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Cross Compliance: what about compliance?

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Abstract
We reviewed some moral hazard (MH) models applied to agri-environmental policies and identified the main methodological aspects of the literature on this topics. Imperfect vs incomplete monitoring , static vs dynamic and single vs multiple agents models are the main lines along which the literature has been organised analysing each component of a MH model. Most papers point out the role of farmers' risk aversion in mitigating MH. Others highlight that the observed high rate of compliance is still somewhat paradoxical given current enforcement strategies with low fines and monitoring levels. Cross compliance confirm these findings and urges further studies on dynamic models and farmers' non profit maximising behaviour.

Keywords: Cross-compiance, Moral Hazard, Enforcement, Agri-environjeljmental schemes

JEL classification: Q15, Q58, D82

1. INTRODUCTION

Cross compliance (CC) was first introduced in the USA in the '70s when provisions for soil and wetlands protection were linked to participation in commodity programs. In the EU CAP some form of CC dates back to the McSharry reform in 1992. However, it is only with the 2003 Mid Term Review that cross compliance became a fully mandatory measure applied to all direct payments. Current debate about the post 2013 CAP suggests an even wider role for CC mechanisms. A group of agricultural economists recently advocated a shift in agricultural policy from market intervention and income support to public good provision (ReformtheCAP, 2009). Even if the Commission will not hold such a radical position it is likely that some further greening of the PAC and a wider application of CC is going to take place in the future in order to justify the large share of the EU budget that still accrues to the agricultural sector.

In the European Union, CC is currently a form of regulation relying on process standards that mainly address environmental or health externalities. As any other form of regulation CC comprises three stages: enactment of legislation; setting up of regulatory administrations and rules; enforcement of the rules. Although the third stage is "as vital for the success of regulation as the first two" (Baldwin and Cave, 1999, p.96) a large share of economic analysis of environmental policies deals with efficiency and distributional issues related to the first two stages (Cohen, 1999). The objective of this study is -instead- to review research progress in Agricultural Economics in the area of implementation and enforcement of CC rules. In particular, we discuss the practical relevance of this literature for current and foreseeable CC policies in EU.

We reviewed material mainly from economic journals referenced in CAB and Econlit. The material included research on micro-economic models on incentives, penalties and monitoring that influence compliance. As CC standards are deeply intertwined with those of

agri-environmental schemes (AES) the review embraces papers that address the second topic whenever the focus is on implementation. On the contrary, papers that focus exclusively on efficiency or efficacy of policy measures (such as those that adopt a cost-benefit approach or those addressing monetary valuation of benefits) are not covered. Similarly, distributional issues are not dealt with. Overall, the review covers a dozen of articles that are broadly organised according to methodological features. The paper is set out as follow: in the second section the main models of enforcement of agri-environmental policies are illustrated and key elements are identified. The reviewed literature is compared with respect to each aspect of the models. In the third section the relevance of the literature for actual CC policies is discussed. The fourth section concludes.

2. PRINCIPAL AGENT MODELS

The major area of the microeconomic literature on CC and agri-environmental schemes comprises mostly normative studies on the contractual mechanisms put in place to overcome informational asymmetries between a principal (the regulator agency) and agents such as farmers. Papers in this area can be classified according to the categories of adverse selection (AS) and moral hazard (MH).

The AS literature covers issues mainly related to the design of contracts whereby the principal can discriminate between agents with different costs of compliance that are only imperfectly known by the principal (hereafter: "regulator"). Acquisition of information on observable farmer characteristics that are correlated with compliance costs, screening contracts and procurement auctions are the main approaches to the problem (e.g. Ferraro 2008). This literature is relevant for AES where fund allocation can be improved by alternative contractual mechanisms. However, direct payments linked to CC are not settable according to costs of compliance or value of produced benefits because of their income support nature. In the CC case, the major issues appear to be just monitoring and punishment not contract design (Latacz Lohmann, 1999).

In a MH model the the regulator cannot observe perfectly and costlessly farmer behaviour after a contract has been signed. Monitoring is imperfect or incomplete and the information asymmetry provides incentives for farmers to cheat and do not comply with contractual obligations. Whenever not detected cheaters can receive a compensation payment (the single farm payment in the case of CC) without bearing any cost of compliance.

Several principal-agent models have been proposed to deal with these aspects, mainly relating to MH or both MH and AS. Different features of the mechanism design have been investigated such as: type of monitoring uncertainty, single farm type vs heterogeneity of farmers, type of compliance (continuum as in the case of input quotas or discrete as in regulations mandating certain practices), temporal pattern of decision (one shot vs dynamic models), type of regulator objective (budget minimisation, welfare maximization), risk attitude of farmers . Figure 1 sketches a tentative classification of the reviewed studies according to some of the above criteria.

Figure 1. MH models of agri-environmental schemes
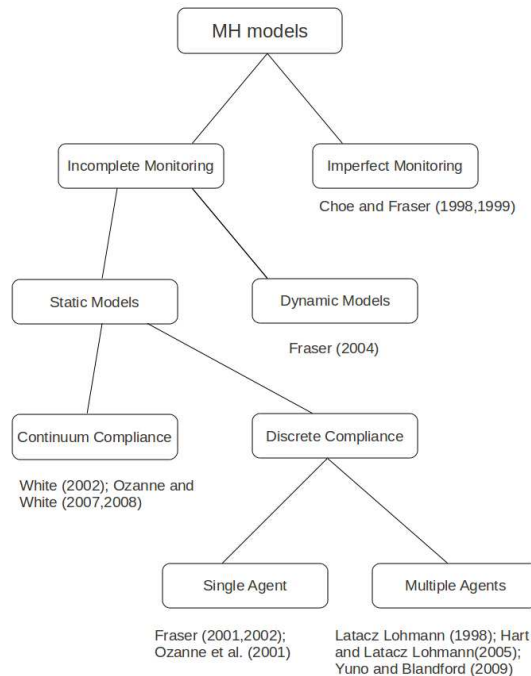
Source: own elaboration

Despite of differences, almost all MH models of Agri-environmental schemes are composed of the same set of elements:

- a behavioural model of the farmer usually portrayed as an expected utility maximiser
- the regulator objective function
- hypothesis on the availability of information and distribution of uncertainty
- model constraints: participation constrains making the scheme attractive for farmers complying with regulation and incentive compatibility constraints which make farmer prefer complying to cheating and non complying.
- a set of policy variables such as: monitoring level and cost, fines, compliance rewards and incentives levels
- policy suggestions stemming from model solution

The remaining of the section is devoted to a comparison of the models for each of the above elements. Comparability across models should be enhanced as within each element similarities and dissimilarities are more easily detected. Whenever possible, we tried to adopt an uniform notation.

2.1. Behavioural model of farmers

Farmers are usually modelled as expected utility maximisers. Some papers assume risk neutral agents (Hart and Latacz-Lohmann, 2005, Latacz Lohmann, 1998, 1999; White, 2002). As it is well know from Becker (1968) incentive schemes for risk neutral agents can freely substitute costly monitoring with arbitrary high fines to induce compliance. Compliance is observed whenever cost of compliance c_i are equal or lower than the expected costs from fines (F) :

$$c_i \leq p * F \qquad\qquad 1)$$

where p is the probability of detection or frequency of monitoring.

When partial compliance is allowed, as in continuum compliance models of an input quota x_i, an alternative to fixed fines is provided by variable fines proportional to the over-quota use of a polluting input : $F = \varphi\left(\tilde{x_i} - x_i \right)$. The problem of the agent is to choose a level of input that minimise compliance costs minus expected fines. Under standard assumptions, compliance is observed up to the level where:

$$c'_i\left(\tilde{x_i} \right) \leq p * \varphi'\left(\tilde{x_i} \; x_i \right) \qquad\qquad 1b)$$

that is, farmers choose that level of input that equals marginal costs of compliance and marginal expected fines (Heyes, 1996).

Being monitor costly, an optimal solution would be to fix fines at the highest possible levels adjusting p in order to satisfy [1]. However, fine levels for agri-environmental or CC infringements cannot be much higher than participation incentives or direct payments due to legislative constraints. Moreover, even if high fines were feasible, a deterrence trap (Hogus, 1994, p.92) is likely to arise due to the limited ability of small and medium farmers to pay draconian sanctions because of wealth constraints.

Most authors cite empirical research reporting high rates of compliance among farmers despite low incentives . Indeed, high rates of environmental compliance have been found also in other industrial sectors giving rise to the so called Harrington paradox (Heyes, 1998). Both risk aversion and honesty are possible candidate to explain why in a context of relatively low fines

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[1] In case of variable fine it would be sufficient to set a fine structure so that (φx) be sufficiently steep.

and detection probabilities high rates of compliance are observed among farmers. In the first case risk aversion makes, *ceteris paribus*, the compliance game less attractive with respect to the sure outcome from compliance. In the second case voluntary compliance is driven by attitudes and values. Hart and Latacz Lohman (2005) model of farm compliance relies upon a percentage of farmers being driven by honesty in constrast to self interest.

It remains an open question whether risk aversion is actually so widespread among farmers. Ozanne and White (2008) support the view that the evidence of risk aversion is strong enough while according to Hart and Latacz Lomanh (2005) empirical studies show mixed results. However, most authors model risk averse agents. Fraser (2001, 2002) and Yano and Blandford (2009) adopt a mean variance framework, Choe and Fraser (1998, 1999) a concave ad hoc specification for the utility function. Another popular way to model risk aversion, at least for numerical simulation purposes, is given by a power utility function with Arrow-Pratt relative risk aversion measureing the attitude toward risk (Fraser, 2002; Yano and Blandford, 2009; Ozanne,Hogan and White, 2001; Ozanne and White, 2008):

$$u(\pi) = \pi^{-\theta} \quad \text{with} \quad \theta + 1 = R_{AP}(x) \qquad \qquad 2)$$

where R_{AP} is the Arrow-Pratt relative risk aversion measure.

2.2. Regulator's objective functions

MH models of monitoring and punishment aim at designing environmental schemes that either maximise a social welfare function (most of the reviewed studies) or minimize public scheme costs for given environmental benefits (Latcz Lohmann, 1998; Hart and Latcz Lohmann, 2005) or simply reduce the amount of moral hazard (Fraser, 2002; Fraser, 2004; Yano and Blandford, 2009). Social welfare functions include monetary valuations of environmental benefits, producer surplus, transfer payments and transaction costs borne by the authority administering the scheme (possibly net of fines). The following example, referring to a model applied to a polluting input quota, is drawn from Ozanne and White (2007, 2008) :

$$z_i = V(x_i^* - x_i) + (b_i - c_i(x_i)) - (1-e)(b_i + M(p)) \qquad \qquad 3)$$

where z_i is the social welfare contribution of the ith farmer and x_i^* is the profit maximising input quantity. $V(x)$ is a value of abatement function with the usual properties, b is the transfer payment offered by the scheme and c is the cost of compliance function defined as profit foregone, that is $c_i = \pi(x_i^*) - \pi(x_i)$. The last term on the right side are the administrative and transactional costs of the scheme: transfer or payment b and monitoring costs M which are function of the monitoring frequency p. Both costs are pre-multiplied by (1+e) where e is the shadow cost of public funds. If required, risk aversion is introduced replacing the second term on the r.h.s. with a utility function having the same argument, $w(b_i - c_i(x_i))$. Hereafter, we will refer to the risk neutral case for the sake of maintaining formulas more readable . Whenever

a producer payoff appears in the formulas risk aversion can be easily introduced by replacing it with an appropriate utility function.

In Yano and Blandford (2009) payments are modelled as a share γ of compliance costs $\left(b_i = yc_i\right)$. Ozanne and White (2007, 2008) consider a continuum of compliance decisions whereby farmers can decide to partially complying by using input quantity $\tilde{x}_i$ (with $x_i > \tilde{x}_i > x_i$). Fines for non compliance are modelled as proportional to input above the quota level as in (1b): $\varphi\left(\tilde{x}, x\right) = \eta\left(\tilde{x} - x\right)$. Ozanne and White (2008) rewrite producer surplus as

$$b_i - c_i\left(\tilde{x}_i\right) - p_i\eta\left(\tilde{x}_i - x_i\right),$$ which is the expected return from the compliance gamble. In their paper the administrative costs are calculated net of expected fines as

$$b_i + M\left(p_i\right) - p\eta\left(\tilde{x}_i - x_i\right).$$ Minor modifications of the social welfare function are required to account for an input charge rather than an input quota scheme as illustrated in Ozanne(2002)[2].

Finally, monitoring costs have been modelled as fixed, linearly dependent on p or as a polynomial of degree 2 in *p*.

Another version of the objective function is proposed by Choe and Fraser (1998, 1999) that consider only two level of input reduction: high (x^*-x_h) and low (x^*-x_l) with payments b_h and b_l respectively. Producer surplus does not contribute to regulator's objective. The authors hypothesise imperfect monitoring whereby all farmers are monitored but detection of high or low effort is subject to a level of accuracy *q*. Effort is perfectly identified when *q* is equal to 1, it is randomly detected for *q* equal to 0.5. As monitoring is imperfect, each level of input reduction implies transfer payments given by a weighted average of b_h and b_l where weights are given by *q* and (*1-q*). Monitoring cost are proportional to accuracy :

$$z_{h,l} = V\left(x_i^* - x\right)_{h,l} - \left(qb_{h,l} + (1-q)b_{h,l} - (q-0.5)m\right) \qquad 4)$$

Fraser (2001) applies a MH model to the problem of slippage in the context of a set-aside policy. In its objective function (which is not explicitly maximised) benefits are given by saving of export subsidies arising from decreases in production when good land instead of bad land is

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[2] In this case x and c(x) are both function of t, the input charge, while F is replaced by $\tau(t)$ the revenue from input taxation. Ozanne and White (2007) show that, under asymmetric information, input quotas and input charges are equivalent instruments and lead to the same outcomes for the MH model.

set aside. V(x) is thus replaced by $\left(p_{EU} - p_w \right)$, the gap between EU and world prices, times the difference between good and bad land yields. In this case transfer payments *b* are equal to a set aside premium for unit of yield (*s*) times the extra reference yield -with respect to the actual reference yield level- needed to induce setting aside of good land $\left(r_g - r_a \right)$. Monitoring costs are assumed as fixed while producer surplus is not accounted for:

$$z_i = \left(p_{EU} - p_w \right)\left(y_b - y_b \right) - \left(s\left(r_g - r_b \right) + M \right) \qquad 5)$$

Differently from the above models, Latacz Lohman (1998) and Hart and Latacz Lohman (2005) assume a regulator whose objective is to minimise budgetary expenses for a predetermined compliance target (in term of percentage of complying farmers) that acts as constraint to the optimization problem. The model is a multi-agent one that accounts for heterogeneous agents with different costs of compliance. If (N_C+N_{NC}) is the number of complying farmer and non complying farmer that participate in the scheme then the objective function of the regulator is to minimise:

$$TC = b\left(N_C + N_{NC} \right) - pN_{NC}\left(b + F \right) + mp\left(N_C + N_{NC} \right) \qquad 6)$$

subject to the constrain that at least M farmers will participate and comply. Farmer participation is determined by the payoff of either cheating or complaying being greater than zero, an occurrence that depends on policy variables such as *p*, *b* and *F* but also on the cost of compliance of single farmers. If a farmer is caught cheating the transfer payment is completely withdrawn and a supplementary fine is applied.

2.3. *Hypothesis on the availability of information and distribution of uncertainty*

The above regulator problems are all set within an asymmetric information context. Indeed, farmers can respond to agri-environmental schemes either a) participating and complying or b) participating and non complying (cheating or compliance gamble) or c) opting out (Latacz Lohmann, 1998). To overcome information asymmetries, regulators have to monitor farmer behaviour. With perfect monitoring all farmers are monitored thus leading to sure detection and disincentive of cheating but at a cost. Incomplete monitoring occurs when the probability of being monitored is positive but lower than unity. Instead, imperfect monitoring refers to the partial accuracy of monitoring as in the Choe and Fraser (1998) model.

From the farmer point of view uncertainty affects payoff: a) when monitoring is incomplete and the chosen action is non compliance ; b) always, when monitoring is imperfect. Because of incomplete or imperfect monitoring the payoffs of farmers are uncertain as those of a lottery (or a gamble). Output price and subsequent profit variability are introduced as further source of uncertainty by some models (Fraser, 2001, 2002; Yano and Blandford, 2009).

Besides imperfectly observed behaviour of agents, information affects regulator options also in other ways. Models from the literature assume that the regulator may or may not have

information about other relevant elements such as: production technology, cost of compliance, risk attitude of farmers, honesty of farmers. Table 1 below show the assumptions about information available to regulators brought about by the reviewed papers.

Table 1: Information available to Regulators facing moral hazard.

Paper	Environm. Benefit function	Production Technology	Cost of Compliance function	Risk attitude	Honesty	Output price
Hart Latacz Lohmann(2005) Latacz Lohman (1998)	n.a.	n.a.	distribution	n.a.	distribution	n.a.
Fraser (2001), (2002)	n.a.	yes	depends on output price	yes	n.a.	distribution
Fraser (2004)	n.a.	n.a.	yes	yes	n.a.	n.a.
Yano and Blandford* (2009)	n.a.	distribution	distribution	yes	n.a.	distribution
Choe and Fraser (1998)(1999)	yes	n.a.	yes	yes	n.a.	n.a.
Ozanne et al. (2001)	yes	yes	yes	yes	n.a.	n.a.
White (2002)**	yes	yes	yes	n.a.	n.a.	n.a.
Ozanne and White (2007)(2008)**	yes	yes	yes	n.a.	n.a.	n.a.

Source: own elaboration. n.a.=not applicable. *Production technology refers to private benefit. ** We consider only the moral hazard model. In the combined moral hazard adverse selection model the regulator has priors on farm type.

In the table only MH models are considered. Actually, White (2002) and Ozanne and White (2007; 2008) propose also MH-AS combined models where the regulator has priors about production technology and cost of compliance types of farmers and can offer differentiated contracts. This is a different assumption with respect to those by Hart and Latacz-Lohmann (1988) where the regulator knows the distribution of cost of compliance among farmers but offer a single contract focussing on MH issues. It is worth noticing that the less demanding is the model in terms on information, the more is the model applicable to large schemes such as EU cross compliance where, for example, detailed information on issues such as benefit functions may be costly to collect (Latacz-Lohmann, 1999).

2.4. Model constraints

Constraints on desired farmer behaviour are a key feature of MH models that characterizes the optimization problem or simply defines the conditions for compliance. Participation or individual rationality (IR) constraint must be fulfilled if the farmer has to enter an agri-environmental scheme. It prescribes that the utility from entering the scheme and complying be equal or larger than the utility of opting out (reservation utility). For a risk neutral agent:

IR: $(b_i - c_i) \geq 0$ 7)

or in the continuum compliance model:

IR: $\left(b_i - c_i\left(\tilde{x}_i \right) \right) + p_i \eta \left(\tilde{x}_i - x_i \right) \geq 0$ \hfill 8)

In the imperfect monitoring case (Choe and Fraser, 1998 and 1999) the constraint modifies in:

IR: $\left(q b_{h,l} + (1-q) b_{h,l} \right) - c_{h,l} \geq 0$ \hfill 9)

since the incentive for a participating farmer is subject to uncertainty because of inaccuracy in monitoring.

Fraser (2001,2002), although not explicitly, sets the IR constraint so that setting aside the good land is worthwhile:

IR: $s\left(r_g - r_b \right) - p\left(y_g - y_b \right) \geq 0$ \hfill 10)

where the first term is the increase in payment arising from setting aside good instead of bad land (analogue to *b* of equation 7) and the second term is the foregone income (expected price times the difference in yield between good and bad land).

A different perspective is adopted by Latacz Lohmann (1998) and Hart and Latacz Lohmann (2005). In their multi-agent model farmers participate in the scheme if either payoff from cheating or payoff from complying are larger than zero. Payoff from cheating and non complying is positive when[3]:

$$b - p(b + F) > 0 \text{ or } b > F\left(\frac{p}{1-p} \right)$$ \hfill 11)

which is a condition that is completely controlled by the regulator. On the contrary, Payoff from complying - given by equation (7) - depends on the distribution $f(c_i)$ of cost of compliance across the population of farmers.

The other constraint considered in MH models of monitoring is the incentive compatibility (IC) one which assures that compliance is preferred to non compliance. In the simplest case and for a risk neutral agents (Ozanne, 2001) the IC states that payoff from complying must be larger than the expected payoff from non complying and being fined F with probability p:

IC: $b_i - c_i(x_i) \geq (1-p) b_i - p_i F$ \hfill 12)

which in the continuum compliance case (Ozanne and White, 2008) becomes :

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[3]According to the model, in case of detection of non compliance the payment is withdrawn and a supplementary fine is applied.

$$\text{IC: } \left(b_i - c_i \left(\overset{\sim}{x_i} \right) \right) - p\eta \left(\overset{\sim}{x_i} - x_i \right) \geq \left(b_i - c_i \left(\overset{\approx}{x_i} \right) \right) - p\eta \left(\overset{\approx}{x_i} - x_i \right) \qquad 13)$$

In this framework incentive compatibility requires that farmers prefer non compliance at input level $\overset{\sim}{x_i}$ to non compliance at input level $\overset{\approx}{x_i} \geq \overset{\sim}{x_i}$. Noticeably, this leads to the same results as (1b). That is, marginal cost of compliance must be lower or equal than the expected increase in penalty for one unit more of input in excess of the quota. Note also that when the riskiness of complying vs non complying is the same and risk aversion is no longer an issue in designing optimal schemes.

In the imperfect monitoring case (Choe and Fraser, 1998 and 1999) the constraint modifies in:

$$\text{IC: } \left(qb_h + (1-q)b_l \right) - c_h \geq \left(qb_l + (1-q)b_h \right) - c_l \qquad 14)$$

when regulator seeks to implement the high input reduction scheme. A similar formula applies for the low input case with pedices inverted.

Fraser (2001,2002) constraint states that the payoff from truthfully setting aside good land and declaring so must be greater than the expected payoff from cheating :

$$\text{IC: } s\left(r_g - r_b \right) - p\left(y_g - y_b \right) \geq s\left(r_g - r_b \right) - p\left(sr_g \right)\delta \qquad 15)$$

where the r.h.s. is given by the increase in the premium gained by declaring to set aside good instead of bad land to which is subtracted the expected fine that the farmer has to pay if caught cheating (a proportion of δ the set-aside premium sr_g times the probability of being detected p).

Fraser (2004) proposes a dynamic two period model of MH with state dependent monitoring. The probability of detection rises in the second period for those farmers that are caught cheating in the first period and assigned to a target group. This is quite a realistic assumption at least for schemes such as EU cross compliance. In the absence of targeting, the IC states the conditions under which behaving always truthfully is preferred to cheating in both periods, since the mixed strategies (cheating in period 1 and behaving truthfully in period 2 or the other way round) are always dominated:

$$\text{IC: } (b_i - c_i) + \frac{(b_i - c_i)}{(1+r)} \geq (1-p)b_i - pF + \frac{(1-p)b_i - pF}{(1+r)} \qquad 16)$$

If targeting is put in place the target group in the second period will be monitored with frequency $p_H > p$. However, farmers that would cheat with the previous probability of detection p will not be prevented to continue to cheat in the second period as the following will hold whenever (16) does hold:

$$\left(b_i - c_i\right) + \frac{\left(b_i - c_i\right)}{\left(1+r\right)} \ge \left(b_i - c_i\right) + \frac{\left(1-p\right)b_i - pF}{\left(1+r\right)} \qquad 17)$$

Furthermore, a resource neutral approach - whereby resources for additional monitoring in the target group are obtained by lowering monitoring frequency ($p_L < p$) of the remaining farmers- is likely to cause further shortfalls. Now even those that previously behaved truthfully in both periods may be tempted to switch to the mixed strategy because of the lower monitoring intensity in the non targeted group. To overcame this shortfall Fraser (2004) proposes to rely on farmer risk aversion by increasing the riskiness of cheating among those in the non target group through an appropriate mean-penalty preserving adjustment in p_L and F. Model results appear to somewhat depend on the two period nature of the game. Infinitely repeated games may lead to more cost-effective solutions as the incentive to non comply in the last period disappear as it is illustrated by Heyes (2000)[4].

According to Latacz Lohmann (1998) and Hart and Latacz Lohmann (2005) a farmer comply if:

$$b - c_i\left(x\right) \ge \left(1-p\right)b - pF \ \text{ or } \ c_i \le p\left(b + F\right) \qquad 18)$$

When cost of compliance is distributed across farmers with density function $\phi(c)$ -or a distribution function $\Phi(c)$ - the share of compliant farmers is given by:

$$\int^{p(b+F)} \phi\left(c\right)dc = \Phi\left(p\left(b+F\right)\right)\Phi \qquad 19)$$

A similar multi agent setting can be found in Yuno and Blandford (2009). According to their model, the regulator can contrast cheating with compliance rewards (R) in addition to fines. Risk neutral farmers will comply if the expected payoff from complying is greater than the one from cheating:

$$\left(b - c_i\left(x\right)\right) + pR \ge \left(1-p\right)b - pF \ \text{ or } \ c_i \le p\left(b + R + F\right) \qquad 20)$$

where the payoff from complying on the r.h.s. is given by the payment net of compliance costs plus the expected compliance reward. The share of complying farmer is found as in the Latacz Lohman model. If an additional amount T of funds per farmer is available then the regulator may decide to increase the monitoring intensity or to spend the amount on compliance rewards. In the first case the frequency of monitoring becomes :

$$p_H = p + \frac{T}{m} \qquad 20)$$

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[4] Another dynamic model has been proposed by White (2005) but in a context of ecological monitoring where MH is not an issue.

where cost of monitoring is assumed equal to *mp*. In the second case the expected compliance reward per farmer is given by:

$$R = \frac{T}{p\alpha_i} \qquad \text{21)}$$

where α_i is the expected *ex ante* compliance rate. By substituting the new value for *p* in equation (18) and then for R in equation (19) the authors find that spending money on compliance rewards has a larger impact on compliance rates than allocating resources to monitoring when:

$$\frac{m}{\alpha_i} > (b + F) \qquad \text{22)}$$

If we conservatively assume that the ex ante compliance rate is close to one, compliance rewards is the preferred option when the loss borne by the detected cheater is smaller than the cost of monitoring. Although monitoring is costly this appear to be a rather restrictive condition at least for schemes such as EU cross compliance.

When IR and IC constraints are part of an explicit social welfare maximisation problem (as in Ozanne et al. 2001; Ozanne and White, 2007, 2008; White, 2002) one important aspect is whether they are binding or not. Ozanne et al. (2001) state that both constraints are binding because of the positive shadow value of public funds (*e*) and marginal costs of monitoring (M'(*p*)). However, a causal inspection of the numerical simulation provided by the authors reveals that only the IC constraint is binding. At the solution, transfer payments exceed costs of compliance and farmers are gaining a positive rent from participating in the scheme. An higher *b* may be necessary to satisfy the IC at minimum cost when monitoring is costly.

Multi-agent models that are framed as a cost minimisation problem for a given target compliance rate allow for IC constraints to be violated at the solution by some participating farmers. Conversely, welfare maximising models with compliance cost heterogeneity (such as White, 2002) lead to corner solutions where the monitoring rate are set so high that all participating farmer are complying when a pooling solution is adopted (Hart and Latacz Lohmann, 2005).

2.5. Policy variables

All MH models with monitoring define three sets of variables: a) choice variables; b) policy parameters, c) endogenous parameters. Often the distinction between the first two set of variable is driven by convenience only: both types of variable are enforcing instruments that the regulator can change. For example in Ozanne et al. (2001) fines are a policy parameter since they are maintained fixed (or predetermined) and the social welfare function is maximised w.r.t. other choice variables: restricted input level (x) , transfer payment (b) and monitoring frequency (p). Conversely, endogenous parameters refer to economic aspects (such as technology, costs,

benefit functions) or behavioural properties (risk aversion, honesty) that are not modifiable by the regulator. The models we reviewed differ to some extent as for their assumptions about variables and policy parameters as it is shown by table 2.

Fines (F) are never modelled as choice variables because of the legislative, administrative and wealth constraints that prevent regulators to rise fines beyond certain levels. Transfer payments and intensity of monitoring are always choice variables or parameter in those model that are not based on explicit optimization. According to the literature these are the key policy instruments of agri-environmental schemes. Those (Ozanne et al. 2001, Ozanne and White, 2007, 2008) who model the compliance choice in the continuum, considers as choice variable also the level of input quotas or, alternatively of input charges (Ozanne, 2002).

Table 2: Choice variables and policy parameters in MH models

Paper	b	x	p or q	F	S	R
Hart Latacz Lohmann(2005) Latacz Lohman (1998)	v	n.a.	v	p	p	n.a.
Fraser (2001), (2002)	p	n.a.	p	p	n.a.	n.a.
Fraser (2004)	p	n.a.	p	p	n.a.	n.a.
Yano and Blandford (2009)*	p	n.a.	p	p	n.a.	p
Choe and Fraser (1998)(1999)	p	n.a.	p	n.a.	n.a.	n.a.
Ozanne et al. (2001)	v	v	v	p	n.a.	n.a.
White (2002)**	v	v	v	p	n.a	n.a.
Ozanne and White (2007)(2008)	v	v	v	p	n.a.	n.a.

Source: own elaboration. v= choice variable , p= policy parameter, n.a= not applicable. *A further parameter for these authors is the additional amount of fund for monitoring (T). ** The paper relies on input charges so x has to be interpreted as the unit input charge.

2.6. Policy prescriptions

Some key results can be identified from the reviewed literature on MH in agri-environmental policies. A general finding is that compliance may be improved by policy settings that induce higher expected losses on risk neutral non compliers (see equation 1) leading to a trade-off between monitoring rates and fine levels. As the maximum fine level is usually constrained by legal or ethical considerations, the regulator must rely on more intense monitoring, an option that increases enforcement costs.

Risk aversion can partially mitigate this problem. Ozanne et al. (2001) simulate agents with rising relative risk aversion and find that the higher the aversion to risk the better the approximation of the optimal solution under MH to the first best solution achievable under perfect monitoring or perfect information. Similarly, Fraser (2001,2002) suggests to use mean penalty preserving schemes that induce larger variance in income of non complying farmers. However, as long as such schemes are characterized by larger fines coupled with lower monitoring intensity, they may conflict with the above mentioned constraints on penalty levels.

If information about farmer risk aversion is scanty fine tuning of enforcement parameters may be difficult to achieve. When compliance is a continuum decision and fines are proportional to over-quota input use, Ozanne and White (2007;2008) show that a variable fine leads to optimal contracts that are independent from farm risk preferences.

In some contexts a single contract is offered to heterogeneous agents with differentiated compliance costs. In this case monitoring efforts should be targeted to farmer with higher compliance costs for whom the difference between expected payoffs under compliance and non compliance is lower. If the scheme allows for withdrawn of transfer payments in addition to fines then transfer payments can substitute fines in discouraging non compliance in a cost effective way when monitoring is costly (Latacz Lohmann,1998).

Also incomplete monitoring raises the level of incentives necessary to make farmers comply with regulation. As a consequence regulators should set payment levels in accordance not only with cost of compliance but also with accuracy of monitoring (Choe and Fraser, 1998, 1999). Incentive payments may be higher than compliance costs also in single agent continuum compliance models with fixed penalties such as the one by Ozanne et al. (2001). Choe and Fraser (1999) hint that overcompensation may be an issue in trade negotiation if payments in excess of compliance costs are treated as income support.

Yuno and Blandford (2009) propose to resort to compliance rewards as alternative to higher transfer payments. However, the higher the reward the riskier the decision to comply. As a result, lower compliance rate among risk-averse farmers may be observed depending on the structure of enforcement costs.

Targeting is a well know issue in enforcement studies on environmental regulation (Heyes, 2000). Regulators should design schemes whereby farmers caught cheating are assigned to target groups subjected to higher monitoring. Fraser (2004) shows that resource neutral targeting can be achieved by lowering the monitoring pressure on non targeted groups. With risk adverse farmers compliance rate are maintained at the previous level thanks to mean penalty preserving adjustments of fees and monitoring intensity.

3. EU Cross-compliance and MH models

Latacz-Lohmann (1999) envisaged three main critical areas for the European CC policy: limited scope for spatial targeting, lack of fine tuning of incentives at farm level and information asymmetries that require appropriate enforcement. As far as enforcement is concerned, the same author argued that CC obligations would have been difficult to observe and monitor and a high degree of monitor would have been requested insofar as the envisaged sanctions were only a fraction of the single farm payment.

Recent evaluations of CC (for example IEE (2007) and ECA (2008)) confirm the relevance of the points raised by Latacz-Lohmann. However CC enforcement is likely to remain a key issue in the foreseeable future. Commission' communication on "The CAP towards 2020" (COM 2010/672) on the one hand envisaged a CC with "a simpler and more comprehensive set of rules without watering down the concept of cross compliance itself", on the other hand

proposes to link a component of direct payment to non-contractual "environmental actions that go beyond cross-compliance and are linked to agriculture".

Current enforcement practices of CC as laid down by Regulations CE 73/2009 and 1122/2009 are based on targeting and a system of stepwise variable sanctions. The sample for on site checks is at least 1% of all farmers submitting aid application. Monitored farmers are partly drawn at random and partly selected on the basis of risk analysis. In turn, risk analysis may be based -inter alia- on the type of statutory management requirements (SMR) or good agricultural and environmental conditions (GAEC) for which the farm is eligible, size of direct payments and outcome of previous monitoring activities.

Fines are calculated as reduction of direct payments differently in the case of neglicence or intentionality of non compliance. In the case of neglicence, a one shot infringement may lead to fines from 1% to %5 of direct payments depending on severity, extent and permanence of the infraction. Repeated non compliance in following periods would results in fines up to a maximum of 15% of direct payments. Once the maximum fine is reached further infringements will be considered as intentional. In this and other cases of intentional non-compliance fines are higher ranging from 15% to 100% of the overall amount of direct payments with exclusion from the affected aid scheme in the following calendar year.

Commission Communication 147/2007 on the application of the system of cross compliance points out that - in member States applying full cross-compliance- about 4.6 % of the eligible farmer were monitored in 2005 of which 16.4% were found non compliant. Non compliance mostly related to cattle registration, GAEC and Nitrate Directive. In Italy a recent study founds a non compliance rate of about 11% in 2007 (MIPAAF, 2010). Overall, about 95% of the fines were applied at the 5% level or lower, with more than two thirds applied at the 1% level.

Comparing the stylised features of CC enforcement in the EU and the main points raised by the reviewed literature we found only a partial overlapping of relevant themes. Most of the literature deals with static models whereas the sanctioning system of CC is a multiple-period one. The trade-off between sanctions and monitoring effort is not so relevant in a setting where direct payments are not related neither to environmental benefits not to enforcement strategies. Even if CC penalties are somewhat variable the continuum models proposed by the literature are only a rough approximation of the field practice. Whether the stepwise system of rising fines envisaged by the EU can lower the impact of risk aversion on compliance decision (as suggested by Ozanne and White, 2008) is an empirical issue.

Evidence of low non-compliance rates coupled with low fines and low probability of detection supports the relevance of the paradox of compliance . Whether this pattern arises because of a large share of honest farmers (Hart and Latacz-Lohmann, 2005) or it is due to the state-dependent enforcement regime (Heyes, 2000) put in place by the EU is another question open for empirical research.

4. CONCLUSIONS

We reviewed some moral hazard (MH) models applied to agri-environmental policies and identified the main methodological aspects of the literature on this topics. Imperfect vs incomplete monitoring , static vs dynamic and single vs multiple agents models are the main lines along which the literature has been organised analysing each component of a MH model.

In a context where the level of the fines is legally constrained, higher rates of compliance can be achieved by improving cost-effectiveness of monitoring and relying on farmer risk aversion. However, how much farmer are risk averse is still an empirical (and debated) question and the observed high rates of compliance remain somewhat paradoxical. Either state dependent enforcement regimes or attitudes of farmers can help explain the empirical evidence. However, both themes have not been given appropriate emphasis in the MH models of agri-environmental schemes. Cross compliance confirm these findings and urges further studies on dynamic MH models and farmers' non profit maximising behaviour.

We want to conclude by commenting on the problematic relationship between MH models and empirical evidence in agri-environmental policies. Despite the formal elegance of these class of models their validation is often based only on numerical simulations. This in turn affect the relevance and direct applicability of the findings. To some extent the corresponding literature in the broader field of environmental regulation (Hey, 1996, 2000; Cohen, 1999) may provide suggestions for the development of models more conducive to empirical tests. Similarly, stylisation of farmer behaviour in MH models may benefit from cross-fertilization with the wider literature on farmer attitudes towards and participation in agri-environmental schemes (see for example: Davies and Hodge, 2006; Knowler and Bradshaw, 2007; De Francesco et al., 2007).

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