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Moral Hazard, Targeting and Contract Duration in Agri-Environmental Policy

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Abstract

This paper extends the multi-period agri-environmental contract model of Fraser (2004) so that it contains a more realistic specification of the inter-temporal penalties for non-compliance, and therefore of the inter-temporal moral hazard problem in agri-environmental policy design. On this basis it is shown that a farmer will have an unambiguous preference for cheating early over cheating late in the contract period based on differences in the expected cost of compliance. It is then shown how the principal can make use of this unambiguous preference to target monitoring resources intertemporally, and in so doing, to encourage full contract duration compliance.

Keywords:

Moral Hazard, Contract Duration, Agri-Environmental Policy, Targeting

JEL Codes:

Q15, Q18, Q58

Introduction

In the last decade or so researchers have begun investigating the moral hazard problem in relation to agri-environmental policy. In such policies farmers voluntarily participate in the production of environmental goods and services in return for payment. However, farmers are also required to incur costs in providing these goods and services. Therefore, such farmers have an incentive not to comply with these requirements, depending both on their likelihood of avoiding detection, and on the penalties for non-compliance if caught cheating. It follows that the policy design problem is to manage farmer behaviour to minimise the negative impact of the moral hazard problem on the policy's cost-effectiveness (see Choe and Fraser, 1999; Ozanne, Hogan and Colman, 2001; Fraser, 2002). However, virtually all these studies, including the most recent, have framed the policy design problem within an atemporal context, choosing instead to investigate a range of circumstantial complications such as heterogeneity among farmers and the relative effectiveness of alternative policy mechanisms (see Hart and Latacz-Lohmann, 2005; Ozanne and White, 2007). This static framing of the policy design problem, while perhaps justifiable in terms of keeping the theoretical specification of the problem manageable, is nevertheless in clear contrast to the design of actual agri-environmental policies, which are typically based on a multi-year contract duration. For example, Natural England (2010) in relation to the Higher Level Stewardship Scheme specifies a ten-year contract period.

One exception to these static studies of the moral hazard problem in agri-environmental policy design is Fraser (2004), which uses a multi-period framework to investigate the potential benefits of "targeting" the use of monitoring resources to enforce compliance. In Fraser's multi-period model this "targeting" involves separating farmers into two groups for monitoring purposes: those who have previously been caught cheating; and those have not.[1]

However, while Fraser's multi-period model enables farmer behaviour to be managed over time to improve policy cost-effectiveness, Fraser's specification of the farmer's dynamic decision problem is very simple. In particular, a farmer is specified to see the penalties for non-compliance as independent of the time period within which non-compliance is detected. Moreover, this static specification of penalties is in contrast to actual agri-environmental policies where there is typically a clear inter-temporal

[1] See Heyes (2000) for a review of other regulation literature which analyses the concept of "targeting".

dimension to the penalties for non-compliance. For example, in relation to Natural England's Higher Level Stewardship Scheme (HLS), it is stated that penalties may involve the withholding of "part or all of any future payments due under your agreement" as well as the recovery of (with "interest charged") "part or all of the payments already made to you under the agreement" (Natural England, 2010, p11).

It should be recognised that each of the above components of the HLS policy's penalty system is designed to mitigate different aspects of the inter-temporal moral hazard problem. Specifically, by threatening farmers with the withholding of future payments if caught not complying, Natural England is discouraging such farmers from cheating early in the contract period for fear of losing all future benefits of participation. And by threatening farmers with the recovery (with "interest charged") of past payments if caught not complying, Natural England is discouraging such farmers from cheating late in the contract period for fear of having to repay all past benefits of participation.

As a consequence, the aim of this paper is to extend the multi-period model of Fraser (2004) so that it contains a more realistic specification of inter-temporal penalties, and therefore of the inter-temporal moral hazard problem. In so doing, it will investigate both the relative incentives for farmers to cheat early and/or late in their contract period, and the potential for the principal to use the targeting of monitoring resources to further mitigate the inter-temporal moral hazard problem.[2]

The structure of the payer is as follows. Section 2 first sets out the extension of the multi-period model of Fraser (2004) so that it contains an inter-temporal specification of the penalties for non-compliance. It then examines the implications of this specification for a farmer's incentives to cheat early and/or late in the contract period. In particular, it is shown that a farmer will have an unambiguous preference for cheating early over cheating late, although cheating all the time, or none of the time, may be superior alternatives to occasional cheating. Next Section 3 provides a numerical analysis of the model of Section 2. This numerical analysis enables both an evaluation of the role of the main parameter values of the model in determining farmer behaviour, and an evaluation of the potential for the targeting of monitoring resources to further mitigate the inter-

[2] Literature in this context seems very thin. One exception is Rice and Sen (2008) which examines the inter-temporal moral hazard problem in relation to basketball players in the WBA.

temporal moral hazard problem. The paper ends with a brief Conclusion which summarises the paper's implications for agri-environmental policy design.

Section 2: The Model

2.1 Extending the Model of Fraser (2004)

The model of Fraser (2004) uses a two-period decision context to capture the "early" and "late" aspects of contract duration for a risk averse farmer. In this context the farmer considers the present value of expected utility from four alternatives:

(i) complying in both periods
(ii) complying in the first period, but not the second
(iii) complying in the second period, but not the first
(iv) not complying in both periods.

The farmer's income (I_i) in each period of complying is given by:

$$I_i = B + x - y \tag{1}$$

where:

I_i = income in period i $(i=1,2)$

B = income independent of participation

x = payment for participating

y = cost of complying

$x > y$

Note that if the farmer chooses not to comply, and is not caught, then:

$$I_i = B + x \tag{2}$$

However, if the farmer chooses not to comply, and is caught, then a penalty is incurred.

In Fraser (2004) this penalty was specified simply as a proportion of the payment for participating in that period (i.e. x), and was therefore independent of the contract duration.[3] In what follows this feature of the model of Fraser (2004) is modified to reflect the type of inter-temporal penalty system discussed previously. Specifically, a farmer caught cheating in period 1 is penalised not just by the recovery of the payment for

[3] Note, however that with the introduction of targeting in Fraser (2004) a farmer caught cheating in period 1 would also experience an increase in the probability of being monitored in period 2.

participation in that period (i.e. *x*), but also by the withdrawal of future benefits through exclusion from participation in period 2. Note as outlined previously that this latter feature of the penalty system is designed to discourage cheating early in the contract period. In addition, a farmer caught cheating in period 2 is penalised not just by the recovery of the payment for participation in that period (i.e. *x*), but also by the recovery, with interest, of the payment for participation in period 1 (i.e. $x\ (1 + r)$; where $r =$ the rate of interest). Note once again that this latter feature of the penalty system is designed to discourage cheating late in the contract period.

Inserting this penalty system into the model of Fraser (2004) means that the present value of the expected utility (*E(U))* from the four alternative farmer behaviours is given by:

$$U(I_{TIT2}) = U(B + x - y) + U(B + x - y)/(1 + r) \tag{3}$$

$$EU(I_{TIC2}) = U(B + x - y) + (pU(B + x) + (1 - p)U(B - x(1 + r)))/(1 + r) \tag{4}$$

$$EU(I_{CIT2}) = pU(B + x) + (1 - p)U(B) + (pU(B + x - y) + (1 - p)U(B))/(1 + r) \tag{5}$$

$$EU(I_{CIC2}) = pU(B + x) + (1 - p)U(B) + (p(pU(B + x) + (1 - p)U(B - x(1 + r))) + (1 - p)U(B))/(1 + r) \tag{6}$$

Where:

p	=	probability of not being monitored in each period.
$U(I_{TIT2})$	=	present value of utility of income from complying in both periods.
$EU(I_{TIC2})$	=	present value of expected utility of income from complying in period 1, but not in period 2.
$EU(I_{CIT2})$	=	present value of expected utility of income from not complying in period 1, but complying in period 2.
$EU(I_{CIC2})$	=	present value of expected utility of income from not complying in both periods.

Note that in equations (3) – (6) it has been assumed that the probability of not being monitored is the same in both periods. This assumption will be relaxed subsequently in the context of considering the potential benefits of the inter-temporal targeting of participants. Note also that the rate of discount of future income has been assumed equal to the rate of interest charged on recovered payments for participation within the penalty system.

An examination of equations (3) and (6) reveals that the key policy parameters in determining the relative size of utility from always complying with expected utility from always not complying are:

(i) p – the probability of not being monitored

(ii) $(x\text{-}y)$ – the relative size of benefits and costs of complying.

For example, if $p = 0$, then with $x > y$:

$$U(I_{TIT\,2}) = U(B + x - y) + U(B + x - y)/(1 + r) \quad (7)$$

$$> U(B) + U(B)/(1 + r) = EU(I_{CIC\,2})$$

More generally, if p is relatively low and (x-y) is relatively high, then it is expected that:

$$U(I_{TIT\,2}) > EU(I_{CIC\,2}) \quad (8)$$

and so the farmer would comply in both periods. While if p is relatively high and (x-y) is relatively low, then it is expected that:

$$U(I_{TIT\,2}) < EU(I_{CIC\,2}) \quad (9)$$

and so the farmer would not comply in both periods.

However, further evaluation of the relative size of equations (3) – (6), and in particular the size of equations (4) and (5) relative to equations (3) and (6) is analytically ambiguous and numerically will also depend on the values of the key policy parameters p and (x-y).

Therefore an assessment of the likelihood of a farmer complying occasionally rather than complying or not complying throughout the contract period is deferred until the numerical analysis of the next Section.

2.2 Cheating Early or Late?

Despite the analytical ambiguity of the size of equations (4) and (5) relative to equations (3) and (6), it is nevertheless possible to examine further the relative incentives to comply early or late in the contract period. For a risk averse farmer this can be done by considering both the expected income and the variance of income from behavioural alternatives (ii) and (iii) (i.e. either cheating late or cheating early). In particular:

$$E(I_{TIC2}) = B + x - y + p(B + x)/(1+r) + (1-p)(B - x(1+r))/(1+r) \qquad (10)$$

while:

$$E(I_{CIT2}) = p(B + x) + (1-p)B + p(B + x - y)/(1+r) + (1-p)B/(1+r) \qquad (11)$$

Moreover, equations (10) and (11) can be rearranged and simplified to give:

$$E(I_{TIC2}) = B + B/(1+r) + px(1+1/(1+r)) - y \qquad (12)$$

$$E(I_{CIT2}) = B + B/(1+r) + px(1+1/(1+r)) - py/(1+r) \qquad (13)$$

It follows from a comparison of equations (12) and (13) that:

$$E(I_{CIT2}) > E(I_{TIC2}) \qquad (14)$$

and so it is unambiguously the case that the present value of expected income from cheating early exceeds that of cheating late. Note, however, that this difference arises not from a difference in the expected benefit of cheating (i.e. $px(1+1/(1+r))$ but rather from a difference in the expected costs of complying (i.e. $py/(1+r) < y$) .

Next consider the variance of the present value of income from cheating late compared with cheating early. In particular[4]:

$$Var(I_{TIC2}) = p(x + x/(1+r) - px(1+1/(1+r)))^2 + (1-p)(-px(1+1/(1+r)))^2 \quad (15)$$

while:

$$Var(I_{CIT2}) = p(x + x/(1+r) - y/(1+r) - px(1+1/(1+r)) + py/(1+r))^2 \quad (16)$$
$$+ (1-p)(-px(1+1/(1+r)) + py/(1+r))^2$$

Moreover, equations (15) and (16) can be rearranged and simplified to give:

$$Var(I_{TIC2}) = p(1-p)(x(1+1/(1+r)))^2 \quad (17)$$

$$Var(I_{CIT2}) = p(1-p)(x(1+1/(1+r)) - y/(1+r))^2 \quad (18)$$

It follows from a comparison of equations (17) and (18) that:

$$Var(I_{CIT\,2}) < Var(I_{TIC2}) \quad (19)$$

and so it is unambiguously the case that the variance of the present value of income from cheating early is less than that of cheating late.

Therefore, combining equations (14) and (19) shows that a risk averse farmer will always prefer the alternative of cheating early to that of cheating late in the contract period because it features both a higher present value of expected income and a lower variance of the present value of income. Moreover, the basis of this preference stems not from a difference in the expected benefits of cheating, but rather from a difference in the expected costs of complying.

Finally in this section, note that because of this unambiguous preference for cheating early compared to cheating late, the potential arises for the principal to consider targeting monitoring resources away from those farmers who are in the late phase of their contract

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[4] Recall that $Var(x) = E(x - E(x))^2$

period and towards those farmers who are in the early phase of their contract period. In so doing, the principal may be able to discourage early cheating without incentivising late cheating. This inter-temporal aspect of targeting is explored further in the numerical analysis of the next Section.

Section 3: Numerical Analysis

In order to undertake a numerical analysis of the model in Section 2 it is necessary to specify both a particular form for the farmer's utility function, and a set of parameter values to act as a Base Case.

In what follows the utility function is specified to take the constant relative risk aversion form[5]:

$$U(I) \quad = \quad \left(\frac{I^{1-R}}{1-R} \right) \tag{20}$$

Where:

R = constant coefficient of relative risk aversion

= $-U''(I).I / U'(I)$.

In addition, the following parameter values are chosen for a Base Case:

B = 12; x = 10; y = 7; R = 0.2, 0.6

r = 0; p = 0.75

On this basis the top panel of Table 1 contains details of the Base Case results in terms of the present value of expected utility for the four behavioural alternatives.

In this Base Case the probability of not being monitored in each period has been set relatively high (i.e. p = 0.75). As a consequence, based on the analytical results in Section 1 it is expected that the farmer will prefer not to comply in both periods compared with complying in both periods. Moreover, the results in Panel 1 confirm this expectation for the lower level of risk aversion of the farmer (i.e. R = 0.2). However, for the higher level of risk aversion (i.e. R = 0.6), the results in Panel 1 show that the farmer would prefer complying in both periods to not complying in both periods. It follows that the combination of higher risk aversion and the increased riskiness of utility brought about by not complying is sufficient to deter non-compliance for this type of farmer. In addition,

[5] See Pope and Just (1991) for empirical evidence to support this specification.

Panel 2 of Table 1 presents results for the case where the probability of not being monitored is considerably lower (i.e. p = 0.5 instead of p = 0.75). The results in this Panel show that even for the lower level of risk aversion (i.e. R = 0.2) compliance in both periods is preferred to non-compliance in both periods. Furthermore, unreported sensitivity analysis of the cost of compliance (i.e. y) is consistent with the analytical findings of Section 1 in that it shows that increases in the value of (x-y) (i.e. the net benefit of compliance) also strengthens the preference for compliance in both periods over non-compliance in both periods for a broad range of attitudes to risk.

Next consider the alternatives of occasion cheating (i.e. cheating early or late). It was shown in Section 1 that cheating early would be unambiguously be preferred to cheating late because of a difference in the expected costs of compliance, and this finding is reflected in the numerical results in Panels 1 and 2 of Table 1. However, in relation to the farmer's preference for cheating early relative to not cheating in either period, or to cheating in both periods, the results in Panels 1 and 2 demonstrate that it is possible for the farmer to prefer cheating early to the other two alternatives. In particular, Panel 1 shows that, although for the more risk averse farmer (i.e. R = 0.6) compliance in both periods is preferred to non-compliance in both periods, the most preferred option for the farmer is to cheat in the first period but comply in the second (i.e. 15.37 > 14.77 > 14.28). Similarly, in Panel 2, although for the less risk averse farmer (i.e. R = 0.2), compliance in both periods is preferred to non-compliance in both periods, the most preferred option for the farmer is to cheat in the first period but comply in the second (i.e. 21.99 > 21.82 > 19.87).

Therefore, this numerical analyses has demonstrated that, depending on the probability of being monitored, the net benefits of compliance, and the risk aversion of the farmer, the balance of risk and expected return for the option of cheating occasionally may be such that this option is preferred both to the lower risk option of always complying and to the higher risk option of always cheating.[6] Nevertheless, this preference for occasional cheating will always be characterised by cheating early rather than late in the contract period.

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[6] Note that for Panel 1 (i.e. p=0.75), if $R=0.4$ then $E(U(I_{CIT2})) > E(U(I_{CIC2})) > U(I_{TIT2})$. That is, cheating early may be the most preferred option even when cheating in both periods is preferred to not cheating in both periods. This example supplements those in Table 1 for which $E(U(I_{CIT2})) > U(I_{TIT2}) > E(U(I_{CIC2}))$.

Finally in this Section return to considering the potential raised earlier for the inter-temporal targeting of monitoring resources. In particular, given the unambiguous preference for cheating early over cheating late in the contract period, the potential arises for the principal to target monitoring resources away from farmers who are in the late phase of their contract period and towards those farmers who are in the early phase of their contract periods. This potential is illustrated in Panel 3 of Table 1 which is based on the Panel 2 parameter values for p=0.5 and R = 0.2 and considers reallocating monitoring resources away from those farmers in period 2 of their contract and towards those farmers in period 1 of their contract. Specifically, this is done by increasing the probability of not being monitored for those farmers in period 2 from 0.5 to 0.6, and decreasing the probability of not being monitored for those farmers in period 1 from 0.5 to 0.4. The results of this inter-temporal targeting of monitoring resources on the present value of the expected utility of each behavioural alternative are presented in the second row of Panel 3. These results show that the consequence of this inter-temporal targeting is both to increase the expected utility of cheating late, and to decrease the expected utility of cheating early, but such that complying in both periods becomes the most preferred option. In other words, by trading off some of the relative disadvantage of the cheating late option the principal is able to use the extra monitoring resources to discourage the cheating early option to the point where full contract duration compliance is preferred.

Conclusion

Most recent contributions to agri-environmental policy design have framed the moral hazard problem within an atemporal context. One exception to this is the study of Fraser (2004), which uses a multi-period contract framework to analyse the moral hazard problem, but specifies the inter-temporal components of the farmer's decision problem in a very simple way. In particular this specification fails to incorporate the inter-temporal dimension to the penalties for non-compliance which is characteristic of actual agri-environmental policies, and which are designed to discourage non-compliance both early and late in the contract period. On this basis, this paper extends the multi-period model of Fraser (2004) so that it contains a more realistic specification of inter-temporal penalties for non-compliance, and therefore of the inter-temporal moral hazard problem.

Section 2 set out the extension of the model of Fraser (2004) and examined the implications of this extended specification for a farmer's incentives to cheat early and/or late or not at all in the contract period. In particular, it was shown not just which parameters play a key role in determining these incentives, but also that a farmer will have an unambiguous preference for cheating early over cheating late in the contract period based on differences in the expected cost of compliance.

Section 3 first provided a numerical evaluation of the role of the main parameter values of the model in determining farmer behaviour: the probability of not being monitored; the net benefits of compliance; and the risk aversion of the farmer. Section 3 then illustrated the potential for the principal to target monitoring resources inter-temporally, by capitalising on the unambiguous preference demonstrated in Section 2 for cheating early over cheating late in the contract period. In particular, it was shown how the principal could reallocate monitoring resources away from farmers late in their contract period and towards farmers early in their contract period, and in so doing discourage the cheating early option sufficiently for full contract compliance to become the preferred option.

Consequently, it may be concluded that the targeting of monitoring resources away from farmers in the late stage and towards farmers in the early stage of their contract period has the potential to further mitigate the inter-temporal moral hazard problem.

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Table 1

Results of the Numerical Analysis[a]

Panel 1 *(p=0.75)*	$U(I_{TIT2})$	$E(U(I_{TIC2}))$	$E(U(I_{CIT2}))$	$E(U(I_{CIC2}))$
R = 0.2	21.82	22.57	23.86	23.97
R = 0.6	14.77	14.67	15.37	14.28
Panel 2 *(p=0.5)*				
R = 0.2	21.82	19.40	21.99	19.87
R = 0.6	14.77	13.34	14.75	12.01
Panel 3 *(R=0.2)*				
p = 0.5	21.82	19.40	21.99	19.87
$p_1=0.4$; $p_2=0.6$	21.82	20.67	21.24	19.69

Note a: B = 12; x = 10; y = 7; r = 0