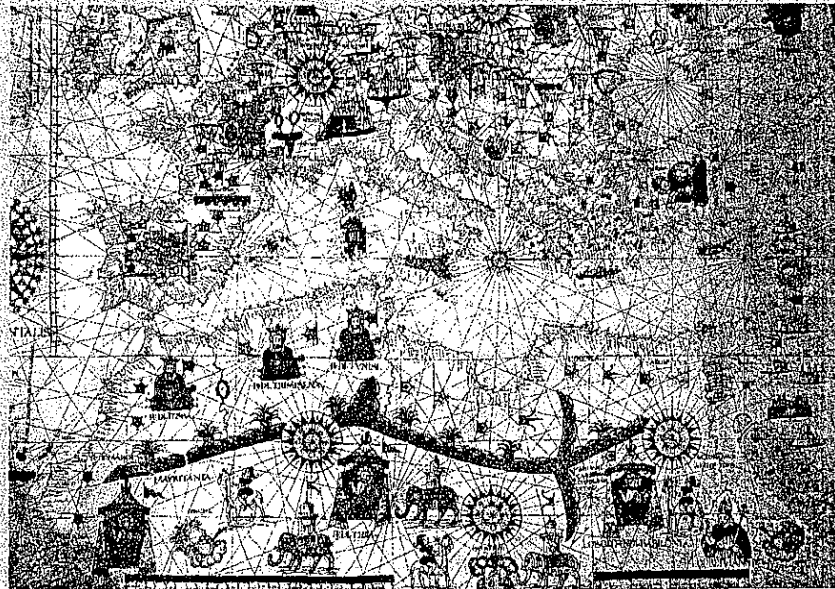


MEDITT

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The Relationship Between Agricultural Insurance and Environmental Externalities From Agricultural Input Use: A Literature Review and Methodological Approach

FABIAN CAPITANIO, FELICE ADINOLFI

Jel classification: D810, Q180, Q510

1. Introduction

Agriculture is arguably the sector of production where factors outside managers' control are more heavily responsible for the final result of the enterprise, something that has contributed to the development and acceptance of forms of public intervention aimed at reducing income variability that have no parallel in other sectors of the economy.

Consequently, both in the United States, Canada and in part of Europe, the attention of farmers and their representatives has focused on the potential offered by the involvement of governments in farm risk management programs (Cafiero et al., 2007).

On the other side, a strong debate in the past arose over the environmental consequences of risk management policy, e.g. crop insurance. In particular, researchers have addressed the question of whether or not the purchase of crop insurance induces farmers both to apply more or less potentially polluting chemical inputs and put in production marginal land.

These relationships between various risk management policy and farmers' agrochemical applications and land use remain unclear up till now for two reasons.

Abstract

The biological nature of agricultural production processes induce a higher degree of uncertainty surrounding the economic performance of farm enterprises. This has contributed to the development and acceptance of forms of public intervention aimed at reducing income variability that have no parallel in other sectors of the economy.

In particular, subsidized crop insurance is a widely used tool. The impact of these programs on the decisions of production generates effects on input use, land use and thus, indirectly, environmental outcomes.

The importance of this issue has grown in parallel with the growth in importance of the collective role of agriculture sector that has addressed the recent guidelines adopted by many developed countries. In this paper we performed an overview of literature on the field of environmental externalities of risk management policies in agriculture. Moreover, we tried to emphasize how risk management tools adoption could offset environmental programs which represent a pillar of the reformed CAP. In this context, an overview about Mathematical programming and risk in the farm model to address the effect of crop insurance and environmental payment on the farmers production behaviour has been implemented.

Key words: uncertainty, risk management, crop insurance, input use decisions, environmental externalities, mathematical programming.

Résumé

La nature biologique des processus de production agricole induit un niveau important d'incertitude concernant la performance économique des exploitations agricoles. Ceci a contribué au développement de formes d'interventions publiques afin de réduire la variabilité des revenus qui n'a pas d'égaux dans les autres secteurs économiques.

Un outil très commun est représenté par l'assurance agricole subventionnée. Les impacts de ces programmes sur les décisions de production engendrent des effets sur l'utilisation des intrants, du sol, tout comme des répercussions indirectes sur l'environnement.

L'importance de cette problématique s'est accrue parallèlement au rôle collectif de plus en plus important de l'agriculture qui a acquis les lignes directrices adoptées par les pays développés. Sur la base de la littérature, cet article offre un aperçu sur les externalités environnementales des politiques de gestion du risque en agriculture. De plus, on a essayé de souligner comment l'adoption des outils de gestion du risque pourrait bouleverser les programmes environnementaux qui sont un pilier de la nouvelle PAC. Dans ce contexte, on offre une analyse de la programmation mathématique et du risque au niveau de l'exploitation pour évaluer l'effet de l'assurance agricole et du paiement environnemental sur le comportement des agriculteurs.

Mots clés: incertitude, gestion du risque, assurance agricole, décision de l'utilisation des intrants, externalités environnementales, programmation mathématique.

First, in terms of intensive margin, the empirical evidence remains unconvincing as to whether chemical and fertilizer applications increase, decrease, or have no effect on yield or profit variance.

Second, in terms of extensive margin, due to the design of crop insurance subsidies and of the disaster payments programs, higher levels of transfer payments are given to comparatively higher-risk areas of production. Since many producers respond to income transfers by increasing production, high-risk areas are likely to see increases in production as well as increases in transfer payments.

In this sense, it is important to stress that since premium rates are a reflection of the amount of risk associated with a parcel of land, then subsidies provide greater transfers to farmers who are operating under risky conditions. While marginal lands are not homogeneous across space, they are often associated with a particular set of environmental characteristics,

the most notable of which is soil erosion. If crop insurance is promoting production on marginal lands, and these lands are found to be highly erosive, crop insurance may be contributing to erosion of farmland, build-up of sediment in n-

earby waterways, and other negative environmental impacts.

In this context, at the same time, in the last years, the Fischler's reform changed the way in which support is guaranteed to farmers. Moreover, the reform represented a systematic attempt to reorient the objectives of farm policy to place greater emphasis on environmental, landscape, food quality and animal welfare objectives (Grant, 2003).

There was five new key elements in the new CAP framework; the introduction of the decoupled payments, cross compliance, re-orientation of the CAP support towards to Rural Development policy by modulation, audit system, new rural development measures.

In this context, actually direct payments are conditional to the respect of minimum standards related to environment, animal welfare and food safety, and modulation of direct payments was turned compulsory, so that each Member States is forced to divert a (small) part of its direct payment endowments to the resources available for Rural Development policies.

The latest CAP reform acknowledged that the increased mobility and leisure time, added at the relocation of population towards rural areas have all acted to increase the marginal value of environmental and goods amenities.

A new role has been attributed at primary sector, so that, production of environmental goods and food quality and safety. This new role is justified in terms of multifunctionality, which means that agro-environmental policies promote non-commodities output jointly produced with agricultural commodity outputs. In fact, for instance, in Europe, within the EU Rural Development Scheme framework, there are several examples of this kind of policy; Members State implemented and receive large «European» subsidy to grant these programs. Examples include English Countryside Stewardship Scheme, the German MEKA programme, and the French «La prime a l'herb».

In short, while either of risk management and environmental policy received a specific regulation, remain unclear until now how these kinds of programs could to act together, without offset both of them.

2. Production's behavior, risk management tools and environmental externalities

The history of the CAP, which established in the past decades the environment to force farmers in pushing in production of food and fibre to the detriment of the quality of rural environments, has been seen as a cause of environmental quality decline.

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Because the non-commodity outputs detain a public-goods characteristics there is not private market and therefore the State has a role in promoting agro-environmental outputs.

Agro-environmental policy may thus be seen to create a «quasi-market» for these goods in that farmers come voluntarily into environmental contracts in return for a payment.

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Although a considerable amount of research has been conducted to examine the impact of various government programs on aggregate supply and price (Houck and Ryan 1972, Chavas and Holt 1990), until recently, few work has focused on the potential environmental impacts of government-sponsored risk management programs such as subsidized crop insurance and crop disaster payments (Horowitz and Lichtenberg 1994, Smith and Goodwin 1996, Wu 1999, Goodwin, Vandever and Deal 2004, Seo, Mitchell and Leatham, 2005).

Among others, one underlying policy question is whether the benefits provided by government-subsidized risk management programs are offset by the costs of such programs, including the costs of unintended environmental effects, and if risk management programs could offset environmental program as foreseen by Fischler's reform.

Government risk management programs, such as subsidized crop insurance and payment in case of disaster

events, undoubtedly introduce potential distortion into farm-level decision-making at both the intensive (input use) and extensive (land use) margins.

Impacts on the environment are largely technical relationships linking land quality, production practices, input use, and environmental measures of interest such as erosion, chemical run-off, leaching, and loss of wildlife habitat.

Recalling the last WTO agreement previously introduced, and the recent Fischler's reform, that settled a new discipline for environmental payments in European agriculture, e.g. linking decoupled payments to cross compliance, we would make clear how both environmental programs and risk management in agriculture (Government financial participation in income insurance and income safety-net programmes and, Payments -made either directly or by way of government financial participation in crop insurance schemes- for relief from natural disasters; art.7 and 8 annex II in Agreement on Agriculture in WTO) were expected into green box.

From this point of view, it becomes interesting to study in depth another relationship among risk management policies in agriculture and environmental policy; in particular, we refer to the content of art.8.

In this context, a point of contention underlying this classification system involves the lack of a precise definition of «minimally trade-distorting». Clearly, absent such a definition, policies that may actually have effects on production and thus international markets may not be subject to the disciplines of the WTO; exactly as ad-hoc disaster relief payments.

At this stage, however, intuition clearly suggests that agents will alter their production behavior with the knowledge that widespread crop losses will trigger disaster payments. The argument is often made that, because disaster payments arrive after harvest and thus differ to production decision, they cannot have an impact on production decisions and thus, will not produce undesirable market distortions.

Such an argument has some merit, but only if producers are surprised by the payments, which is not in our case.

Rational expectation theory suggests that anticipation of future opportunities for updating base acreage may influence current production decisions, thus breaking the «decoupled» nature of the programs.

Producers' behavior throughout the 1980s and 1990s demonstrated that these policies were quickly incorporated into producers' expectation; the likelihood that disaster payments would be received during periods of low yields almost certainly affected producers' planting decisions.

3. Literature review: intensive and extensive margin

3.1. Impacts at the intensive margin

Whereas in most economic sectors uncertainty in price may represent the dominant source of risk, in agriculture this eventuality may not be true; in this context, the litera-

ture on the field has been focused primarily on the impact of production (yield) risk on input use.

Concerning the use of chemical input, early studies examined the impact of price uncertainty on a competitive, one-input, one-output firm (Sandmo 1971, Ishii 1977, Katz 1983, Briys and Eeckhoudt 1985, Hey 1985). Sandmo's seminal paper showed that in the presence of price uncertainty the risk-averse firm will produce less than if prices were known.

Pope and Kramer (1979) proposed one of the first models concentrating on production risk and its effects on input use. They consider a stochastic production function, a constant relative risk aversion utility function, and allow for inputs to either increase or decrease risk. In the single input case, they show that a risk-averse agent uses more (less) of an input which marginally decrease (increase) risk.

The first authors which investigate on the relationship among crop insurance and input usage were Ashan, Ali, and Kurian (1982). They show that in the context of a one-input, one-output model, full coverage crop insurance encourages risk taking and causes farmers to choose inputs as if they were risk neutral. Quiggin (1992) develops a model which introduces the conditions under which, due to the moral hazard problem, crop insurance would lead to a reduction in input use.

One of the most cited contribute is referred to Horowitz and Lichtenberg work.

They pointed out that in many instances pesticide are more accurately viewed as risk-increasing, and thus their use may increase rather than decrease with crop insurance, while the conventional wisdom is that pesticides are risk-reducing inputs.

Since Horowitz and Lichtenberg's contribute is based on data prior at 1992, before, therefore, of the Reform Act brought in US in 1994, same aspect in farmers' behaviour could be altered in a while.

Almost immediately, Smith and Goodwin (1996) criticized Horowitz and Lichtenberg's findings that multiple peril crop insurance could force farmers to increase chemical input use. They emphasized the strong linkage between increase in expected yield and the increase in variance of the yield, whether we consider an input as risk-increasing. The increase in variance positively affects the likelihood of an indemnity payment but the increase in mean yield offset it. The net effect is ambiguous.

Smith and Goodwin doubt that the expected indemnity payment increases with input use for two reasons. First, chemical inputs increases productions cost, and lower (increase) the expected profits (losses) when indemnity payments are made. Secondly, the critical yield that triggers an indemnity payment is determined by the farm's yield history.

Wu (1999) found that crop insurance for corn in Nebraska caused a shift in production from hay and pasture to corn. This could imply that subsidies for crop insurance may also promote environmental degradation due to the increasing in production which may result in increases in overall chemical usage for crops.

It is important to underline that this shift involve into consideration either environmental externalities at the extensive and intensive margin. Wu also points out that an increase in chemical application rates may be due to the 'moral hazard' created by crop insurance.

Literature cited focuses primarily on studies that address the issue of acreage expansion and contraction occurring as a result of crop insurance and/or disaster aid, and the environmental impacts that result from these programs.

Plantinga (1996), carrying out his study on the environmental effects of milk price supports in Wisconsin, illustrates that some government policies aimed to manage both price and yield risk, including price controls, crop insurance and others, could cause forced distortions in markets as well as farm-level decision making.

He emphasized that a reduction in the price support would reduce incentives for profit maximizing producers to operate on marginal lands. This eventuality would imply enhance in environmental quality by reducing soil erosion and improving wildlife habitat through forestation.

In 1996 Griffin addressed the production impacts of crop insurance and disaster payments. He addressed the environmental impacts of public intervention in risk management in additional acreage, estimating an amount of soil erosion of the 16 million acres. Keeton et al. (1999) estimated the effects of disaster assistance and crop insurance on land-use patterns for the same crops in the plains and Midwestern states. More specifically, Keeton et al. tried to investigate on the possibility that government programs could push farmers in production to risky regions of the U.S. Their results pointed out that for every 1-percentage point increase in crop insurance participation, an additional 1.5 million acres are planted to the top six crops in the U.S. Lastly, Goodwin and Smith (2003) found that almost half of the reductions in soil erosion due to the Conservation Reserve Program (CRP) were offset by participation to income support programs which positively affected the raises in erosion from farmer responses.

Unsurprisingly, all of these contributes are related to United States.

Because North America experienced a long history of crop insurance, they have a reliable time series which allowed economists to consistently estimate crop insurance adoption patterns, chemical input use and crop acreage allocation. Differently, in Europe such data are unavailable and this could justify the lack of this kind of analysis.

4. Address the effect of constraints in planning. Mathematical programming and risk in the farm model

Following the above considerations, the problem becomes to correctly represent farmer's behaviour at the farm

level keeping into consideration farmer's benefits from risk management tools adoption and environmental payments. Since technical constraints on farming are not easily to incorporate in econometrics analysis (e.g. water scarcity, type of soil), mathematical programming models represent a valid alternative to address the effect of constraints in planning. Fundamentally, it is a method for finding a solution to a problem where one function or objective is maximized or minimized while other functions or constraints are satisfied. Mathematical programming models developed by agricultural economist can be divided into two main categories: farm models and sector models (Hazell&Norton, 1986).

Farm models focus on optimal organization of farm production, given limited resource such as labor and land. They generally include a range of production activities representing production of various crops and livestock products, and the models often accounts for various ways of producing the products. The objective function in the model is intended to reflect the objective of the decision maker (usually the farmer).

Farmers autonomously make their decisions solving a mathematical programming problem; this happens any time farmers bid for renting a land plot in order to calculate its shadow price, or plan new investments, or produce using the given assets or, finally, anticipate the sets, availability of land, machinery, animals and so on. From a linear programming point of view, these data represent the right terms of the constrain equations. Any farmer chooses from a list of activity options which we can divide in two categories: activities that can be run entirely within one year and activities that generate results over multiple years (investments). The decision variables are the quantity of these activities the farmer actually implement, once the problem is solved. Investments are bounded to be integer and the same investment type is available in different size-options, allowing scale-effects to emerge in the model. As the farm objective is the maximization of household income, the parameters of the objective functions are the gross margins of the various activities. Both available resources and activity gross margins differ across farms. While the former is obvious, the latter is a consequence of the heterogeneous managerial coefficients. The matrix of the constraint coefficients links the available activities with their technical requirements.

Basically, the recurs at mathematical programming modeling is due to the fact that in this way it is possible to assume behavioral rules behind the reaction of the farmers; simulated reaction is assumed to be the answer to an optimization problem; constraint limit optimizing behavior; can be useful in inter-disciplinary research, i.e. it can model hydrology in an economic model of surface or ground water; can be used to solve a system of equations; can constrain a problem to depict current as well as past situations.

As pointed out from Preckel et al¹ «One advantage of the mathematical programming approach is that it allows us to fully utilize information that is known about the existing system while incorporating the new policy or technology

¹ «Primal/dual positive math programming: illustrated through an evaluation of the impacts of market resistance to genetically modified grains», American Journal of Agricultural Economics, Aug. 2002.

into that framework. A second advantage is that the computational power of the mathematical programming approach allows much greater regional and commodity disaggregation, thus allowing much more detailed analysis of the effects of the changes across commodities, regions, types of farms etc. However, one disadvantage of the mathematical programming approach is that consumers of model results typically require mathematical programming model results to faithfully reproduce historical conditions in the absence of the policy or technology change prior to subjecting the model to the change. (However, for some unknown reason, the same consumers of model results appear to hold econometric models to lower standards for model detail and accuracy of base case results.)».

Agricultural sector models are used to analyze producers' reaction to external change, at the aggregate level. Supply functions or production activities represent production in the sector model, and demand function represent consumer demand of the various products. Without risk, both prices and quantities of the products are considered known.

Since risk is often cited as a factor which influences decision, we need to review methods for incorporating risk and risk reactions into mathematical programming models.

Risk models based on mathematical programming depict the risk inherent in model parameters. Risk considerations are usually incorporated assuming that the parameter probability distribution (i.e. the risk) is known with certainty. The task becomes one of adequately representing these distributions as well as the decision maker response to parameter risk. Many different programming formulations have been presented to solve risk problem in farming planning.

The desire to reflect uncertainty of future events within decision-making problems has led to a number of risk models. Many of these risk models attempt to reflect the decision maker's expectations of possible outcomes and their probabilities, along with the decision maker's attitude toward assuming risk.

Linear programming is understandably often the mathematical programming model of choice when first addressing a complex real-world problem. But only a small portion of all measurable real-world problems can be treated as linear to a sufficient degree of accuracy; hence, nonlinear programming (NLP) must be used to improve the model accuracy, realism and validity. We could expect that nonlinear programming will eventually be just as important as linear programming in practice.

Several reasons have made linear programming models widely used: the model is uniform and easy to set up; the theory is well-developed, easily understood, «nice and clean»; the algorithms are easy to understand and to trust; data input and post-optimality analysis are automated and standardized; large models can be solved efficiently. On the contrary, nonlinear programming models do not have a universal form and take a lot experience and expertise to set up properly. The solution concepts, e.g., KKT-points and local solutions, are elusive and most algorithms are sophis-

ticated and take time to understand. Furthermore, they are not as robust for large scale problems as linear programming and there is no guarantee of global solutions.

Briefly, from Lambert and McCarl (1985) «by definition the expected utility of any distribution of wealth equals the mathematical expectation of the utility of wealth evaluated at each of the possible states of nature. If all increments of wealth are caused by the decision being considered, then wealth arising from a decision X would equal initial wealth plus net income due to X . Assuming that total wealth is a simple linear function of X and that W_0 is the vector of net wealth contributions per unit of X under the k th state of nature, then C_k is the increment to wealth under the k th event. Total wealth under k th state of nature thus can be written: $W_k(CX) = W_0 + C_k X$. Using this relationship, the expected utility from a decision X over N -possible discrete states of

nature would be $EU[W(CX)] = \sum_{k=1}^N Pr_k U(W_0 + C_k X)$ where Pr_k is the probability of the k th state of nature occurring and $U(W_0 + C_k X)$ is the utility obtained from the wealth level achieved under state k with decision X ».

Suppose now, that we wish to find the decision X^* that maximizes expected utility over all feasible decisions. This could be accomplished by solving the following programming

problem: $Max_X \sum_{k=1}^N Pr_k U(W_0 + C_k X)$ with $\sum_j a_{ij} X_j \leq b_i$ and $X > 0$.

This formulation is inherently a nonlinear programming problem (also called «direct expected utility maximizing nonlinear program», that is, DEMP)

5. A possible effort of an empirical investigation by non-linear programming model

Theoretically, farmers' enrollment decisions in the Environmental Program (EP) involve dealing with various sources of uncertainty.

Especially, a farmer's bidding strategy is influenced by two sources of uncertainty; farming income and the EP bidding process and rules. The decision to participate in the EP must be made in the face of the well-known revenue uncertainty of agricultural production resulting from variability in output prices and crop yields. Producers are also faced with uncertainty about the EP bidding process and rules including their ignorance of the environmental scoring rules, combining scores to rank bidders, and other bidders' strategies. In particular, they formulate their bidding strategies in the presence of uncertainty about the trade-off between bids and environmental scores and the weight of the cost factor in the total «Environmental Benefit Index» (EBI) that is composed of a set of environmental criteria such as, wildlife, water quality, soil erosion, enduring benefits, air quality, and state or national conservation priority area.

As emphasized above, the purpose of this study is to develop a model of farmer decision-making to understand how farmers formulate their participation strategies when deciding to enroll in the EP under uncertainty; moreover, if

their participation strategies could be offset by risk management programs, such as crop insurance.

To be clear, for example, consider two farmers who farm in different regions. For unsubsidized insurance one farmer would pay £10 per £100 of liability; the other £20 per £100 of liability for the same insurance policy. In relative risk terms, the farmer paying £20 would have yields that are twice as risky for the same insurance policy. Given a 50 percent subsidy, the lower risk farmer receives a £5 per £100 of liability transfer and the higher risk farmer receives £10. Any expected utility model for risk averse decision makers would suggest that this design encourages both farmers to not only increase their level of production, but to possibly increase it onto riskier, marginal lands as well. Marginal lands make up what is referred to as the extensive margin or areas of farmland that are of a lower quality in terms of crop yield and productivity. Marginal lands are often located on the edge of production and are likely to be used given an increase in commodity prices or a decrease in production costs.

The idea is that as a subsidy decreases, lower risk farmers would be less motivated to subscribe crop insurance and riskier farmers could leave their production (probably from marginal land).

How to model it?

We could assume that the modeled farmer earns income by cultivating crops on total acreage S and purchasing inputs $x = \{x_1, x_2, \dots, x_N\}$ to crops $j = 1, \dots, J$.

Farmer has also the possibility to subscribe a crop insurance contracts, characterized by the following payoff: $\{I_j, M_j\} = 1, \dots, I$, where I_j represents the random (eventual) insurance indemnity and M_j is the non random insurance premium for crop j ; moreover, at sowing time, farmer choose to entry in the environmental payments (decoupled payments), $\lambda \in \{0, 1\}$. If farmer facing revenue reductions of more than 30% of the preceding three years average, then disaster payment are guaranteed from public solidarity.

Running the model, we assume that crop insurance and input decisions has been made simultaneously. This does not require that timing of the decisions be contemporaneous, but only that, the planning processes underlying both decisions occur simultaneously. It appear a logical consequences of assuming that farmer decisions are affected from the overall economic environment, i.e. government risk management programs, payment in case of disaster events, environmental payments, which undoubtedly introduces a potential distortion into farm-level decision-making at both the intensive and extensive margins.

At sowing time, total farm revenue P is plausibly based on the expectation made on price, yield and costs experienced in previous season, so that:

$$E(p_i y_i) = p_i^e y_i^e + cov(p_i^e y_i^e) - c_i$$

where E is an expectation operator; p_i^e is the expected per quintal price of the i th crop; y_i^e denotes the expected yield

per hectare of the i th crop; $cov(p_i y_i)$ denotes the covariance between price and yield and underline the natural hedging mechanism among price and yield; c_i is the per hectare cost of production.

Per hectare revenue for crop j when crop insurance is subsidized, payments in case of disaster events are guaranteed and environmental payments occur is:

$$\pi_{ijf} = p' y'(x_j) - c_{jf} - r' x_j + \lambda EP_j + \sum_i (I_{if} - M_{ijf})$$

where p' is the vector of the the random price, y' is the vector of the random crop yield per acre as a function of the input levels x_j , is the non-random variable cost, and r is the price vector of inputs x . represents the environmental payments and λ is an indicator variable for participation in the environmental program ($l = 1$ if the farmer choose to participate, 0 otherwise).

In this scenario, income per crop could be represented as $S_j \pi_j$, where S_j is acreage planted to crop j , and total crop income

$$\pi \text{ is the sum of income over all crops: } \pi = \sum_j S_j \pi_j.$$

The representative farmer maximizes the expected utility of income, choosing the acreage allocation S_j , input use x_j , and participation in the environmental program λ , and insurance program i :

$$\max_{S_j, x_j, i, \lambda_j} \int u(\pi) dF(p_1, p_2, \dots, p_j, y_1, y_2, \dots, y_j) \quad (2)$$

where $u(\bullet)$ is the farmer's utility function and $F(\bullet)$ is the joint distribution function of prices and yields.

Constraints include an acreage allocation constraint $\left(S \geq \sum_j S_j \right)$; solving this optimization program gives the optimal acreage allocation and input use for each crop (S_j and x_j for all j).

In this way, as introduced by Seo et all, the intensive margin effect of the availability of crop insurance and disaster payments for a crop could be identified with the difference in the optimal use of input when the program are available versus when it is not. Similarly, we could look at the extensive margin effect as a changing in optimal acreage when the same programs are available.

6. Concluding remark

The environmental impacts of agricultural production activities continue to play a significant role in policy debates concerning the role of the government in the agricultural sector of the economy. It has been argued that government policies that reduce the production risk facing a producer create potential incentives for the producer to undertake activities harmful to the environment. For example, the provision of public-subsidized crop insurance may encourage producers to bring economically marginal land into production. If that land is also more environmentally fragile than land already in production, this reduction in risk provided by

public-subsidized crop insurance could lead to a reduction in environmental quality. In addition to crop insurance, the government has provided a myriad of other programs designed, among other things, to provide income support and reduce income variability in the agricultural sector.

Some of these program payments are linked yet to the current production of a particular crop, while other program payments are decoupled from current production.

If these programs provide incentives to expand production on the extensive margin, they may also lead to reductions in environmental amenities.

In addition to encouraging production on environmentally fragile land, agricultural subsidy and risk management policies provide incentives for producers to alter crop mix, cropping practices (including input use), and conservation practices. If a crop receives higher deficiency payments or insurance premium subsidies, farmers have an incentive to alter production in favour of that crop. If that crop also requires more extensive cultivation and input use, this shift will lead to a reduction in environmental amenities.

Government payments that increase the current return to crop production may discourage the implementation of conservation practices that may increase or maintain long-term crop yields at the expense of short-term yield. Government payments that increase the return to crop production may also decrease the incentive to shift land into less environmentally damaging uses, such as pasture or range.

While much attention has been focused on the impact of government policies on water quality, soil erosion is a key indicator of changes in environmental quality. The extent of soil erosion on agricultural land is dependent on the specific use of the land (e.g., cultivated vs. noncultivated cropland), the level of cover vegetation, the physical and chemical characteristics of the soil, and the agricultural practices (including cropping and conservation) employed on the land. If agricultural subsidy and risk management policies have the potential to alter land use, cropping practices, and conservation practices, they may contribute to increases in soil erosion. In addition to reducing future crop yields, soil erosion increases leaching and surface runoff which contributes to water quality degradation, habitat destruction, and flooding associated with increases in sedimentation.

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