), Turvey (1992), and Wu (1999) have examined the impact of crop insurance on the choice of crop type. Soule, Nimon, and Mullarkey (2000) provide an excellent overview of this and other extensive margin related studies.

chase decision. Conversely, if farmers are risk averse, then all will purchase actuarially fair crop insurance. Subsidized crop insurance based on a perfectly separating equilibrium creates an incentive for the extensive margin to expand, with the expansion taking place at the lower end of the quality spectrum, i.e., there is adverse selection. All land in production without crop insurance remains in production with subsidized crop insurance. It is profitable to purchase subsidized crop insurance for all qualities of land in production with the introduction of this type of insurance.

An actuarially fair *pooling equilibrium*, in which total premiums across all land in production equals expected total indemnity payments, creates an incentive for the extensive margin to expand at the lower end of the quality spectrum, again leading to adverse selection. In the short-run, owners of the highest quality land will not insure their crops, while owners of the lowest quality land will purchase insurance, exacerbating the adverse selection problem. Over the long-run, for risk neutral farmers the pooling equilibrium premium rate increases until a limiting solution is obtained in which the owners of only one land quality type are indifferent between insuring and not insuring that single quality of land. For all practical purposes, this essentially dissolves the pooling equilibrium. However, for risk averse farmers there will be a nondegenerate pooling equilibrium in the long-run, displaying some degree of adverse selection. Subsidizing the insurance premiums in a pooling equilibrium leads to two opposing effects. The disincentive for higher quality landowners to purchase insurance that partially subsidizes lower quality land is mitigated with subsidies on the insurance premiums. However, the incentive to expand the extensive margin at the low end of the quality spectrum is exacerbated.

1. A Simple Model of Agricultural Production

In this section, a simple model of agricultural production in a stochastic environment is developed in order to lay a foundation for examining the impacts of crop insurance on a representative farmer's land utilization. The rational, profit-maximizing producer is subject to random multiplicative supply disturbances, but is assumed to commit inputs prior to the realization of such shocks. Land is the quasi-fixed input, and the farmer is assumed to choose an interval of quality on which to produce. The higher the quality of land, the greater the mean and the smaller the variance of production.

The quality of any given plot is $\theta \in [0,1]$. With access to reasonably functioning credit markets, farmers should be able to finance production on any land with positive economic returns. Therefore, the producer may be assumed to have access to land of all qualities, but chooses to produce only on those lands with positive expected profits. Let the amount of planted acreage of a given level of quality be $k(\theta)$. Therefore, $\theta\, k(\theta)$ can be thought of as the 'effective' land of quality θ in use.[2]

[2] For example, if the amount of land of quality $\theta = 0.75$ is 1 acre, the resulting equivalent usage of the best land possible (i.e. the 'effective acreage') is 0.75 acres.

Given land of some quality θ, planned production is a function of the utilization of the quasi-fixed input, effective acreage, and a variable input, labor. All inputs are fully committed prior to the realization of the stochastic process that distinguishes planned from actual output. For simplicity, we will assume a Cobb-Douglas technology for planned production,[3]

$$\bar{q}(\theta) = \sqrt{\theta k(\theta)\ell(\theta)}\,. \tag{1}$$

Realized output is a function of planned production and a stochastic multiplicative disturbance, $\varepsilon(\theta)$,

$$q(\theta) = \bar{q}(\theta)[1+\varepsilon(\theta)]\,, \tag{2}$$

where $\varepsilon(\theta)$ is normal with mean 0 and variance $\sigma^2(\theta)$, independently distributed across θ. Total production follows a Weiner process across land quality, so that actual production for land of quality $\hat{\theta}$ and higher in production is,

$$Q(\hat{\theta}) = \int_{\hat{\theta}}^{1} [\bar{q}(\theta)d\theta + \bar{q}(\theta)\varepsilon(\theta)\sqrt{d\theta}]\,, \tag{3}$$

where $\hat{\theta} \in [0,1]$.

We assume that the variance of the best quality land is nonnegative and that variance decreases with land quality:

$$\sigma^2(1) \geq 0\,; \tag{4}$$

$$\frac{d\sigma^2(\theta)}{d\theta} \leq 0\,. \tag{5}$$

Note that "better" land results in production with a higher mean *and* a lower variance per unit of land (i.e., the variability of yield per acre decreases with quality). Also note the lack of moral hazard in our model: $\sigma(\theta)^2$ depends only on θ, and not on the level of input use. Deliberate actions on the part of the representative rancher to increase the variability of yields, in the presence or absence of crop insurance, are not considered here since the

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[3] The fundamental results of this paper can be generated with any technology that can be represented by a linear homogenous production function of n variable inputs and effective land as a quasi-fixed input.

optimal equilibrium mix minimizes the long-run average total cost of planned output.[4]

An economically rational, risk neutral farmer makes decisions based upon expected values. Therefore, expected total supply, given utilization of all land of quality $\hat{\theta}$ and higher, is

$$\bar{Q}(\hat{\theta}) = \int_{\hat{\theta}}^{1} \bar{q}(\theta) d\theta . \tag{6}$$

Total cost, for each quality θ, is the sum of variable cost and the rent on the quasi-fixed input, effective land. Noting that

$$\bar{q}(\theta) = \sqrt{\theta k(\theta)\ell(\theta)} \Rightarrow \ell(\theta) = \bar{q}(\theta)^2 / \theta k(\theta) ,$$

total cost for given θ can be represented by

$$TC(\theta) = \frac{w\bar{q}(\theta)^2}{\theta k(\theta)} + r(\theta)k(\theta) , \tag{7}$$

where w is the (deterministic) wage rate for the variable input labor and r(θ) is the internal rate of return on a unit of land with quality θ. Marginal cost, given θ, is the derivative of total cost with respect to planned supply,

$$MC(\theta) = \frac{2w\bar{q}(\theta)}{\theta k(\theta)} . \tag{8}$$

2. Rational Expectations Market Equilibrium

The short-run, rational expectations equilibrium for risk neutral producers in a competitive market is defined by the equality of the expected marginal cost of planned output and the market price. Market demand is given by

$$p(\hat{\theta}) = \alpha - \beta Q(\hat{\theta}) . \tag{9}$$

The short-run market equilibrium can be represented by equating the right hand side of equation (8) with the expected value of the right-hand side of equation (9),

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[4] This is not meant to imply that the problems associated with ‘moral hazard’ types of informational asymmetries cannot play a role in the relationship between a farmer and an insurer. However, this paper aims to explicitly focus upon the environmental impacts of altering land use in response to a crop insurance scheme. Adverse selection is the most direct approach to this end.

(10) $$\frac{2w\overline{q}(\theta)}{\theta k(\theta)} = \alpha - \beta\overline{Q}(\hat{\theta}),$$

from which it follows that

(11) $$\overline{q}(\theta,\hat{\theta}) = \frac{\theta k(\theta)[\alpha - \beta\overline{Q}(\hat{\theta})]}{2w} \;\forall\; \theta \in [\hat{\theta},1].$$

This expression then implies that total planned supply, over all values of θ for which land is employed in production of the crop, is implicitly defined by

(12) $$\overline{Q}(\hat{\theta}) = \int_{\hat{\theta}}^{1} \overline{q}(\theta)d\theta = \frac{[\alpha - \beta Q(\hat{\theta})]}{2w}\int_{\hat{\theta}}^{1} \theta k(\theta)d\theta.$$

Let $K(\hat{\theta}) = \int_{\hat{\theta}}^{1} \theta k(\theta)d\theta$ denote *total effective land* in production. Substitution into equation (12) yields total planned quantity as

(13) $$\overline{Q}(\hat{\theta}) = \frac{K(\hat{\theta})\alpha}{2w + K(\hat{\theta})\beta}.$$

This result, coupled with our residual demand equation (9), allows us to solve for the short-run equilibrium mean output price,

(14) $$\overline{p}(\hat{\theta}) = \frac{2w\alpha}{2w + K(\hat{\theta})\beta}.$$

Finally, substitution into our equilibrium conditions (equation (11)) allows us to solve for planned production for each quality level,

(15) $$\overline{q}(\theta;\hat{\theta}) = \frac{\theta k(\theta)\alpha}{2w + K(\hat{\theta})\beta}.$$

We complete the basic model setup with the variances and covariances for quantities and prices:

(16) $$\mathrm{V}(q(\theta)) = \frac{\alpha^2\theta^2 k(\theta)^2\sigma(\theta)^2}{[2w + K(\hat{\theta})]^2};$$

(17) $$\mathrm{V}(Q(\hat{\theta})) = \frac{\alpha^2\int_{\hat{\theta}}^{1}\theta^2 k(\theta)^2\sigma(\theta)^2 d\theta}{[2w + K(\hat{\theta})\beta]^2};$$

(18) $$\mathrm{V}(p(\hat{\theta})) = \frac{\alpha^2\beta^2\int_{\hat{\theta}}^{1}\theta^2 k(\theta)^2\sigma(\theta)^2\, d\theta}{[2w + K(\hat{\theta})\beta]^2},$$

(19) $$\mathrm{Cov}(Q(\hat{\theta}), p(\hat{\theta})) = -\frac{\alpha^2\beta\int_{\hat{\theta}}^{1}\theta^2 k(\theta)^2\sigma(\theta)^2\, d\theta}{[2w + K(\hat{\theta})\beta]^2}.$$

Note that the realized crop yield on a single land quality, θ, is uncorrelated with market price, due to the Brownian motion hypothesis across qualities. However, if each farmer owns some land of various qualities (with strictly positive Lebesgue measure on the unit interval), then the total farm output will be (negatively) correlated with the observed market price. These variance-covariance measures could be combined with information on the distribution of land quality ownership to derive the optimal inputs, output and insurance choices for risk averse farmers under various assumptions or conditions.

The above results are now used to develop an expression for the profit of risk-neutral producers in a long run, rational expectations equilibrium. Expected total revenue is the product of expected output price (14) and expected production (15). Similarly, expected total costs are obtained by substituting our expressions for the expected equilibrium price and quantity into our cost relationship (7). Therefore, expected profit for land of quality θ is given by

(20) $$E[\pi(\theta)] = \frac{w\alpha^2\theta k(\theta)}{[2w + K(\hat{\theta})\beta]^2} - r(\theta)k(\theta).$$

Let r_0 denote the exogenous (i.e., market determined) risk free rate of return on alternative capital investments. The marginal land quality in the crop market, $\hat{\theta}$, is defined by the condition $r(\hat{\theta}) = r_0$, where

(21) $$r(\theta) = w\alpha^2\theta \big/ [2w + K(\hat{\theta})\beta]^2,$$

is the internal rate of return for land with quality θ. Noting that

(22) $$\frac{dr(\hat{\theta})}{d\hat{\theta}} = \frac{w\alpha^2}{[2w + K(\hat{\theta})\beta]^2} + \frac{2w\alpha^2\beta\hat{\theta}k(\hat{\theta})}{[2w + K(\hat{\theta})\beta]^3} > 0,$$

it follows that all land of quality $\hat{\theta}$ and higher will be fully utilized in the production of the crop in the long-run equilibrium, while all lower quality land will be left idle.

3. An Actuarially Fair, Perfectly Separating Crop Insurance Equilibrium

Consider a multiple peril crop insurance scheme where a farmer receives an indemnity if yields fall below some threshold value. This threshold is determined by the product of the *coverage level* ρ and a predetermined production level representing the actual yield history of each plot covered. Assume that this yield history equals historical planned production, which in turn equals the current period's planned production. If paid, the value of the indemnity equals a guaranteed price times the difference between realized yields and the contract's threshold level. Therefore, the gross indemnity for land of quality θ, can be represented by

$$i(\theta) = p_g[\max\{\rho\overline{q}(\theta) - q(\theta), 0\}], \tag{23}$$

where p_g represents the insurance contract's guaranteed price. Alternatively, expression (23) can be rewritten as:

$$i(\theta) = p_g\overline{q}(\theta)\max\{\rho - 1 - \varepsilon(\theta), 0\}. \tag{24}$$

Begin by considering a perfectly separated equilibrium insurance program in which, for each land quality θ, the insured pays a premium that equals the expected value of the indemnity. Let τ(θ) represent the fair premium E[i(θ)], so that

$$\tau(\theta) = p_g\overline{q}(\theta)E[\rho - 1 - \varepsilon(\theta) \mid \varepsilon(\theta) < 1 - \rho], \tag{25}$$

Recall that the expected value of a mean zero, normally distributed random variable given some truncation at ε* is σλ(ε*/σ), where λ is the standard inverse Mills ratio. The actuarially fair premium, given land quality θ, can then be expressed as

$$\tau(\theta) = p_g\overline{q}(\theta)\left[\rho - 1 + \sigma(\theta)\cdot\frac{\phi((1-\rho)/\sigma(\theta))}{\Phi((1-\rho)/\sigma(\theta))}\right]. \tag{26}$$

For any given coverage level, ρ, the fair premium over the entire market for the crop is therefore

$$\mathrm{T}(\hat{\theta}) = p_g\int_{\hat{\theta}}^{1}\left\{\overline{q}(\theta)\left[\rho - 1 + \sigma(\theta)\frac{\phi((1-\rho)/\sigma(\theta))}{\Phi((1-\rho)/\sigma(\theta))}\right]\right\}d\theta, \tag{27}$$

which in turn equals the total expected indemnity payments for this crop. Thus, with a perfectly separating, actuarially fair insurance policy, expected profits remain unchanged when crop insurance is introduced. The premium required is identically equal to the expectation of indemnities, and therefore expected net payments from an insurance contract are zero. In addition, land and other input use decisions remain the same with or without crop insurance. Finally, if farmers are risk neutral, then each one is indifferent between the insurance and no insurance choice, and observed insurance purchases could be anything from no land to all land in production. However, if farmers are risk averse, then we would expect to see all farmers purchasing actuarially fair insurance in a perfectly separating equilibrium.

4. An Actuarially Fair Pooling Equilibrium

We now turn to the impact of crop insurance on land input decisions wherein the owners of land of all qualities pay the same premium rate for a given coverage level. Consider, as a starting point, a "long-run" equilibrium in which entry and exit have driven economic profits for land of marginal quality $\hat{\theta}$ to zero. In the current context, adverse selection arises when the insurer is unable to offer premiums that are actuarially fair for each land quality and therefore offers a common premium schedule, based only on the coverage level and the overall average expected indemnity payment, to all farmers.

Note that a rational farmer will only insure a given divisible parcel of land if the insurance offered for that parcel has a non-negative expected pay-off. Since inferior land has a higher variability of yields relative to higher quality land, the expected indemnity, net of premium, will be positive for parcels at the very low end of the quality spectrum and negative for land at the high end. The benefit of passing off inferior land is then exacerbated by the fact that the poorer land has a lower mean output than the land from which the payment threshold is derived.

Because of the increased profitability of low quality land, due to the positive expected net indemnity payments, adverse selection results in some lands having higher economic values in the presence of crop insurance than they would in its absence. Some of this acreage will be of quality $\theta < \hat{\theta}$ due to the continuity of the profit function and the expected indemnity payment $p_g\bar{q}(\theta)\left[\rho - 1 + \sigma(\theta)\phi((1-\rho)/\sigma(\theta))\big/\Phi((1-\rho)/\sigma(\theta))\right]$. A subset of the previously unemployed lands would therefore enter into production. Thus, the introduction of crop insurance in pooling equilibrium results in the employment of land with a minimum quality that is lower than the minimum quality without insurance or in a perfectly separated equilibrium.

Consider the case where the insurance policy is a new offering, and the insurer sets a single premium rate that is actuarially fair for the market as a whole as it exists prior to the insurance offering, but not necessarily so for an arbitrarily chosen quality level θ. Therefore, the insurance contract resembles that of the previous section, but with an identical premium for all θ. From the definition for the expected indemnity payment for land of quality θ, the expected value of total indemnities is equal to

(28) $$I(\hat{\theta}) = p_g \int_{\hat{\theta}}^{1} \bar{q}(\theta)\left[\rho - 1 + \sigma(\theta)\frac{\phi((1-\rho)/\sigma(\theta))}{\Phi((1-\rho)/\sigma(\theta))}\right]d\theta .$$

The actuarially fair pooling equilibrium insurance premium is then equal to

(29) $$\bar{\tau}(\hat{\theta}) \equiv I(\hat{\theta}) \Big/ \int_{\hat{\theta}}^{1} \bar{q}(\theta)d\theta .$$

It can be shown that Mill's ratio, $\phi((1-\rho)/\sigma(\theta)) \big/ \Phi((1-\rho)/\sigma(\theta))$, is a positive valued, decreasing function of the limit point, (1-ρ)/σ(θ). The standard error, σ(θ), is decreasing in θ, so that the term $\left[\rho - 1 + \sigma(\theta)\phi((1-\rho)/\sigma(\theta)) \big/ \Phi((1-\rho)/\sigma(\theta))\right]$, which determines the relative magnitude of the expected indemnity payment for land of quality θ, is decreasing in θ. By the second mean value theorem,[5] therefore, there is a quality level, say $\bar{\theta}$, for which the initial pooling equilibrium insurance contract is a fair bet. For land qualities lower than this level, the contract is profitable, while for higher land qualities it is unprofitable. Hence, the highest quality land will not be insured, while some land with quality levels in the neighborhood of $\hat{\theta}$, but strictly less than this value, will become profitable with the crop insurance program. These lands will initially come into production, purely because of the introduction of crop insurance and the inherent subsidy on low quality land that results from a pooling equilibrium.

Intuitively, a farmer will choose not to insure any land of quality $\theta > \bar{\theta}$, because the expected indemnities on such acreage are below the premiums charged. On the other hand, there are incentives to purchase contracts for land of quality $\theta < \bar{\theta}$. Such acreage has expected indemnities that are greater than the premiums required. Therefore, the economic returns on lands of quality $\theta < \bar{\theta}$ are unequivocally higher. This in turn implies that the minimum (or marginal) land quality must decrease. A pooling equilibrium in crop insurance implies land that would not otherwise be employed now becomes utilized.

As other studies have noted, primarily beginning with the seminal work of Rothchild and Stiglitz (1976), the long-run actuarially fair pooling rate will necessarily rise to account for the fact that the very best risks are not purchasing insurance, while some of the worst risks are. This will tend to reduce the short-run adverse selection entry of marginal farmland at the low end of the quality spectrum. Moreover, an increase in the insurance premium will also lower the upper bound $\bar{\theta}$ for the break-even land quality, exacerbating the adverse selection problem at the high end of the quality spectrum. In the limit, with risk neutral farmers and an actuarially fair pooling premium, the equilibrium dis-

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[5] The second mean value theorem states that if f and g are continuous functions on the closed and bounded interval $[a, b]$, then there is a point $c \in [a, b]$ such that $\int_a^b f(x)g(x)dx = f(c)\int_a^b g(x)dx$. For the present case, define $f(\theta) = [\rho - 1 + \sigma(\theta)\,\phi((1-\rho)/\sigma(\theta)) \big/ \Phi((1-\rho)/\sigma(\theta))]$ and $g(\theta) = \bar{q}(\theta)$.

solves in the long-run to a single quality type, which necessarily lies at the low end of the quality spectrum of land in production. Moreover, the owners of that specific quality of land will be indifferent between the insurance and no insurance choice, so that the long-run pooling equilibrium is essentially equivalent to no insurance in this case. However, if farmers are risk averse, then there will be a counterbalance to the dissolution of the pooling equilibrium, with a positive interval of land at the low end of the quality spectrum being insured in both the short and the long-run.

Finally, consider a pooling equilibrium crop insurance program where the insurance premium is subsidized by the federal government. The change in profits induced by crop insurance is then indemnities paid less the product of (1-s) and the premiums paid,

$$\Delta\pi(\theta) = i(\theta) - (1 - s)\tau(\theta)\,, \tag{30}$$

where s indicates the subsidy level, i is the indemnity paid on land of quality θ, and $\tau(\theta)$ is the insurance premium. Indemnities less premiums net of subsidies increase and the economic value of land increases, resulting in additional marginal land becoming profitable and entering into production. Adverse selection for low quality land worsens. On the other hand, however, subsidies mitigate the problem associated with the adverse selection at the high end of the quality spectrum in the pooling equilibrium. More high quality/low risk land becomes enrolled in the program as expected indemnities become greater than premiums net of subsidies. If the subsidy is set high enough (including, if necessary, negative premiums paid by farmers), then land of the best quality will be brought into the federal crop insurance program.

4. Conclusions

The passage of the Freedom to Farm Act of 1996 signaled a new regime in U.S. farm policy. Without the luxury of price supports, producers have had to consider alternative risk management tools to cope with increased revenue volatility. Federally subsidized crop insurance is one such alternative and has moved to the forefront of many policy discussions. A concern expressed by some policy analysts and researchers is that crop insurance may indirectly degrade the environment through the expansion of the extensive margin in agricultural production. In this paper, we developed a formal economic theory to analyze this issue.

Using a stylized model, we find that the introduction of crop insurance typically results in the expansion of the extensive margin. If a perfectly separating, actuarilly fair equilibrium exists, crop insurance does not effect land utilization or any other operational choices. However, in the more practically feasible pooling equilibrium, additional acres are cultivated in the short-run. In particular, crop insurance results in the employment of land with a minimum quality that is strictly lower than the minimum quality without insurance. Subsidies merely exacerbate this problem.

In the long-run, adverse selection shrinks the pooling equilibrium. If farmers are strictly risk neutral, the equilibrium dissolves into one in which the lowest end of the quality spectrum is the only acreage insured. Risk aversion implies an equilibrium with a positive interval of land at the low end of the quality spectrum being insured. A long-run pooling equilibrium unequivocally results in the expansion of the extensive margin at the low end of the quality spectrum, regardless of risk preferences. Subsidies mitigate the adverse selection issue for lands of higher qualities and therefore increase participation, but once again exacerbate the expansion of the extensive margin at the low end of the quality spectrum. We conclude that under reasonable conditions, subsidized crop insurance creates incentives to utilize greater quantities of marginal quality land. If, as the empirical studies reviewed by Soule, Nimon and Mullarkey (2000) suggest, economically marginal land is also environmentally marginal, crop insurance contributes to the degradation of the environment.

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