Moral Hazard and Risk Management

in Agri-Environmental Policy

by

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ABSTRACT

This paper develops the key finding of Hogan, Ozanne and Colman (2000) that risk aversion among farmers ameliorates the moral hazard problem in relation to agri-environmental policy compliance. It is shown that risk averse farmers who face uncertainty in their production income are more likely to comply with such a policy as a means of risk management. In addition, it is shown that a principal who has control over both the level of monitoring and the size of penalty if detected can reduce non-compliance by adjustments to these instruments which increase the variance of farmers' income but leave the expected penalty unchanged. It is concluded that risk management by both principals and agents has the potential to diminish the moral hazard problem, especially given proposed developments in agri-environmental policy in the European Union.

INTRODUCTION

Agri-environmental policy mechanism design has recently become a popular topic among economists working on European Union agricultural policy. Arising from the mainstream economic area of principal-agent theory with imperfect information, a series of papers has addressed the two issues of adverse selection and moral hazard in the context of the Common Agricultural Policy (CAP): Bourgeon, Jayet and Picard (1995); Latacz-Lohmann (1998, 1999); Choe and Fraser (1998, 1999); Moxey, White and Ozanne (1999); Fraser (2001); Hogan, Ozanne and Colman (2000).

Between them, these papers have addressed a range of features of policy mechanism design:

(i) the context of the agri-environmental policy: nitrate leaching (Latacz-Lohmann; Moxey, White and Ozanne; Hogan, Ozanne and Colman); environmentally sensitive areas (Choe and Fraser); and set-aside (Bourgeon, Jayet and Picard; Fraser).

(ii) whether the principal is dealing with adverse selection only (Bourgeon, Jayet and Picard; Moxey, White and Ozanne), or both adverse selection and moral hazard (Latacz-Lohmann; Choe and Fraser; Hogan, Ozanne and Colman; Fraser)

(iii) in the situation where moral hazard is included, whether farmers are risk neutral (Latacz-Lohmann) or risk averse (Choe and Fraser; Hogan, Ozanne and Colman; Fraser)

(iv) in the situation where moral hazard is included, whether monitoring uncertainty is due to imperfect monitoring (Choe and Fraser), or incomplete monitoring (Latacz-Lohmann; Hogan, Ozanne and Colman; Fraser)

(v) in the situation where moral hazard is included, where the principal has as an instrument of policy choice the level of monitoring only (Hogan, Ozanne and

Colman), or both the level of monitoring and the level of penalty/reward (Choe and Fraser; Latacz-Lohmann; Fraser).

The key result to come out of the paper by Hogan, Ozanne and Colman (2000), is that previous studies, particularly those which overlook the issue of risk aversion among farmers, "may have exaggerated the moral hazard problem" (p19). More specifically they show that, at levels of risk aversion which are high relative to estimates in the literature, the principal's problem collapses to one of adverse selection only.

The aim of this paper is to develop further the insight of Hogan, Ozanne and Colman (2000) regarding the importance or otherwise of the moral hazard problem in agri-environmental policy mechanism design. First, as a corollary to the key result of Hogan, Ozanne and Colman (2000) it is shown that full recognition of the income risk faced by farmers, where this income comprises not just policy payments but also production income, serves to diminish the attraction of non-compliance among even moderately risk averse farmers. Bearing in mind that the implementation of the Agenda 2000 cereal reforms will substantially increase the riskiness of production income for growers, this observation is of considerable relevance to current policy design concerns. Second, as a further extension of the analysis of Hogan, Ozanne and Colman (2000) the paper explores the trade-off between the penalty for non-compliance and the level of monitoring used by the principal. Drawing on the mainstream economics contributions of Polinsky and Shavell (1979) and Kaplow and Shavell (1994), the paper develops the concept of a mean-penalty preserving increase in non-compliance risk. This concept is then used to show how the moral hazard problem among risk averse farmers can be diminished without any change in expected penalties. The mechanism used in applying this concept is a shift in the balance of compliance instruments away from the level of monitoring and towards the size of penalty, which given current proposals in the UK to introduce unlimited fines for non-compliance, seems also to be a finding of considerable relevance to current policy design concerns (Hogan, Ozanne and Colman, 2000).

The structure of the paper is as follows. Section 1 develops the model of Fraser (2001), which uses the context of set-aside as a framework for analysing the moral hazard problem, to incorporate the two extensions proposed above. In particular, this development shows both the joint dependence of income variance on production and policy compliance payments, and the joint role of the non-compliance penalty and the level of monitoring in determining this income variance. Using this extended framework, Section 2 undertakes a numerical analysis which illustrates the extent to which the moral hazard problem can be diminished among risk averse farmers by an increase in the level of production income uncertainty and by a mean-penalty preserving adjustment of the compliance instruments. The paper ends with a brief conclusion which addresses policy implications.

SECTION 1: The Model

The model developed in Fraser (2001) is one of set-aside choice by a farmer with heterogeneous land quality and facing an uncertain price for production. From the principal's point of view, adverse selection in terms of output control occurs if the farmer chooses to set aside "poor" land rather than "good" land, and the problem of moral hazard arises through the principal combating this adverse selection by offering set-aside payments differentiated by land quality, thereby creating the incentive for the farmer to "cheat" by claiming to have set aside "good" land while actually having set aside "poor" land.

More specifically it is assumed that the farmer has three land types, good, average and poor, in equal proportions, and that the compulsory set-aside rate is one-third of total land. It is also assumed that although there is price uncertainty, there is no yield uncertainty. These assumptions are made for the purpose of analytical simplification, however the implications of their relaxation are discussed in the Conclusion.

On this basis, total income (I) from "cheating" and setting-aside poor land while claiming to set-aside good land is:

$$I = sr_g + p(y_g + y_a) \text{ if not detected} \quad (1)$$

$$I = sr_g + p(y_g + y_a) - sr_g x \text{ if detected} \quad (2)$$

where: y_a = yield from average land

y_g = yield from good land

p = uncertain price per unit of output

s = set-aside premium per unit of reference yield

r_g = reference yield for good land

x = parameter determining the size of penalty.

With a probability of detection of q, expected income from cheating ($E_C(I)$) is given by:

$$E_C(I) = (1-q)(sr_g + \bar{p}\ (y_g + y_a)) + q(s(1-x)r_g + \bar{p}\,(y_g + y_a)) \quad (3)$$

where: $\bar{p}$ = expected price.

In addition, the variance of income from cheating ($Var_C(I)$) is given by:

$$Var_C(I) = \int^p (1-q)(sr_g + p(y_g + y_a) - E_C(I))^2 f(p)dp$$

$$+ \int^p q\,(s(1-x)r_g + p(y_g + y_a) - E_C(I))^2 f(p)dp \quad (4)$$

where: f(p) = probability distribution governing price.

Consider the first term on the right-hand-side of (4). Substituting for $E_C(I)$ using (3) and rearranging gives:

$$(1-q)(y_g + y_a)^2 Var(p) \quad + \quad (1-q)(q(sr_g - s(1-x)rg))^2 \quad (5)$$

A similar process for the second term gives:

$$q(y_g + y_a)^2 Var(p) \quad + \quad q((1-q)(s(1-x)r_g - sr_g))^2 \quad (6)$$

where: Var(p) = variance of price.

Combining (5) and (6) gives:

$$Var_C(I) = (y_g + y_a)^2 Var(p) \quad + \quad ((1-q)q^2 + q(1-q)^2)(sr_g x)^2 \quad (7)$$

Equation (7) shows that the variance of income from cheating is the sum of the variance of production income and the variance of income associated with the penalty if detected.

Alternatively, total income from telling the truth and setting-aside good land is given by:

$$I = sr_g + p(y_a + y_p) \quad (8)$$

where: y_p = yield from poor land.

In this case expected income from telling the truth ($E_T(I)$) is given by:[1]

$$E_T(I) \quad = \quad \bar{p}(y_a + y_p) + sr_g \tag{9}$$

and the variance of income from telling the truth ($V_T(I)$) is given by:

$$V_T(I) \quad = \quad (y_a + y_p)^2 Var(p) \tag{10}$$

A comparison of (3) and (9) shows that:

$$E_C(I) - E_T(I) \quad = \quad \bar{p}(y_g - y_p) - qxsr_g \tag{11}$$

while a comparison of (7) and (10) shows that:

$$\begin{aligned} Var_C(I) - Var_T(I) \quad = \quad & Var(p)((y_g + y_a)^2 - (y_a + y_p)^2) \\ & + ((1-q)q^2 + q(1-q)^2)(sr_g x)^2 \end{aligned} \tag{12}$$

If the farmer is risk neutral the decision of cheating or not depends on whether equation (11) exceeds or is less than zero. Moreover, this balance clearly depends on the production-based expected rewards to cheating (the first term on the right-hand-side) relative to the policy-based expected costs of being caught (the second term). However if the farmer is risk averse, then equation (12) also needs to be considered. And since both terms on the right-hand-side of (12) are positive, the more risk averse is the farmer, the more important the value of this expression will be in determining the choice of whether or not to cheat. This observation relates to the finding of Hogan, Ozanne and Colman (2000) that moral hazard is less of a problem the more risk averse are farmers. And as a corollary, it can be observed that this situation also applies the more uncertain is production income: the size of (12) is positively related to Var(p).

Finally in this section consider the role of the policy-determined expected level and variance of the penalty from being caught. The expected penalty from being caught (E(C)) is given in

(11) as:

$$E(C) = qxsr_g \tag{13}$$

while the contribution of the prospect of paying a penalty to the variance of income (Var(C)) is given from (12) as:

$$Var(C) = ((1-q)q^2 + q(1-q)^2)(sr_g x)^2 \tag{14}$$

An examination of (13) confirms the observation of Latacz-Lohmann (1998) that for a risk neutral farmer "the probability of detection and the size of sanction are perfect substitutes with respect to reducing non-compliance" (p7). However, an examination of (14) shows that this perfect substitutability breaks down in the case of risk aversion. As noted by Kaplow and Shavell (1994) "risk-bearing costs are not linear" in the two non-compliance parameters (p8). In particular:

$$\frac{\partial Var(C)}{\partial q} = (1 - 2q)\,(sr_g x)^2 \tag{15}$$

while:

$$\frac{\partial Var(C)}{\partial x} = 2(sr_g)^2((1-q)q^2 + q(1-q)^2)x \tag{16}$$

Equation (15) shows that:

$$\frac{\partial Var(C)}{\partial q} \begin{matrix} > \\ < \end{matrix} 0 \text{ as } q \begin{matrix} < \\ > \end{matrix} \frac{1}{2} \tag{17}$$

while (16) shows that $\frac{\partial Var(C)}{\partial x}$ is unambiguously positive.

It follows that if:

$$q > \frac{1}{2}$$

then it is possible for q to be decreased and x increased such that the expected penalty from being detected is unchanged, yet the variance of this penalty is unambiguously increased. In other words, in this situation it is possible to diminish the moral hazard problem among risk averse farmers without any change in the expected penalty from cheating. That this option is likely to feature a decrease in monitoring costs because of the associated decrease in the probability of detection only serves to enhance its appeal.

In the alternative situation of:

$$q \quad < \quad \frac{1}{2}$$

off-setting adjustments in q and x which are mean-penalty preserving have conflicting impacts on Var(C) according to (15) and (16). However, the non-linearity of Var(C) in these parameters suggests adjustments in q and x which are off-setting with respect to E(C) are unlikely to be so with respect to Var(C). And while casual assessment of (15) and (16) suggests the impact of changes in x are likely to dominate those in q, particularly for values of q close to $\frac{1}{2}$, a numerical analysis is needed to evaluate this analytical ambiguity.

Nevertheless, it may be concluded from the analysis of this section that moral hazard associated with policy non-compliance is likely to be less of a problem among risk averse farmers the more uncertain is their production income. In addition, the analysis suggests that, for a principal with control over the magnitude of both the probability of detection and the size of penalty, the potential exists to diminish the problem of moral hazard among risk averse producers without any change in the expected penalty from detection. These analytical findings are illustrated numerically in the next section.

SECTION 2: Numerical Analysis

In order to undertake a numerical analysis which illustrates the findings of the previous section use is made of the decision framework outlined in Fraser and Rygnestad (1999). This framework contains a complete specification of the circumstances in which the farmer is to make the decision of which land to set aside, including the cost of producing on land of different qualities. In particular, expected profit ($E(\pi)$) is given by:[2]

$$E_T(\pi) = (\bar{p} - d_p)y_p + (\bar{p} - d_a)y_a + sr_g - F \tag{18}$$

and

$$E_C(\pi) = (\bar{p} - d_g)y_g + (\bar{p} - d_a)y_a + sr_g - qxsr_g - F \tag{19}$$

where: d_p = cost/tonne on poor land

d_a = cost/tonne on average land

d_g = cost/tonne on good land

F = fixed costs

while the variance of profit ($Var(\pi)$) is as specified by equations (4) and (10) for cheating and truth-telling respectively because there is no uncertainty of costs. Moreover, although use is made of the details contained in Fraser and Rygnestad (1999) regarding the on-farm specification of the yield response functions for these qualities of land, unreported numerical analysis shows that "optimal" yields are relatively insensitive to the other parameters in the farmer's decision framework. Consequently, in what follows choice of optimal yield is suppressed.

This approach provides the following parameter values:

$y_g = 10.00$; $y_a = 8.01$; $y_p = 5.03$; $\bar{p} = 110$; $s = 70$; $d_g = 36$; $d_a = 38$; $d_p = 42$; $F = 688$

plus from Fraser (2001):

$r_g = 10$; $q = 0.5$; $x = 1$

as a Base Case.

Finally, assume the attitude to risk of the farmer can be represented by the mean-variance framework and the constant relative risk aversion functional form:[3]

$$E(U(\pi)) \quad = \quad U(E(\pi)) + \frac{1}{2} U''(E(\pi)) \ . \ Var(\pi) \tag{20}$$

where:
$$U(\pi) \quad = \quad \frac{\pi^{1-R}}{1-R} \tag{21}$$

and R = constant coefficient of relative risk aversion

$\quad\quad = - U''(\pi) \ . \ \pi / U'(\pi)$

On this basis, Table 1 contains details of the numerical results regarding the levels of expected utility from cheating and truth-telling for a range of attitudes to risk and of coefficients of variation of price.[4] Table 1 shows that using the Base Case parameter values a risk neutral (ie R = 0) farmer will choose to cheat regardless of the variability of production income. But for a risk averse farmer the additional variability of profit introduced by cheating is a disadvantage which must be balanced against the expected gains from cheating. Nevertheless, Table 1 shows that in the case where there is no uncertainty of production income, the expected gains from cheating always dominate, and even the most risk averse farmer (ie R = 0.75) chooses to cheat.

The situation changes, however, once uncertainty of production income is allowed for. For example, in the case of $CV_p = 0.2$, such as could be argued to represent the situation before the implementation of the Agenda 2000 reforms, Table 1 shows that the most risk averse farmer chooses not to cheat, while for the farmer with R = 0.5 the relative attraction of cheating is marginal. Moreover, with increased exposure to world price uncertainty, as represented by the case of $CV_p = 0.35$, further numerical analysis shows that all farmers with R > 0.28 would choose not to cheat. Consequently, Table 1 is a clear illustration of the finding in Section 1 that moral hazard associated with policy non-compliance can be expected to be less of a problem among risk averse farmers once European Union markets become more completely exposed to world price fluctuations. This feature of the results is a manifestation of the general principle that farmers who are exposed to substantial risk will look for opportunities for risk management, including in this case choosing to reduce income risk by being policy compliant.

Next consider the second finding of Section 1 that a principal with control over the magnitude of both the probability of detection and the size of penalty may also be able to "manage" the risk faced by farmers considering cheating and do so without altering the expected penalty from detection. In this context, Table 2 contains details of a range of (q, x) combinations which are mean-penalty preserving and, for each combination, the associated variance of penalty. The bottom three combinations illustrate the analytical finding of Section 1 that, for $q > 0.5$, mean-penalty preserving adjustments in q and x will affect Var(C) monotonically, with Var(C) inversely related to q and positively related to x. Moreover, the top three combinations suggest that changes in x are the dominant factor determining the overall impact of mean-penalty preserving adjustments in q and x, with Var(C) clearly positively related to x across the full range in Table 2. It follows that a principal has the potential to deter cheating among risk averse farmers without any increase in expected penalty across this full range.

To illustrate this potential, consider the results presented in Table 3 which show the impact on the expected utility from cheating of a range of mean-penalty preserving increases in x (decreases in q). The top panel of Table 3 is based on $CV_p = 0.2$ and repeats the results in Table 1 that for the Base Case settings farmers with risk aversion coefficients of 0.5 or below would choose to cheat. However, it is also shown that with a small increase in x to 1.1 (q = 0.45), a risk averse farmer with R = 0.5 would no longer choose to cheat. Even though the expected penalty from detection is unchanged, the increase in the variance of income assisted with the increase in x is sufficient to deter cheating. Moreover, this panel of results shows that if x were increased to 2 (q = 0.25) even a farmer with R = 0.25 would choose not to cheat. Finally, note that in a situation with a higher level of variability in production income (CV_p = 0.35), an increase in x only to 1.2 is sufficient to deter a farmer with R = 0.25 from cheating. It follows that once European Union farmers become more exposed to world price uncertainty, only modest increases in penalties for non-compliance will be required for the moral hazard problem to be confined to only the least risk averse of farmers.

CONCLUSION

The aim of this paper has been to develop further the key finding of Hogan, Ozanne and Colman (2000) that risk aversion among farmers ameliorates the moral hazard problem in relation to agri-environmental policy compliance. Extending the model of Fraser (2001), it was shown in Section 1 that risk averse farmers who face uncertainty in their production income are more likely to comply with the requirements of an agri-environmental policy. In addition, it was shown that a principal who has control over both the level of monitoring and the size of penalty if detected not complying has the potential to reduce non-compliance among risk averse farmers by adjustments to these instruments which increase the variance of farmers' income, but leave the expected penalty for non-compliance unchanged. These findings were illustrated in Section 2 using a numerical analysis. Overall, it was shown that, for risk averse producers facing substantial production income uncertainty, choosing to comply with their agri-environmental policy is a form of risk management which has the effect of diminishing the moral hazard problem. And for the principal mean-penalty preserving, adjustments of the instruments of non-compliance are a form of risk management which similarly diminishes the problem of moral hazard among risk averse farmers.

These findings are thought to be of considerable relevance in the context of European Union agri-environmental policy. First, the implementation of the Agenda 2000 reforms will see a substantial increase in the exposure of cereal growers to world price uncertainty and, as a consequence, to income risk. In this situation risk management strategies will become a more prominent concern for farm managers, and the opportunity to reduce risk by complying with an agri-environmental policy therefore will become more attractive. Note in this context that the model used in this paper has under-represented the importance of production income risk relative to non-compliance risk both by assuming the agri-environmental policy (set-aside) applies to one-third of land, rather than the 10% of the Agenda 2000 agreement, and by ignoring yield uncertainty as a component of production income risk. Given the results in Table 1 it follows that, if the increase in exposure of farmers to world price variability with the implementation of the Agenda 2000 reforms were not as large as suggested (ie CV_p from 0.2 to 0.35), but this under-representation were allowed for, then the dominance of production-related risk in total income risk would still result in the risk management strategy of policy compliance being popular even among farmers with relatively low levels of risk aversion (ie R = 0.28 or more).

Second, as noted by Hogan, Ozanne and Colman (2000) proposals “currently before the UK Parliament will, if passed, introduce unlimited fines for failure to comply with SSSI management agreements” (p10). In this situation, UK policy-makers will have the opportunity to implement their own risk management strategy as outlined above and thereby reduce the attraction of non-compliance to risk averse farmers without any increase in expected penalties, and with the expectation of savings from reduced monitoring costs.

It may be concluded that the elevation of risk management as a desirable strategy for risk averse farm managers will diminish the problem of non-compliance for agri-environmental policy makers.

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FOOTNOTES

1 Note it is assumed in what follows that the incentive compatibility constraint in relation to setting-aside average land is satisfied:

$$\bar{p}\,(y_a + y_p) + sr_g \;>\; \bar{p}\,(y_g + y_p) + sr_a$$

where: r_a = reference yield for average land.

2 Note that compensatory payments have been suppressed as they are constant across land types.

3 See Hanson and Ladd (1991) and Pope and Just (1991) for arguments supporting these assumptions.

4 See Hazell, Jaramillo and Williamson (1990) for evidence supporting this range of variation in world wheat prices. Note also that Bardsley and Harris (1987) estimate a risk aversion coefficient for wheatgrowers in Australia of 0.7, while Newbery and Stiglitz (1981) suggest levels between 0.5 and 1.2 are consistent with most empirical estimates.

Table 1

Impact of Changes in the Uncertainty

of Production Income on E(U(π))

	CV_p					
	0		0.2		0.35[a]	
	$E_T(U(\pi))$	$E_C(U(\pi))$	$E_T(U(\pi))$	$E_C(U(\pi))$	$E_T(U(\pi))$	$E_C(U(\pi))$
R						
0	930.58	978.98	930.58	978.98	930.58	978.98
0.25	224.65	230.56	222.65	226.97	218.52	219.58
0.5	61.01	61.58	60.29	60.30	58.79	57.65
0.75	22.09	22.11	21.90	21.76	21.49	21.05

Note a: $E_T(U(\pi)) = E_C(U(\pi))$ for R = 0.28

Table 2

Impact of Mean-Penalty Preserving

Changes in q and x on Var(C)

	E(C)	Var(C)
q, x		
0.1, 5	350	1102500
0.25, 2	350	367500
0.5, 1	350	122500
0.75, 0.67	350	40833
0.9, 0.56	350	13611

Table 3

Impact of Mean-Penalty Preserving

Changes in q and x on $E_C(U(\pi))$

	$E_T(U(\pi))$	$E_C(U(\pi))$			
		x = 1 (q = 0.5)	x = 1.1 (q = 0.45)	x = 1.2 (q = 0.42)	x = 2 (q = 0.25)
CV_p = 0.2					
R = 0.25	222.65	226.97	226.41	225.86	221.38
R = 0.5	60.29	60.30	60.10	59.90	58.30
CV_p = 0.35					
R = 0.25	218.52	219.58	219.02	218.46	213.99
R = 0.5	58.79	57.65	57.45	57.25	55.65