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## Negative externalities of crop insurance subsidies: a case study in Italy

### Abstract

This study evaluates the impacts of risk management policies on the environment. The effects of public risk management programmes, such as subsidised crop insurance on optimal nitrogen fertilizer use and land allocation to crops, were examined empirically by developing a mathematical programming model of a representative wheat-tomato farm in Puglia, a region in southern Italy. The results show that with current crop insurance programmes, for tomato the optimal nitrogen fertilizer rate slightly increases and the optimal acreage substantially increases, whereas for wheat they both decrease. Hence, this type of public intervention could lead to an increase in surface and groundwater pollution by nitrates.

**Keywords:** uncertainty, risk management, crop insurance, input use, environmental externalities, multifunctionality.

### Introduction

Agriculture is arguably the sector of production, where factors beyond the manager's control most affect 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. In the United States, Canada and 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 programmes (Cafiero et al., 2007).

However, the environmental consequences of risk management policy, such as crop insurance, have been hotly debated. 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 bring marginal land into production.

Therefore, in terms of the intensive margin, it has to be ascertained whether chemical and fertilizer applications increase, decrease, or have no effect on yield or profit variance. By contrast, in terms of the extensive margin, due to the design of crop insurance subsidies, 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 context, the Fischler reform has in the last few years changed the way in which support is guaranteed to farmers. Moreover, the reform represented a systematic attempt to reorient farm policy to place greater emphasis on environmental, landscape, food quality and animal welfare objectives. There are five new key elements in the reworked CAP framework: the introduction of decoupled pay-

ments, cross compliance, re-orientation of CAP support towards rural development policy by modulation, an audit system and new rural development measures. In this context, direct payments are conditional upon the respect of minimum environmental, animal welfare and food safety standards. Modulation of direct payments has been made compulsory, so that each Member State is forced to divert a (small) part of its direct payment endowments to the resources available for rural and regional development policies. The latest CAP reform acknowledged that increased mobility and leisure time, added to the relocation of population towards rural areas, have all acted to increase the marginal value of environmental amenity.

A new role has been attributed to the primary sector, namely production of environmental goods and food quality and safety. This new role may be explained in terms of multifunctionality, which means that agro-environmental policies promote non-commodity outputs jointly produced with agricultural commodity outputs.

At the same time, the new regulations arising from Health Check confer management autonomy on Member States for the first time, authorised to use up to 10% of the national maximum plafond, to supply specific aid in clearly defined cases. Among specific subsidies (Measure d: insurance), there is the possibility of using the first pillar for subsidising measures to cover the risk of economic losses caused by adverse weather conditions and by animal or plant diseases or parasite infestation (Art.70, EC Regulation 73/2009). In actual fact, Measure d allows financial contributions to be granted for payment of crop insurance premiums up to a maximum of 65% of the total premium in the form of EU co-financing (absolutely new in the history of the CAP in this context). This co-financing cannot exceed 75% of the national financial contribution.

In short, while both risk management and environmental policy have been specifically regulated, it remains unclear to date how such programmes might act together, without one offsetting the other.

Hence, the main objective of this investigation is to clarify the relationship between risk management policy and environmental policy in the context of farmers' agrochemical applications and land use. To our knowledge, this study is the first attempt of its kind in Europe, and the results may well bring about a review of Government risk management programmes, which undoubtedly introduces potential distortion into farm-level decision-making, which could be affected at both the intensive (input use) and extensive (land use) margins. There could be a knock-on effect in terms of rural and regional policy, which currently represents for southern Europe, i.e. Italy, the driving force of development.

## 1. Production behavior, risk management tools and environmental externalities

Several studies have, in recent decades, focused on the potential environmental impacts of government-sponsored risk management programmes such as subsidised crop insurance and crop disaster payments (Horowitz and Lichtenberg, 1993; Smith and Goodwin, 1996; Wu, 1999; Seo, Mitchell and Leatham, 2005). All such studies concern the United States. Since North America has experienced a long history of crop insurance, they have a reliable time series, which allows economists to consistently estimate crop insurance adoption patterns, chemical input use and crop acreage allocation. On the contrary, in Europe such data are unavailable, which may account for the lack of this kind of analysis.

An underlying policy question is whether the benefits provided by government-subsidised risk management programmes are offset by the costs of such programs, including the costs of unintended environmental effects, and whether or not risk management programmes could offset environmental programmes (e.g. as predicted by Fischler's reform).

**1.1. Literature review.** 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). 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 decreases (increases) risk.

The first to investigate the relationship between crop insurance and input usage were Ashan et al. (1982), who showed 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) developed 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 contributions is that of Horowitz and Lichtenberg (1993), who pointed out that in many instances pesticides are more accurately viewed as risk-increasing. Hence, 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 contribution was based on data prior to 1992, hence, before the Reform Act came into force in US in 1994, some aspects of farmer behavior may have changed in the meantime.

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 increase in yield variance, if an input is considered as risk-increasing. The increase in variance positively affects the likelihood of an indemnity payment, but the increase in mean yield offsets it. The net effect is ambiguous.

Smith and Goodwin doubted that the expected indemnity payment increased with input use for two reasons. First, chemical inputs increase production costs, 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. In other words, crop insurance subsidies may also promote environmental degradation due to the increase in production, which may result in increases in overall chemical use for crops. Importantly, this shift involves considering environmental externalities at the extensive and intensive margin. Wu also pointed out that an increase in chemical application rates may be due to the 'moral hazard' created by crop insurance.

## 2. The Italian crop insurance system

In Italy, the Government's involvement in agricultural risk management is based on the wholly state-financed National Solidarity Fund (FSN), set up in 1974 with two main objectives: to compensate farmers for damage due to natural disasters and support the use of crop insurance. Until recently, access to disaster payments was open to all farmers, irrespective of the signing of insurance contracts. From 1981 through 2005, appropriations by the FSN have totalized about €9.4 billion; 72% of the amount

spent has been directed to disaster payments, while insurance subsidies have absorbed the remaining 28%. Over the same period, disaster payments averaged €234 million per year, reaching a maximum of €522 million in 1990. The Italian system of compensation for natural disaster damage is mainly reactive, in the sense that the initial yearly endowment of funds received by the FSN can be integrated with *ad hoc* specific legislative measures, when necessary. In 2002, total appropriations for the FSN were €481 million (Borriello, 2003). The law, which established the FSN, also authorized operation of farmers' associations at the provincial level (*Consorti di Difesa*), which were assigned two functions: (i) collection of farmers' insurance demands (mainly for hail), and transferring them to the insurance companies; (ii) coordination and enforcement of common preventive measures. Despite subsidies of about 35% to 40% of actual premiums, the spread of insurance in Italian agriculture has been rather thin: the share of insured value on total crop production – mainly fruit crops and vineyards – has never exceeded 15%, reached in 1998 and decreasing in subsequent years. One likely reason is the possibility for Italian farmers to access compensation for natural disasters even without the signing of insurance policies. The Italian system has been modified, in recent years, with more emphasis on crop insurance, in an attempt to reduce the cost of ex-post compensation in the event of disasters. The main changes are the possibility for farmers to underwrite newly designed contracts for innovative multi-risk coverage directly with insurance companies, with premiums subsidised by up to 80%, and state-supported reinsurance. Eligibility for indemnity shall be determined by an yield loss, taking into account the overall yield of the farmer only income from agriculture which exceeds 30% of average gross income or the equivalent in net income terms (excluding any payments from the same or similar schemes). Moreover, the amount of such payments shall compensate for less than 70 % of the producer's income loss in the year the producer becomes eligible to receive this assistance.

### 3. Non-linear programming model and empirical investigation

Because North America experienced a long "history" of crop insurance, they have a consistent time series, which allows economists to consistently estimate crop insurance adoption patterns, chemical input use and crop acreage allocation. That was the main reason behind the widespread econometric approach utilized in north-Americans' literature. In Europe such data are at moment unavailable and a different empirical approach is needed.

For the above considerations, the problem becomes to correctly represent farmer's behavior at the farm level, so as to take into account farmer's benefits from risk management and environmental payments.

Moreover, technical constraints on farming are not easily incorporated in econometrics analysis (e.g. water scarcity, type of soil), whereas mathematical programming models offer an immediate way to address the effect of constraints. For these reasons, mathematical programming is the main method used throughout this work.

Turvey (1992) developed a mathematical programming model for a Canadian example to examine optimal acreage allocations and farmer welfare with different policies and parameters but, in his framework, he did not endogenize input use.

In this investigation, we developed a mathematical programming model of a representative Apulia (south of Italy) farmer aimed to determine: 1) how public risk management programs and environmental payments affect optimal farm level acreage allocation to wheat and tomato (extensive margin); and 2) the optimal use of nitrogen fertilizer on each crop (intensive margin). We endogenized input use and land allocation decisions, as well as the farmer's participation in public risk management programs for each crop, specifically an "all-risk" insurance (ARI). In addition, we also endogenized the farmer's choice concerning the coverage level for ARI. Starting from these considerations, we combined the mathematical programming and simulation-based approaches by using direct expected utility maximizing non-linear programming (NLP) (Lambert and McCarl).

Following Lambert and McCarl (1985), 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 enrol in the EP under uncertainty. Moreover, whether their participation strategies could be offset by risk management programs, such as crop insurance.

In order to analyze the effects of the introduction of a subsidy on the premium of ARI on yields, we used the Italian Farm Accountancy Data Network (FADN) dataset of two samples of firms for the Apulia region. In particular, we considered to differentiate wheat and tomato products, in terms of expected variability of yields/revenue. Our analysis concerns two case studies of the same low-land/highland system, which are equally suitable for both crops.



The choice of wheat and tomato is due to their different yield variability (tomato yields generally show higher variability than wheat) and to different production characteristics.

From the FADN-RICA database, we selected 1092 farms, which were part of the sample each year over the period from 2003 to 2008. Theoretically, farmers' enrolment decisions in the EP mean dealing with various sources of uncertainty. 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 yield<sup>1</sup>. Any expected utility model for risk-averse decision makers would suggest that subsidizing premiums would encourage farmers both to increase their level of production, and possibly increase it into riskier areas.

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

By modelling it, we could assume a multioutput firm with a fixed amount of land  $L^*$  that can be allocated between  $j$  crops. The producer's problem is to select levels of  $x$  variable inputs for each of the  $j$  crops in the production plan and to allocate  $L^*$  hectares of land among these  $j$  crops. The modelled farmer is a price taker in the output and variable input markets. He/she has the possibility to subscribe an *all risk* (ARI) crop insurance contract guaranteeing yield losses up to 30% of average yield of the overall farm gross production product, with the following payoff:  $\{I_j, M_j\}$  for  $j = 1, \dots, J$ , 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, the farmer could choose to receive the environmental payments (decoupled payments),  $\lambda \in \{0, 1\}$ , by comply his crop practice with the CAP's rules. We are assuming that crop insurance and input decisions are made simultaneously. This requires that the planning processes underlying both decisions occur simultaneously, which would appear a logical consequence of assuming that farmer decisions are affected by the overall economic environment, i.e. government risk management programmes and environmental payments.

<sup>1</sup> For clarity's sake, 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.

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

$$E(p_j y_j) = p_j^e y_j^e + \text{cov}(p_j^e y_j^e) - c_j, \quad (1)$$

where  $E$  is an expectation operator,  $p_j^e$  is the expected per quintal price of the  $j$ th crop,  $y_j^e$  denotes the expected yield per hectare of the  $j$ th crop,  $\text{cov}(p_j, y_j)$  denotes the covariance between price and yield and underlines the natural hedging mechanism between price and yield,  $c_i$  is the per hectare cost of production.

Per hectare revenue for crop  $j$  and farmers  $I$ , when crop insurance is subsidised and environmental payments occur is:

$$\pi_{ij} = p' y'(x_j) - c_j - r' x_j + \mathcal{G} EP_j + \sum_i (I_{ij} - M_{ij}), \quad (2)$$

where  $p'$  is the vector of the random price,  $y'$  represents the vector of the random crop yield per hectare as a function of the input levels  $x_j$ ,  $c_i$  is the non-random variable cost,  $r$  is the price vector of inputs  $x_j$ , and  $EP$  represents the environmental payments (where  $\mathcal{G}$  is an indicator variable for participation in the environmental program;  $\mathcal{G} = 1$  if the farmer chooses to participate, 0 otherwise). The non-random cost and the input are depending on the acreage planted  $S$ .

Income per crop could be identified as  $S_j \pi_j$ , where  $S_j$  is acreage planted to crop  $j$ , and total crop income  $\pi$  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 both environmental programme  $\mathcal{G}$  and insurance programme:

$$\max_{A_j, x_j, \mathcal{G}_j, i} \int u(\pi) dF(p_1, p_2, \dots, p_j, y_1, y_2, \dots, y_j) \quad (3)$$

The farmer's utility function  $u(\bullet)$  is the Von Neumann-Morgenstern ( $u' > 0, u'' < 0$ ), under the hypothesis of risk aversion, such that  $\partial^2 U / \partial^2 \pi < 0$  (Pratt, 1964), and decreasing absolute risk aversion (DARA),  $F(\bullet)$  identifies the joint distribution function of prices and yields.

The optimal acreage allocation and input use for each crop ( $S_j$  and  $x_j$  for all  $j$ ), follows the constraints

$$\text{on acreage allocation} \left( S \geq \sum_j S_j \right).$$

In this way, as introduced by Seo et al. (2005), 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  $x_j$ , when the programme is available versus when it is not. Similarly, the extensive margin effect could be viewed as a change in optimal acreage  $S_j$ , when the same programmes are available.

**3.1. Empirical model.** Following Lambert and McCarl, using a negative-exponential (DARA) utility function for the empirical analysis, we develop a solvable expected utility maximization model, which is: (a) free of restrictions on the forms of the utility function; and (b) free of assumptions regarding the distribution of the uncertain parameters<sup>1</sup>. The underlying assumption in the model implies that wealth effects do not affect production decisions.

This eventuality, which allow us to ignore all other farmers income, foster the adoption of a negative exponential utility ( $v(c) = -\exp(-\theta_c)$ ), where the utility function for problem 3 is:

$$\sum_k [1 - \exp(-R\pi_k)], \quad (4)$$

where  $k$  indexes each state (Monte Carlo random drawn),  $R$  is the coefficient of risk aversion<sup>2</sup>, and  $\pi_k = \sum_j S_j \pi_{jk}$  is profit associated to the state  $k$ .

Income from crop  $j$  in state  $k$  is:

$$\pi_{jk} = p_k y'_{jk}(x_j) - c_j - r'x_j + \mathcal{G}EP_{jk} + \sum_i (I_{ijk} - M_{ijk}), \quad (5)$$

which differs from equation 2 in the index  $k$  that scored each random variable.

In this context, the ARI insurance indemnities for any state  $k$  and crop  $j$  could be represented as:

$$I_{ARI,jk} = PEF_{ARI,j} \max \left\{ CVG_{ARI,j} y_j - y_{jk}^*, 0 \right\}, \quad (5a)$$

where  $y_j^*$  is the average yield used by ARI.

Given that we set the model at only one trigger level, the non-random insurance premium for each crop does not depend, unlike in Seo et al., on several coverage levels. This makes it easier to calculate the expected net indemnity, which is equal to the expected indemnity minus the actual premium, and better represents the Italian crop insurance market.

Since the integration required to obtain the expected indemnity is analytically intractable for the model, we used Monte Carlo integration. In agri-

culture, simulation models are routinely applied to biological system analysis (e.g., crop simulation or environmental models) and there is always some uncertainty present in the system, which can be modelled by sampling from appropriate probability distributions.

Following Greene (2000), “in certain cases an integral can be approximated by computing the sample average of a set of function values. The approach taken here was to interpret the integral as an expected value. We, then, had to establish that the mean we were computing was finite. Our basic statistical result for the behavior of sample means implies that, with a large enough sample, we can approximate the integral as closely as we like.

The general approach is widely applicable in Bayesian econometrics and has begun to appear in classical statistics and econometrics as well<sup>3</sup>.

Green considers the general computation:

$$F(x) = \int_L^U f(x)g(x)dx, \quad \text{where } g(x) \text{ is a continuous}$$

function in the range  $[L, U]$ , and further, he supposes that  $g(x)$  is non-negative in the entire range. To normalize the weighting function, we suppose,

as well, that  $K = \int_L^U g(x)dx$  is a known constant.

Then,  $h(x) = g(x)/K$  is a probability function in the range because it satisfies the axioms of probability.

$$\text{Let } H(x) = \int_L^x h(t)dt.$$

Then,  $H(L) = 0$ ,  $H(U) = 1$ ,  $H'(x) = h(x) > 0$ , and so on.

Then,

$$\int_L^U f(x)g(x)dx = K \int_L^U f(x) \frac{g(x)}{K} dx = KE_{h(x)}[f(x)], \quad \text{where}$$

we use the notation  $KE_{h(x)}[f(x)]$  to denote the expected value of the function  $f(x)$ , when  $x$  is drawn from the population with probability density function  $h(x)$ . We assume that this expected value is a finite constant<sup>4</sup>.

Thus, the expected indemnity is the average indemnity for each policy over all states:  $k : \sum_k I_{ijk} (PEF_{ij}, CVG_{ij})$ .

Random crop yield could follows a beta distribution with mean and variance that depend on applied nitrogen fertilizer. In fact, the beta distribution is commonly used for crop insurance analyses (Goodwin and Ker review several examples).

<sup>1</sup> In Lambert, D.K., and McCarl B., 1985. “Risk Modeling Using Direct Solution of Nonlinear Approximations of the Utility Function”, *American Journal of Agricultural Economics* 67 (4), p. 847.

<sup>2</sup> Values for  $R$  were chosen in accordance with the previous investigation carried out on the effects of the public subsidy at premium.

<sup>3</sup> Used to estimate numerically the expected indemnity, Greene pp. 181-183.

<sup>4</sup> Used to estimate numerically the expected indemnity, Greene pp. 181-183.

Generally, crop yield  $y$  may be distributed as a beta random variable for several reason. First, because crop yields are known to fall in a range from 0 to some maximum possible value. Second, crop yield distribution can be significantly skewed either to the right or to the left and the beta distribution has such flexibility.

Using a conditional beta density for crop yield requires specifying or estimating the mean and the variance as functions of the nitrogen fertilizer rate, and then substituting these functions into equations:

$$v = \frac{(\mu_y - A)^2 (B - \mu_y) - \sigma_y^2 (\mu_y - A)}{\sigma_y^2 (B - A)} \quad \text{and}$$

$$\gamma = \frac{(\mu_y - A) (B - \mu_y)^2 - \sigma_y^2 (B - \mu_y)}{\sigma_y^2 (B - A)}$$

by obtain equations for  $v$  and  $\gamma$ .

With this conditional distribution for yield, implicitly, the farmer directly chooses the mean and the variance of the yield distribution when apply the nitrogen fertilizer rate. Following the Nelson and Preckel conditional yield distribution, the farmer's choice of the nitrogen fertilizer rate even affect indirectly the mean and variance of the yield distribution, through the approximating functions used for the parameters  $v$  and  $\gamma$ .

For this analysis, the functions for the dependence of the mean and variance of wheat and tomato yield on the nitrogen application rate were estimated using data from experiments conducted between 2003 and 2005 in Apulia region, Foggia province (Elia et al). Nitrogen fertilizer rates were experimentally varied from 0 to 300 q/ha and correspondently wheat and tomato yields has been measured for each plot for a total of 53 observations.

A quadratic equation identifies the final result for mean and variance with all estimated coefficients significant at the 5% level.

The final equations for the mean  $\mu$  and variance ( $\sigma$ ) of durum wheat and tomato yield, respectively, as a function of the nitrogen rate  $x$  are:

$$\begin{aligned} \mu_w &= 112.4 + 23.87x_w - 0.108x_w^2, \\ \sigma_w^2 &= 16455 + 367.3x_w + 3100x_w^2, \\ \mu_t &= 189.89 + 34.56x_t - 0.342x_t^2, \\ \sigma_t^2 &= 23456 + 546.78x_t + 4560x_t^2. \end{aligned} \quad \text{and}$$

The model was solved using the non-linear program solver included in GAMS (General Algebraic Modeling System). Simulation for draw yields from the assumed distribution, and prices were carried out by

Excel. The optimal fertilizer rate was determined as an integer variable by specifying fertilizer rates in 0.1 q/ha increments centered at the province mean for each crop; the fertilizer rate implied also the level of the mean and variance of the yields.

GAMS interfaced with Excel by the GDXXRW program distributed with GAMS. GAMS sends the required means and variances to Excel, then Excel generates appropriately correlated yields and prices using the method of Richardson and Condra, as suggested from McCarl to Seo et al.

Table 1 reports the price and yield parameters adopted for the empirical analysis.

Table 1. Parameter value used for empirical analysis

Parameter	Wheat	Tomato
Yield mean	32.8 q/ha	460.2 q/ha
Yield standard deviation	12.4 q/ha	275.9 q/ha
Price mean (2000-2008)	75 Euro/q	81 Euro/q
Price standard deviation	45 Euro/q	35 Euro/q
Nitrogen price	0,60 Euro/Kg	0,60 Euro/Kg

#### 4. Results

With regard to the optimal fertilizer use and acreage allocation, when the subsidized insurance program is available, unsurprisingly, our results show (Table 2) that crop insurance generally has a positive effect on the optimal nitrogen fertilizer rate for both wheat and tomato. Depending on the crop and the farmer's level of risk aversion, the optimal rate increases by about 5 q/ha. Crop insurance has a large effect on the optimal acreage allocation. When ARI is available, optimal tomato acreage almost doubles, accompanied by an appropriate decrease in wheat hectares.

The results in table 2 also show that as farmer risk aversion increases, the optimal nitrogen rate decreases for all alternatives regardless of the crop, because nitrogen is used as a risk-increasing input. In addition, optimal tomato acreage decreases and optimal wheat acreage increases, because tomato is the riskier crop. For the range of risk aversion levels explored, the optimal insurance coverage level slightly changed for tomato, but increased for wheat.

In our study, crop insurance positively affected both crops at the intensive margin even if we need to be careful to compare our results with others reached in the past due to the different areas investigated.

Regardless of yield distribution, when crop insurance is available, farmers find it optimal to bear more risk and so choose fertilizer rates, accordingly. Given our conditional yield distributions, this means an increase in the fertilizer rate. Once again, since our analysis was conducted in a different scenario, it

would be prudent to avoid comparing it to others carried out in the past. It is important to emphasize that change in price level could hugely affect our results. In fact, in the two-year period of 2007-2008 there was serious tension on the commodities market, that drove the wheat price till up an extraordinary. In this context, it is worthwhile point out that the increase in price of wheat positively affect the acreage allocation of this crop, altering the results of our analysis. However, due to the fall in price experienced after 2008, our results should be satisfactory in their reliability.

Table 2. Optimal farmer choice at the intensive and extensive margin

	Moderately risk-averse <sup>a</sup>		Highly risk-averse <sup>a</sup>	
	Tomato	Wheat	Tomato	Wheat
	Optimal nitrogen fertilizer rate (q/ha)			
Government programme				
EP only	123.56	71.54	119.97	70.23
ARI and EP	128.87	76.28	125.13	74.98
	Optimal acreage allocation (ha)			
Government programme				
EP only	9.93	24.56	7.87	31.52
ARI and EP	14.89	21.13	12.75	28.72

## Conclusion

The environmental impact of farming continues to play a significant role in policy debates over the role of 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 to undertake activities harmful to the environment. For example, the provision of state-subsidised crop insurance may encourage producers to bring economically marginal land into production. If that land is also more environmentally fragile than land already farmed, this reduction in risk provided by state-subsidised crop insurance could lead to a reduction in environmental quality. In addition to crop insurance, the government has set up a myriad of other programmes designed, among other things, to provide income support and reduce income variability in the agricultural sector. Some of these programme payments are linked to the current production of a particular crop, while other programme payments are decoupled from current production.

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While such programmes provide incentives to expand production on the extensive margin, they may also lead to reductions in environmental amenity and prejudice multifunctionality objectives. In addition to encouraging production on environmentally fragile land, farm subsidies and risk management policies provide incentives for producers to alter their crop mix, cropping practices (including input use) and conservation practices.

Unsurprisingly, the results of our investigation show that crop insurance generally has a positive effect on the optimal nitrogen fertilizer rate for both wheat and tomato. Crop insurance has a major effect on the optimal acreage allocation for both crops considered and positively affected both crops at the intensive margin level. Moreover, when crop insurance is available, farmers find it optimal to bear more risk, hence, they would choose fertilizer rates accordingly which, given our conditional yield distributions, would mean an increase in the fertilizer rate. Our results, concerning the intensive margin effect, mainly depend on the crop production function and, more generally, they depend on the utility function used. The adoption of different utility functions, would give different magnitudes and different direction for the effect of fertilizer on the variance of crop yield (Hennessy, 1998).

Although it would be prudent to avoid comparing our analysis to others carried out previously. It would appear clear the effects of insurance subsidy both at the intensive and the extensive margin, as pointed out of Goodwin and Smith (2003), Skees (1999), and Wu (1999).

In our analysis, insurance subsidies at premium has the potential to alter land use, cropping practices and conservation practices, and may contribute to increases in soil erosion.

The policy implication, which could be drawn from these results, is that public support at risk management tools (i.e. crop insurance) in agriculture could offset the benefits of environmental programmes, as foreseen by Fischler's reform of Europe's agricultural support system. In this sense, Government risk management programmes, undoubtedly, introduce potential distortion into farm-level decision-making, which affect both the intensive (input use) and extensive (land use) margins. In this context, southern regions in Europe, such as Puglia, which are greatly affected by regional development policy, could see their future patterns of development jeopardized.



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