MANCHESTER 1824

The University of Manchester

Economics Discussion Paper Series EDP-1701

Going Green To Be Seen: The Case of Biodiversity Protection on Farmland

Prasenjit Banerjee
Ada Wossink
Rupayan Pal

January 2017

Economics
School of Social Sciences
The University of Manchester
Manchester M13 9PL

GOING GREEN TO BE SEEN: THE CASE OF BIODIVERSITY PROTECTION ON FARMLAND

Prasenjit Banerjee*[1], Ada Wossink[2], and Rupayan Pal[3]

1 September 2016

Abstract

We provide a framework to analyze the non-separability of self-interest and endogenous social preferences in the context of voluntary biodiversity protection on farmland. A farmer's social reward (esteem/disesteem) interacts with the proportion of the peer group taking up the conservation practice. We use the framework to address how to incentivize different types of farmers ('green' or brown') under asymmetric information about their true motivation. It follows that under perfect Bayesian equilibrium, the regulator can separate out the farmer types by monitoring their (observable) conservation activities and that a status reward is needed to keep 'green' farmers interested.

Key Words: Mechanism Design, Social Norm, Motivation Crowding, Signaling, Public goods, Agriculture.

JEL-code: D03 (Behavioral micro-economics - underlying principles); Q57 (Environmental Economics - biodiversity conservation); Q58 (Environmental Economics - governmental policy); D82 (Asymmetric and Private Information - Mechanism Design)

[1, 2] Economics, University of Manchester, UK; [3] Indira Gandhi Institute of Development Research, Mumbai, India.
Email: [1]prasenjit.banerjee@manchester.ac.uk; [2]ada.wossink@manchester.ac.uk; [3]rupayan@igidr.ac.in
*Corresponding author: University of Manchester, Economics, Arthur Lewis Bldg, Oxford Road, Manchester M13 9PL, United Kingdom

1. Introduction

The loss of biodiversity is a major public environmental concern. Agricultural practices are an important cause of biodiversity loss and agri-environmental policies are aiming at improving these. Voluntary green payment policies are receiving increasing attention as a means for enhancing the supply of environmental public goods from land that remains in agricultural production (OECD, 2010). In the European Union, in particular, there has been a movement towards this type of policy. The implementation progressed rapidly and agri-environmental schemes now constitute a central element of the Common Agricultural Policy in terms of agricultural area covered and expenditures[1]. Despite many reviews and changes made, there is ample evidence that the ecological results from these schemes are largely underwhelming which puts into question the cost-effectiveness (*e.g.*, De Snoo *et al*., 2013; Sauer and Wossink, 2013; Batáry et al., 2015). Intriguingly, at the same time there is increasing evidence that a large percentage of farmers (also) engage in voluntary biodiversity conservation activities for which they do not receive payment[2].

Economic research to support agri-environmental policy design rests on models that presume rational behavior. But relying on rational choice theory to guide environmental policy makes sense only if people make, or act as if they make, consistent and systematic choices. Numerous empirical studies over the last four decades reveal that rational choice theory might be a poor guide for economics in many circumstances (see Kahneman and Tversky 2000). This applies even more so to agri-environmental economics. There is a rich literature supporting the importance of social and psychological influences on farmers' decision making. Farmers farm for reasons other than just maximizing profit and a myopic view of the profit maximization goals as driving farmers' decisions may misrepresent their behavior (Howley 2015). In addition, the problem is that rationality in economics is a social construct based on active market exchange, not an individual construct based on isolated introspection (Arrow 1951). Assuming rational behavior for agri-environmental policy decisions may then be specifically problematic because nature's goods and services frequently lack the active market-like arbitrage needed to encourage consistent choice (Crocker et al., 1998). Agri-environmental policies might well be more cost-effective if we

[1] Agri-environmental schemes became a mandatory part of the policy toolkit in EU Member States as part of Pillar II (Rural Development Policy) in 2005. Over 2007-2013, the annual average spending from EU's Fund for Rural Development was €3.3 billion. It is the highest conservation expenditure in the EU.

[2] A well-documented example of this is farmers' participation in the Campaign for the Farmed Environment. Approximately half of arable farmers in England recorded land within at least one of the Campaign voluntary measures in 2012. See https://www.gov.uk/government/statistics/campaign-for-the-farmed-environment

transform our rational choice models to include bounded rationality, bounded self-interest, and bounded willpower (Thaler and Sunstein, 2008). Perhaps incentive design could be more accurate and effective if we treat preferences as context-dependent and having a social element.

The economic literature on farmer participation in agri-environmental schemes is substantial but in this context their motivational behavior has received limited attention. However, there is little doubt that where agricultural stewardship of the countryside and its amenities is concerned, farmers obtain non-monetary satisfaction (e.g., Chouinard et al. 2008; Greiner and Gregg 2011). Psychologists have attributed this to non-financial motives and to intrinsic motivation and self-identity, in particular (see Lokhorst et al., 2014; Rode et al., 2015). An obvious first implication is that offering economic incentives to foster pro-environmental behavior can have crowding-out effects of intrinsic motivation, reducing the total contribution provided by farmers (Frey 1997; Bowles 2008; Bowles and Polanía-Reyes, 2012). These crowding effects are expected to be person and context specific since these follow from the meaning the payment conveys to the recipient rather than from the use of economic incentive *per se* (Bowles and Polonía-Reyes, 2012). But there is also further complexity stemming from the cultural and contextual setting and heterogeneity therein. Farmers are known to constitute a judgmental peer group and to compare themselves continually (Burton and Paragahawewa 2011). Unlike many other occupations, work on the land is open to the direct, uninvited and unavoidable scrutiny of the peer group and thus "agricultural land becomes the display of the farmer's knowledge, values and work ethic" (Rogge et al., 2007, pg 160).

In line with the arguments above, farmers' conservation activities can be attributed to extrinsic, intrinsic, and image motivation (e.g., Benabou and Tirole, 2006). The first motivation leads to functional utility which includes attributes due to the agri-environmental payment and the net agronomic effect. Supplementary utility is associated with altruism and 'warm-glow' utility. For farmers that value reputation, image motivation leads to additional supplementary utility from the esteem gained from the conservation activity. Image motivation, or signaling motivation, refers to an individual's tendency to be partly motivated by others' perception (Batson 1967; Akerlof, 1980; Ariely et al. 2009). When a farmer selects conservation activities this is by construction a signal of his pro-social preferences. Thus, farmers might take up conservation activities for less altruistic reasons since these enable signaling pro-social awareness. This signal could be sent to other farmers or significant others who are able to observe the implemented conservation practices such as friends and family.

The signal could also be sent to the retrospective future self to bolster self-perception. Kuhfuss et al. (2015b) for example shows that almost half of the farmers in their sample were willing to maintain contracted practices after the end of the contract and that information about what other farmers intended to do (the social norm) influenced their own decision. This suggests that for farmers that value reputation, the increase in the signaling value counteracted the effect of the lost payment, in effect crowding-in reputational motives (see Brennan and Pettit, 2004).

Previous studies assume social preferences as given whereas in reality these depend on institutional factors (e.g., society, taste, religion, property rights) and the distribution of preferences (i.e., the number of people actually having a particular type of preference), and so on (see Bowles, 1998; Lindbeck et al 1999; Bowles and Polanía-Reyes, 2012). The interaction between preferences and social norms arises endogenously from the interplay of esteem and disesteem with the prevailing norm (see Bénabou and Tirole, 2006 and 2011). People seek social approval of behavior and take actions in line with *the right thing to do* with *the right thing* depending on the existing social norm[3] (Hermalin 1998; Vesterlund 2003; Potters et al., 2007). Thus, given a norm, the relative number of farmers who follow it at a given time and place actually determines whether taking such action will lead to esteem or disesteem. Policy makers can exploit the interaction between preferences and social norms by public disclosure (Kuhfuss et al 2015; Genius et al 2013; Allcott 2011). But such a "naming and shaming" policy can also backfire (Bénabou and Tirole (2011). If a farmer perceives the leadership role as diminished the scarcity value of their reputation is reduced and they may decide to do less.

We address the open question how to incentivize different types of farmers to protect farmland biodiversity at least cost. We account for endogenous social preferences and asymmetric information. An individual farmer's true motivation is unknown and they can be either 'green' (with social preferences) or 'brown' (reputation seeker). Payment would undermine a *green* farmer's value of esteem. Neither does a regulator want to transfer money to a *brown* farmer. This would imply spending public funds on those who wish to comply with the norm. Our results contradict the standard finding in the literature in the context of mechanism design for agents with social preferences that *green* farmers will *over-protect*

[3] For example, walkers-by were more likely to put money into a Salvation Army kettle, when they had observed someone else doing so (Bryan and Test 1967); the number of people who want to receive welfare benefits to live off may increase when more people do the same (since living on benefits may become relatively less embarrassing when more people do the same, see Lindbeck et al. 1999).

and that *brown* farmers will *bypass economic gain* to gain a moral reputation (Fischer and Huddart 2008; Bowles and Hwang 2008; Banerjee and Shogren 2012). Our results show that a green farmer may not always over-protect and that a brown farmer is not always willing to bypass economic rents to gain a green reputation. Rather both these decisions depend on the proportion of the peer group doing *the right thing*. A brown farmer behaves in a self-interested manner if this proportion is low but where this proportion is sufficiently high this farmer will mimic the green farmer to avoid the disesteem attached to non-compliance with the social norm. It also follows that an additional status reward would be needed to keep the green farmer motivated.

Next, we extend our analysis to account for the effect of social signaling on the contract. Of concern for a regulator is the welfare implication of social signaling. There would be negative effects in particular when conservation practices are being implemented merely to increase self-image; i.e. the farmer being little concerned about the proper implementation of the practice to ensure ecological effectiveness. Another implication of social signaling could be that preference is redirected toward the status salient practices rather than the most farm economically and ecologically effective ones given local conditions. Both green and brown types of farmers are willing to gain a good reputation and it might be difficult to separate them out. If a brown farmer can successfully signal as green, the program may face a welfare loss because reputation-seeking brown farmers lack true conservation motives. Farmers with a positive attitude toward biodiversity protection are expected to do substantially more for the environment than brown farmers who would merely *tick the boxes* and are expected to shirk from the desired actions whenever possible (Ahnström et al. 2008; Greiner and Gregg 2011; Lokhorst et al 2011). The challenge for the regulator under asymmetric information is how to design the contract while separating the types based on the signals received. To address this conundrum, we consider a two-period signaling game between the regulator and a farmer who can be again one of two types. In period one, the farmer chooses biodiversity protection action, which becomes common knowledge at the end of the period, and receives monetary compensation from the regulator. In period two, the regulator selects a green type farmer to facilitate her biodiversity protection action and offers her monetary compensation. Results show, under perfect Bayesian equilibrium, the regulator can separate out the types—a green farmer over-protects in period one whereas a brown farmer chooses her optimal action.

We present two examples where the role of social preferences and social norms has a bite in constructing cost-effective agri-environmental policy. Of particular interest is the growth in initiatives promoting the voluntary uptake of unpaid environmental land management. Our first main example is in the UK where in 2009 the farming organizations launched the Campaign for the Farmed Environment (CFA) to improve the environmental conditions of agricultural habitats and landscapes throughout lowland England. Detailed survey data shows that during the 2013/14 crop year, 44% of holdings in England had land within one of the 22 CFE-listed unpaid voluntary measures. Given that an attribute of conservation management on farm land is that it involves some sacrifice of financial profit the CFE results strongly suggest other non-monetary motives. Our second example is a new stewardship initiative, ‘Chlorpyrifos: Say NO to Drift’, which was launched by the three major UK approval holders in October 2011. The aim of this initiative was to achieve 100 percent uptake of low-drift nozzles and an extended no-spray buffer zone of 20 metres by all UK farmers applying the insecticide with a conventional boom sprayer. Support for the campaign was of crucial importance because without it would be unlikely that chlorpyrifos products could have been retained in the UK market.

Our contributions are the following. Firstly, we design efficient voluntary incentive mechanism by incorporating endogenous social preferences, conditional on social norms. As mentioned above, nearly all previous analyses on mechanism design for agents with social preferences have treated social preferences, in particular, reputational concern, as exogenous. But in reality they depend on societal preferences, norms, culture and so on. Adding social norms (i.e., average behavior of the peer group) into social preferences, we encounter leaders’ costs and recognize additional social reward for them. Secondly, previous studies are potentially limited as they do not consider the possibility of signaling by farmers. It is important to recognize leaders’ motivation in implementing social projects as their intrinsic motivation and authoritative role enhance efficiency of such projects and establish a norm of good behavior (Kosfeld and Rustagi 2015; Fehr, Herz, and Wilkening 2013; Andreoni and Petrie 2004). For a policy maker it is not always easy to identify true leaders’ actions as others may also successfully mimic leaders. Our two-period dynamic mechanism implements leaders’ actions by extracting signals from both types.

We continue as follows. Section 2 presents a benchmark model of mechanism design with standard preferences, Section 3 adds social preferences into it, section 4 incorporates endogenous norms within this set-up, Section 5 extends the model by examining a signaling problem in a two-period dynamic set up, Section 6 describes two examples, and then Section 7 concludes.

2. Mechanism design with standard preferences

Consider each farmer is endowed with fixed acres of homogeneous land, X. A farmer decides whether to enrol x acres of this land for biodiversity protection, $x \geq 0$ and $x \leq X$, by implementing organic farming, conservation practices or restricting agricultural activity to shelter endangered species, and so on. Such action taken by the farmer is privately costly, $C(x;\ \Gamma)$, where C is a standard cost function. The opportunity costs of introducing pro-environmental methods of farming depend on both the number of acres and on land quality, i.e., marginal productivity of the land (see Hanley et al., 2012). The term Γ is the productivity parameter—everything else equal, an extra acre of land dedicated to biodiversity-friendly farming incurs higher opportunity costs for a higher Γ. The farmer receives a monetary transfer, *t*, from the regulator to compensate the forgone profit for each acre of land enrolled.

Environmentally responsible farming practice can be cost saving and the maintenance of an attractive landscape, ecological diversity or uptake of organic farming can increase profit as consumers have preferences for such 'green' products. Let $\pi(x)$ be the material profit from practicing green farming. The utility of a farmer is

$$U = [\pi(x) + tx] - C(x;\ \Gamma) \qquad (1).$$

According to standard voluntary mechanism design (see, Smith and Shogren 2002; Baliga and Maskin, 2003; Laffont 1995), a regulator aims to maximize social welfare from biodiversity protection on farmland in such a way that the farmer is no worse off by participating in the program (i.e., satisfying the participation constraint). The social welfare is the social benefit from biodiversity protection and the utility of the farmer minus the opportunity costs of public funds paid to the farmer for participation. Under complete information about the quality of the land, the regulator offers an optimal transfer-to-acre contract, (t, x), to the farmer by solving the following

$$\max_{x,t} W = B(x) + U - \lambda tx \text{ s.t. } U \geq 0, \qquad (2)$$

where $B(x)$ is the social benefit function which is concave in its arguments and λ represents opportunity costs of public fund. Expression (2), the participation constraint, implies a farmer should receive a non-negative return from participation. Optimality requires

$$\frac{\partial C(x;\Gamma)}{\partial x} = \left[\frac{\frac{\partial B(x)}{\partial x}}{\lambda} + \frac{\partial \pi(x)}{\partial x}\right] \quad (3)$$

and

$$tx = C(x;\Gamma) - \pi(x) \quad (4).$$

The FOC of the optimization problem (expression (3)) shows that the marginal costs of participation should be equal to the sum marginal social benefit weighted by the dead-weight loss of taxation and marginal material payoff to the farmer. Solving the FOC, an optimal monetary transfer to the farmer can be obtained (expression (4)) which exactly compensates the farmer's contribution in terms of the costs of taking action minus the material profit from the *green*-action.

Under asymmetric information about land quality, a farmer can be one of two types—low and high quality farmer with low and high land quality Γ, $\Gamma \in \{\Gamma^L, \Gamma^H\}$ with $\Gamma^L < \Gamma^H$. A high-quality farmer should earn higher land rents than a low-quality farmer. The regulator knows there are two types but cannot distinguish between them. The regulator designs a voluntary incentive mechanism incorporating private information about land quality and offers an optimal contract $\{x^i, t^i\}$ for land enrolled in a biodiversity conservation program so that a farmer of type *i* is no worse off when he voluntarily chooses the contract, $i = L, H$. According to the Revelation Principle, if the farmer accepts the contract, she enrols the land in the program and receives compensation as specified in the contract. The mechanism provides the incentive for each farmer to reveal this private information. The regulator's goal is to choose the contract by maximizing the social welfare which is the weighted average of the utility of the farmer, including the benefits from biodiversity protection, net of the cost of funding the project,

$$\max_{x^L,x^H,t^L,t^H} W = q[B(x^L) + U^L - \lambda t^L x^L] + (1-q)[B(x^H) + U^H - \lambda t^H x^H] \quad (5)$$

where, q is the probability that the farmer is of low-type. The regulator has to consider the following (binding) participation and incentive compatibility constraints,

$$[\pi(x^H) + t^H x^H] - C(x^H;\Gamma^H) \geq 0 \quad (6)$$

$$[\pi(x^L) + t^L x^L] - C(x^L;\Gamma^L) \geq [\pi(x^H) + t^H x^H] - C(x^H;\Gamma^L) \quad (7)$$

A high quality farmer does not have any incentive to hide her private information of land quality, she will participate if she is no worse off from participation (i.e., expression (6) is satisfied). Under asymmetric information, a low quality farmer, however, mimics the high quality farmer. If the low quality farmer's net gain from participation is the same (at least) as the net gain of the high quality farmer, the dominant strategy is to reveal the private information and take part in the program (i.e., the incentive compatibility constraint (7) is satisfied).

Substituting (6) and (7) into (5), the FOC of the optimization problem implies

$$x^H: \left[\frac{\frac{\partial B(x^H)}{\partial x^H}}{\lambda} + \frac{\partial \pi(x^H)}{\partial x^H}\right] = \frac{\partial C(x^H; \Gamma^H)}{\partial x^H} - \frac{q\,(1-\lambda)(1-q)}{\lambda(1-q)}\left[\frac{\partial C(x^H; \Gamma^H)}{\partial x^H} - \frac{\partial C(x^H; \Gamma^L)}{\partial x^H}\right] = 0 \qquad (8)$$

$$x^L: \left[\frac{\frac{\partial B(x^L)}{\partial x^L}}{\lambda} + \frac{\partial \pi(x^L)}{\partial x^L}\right] = \frac{\partial C(x^L; \Gamma^L)}{\partial x^L} \qquad (9).$$

Now $\frac{\partial C(x^H; \Gamma^H)}{\partial x^H} > \frac{\partial C(x^H; \Gamma^L)}{\partial x^H}$, since an extra acre of land dedicated to biodiversity-friendly farming incurs higher opportunity costs for a higher Γ. So, (8) implies $\left[\frac{\frac{\partial B(x^H)}{\partial x^H}}{\lambda} + \frac{\partial \pi(x^H)}{\partial x^H}\right] - \frac{\partial C(x^H; \Gamma^H)}{\partial x^H} = -\frac{q\,(1-\lambda)(1-q)}{\lambda(1-q)}\left[\frac{\partial C(x^H; \Gamma^H)}{\partial x^H} - \frac{\partial C(x^H; \Gamma^L)}{\partial x^H}\right] > 0$, considering $\lambda > 1$. It follows that the high quality farmer sets aside fewer than optimal acres of land for biodiversity protection and the low-type farmer sets aside optimal acres of land (expression (9)) at the margin. From binding constraints (6) and (7), we have,

$$t^H x^H = C\left(x^H;\, \Gamma^H\right) - \pi(x^H) \qquad (10)$$

$$t^L x^L = C\left(x^L;\, \Gamma^L\right) - \pi(x^H) + \left[C\left(x^H;\, \Gamma^H\right) - C\left(x^H;\, \Gamma^L\right)\right]$$
(11).

In addition, the low-type farmer captures positive information rents, as shown in (11), as $C\left(x^H;\, \Gamma^H\right) - C\left(x^H;\, \Gamma^L\right) > 0$. The high quality farmer obtains zero information rents as she does not have any incentive to mimic the low-quality farmer because then she would incur a monetary loss. The regulator surrenders this information rent because he wants to keep the high-quality farmer in the project. Also, the regulator accepts the high-quality farmer's participation in term of acres although it is less than the optimal level in order to minimize the information rents paid out.

3. Mechanism with social preferences

Now we consider the role of social preferences in mechanism design. Let ϑ_t denote the farmer's intrinsic valuation of money; she then enjoys intrinsic satisfaction, $\vartheta_t tx$, when she receives *t* monetary transfer from the regulator, and sets aside *x* acres of land for biodiversity protection. In addition she enjoys an intrinsic satisfaction, ϑ_x, when undertaking actions to protect biodiversity on *x* acres of private land (i.e., a true altruism). We assume that $\mathbf{V} \equiv (\vartheta_x, \vartheta_t)$ follows a distribution function *F(v)* and density *f(v)* with mean $(\overline{\vartheta}_x, \overline{\vartheta}_t)$. Its realization is private information.

A farmer's choice of undertaking actions for biodiversity protection depends also on the *reputational* value. Reputation captures society's judgments and reactions to a private farmer's contribution toward biodiversity protection. Assume the value of reputation, *R*, depends linearly on observers' posterior expectations of the farmer's psychological attributes, e.g., whether she intrinsically cares about biodiversity (i.e., governed by ϑ_x) or does so only for money (i.e., governed by ϑ_t). Following Bénabou and Tirole (2006), reputational payoff from choosing x given the monetary incentive *t* is,

$$R(x,t) = \alpha[\gamma_x E(\vartheta_x|x,t) - \gamma_t E(\vartheta_t|x,t)] \quad ; \quad \gamma_x, \gamma_t \geq 0,$$

where α captures the *visibility* of a farmer's contribution to biodiversity protection, and γ_x and γ_t express how a farmer would like to be perceived—*socially responsible* (γ_x) or *selfish* (γ_t). Assume γ_x and γ_t are exogenously given. Visibility and the weight a farmer assigns to reputation define the farmer's overall concern about reputation, $\alpha\gamma_i$, $i = x, t$. For simplicity, assume reputational concern is identical across farmers, with fixed γ_i and α.[4]

Then the utility function of the farmer becomes

$$U = \pi(x) + \vartheta_t tx - C(x;\, \Gamma) + \vartheta x + R\,.$$

[4] The marginal impact of land retirement on reputation is positive, $R_x = \alpha\left[\gamma_x \frac{\partial E(\vartheta_x|x,t)}{\partial x} - \gamma_t \frac{\partial E(\vartheta_t|x,t)}{\partial x}\right] = \alpha[\cdot] > 0$. A landowner who retires land for species protection sends a positive signal about his social preferences, i.e., $\frac{\partial E(\vartheta_x|x,t)}{\partial x} > 0$. Also, other people think the landowner's decision might not be driven by money, i.e., $\frac{\partial E(\vartheta_t|x,t)}{\partial x} < 0$ (see the proof of Proposition 2 in Bénabou and Tirole, 2006).

Solving for private utility, the maximization problem of a farmer gives us the following first order conditions,

$$\frac{\partial C(x;\Gamma)}{\partial x} = \frac{\partial \pi(x)}{\partial x} + \vartheta_t t + \vartheta_x + R_x \qquad (12)$$

and, second order condition requires $\pi_{xx} - C_{xx} + R_{xx} < 0$. Intuitively this FOC means that the farmer's marginal costs from actions towards biodiversity protection should be equal to the marginal benefit obtained from private payoff (e.g., selling organic products at a premium, revenue from tourists attracted by the landscape etc.) and satisfaction from monetary compensation from the regulator, intrinsic value, and reputational gain.

The monetary gain could also reduce contributions towards the social project through the classic *crowding out effect* according to which extrinsic incentives reduce the incentives of intrinsically-motivated people (see Frey and Jegen 2001; Bowles 2008). The intuition behind the crowding out effect due to reputation is that a person cares more about reputation than money and that taking money for doing a socially-beneficial work reduces one's reputation in society. The following comparative static result shows that effect:

$$\frac{\partial x}{\partial t} = \frac{R_{xt} + \vartheta_t}{-(\pi_{xx} - C_{xx} + R_{xx})} \qquad (14).$$

Since receiving tax-payers' money from the regulator for a socially-beneficial project can be viewed as 'money hungry' behavior, the cross partial derivative of reward for additional reputation (R_{xt}) is negative.[5] A farmer with reputational concerns will reduce the participation *x* given the monetary incentive *t*, i.e., a crowding out effect ($\frac{\partial x}{\partial t} < 0$), if she values reputational gain more than monetary gain (i.e., $|R_{xt}| > |\vartheta_t|$).

The regulator can design an incentive mechanism to address this crowding out effect by deriving an optimal contract $\{x^i, t^i\}$ to induce a farmer to participate in the biodiversity protection program. By optimizing the farmer's utility, the optimal contract ensures the farmer is no worse off when voluntarily choosing the contract. In this case, intrinsic valuation of species protection is assumed to be identical for all farmers (assume ϑ_x is normalized to 1) and intrinsic valuation of money (ϑ_t) can be varied at two levels—high or brown (ϑ^B) and low or green (ϑ^G), with $\vartheta^G < \vartheta^B$.

[5] For a detailed mathematical proof, see Proposition 2 in Bénabou and Tirole (2006) and Banerjee and Shogren (2012).

In the benchmark *full information* case, the regulator knows the intrinsic valuation of money for the farmer. The regulator maximizes the net social benefits from protecting biodiversity, by choosing *x* and *t*, subject to the farmer's participation constraint.

$$Max\ W = B(x^i) + \pi(x^i) + \vartheta_t{}^i t^i x^i - C(x^i;\ \Gamma\ ) + x^i + R^i - \lambda t^i x^i$$

Subject to $\pi(x^i) + \vartheta_t{}^i t^i x^i - C(x^i;\ \Gamma\ ) + x^i + R^i \geq \underline{U}^i$

where, $B(x^i)$ is the social benefit from biodiversity protection, λ is the opportunity costs of public fund, and $\underline{U}^i$is *ith* farmer's reservation utility, where $i = G, B$. Optimal regulation implies: (i) information rents are zero; and (ii) the marginal cost of land retirement equates to the marginal benefits from the monetary reward, intrinsic satisfaction, and reputation.

Under *incomplete information* about the intrinsic valuation of money, the regulator only knows a farmer can be one of two types – green and brown with low and high intrinsic valuation of money. The regulator knows the *brown* farmer wants to buy reputation, and he knows the *green* farmer might reduce the amount of land she is willing to set aside when offered monetary compensation.

The farmer tries to maximize her utility from participating in the mechanism—she may reveal the truth or give false information. A green farmer has nothing to hide if she wants a good reputation. —she will participate if the following is satisfied,

$$\vartheta_t^G t^G x^G = \underline{U}^G - \pi(x^G) + C(x^G;\ \Gamma\ ) - x^G - R^G\ \ .$$

But the brown farmer wants to gain a good reputation by falsely reporting that she has a low intrinsic valuation of money. She will reveal her private information and participate if the following incentive compatibility constraint is satisfied,

$$\pi(x^B) + \vartheta_t^B t^B x^B - C(x^B;\ \Gamma\ ) + x^B + R^B \geq \pi(x^G) + \vartheta_t^B t^G x^G - C(x^G;\ \Gamma\ ) + x^G + \omega,$$

where $\omega = m(\vartheta_t^B; \vartheta_t^G)$and $m(\vartheta_t^B; \vartheta_t^G)$ is the reputation of the brown farmer pretending to be a green farmer. Since the intrinsic valuation of money by the brown farmer exceeds that by the green farmer (i.e., $\mathrm{m}(\vartheta_\mathrm{t}^\mathrm{B}; \vartheta_\mathrm{t}^\mathrm{G}) < \mathrm{R}^\mathrm{G}$ as $\vartheta_\mathrm{t}^\mathrm{B} > \vartheta_\mathrm{t}^\mathrm{G}$), ω is negative. The brown farmer *gives up* economic rents to gain a good reputation. The regulator optimizes welfare with respect to the binding constraints. Optimal condition shows: (i) the green farmer does not capture any rents and *over-invests* in biodiversity protection; and (ii) the brown farmer enrolls the optimal acres of land for biodiversity protection and sacrifices economic rents (for details, see Banerjee and Shogren 2012). The mechanism is incentive-compatible as reporting the true information is the dominant strategy of each type of farmer.

4. Mechanism with social preferences and endogenous social norm

Now we incorporate the interaction between social norm and preferences into incentive mechanism. We consider a continuum of farmers and each of them decides whether to participate in the program by setting aside land for biodiversity protection, i.e., each makes a choice $x \in (0, 1]$. We also assume that the farmer's intrinsic satisfaction from land retirement is normalised to one. A farmer can be one of two types—green and brown—based on her intrinsic valuation for money– high ϑ_t leads to low reputational value (i.e., *brown* farmer). For notational simplicity, we denote ϑ_t as ϑ. We assume the distribution function of the intrinsic satisfaction from land under conservation practices is $F(\vartheta)$ with finite support $V \equiv [\vartheta_{min}, \vartheta_{max}]$, and the density of ϑ is $f(\vartheta)$, where $f(.)$ is continuously differentiable, with mean $\overline{\vartheta}$. We also define the following two conditional moments, X^+ and X^-, means in the upper and lower tails, for any candidate cut-off ϑ,

$$X^+ = E(\tilde{\vartheta}|\tilde{\vartheta} < \vartheta) \qquad (15)$$

$$X^- = E(\tilde{\vartheta}|\tilde{\vartheta} > \vartheta)\ . \qquad (16)$$

The expression (15) governs 'esteem' conferred by participation. Since the intrinsic valuation for money is below the average level expression (15) corresponds to virtue. The second expression (16) governs 'disesteem' conferred by abstention. It implies that if a farmer's intrinsic valuation for money is greater than the cut-off level, abstention from the project is viewed as irresponsible. The difference between the conditional moments defines net reputational gain, Ω:

$$\Omega = \mu\big(X^+(\vartheta) - X^-(\vartheta)\big),\ \forall\vartheta \in \text{V and } \mu \text{ is fixed.} \qquad (17)$$

Given the green norm and monetary transfer *t*, a farmer dedicates a positive amount of land to biodiversity conservation practices (i.e, $x \geq 0$) if $\frac{\partial U}{\partial x} \geq 0$. We define a threshold level of intrinsic valuation that satisfies this participation, denoted by ϑ^*, such that

$$\left.\frac{\partial U}{\partial x}\right|_{x=0} = \pi'(x) + \vartheta^* t - C'(x;\Gamma) + \Omega' = 0 \qquad (18)$$

Assuming an interior solution, the net reputational incentive at the cut-off level is

$$\Omega(\vartheta^*) = \mu_t\big(X^+(\vartheta^*) - X^-(\vartheta^*)\big)$$

When more people start doing 'the right thing', ϑ^* decreases (see Figure 1), honour from scarcity value decreases, but disesteem from abstention worsens. The effect on net reputational incentive depends on the relative strength of esteem and disesteem. If esteem decreases, $\Omega'(\vartheta^*) > 0$, the decisions become substitutes — i.e., a farmer who was among the few heroic early birds, withdraws participation when others join the program. An esteem effect dominates when the number of farmers who participate in the biodiversity protection program (i.e., 'do the right thing') is very low. A complementarity effect is observed when the disesteem effect dominates (i.e., $\Omega'(\vartheta^*) < 0$) — when only a few deviants fail to comply with the norm[6].

We now investigate whether extrinsic incentives crowd out intrinsic and reputational motives (Frey 1997; Benabou and Tirole 2006). The non-separable utility function can generate an adverse effect on utility due to any increase in monetary incentive to do the right thing. A comparative static result of the following utility maximization problem of an individual farmer shows,

$$\text{Max}_x\, U = \pi(x) + \vartheta t x - C(x;\, \Gamma\,) + x + \Omega$$

$$\frac{\partial x}{\partial t} = -\frac{\vartheta + \Omega_{xt}}{\pi'' - C'' + \Omega''} \qquad (19)$$

where $\Omega_{xt}$is the cross partial derivative of net reputational payoff. Expression (19) shows the effect of the material incentive on the farmer's decision on the number of acres of land to enroll in the agri-environmental project. Expression 19 further shows that receiving money for doing the *right thing* sends a signal that the farmer is relatively more concerned about money than farmland-biodiversity compared to other farmers—it reduces the marginal net reputational value (i.e., $\Omega_{xt} < 0$).[7] A farmer, driven by either esteem or disesteem loses relative reputation from the monetary incentive. The farmer will contribute less to biodiversity protection given monetary incentives if esteem/disesteem is valued more than monetary gain at the margin (i.e, $\vartheta < |\Omega_{xt}|$). If the farmer enjoys the esteem of being a leader, the relative position worsens. Similarly, if a farmer is among those who fail to comply

[6] This holds under certain conditions on the distribution of farmers' preferences. For details, see Bénabou and Tirole (2006).
[7] Monetary incentive crowds out the reputational motive for honour-driven farmers when the cut-off value of intrinsic motivation is moderately low.

with the perceived norm, taking money for biodiversity protection would increase disesteem Monetary incentives are ineffective for esteem driven behavior and disesteem -driven behavior, provided that: (i) the private net cost of participation is low; and (ii) participation is easily observable (i.e., high μ).

Suppose that average opinion becomes *green* following an aggregate exogenous shift in the distribution of farmers' preferences , i.e., more and more farmers now think biodiversity protection is the right thing to do and abstaining from such action is 'just not done'. The original distribution of intrinsic valuation shifts by $\theta,\ F(\vartheta-\theta)$ with density $f(\vartheta-\theta)$ and with support: $\mathrm{v}_\theta=[\vartheta_{min}+\theta,\vartheta_{max}+\theta]$. Net reputational return becomes: $\Omega_\theta(\vartheta)\equiv\Omega(\vartheta-\theta)$. We normalize ϑ such that min Ω at $\vartheta=0$ and min Ω_θ at $\vartheta=\theta$. As before, we have two types: a farmer can be one of two types—green and brown depending on $(\vartheta^B-\theta>\vartheta^G-\theta)$.

4.1.Complete Information

Under complete information (i.e., when the regulator knows who is green and who is brown), the regulator maximizes the following objective function,

$$max\ W=B(x^i)+\pi(x^i)+\vartheta^i t^i x^i+x^i+\ \Omega_\theta^i-C(x^i;\ \Gamma)-\lambda t^i x^i$$

subject to $\pi(x^i)+\vartheta^i t^i x^i+x^i+\Omega_\theta^i-C(x^i;\ \Gamma)\geq\underline{U}^i$

where, $i=G,B$ and $\underline{U}^i$ is reservation utility of farmer *i*. The participation constraint ensures that the farmer is no worse off when accepting the contract.

Optimality requires,

$$\frac{\partial B(x^i)}{\partial x^i}\frac{\vartheta^i}{\lambda}+\frac{\partial\pi(x^i)}{\partial x^i}+1+\frac{\partial\,\Omega_\theta^i}{\partial x^i}=\frac{\partial C(x^i;\Gamma)}{\partial x^i}\qquad(20)$$

This implies that the sum of marginal social benefit, material profit, intrinsic satisfaction, and reputational gain from the agro-environmental project should be equal to the marginal cost. Solving this, we obtain optimal acres of land, x*, dedicated to biodiversity protection; substituting x^* into the participation constraint gives the optimal monetary transfer, t^*, for the i^{th} farmer

$$t^{*i}x^{*i}=\underline{U}^i-\pi(x^{*i})-x^{*i}-\ \Omega_\theta^i+C(x^{*i};\ \Gamma)\Big/_{\vartheta^i}\ .\qquad(21)$$

This shows that a farmer *i* is exactly compensated for her forgone economic costs net of the farmer-specific intrinsic and reputational benefit. A green farmer with lower ϑ will receive less transfer than a brown farmer. No farmer can extract any information rent.

4.2.Asymmetric Information

Under asymmetric information, the regulator knows that the average behaviour/opinion has shifted to 'green' and a farmer can be one of two types – green and brown – but cannot distinguish between them. Assume that the probability that a farmer is a green type is *p*. A *green farmer* does not want to hide her private information *when the average opinion is green*. This farmer looks for a contract which provides the same utility that she could get under a brown-peer group standard – i.e., the participation constraint or individual rationality constraint is satisfied. Under a brown-community standard, this green farmer used to enjoy a *esteem value* (i.e., scarcity rents from being a 'leader' or 'saint-type' in the peer group). When more farmers join the 'green club' due to the change in the peer group standard, this scarcity value is lost. The participation constraint ensures that, even after a change in average behavior or opinion, this type of farmer is still no worse off by choosing the contract (i.e., she should be able to maintain her honour value).

$$U^{GG} \geq U^{GB} \Rightarrow \pi(\,x^G) + \vartheta^G t^G x^G + x^G + \Omega_\theta^{GG} - C(x^G;\Gamma) \geq \pi(\,x^G) + x^G + \Omega_\theta^{GB} - C(x^G;\Gamma) \quad (22)$$

where, x^i is the contribution of a type *i* farmer when the average opinion is *green*; t^i is the transfer received by a type *i* farmer when the average opinion is *green*; and Ω_θ^{ii} is the net reputational gain of a type *i* farmer when the average opinion is *i*, with *i* = Green, Brown. The term Ω_θ^{GB} in (22) captures the green farmer's net reputational gain when the peer group standard becomes brown.

A *brown farmer will* mimic a green farmer by hiding private information about the true intrinsic valuation *when the average opinion is green*. This farmer wants to be viewed as green since the average opinion in the peer group shifts to green. A brown type joins the program to avoid social disesteem; the motivation is to gain a reputation as good as that of the green type. The brown farmer accepts a contract which gives the same utility as that for the green farmer.

$$U^{BG} \geq U^{G} \quad \Rightarrow \pi(\,x^B) + \vartheta^B t^B x^B + x^B + \Omega_\theta^{BG} - C(x^B;\,\Gamma\,) \geq \pi(\,x^G) + \vartheta^B t^G x^G + x^G + \Phi_\theta^{GG} - C(x^G;\,\Gamma\,) \quad (23)$$

The term Φ_{θ}^{GG} in (23) represents a brown farmer's net reputational gain pretending to be a green farmer under a green peer group standard.

The regulator faces a trade-off in designing an efficient mechanism: a green farmer's participation could be reduced due to the crowding out effect of extrinsic motivation. The regulator does not want to lose these green farmers as their presence in a community may increase others' contribution to protect the farmland biodiversity (see Andreoni and Petrie (2004). In contrast, a brown farmer could refuse to participate if the monetary reward is insufficient when on average farmers are brown. T Here, we define an efficient mechanism to induce the two types of farmers when the average opinion about biodiversity protection becomes favorable (i.e., green).

$$Max\ W = p\left[B(x^G) + \pi(x^G) + \vartheta^G t^G x^G + x^G + \Omega_{\theta}^{GG} - C(x^G;\ \Gamma) - \lambda t^G x^G\right] + (1 - p)\left(B(x^B) + \pi(x^B) + \vartheta^B t^B x^B + x^B + \Omega_{\theta}^{BG} - C(x^B;\ \Gamma) - \lambda t^B x^B\right)$$

Substituting binding constraints into the objective function, we get

$$Max\ W = p\left[B(x^G) + \pi(x^G) + x^G + \Omega_{\theta}^{GG} - C(x^G;\ \Gamma) + (1 - \tfrac{\lambda}{\vartheta^G})(\Omega_{\theta}^{GB} - \Omega_{\theta}^{GG})\right] + (1 - p)\left[B(x^B) + \pi(x^B) + x^B + \Omega_{\theta}^{BG} - C(x^B;\ \Gamma) + (1 - \tfrac{\lambda}{\vartheta^B})\left\{\left(\pi(x^G) + x^G + \Omega_{\theta}^{GG} - C(x^G;\ \Gamma)\right) - \left(\pi(x^B) + x^B + \Omega_{\theta}^{BG} - C(x^B;\ \Gamma)\right) + \tfrac{\vartheta^B}{\vartheta^G}\left(\Omega_{\theta}^{GB} - \Omega_{\theta}^{GG}\right) + \left(\Phi_{\theta}^{GG} - \Omega_{\theta}^{GG}\right)\right\}\right]$$

The necessary first order conditions imply,

$$x^G: \left(\frac{p}{A}\right)\frac{\partial B(x^G)}{\partial x^G} + \frac{\partial \pi(x^G)}{\partial x^G} + 1 + \frac{\partial\, \Omega_{\theta}^{GG}}{\partial x^G}\left(\frac{p-B}{A}\right) + \left(\frac{B}{A}\right)\frac{\partial\, \Omega_{\theta}^{GB}}{\partial x^G} = \frac{\partial C(x^G;\Gamma)}{\partial x^G} \qquad (24)$$

$$x^B: C\,\frac{\partial B(x^B)}{\partial x^B} + \frac{\partial \pi(x^B)}{\partial x^B} + \vartheta^B + \frac{\partial\, \Omega_{\theta}^{BG}}{\partial x^B} = \frac{\partial C(x^B;\Gamma)}{\partial x^B} \qquad (25)$$

where, $A = p + (1-p)\left(1 - \frac{\lambda}{\vartheta^B}\right)$; $B = \left(\left(1 - \frac{\lambda}{\vartheta^G}\right)p + (1-p)\left(1 - \frac{\lambda}{\vartheta^B}\right)\frac{\vartheta^B}{\vartheta^G}\right)$; $C = \left(\frac{1-p}{\frac{\lambda}{\vartheta^B} - p}\right)$; and A, B, and C are positive parameters. Compared to the full information case, a green farmer contributes more to the biodiversity protection project because she wants to compensate for the relative reputational loss due to a change in average opinion ($\frac{\partial\, \Omega_{\theta}^{GB}}{\partial x^G} > 0$ in expression (19)). The brown farmer contributes at the optimal level.

From the binding constraints, we can rewrite them,

$$U^{GG} = U^{GB} \Rightarrow \vartheta^G x^G t^G = \Omega_\theta^{GB} - \Omega_\theta^{GG} \tag{26}$$

$$U^{BG} = U^{GG} \Rightarrow \vartheta^B x^B t^B = \Phi_\theta^{GG} - \Omega_\theta^{GG} + \Omega_\theta^{GB} - \Omega_\theta^{GG} \tag{27}$$

The binding participation constraint (26) reveals the fact that the green farmer needs some extra rent to compensate loss of esteem (i.e. the loss of relative reputation) due to a change in average behavior (i.e., scarcity rents). We argue that this extra rent cannot be a monetary compensation as that would crowd out the private incentive of the *leaders* (i.e., green farmers) (see Cappelen et al 2015). Similar to the evidence in the literature that a leader cares about her 'authoritative' role in society and the intrinsic satisfaction of being a leader is more valuable than economic rents (Fehr et al 2013), our result suggests that explicit monetary incentives may not be the effective tool to motivate the green farmer. Perhaps a 'social reward' that recognizes and celebrates this individual's 'early bird' role in biodiversity protection when the average behavior was still brown could be useful. This finding is in line with Besley and Ghatak (2008) who argue that motivated agents need a 'status incentive' to participate in a pro-social programme. In contrast, a brown farmer pretends to be a green farmer when the peer group standard becomes green. She would like to gain a reputation as good as the green farmer and would be happy to give up economic rent to gain such a green reputation (since $\Phi_\theta^{GG} < \Omega_\theta^{GG}$ in (27)).

5. Signaling

In the previous section of one period mechanism design, a regulator offers a contract menu that specifies acres-to-transfer to a farmer who can be one of two types. Under asymmetric information, a farmer chooses her optimal contract and reveals her type. Such a contract can induce both types of farmer with different land acre enrolment and monetary transfer. But, biodiversity protection on farmland is not just enrolling some acres of land, it requires continuous costly efforts from a farmer. It is difficult then to list all the requirements in the contract and offer monetary compensation accordingly. Instead a regulator may want to include only the green farmer who has the motivation to exert costly effort to protect farmland biodiversity. By identifying the true green farmer, this contract would ensure improved ecological performance and proper utilization of public fund. But, under asymmetric information a brown farmer may successfully signal being green as well by mimicking a green farmer. This may generate a welfare loss as a brown farmer would merely *tick the boxes* and is expected to shirk from the desired actions whenever possible. The challenge for the regulator under asymmetric information is to design a contract toinduce the green type based on the signals received. In this section, we investigate whether and how a regulator can design a mechanism by separating the types out in a two-period dynamic setting.

As before, a regulator designs a contract for a farmer who can be one of two types, green (G) (with ϑ^G) and brown (B) (with ϑ^B and $\vartheta^G < \vartheta^B$). In period zero, nature selects the type of the farmer. In period one, the farmer chooses biodiversity protection action x_1 and produces $g(x_1)$ of public good which becomes common knowledge at the end of period one. In return, the farmer receives monetary compensation t from the regulator. In period two, the regulator selects a green type farmer to facilitate her biodiversity protection action and offers monetary compensation t_s in return. By 'facilitation' we mean the regulator provides support (e.g., expert opinion/information) to the green farmer how to successfully and cost-effectively manage farmland biodiversity. For example, until recently DEFRA in England spent £20 million/year to assist farmers with 'professional environmental advice' to achieve environmental goal under agri-environmental schemes (at the entry level stewardship) (see Hanley et al 2012; DEFRA 2005)[8]. From the analysis above it follows that this public money could have been spent more effectively if this costly facilitation can be provided to those who utilize it better to protect biodiversity. This can also be used as an incentive in the mechanism—those who qualify for receiving such facilitation can gain a green reputation.

The utility of a farmer of type *i* in period one is as follows.

$$U_1^i = \pi(x_1^i) + g(x_1^i) + \vartheta^i t - C(x_1^i) + r(\vartheta^i, x_1^i),$$

where $\pi(x_1^i)$ is the material profit of type *i* farmer in period one from practicing green farming and $C(x_1^i)$ is the associated cost incurred by the farmer: $g' > 0$, $g'' < 0$, $\pi' > 0$, $\pi'' < 0$, $C' > 0$ and $C'' > 0$. Reputation of a farmer of type i for undertaking biodiversity protection action in period 1 is denoted by $r(\vartheta^i, x_1^i)$, where $\frac{\partial r}{\partial x_1^i} > 0$, $\frac{\partial^2 r}{\partial {x_1^i}^2} < 0$, $\frac{\partial r}{\partial \vartheta^i} < 0$ and $\frac{\partial^2 r}{\partial {\vartheta^i}^2} < 0$. That is, a farmer's reputation positively depends on biodiversity appreciation—if more biodiversity is protected and more ecosystem services are generated reputational value

[8] For example, CapeNature's Biodiversity Stewardship programme, which was initiated in 2003, facilitates biodiversity conservation on privately owned land in Western Cape, South Africa, by providing advice, management plans and assistance in planning invasive alien species clearing and fire management schedules and supports to benefit more from the biodiversity through ecologically sensitive income-generating avenues (CapeNature, 2016). Participation in this program is purely voluntary. Similar biodiversity protection programs are in place in other South African provinces as well (Driver et al., 2012; Selinske, 2013).

increases. Also, satisfaction from monetary compensation for doing the right thing adversely affects reputation.

In period two, the utility of type-*i* farmer depends on whether the regulator facilitates her biodiversity protection action or not, among other things, which can be expressed as follows.

$$U_2^i = \begin{cases} U_2^{si} = \Pi(x_2^i) + f(x_2^i) + \vartheta^i t_s - C(x_2^i) + R(\vartheta^i, x_2^i), \text{when her action is facilitated;} \\ U_2^{ni} = \pi(x_2^i) + g(x_2^i) + \vartheta^i t - C(x_2^i) + r(\vartheta^i, x_2^i), \text{when her action is } not \text{ facilitated;} \end{cases}$$

where x_2^i denotes the biodiversity protection action undertaken by the farmer of type i in period 2. $\Pi(x_2^i)$ and $f(x_2^i)$ denote the farmers material benefit and production of public good, respectively, when the regulator facilitates her biodiversity protection action: $\Pi(.) \geq \pi(.)$, $\Pi' \geq \pi' > 0,\ \Pi'' \leq \pi'' < 0,\ f(.) > g(.),\ f' > g' > 0,\ f'' < g'' < 0, C' > 0$ and $C'' > 0$. The term t_s denotes the monetary compensation paid to the farmer when her action is facilitated by the regulator. $R(\vartheta^i, x_2^i)$ and $r(\vartheta^i, x_2^i)$ denote reputation of the farmer of type i in period 2 for undertaking biodiversity protection action (a) when her action is facilitated by the regulator and (b) when her action is not facilitated by the regulator, respectively. As before, (a) $\frac{\partial R}{\partial x_2^i} > 0$, $\frac{\partial^2 R}{\partial {x_2^i}^2} < 0$, $\frac{\partial R}{\partial \vartheta^i} < 0$ and $\frac{\partial^2 R}{\partial {\vartheta^i}^2} < 0$, and (b) $\frac{\partial r}{\partial x_2^i} > 0$, $\frac{\partial^2 r}{\partial {x_2^i}^2} < 0$, $\frac{\partial r}{\partial \vartheta^i} < 0$ and $\frac{\partial^2 r}{\partial {\vartheta^i}^2} < 0$. For simplicity, let us consider that in period 2 type i farmer's reputation function, when her biodiversity protection action is facilitated by the regulator, is as follows. $R(\vartheta^i, x_2^i) = \frac{1}{\vartheta^i}[f(x_2^i) - g(x_2^i)]$. Without any loss of generality, type i farmer's reputations in period 1 and in period 2 in the case of no facilitation are normalized to be equal to zero, i.e., $r(\vartheta^i, x_1^i) = r(\vartheta^i, x_2^i) = 0,\ i = G, B$.[9] It is evident that for any given biodiversity protection action *x* of a farmer, her payoff is strictly greater if her action is facilitated by the regulator: $U_2^{si} > U_2^{ni}$. We assume that the participation constraint of a farmer is always satisfied regardless of her type, i.e., $U_1^i, U_2^{si}\ and\ U_2^{ni} > \underline{U}^i$, where $\underline{U}^i$ is the reservation utility of the type i farmer.

5.1 Complete Information Scenario

[9] Alternatively, we can write, $r(\vartheta^i, x_1^i) = \frac{1}{E(\vartheta^i)}[g(x_1^i) - g(x_1^i)] = 0$ and $r(\vartheta^i, x_2^i) = \frac{1}{E(\vartheta^i)}[g(x_2^i) - g(x_2^i)] = 0,\ i = g,\ B$.

Under complete information scenario (i.e., farmer's type is common knowledge), we solve the game by the standard backward induction method. In period 2, the problem of type i farmer when the regulator facilitates her action can be written as follows.

$$\text{Max}_{x_2^i}\, U_2^{si} = \Pi\left(x_2^i\right) + f\left(x_2^i\right) + \vartheta^i t_s - C\left(x_2^i\right) + \frac{1}{\vartheta^i}\left[f\left(x_2^i\right) - g\left(x_2^i\right)\right].$$

The FOC requires,

$$\frac{\partial U_2^{si}}{\partial x_2^i} = \Pi' + f' - C' + \frac{1}{\vartheta^i}[f' - g'] = 0 \tag{28}$$

and the SOC is satisfied as $\frac{\partial^2 U_2^{si}}{\partial {x_2^i}^2} < 0$, since $\Pi'' < 0$, $f'' < 0$, $C'' > 0$ and $f'' - g'' < 0$. Let $x_2^i = x_2^{sB*}$ solves for (28) when the farmer is of *brown*-type (i.e., $i = B$): $\left.\frac{\partial U_2^{sB}}{\partial x_2^B}\right|_{x_2^B = x_2^{sB*}} = 0$.

Then the LHS of (28) for the *green*-type farmer, at $x_2^G = x_2^{sB*}$, is

$$\left.\frac{\partial U_2^{sG}}{\partial x_2^G}\right|_{x_2^G = x_2^{sB*}} = \Pi'(x_2^{sB*}) + f'(x_2^{sB*}) - C'(x_2^{sB*}) + \frac{1}{\vartheta^G}[f'(x_2^{sB*}) - g'(x_2^{sB*})]$$

$$= \left(\frac{\vartheta^B - \vartheta^G}{\vartheta^G\,\vartheta^B}\right)[f'(x_2^{sB*}) - g'(x_2^{sB*})] > 0, \text{ since } \vartheta^B > \vartheta^G \text{ and } f' > g' > 0.$$

It implies that $x_2^{sG*} > x_2^{sB*}$, where x_2^{sG*} is the solution of (28) for the *green*-type farmer. That is, a *green*-farmer undertakes greater action for biodiversity protection and, thus, produces more of the public good when the regulator facilitates her action, compared to that of a *brown*-farmer. As a result, the social welfare in period 2 is higher when the regulator facilitates a green-farmer's biodiversity protection action: $W_G > W_B$, where W_i is the social welfare when type i farmer's action is facilitated by the regulator. Let $\underline{W}$ be the social welfare when the regulator utilizes the public fund required to facilitate the farmer's biodiversity protection action for other purpose(s), which is such that $W_B < \underline{W} < W_G$. That is, under complete information, the regulator facilitates the biodiversity protection action of a *green*-farmer, but *not* of a *brown*-farmer.

5.2. Asymmetric Information Scenario

Let us now consider that true intrinsic valuation for money is the famer's private information. That is, the farmer knows her true type, green (G) or brown (B), but the regulator does not know it. The regulator only knows that the farmer is either of two types – green or brown. However, in absence of any additional information, the regulator believes that the farmer's intrinsic valuation for money is low ($v = v^G$) with probability ρ ($0 \le \rho \le 1$) and high ($v = v^B$) with probability $1 - \rho$. That is, according to the regulator's prior beliefs, the farmer is of a *green*-type with probability ρ and the farmer is of *brown*-type with probability $1 - \rho$. These beliefs are common knowledge. As noted before, facilitation of the farmer's biodiversity protection action by the regulator is beneficial for the society only if the farmer is of *green*-type ($W_B < \underline{W} < W_G$). However, the farmer's payoff is strictly greater regardless of her type if her action is facilitated by the regulator ($U_2^{si} > U_2^{ni}, \ \forall \ i = G, B$). That is, both types of farmers would like to get facilitated by the regulator.

Now, if the regulator's prior beliefs are such that expected social welfare of period 2 is less than the reservation level of social welfare, i.e., if $E(W) = \rho W_G + (1-\rho)W_B < \underline{W}$, the regulator will not facilitate the farmer's biodiversity protection action, unless he can update his prior beliefs. In this case, the *green*-type farmer would try to signal her true type credibly to the regulator by choosing her biodiversity protection action in period 1 appropriately. This is the case of separating equilibrium, which induces period 2's outcome to be identical to the symmetric information case by revealing all private information through the signal – the farmer's biodiversity protection action in period 1. However, given the regulator's priors, if expected social welfare of period 2 is greater than or equal to the reservation level of social welfare, i.e., if $E(W) = \rho W_G + (1-\rho)W_B \geq \underline{W}$, the regulator will always facilitate biodiversity protection action in absence of any additional information available. In such a scenario, the *brown*-type farmer would try to masquerade her true identity by mimicking *green*-type farmer's behavior in period 1. This is the case for pooling equilibrium, which does not reveal any private information.

Separating Equilibrium. The pair of biodiversity protection actions (x_1^G, x_1^B) forms a separating equilibrium, if by observing x_1^G (alternatively x_1^B) the regulator concludes with certainty that the farmer is of *green*-type (alternatively *brown*-type). It is well known that if such (x_1^G, x_1^B) are to be perfect Bayesian equilibrium (PBE) these must depend on the belief structure of the regulator. For the regulator to update his beliefs, biodiversity protection actions of period 1 must satisfy the following incentive compatibility constraints

IC^G: $U_1^G(x_1^G) + \delta U_2^{sG^*} \geq U_1^{G^*} + \delta U_2^{nG^*}$, (29)

IC^B: $U_1^B(x_1^G) + \delta U_2^{sB^*} \leq U_1^{B^*} + \delta U_2^{nB^*}$, (30)

where δ $(0 < \delta \leq 1)$ is the discount factor of a farmer regardless of her type. $U_2^{si^*}, U_2^{ni^*}$ and $U_1^{i^*}$ are symmetric information optimal payoffs of the type i $(= G, B)$ farmer 'in period 2 when her action is facilitated by the regulator', 'in period 2 when her action is not facilitated by the regulator' and 'in period 1', respectively. To illustrate it further, note that

$$\left.\begin{aligned}
&U_2^{sG^*} = \text{Max}_{x_2^G}\, U_2^{sG} = \underset{x_2^G}{\text{Max}}\ \Pi(x_2^G) + f(x_2^G) + \vartheta^G t_s - C(x_2^G) + \tfrac{1}{\vartheta^G}[f(x_2^G) - g(x_2^G)],\\
&U_2^{sB^*} = \text{Max}_{x_2^B}\, U_2^{sB} = \underset{x_2^B}{\text{Max}}\ \Pi(x_2^B) + f(x_2^B) + \vartheta^B t_s - C(x_2^B) + \tfrac{1}{\vartheta^B}[f(x_2^B) - g(x_2^B)],\\
&U_2^{nG^*} = \text{Max}_{x_2^G}\, U_2^{nG} = \underset{x_2^G}{\text{Max}}\ \pi(x_2^G) + g(x_2^G) + \vartheta^G t - C(x_2^G),\\
&U_2^{nB^*} = \text{Max}_{x_2^B}\, U_2^{nB} = \underset{x_2^B}{\text{Max}}\ \pi(x_2^B) + g(x_2^B) + \vartheta^B t - C(x_2^B),\\
&U_1^{G^*} = \text{Max}_{x_1^G}\, U_1^{G} = \underset{x_1^G}{\text{Max}}\ \pi(x_1^G) + g(x_1^G) + \vartheta^G t - C(x_1^G)\ \textit{and}\\
&U_1^{B^*} = \text{Max}_{x_1^B}\, U_1^{B} = \underset{x_1^B}{\text{Max}}\ \pi(x_1^B) + g(x_1^B) + \vartheta^B t - C(x_1^B).
\end{aligned}\right\} \quad (31)$$

Inequalities (29) and (30) are the incentive compatibility conditions for the *green*-type and *brown*-type farmers, respectively. Condition (29) says that by setting x_1^G in period 1 the *green*-type farmer will induce facilitation of her biodiversity protection action in period 2 by the regulator and have a higher two-period discounted payoff than by setting x_1^{G*}, which is the symmetric information level of biodiversity protection action, in period 1 and discouraging facilitation by the regulator. By rearranging the terms of condition (29) we get $U_1^{G^*} - U_1^G(x_1^G) \le \delta\,(U_2^{sG^*} - U_2^{nG^*})$, that is, for the *green*-type farmer the loss in period 1 due to deviation from the symmetric information level of biodiversity protection action must be less than the corresponding (discounted) gain in period 2.

Condition (30) says that the *brown*-type farmer attains a higher two-period discounted payoff by setting her symmetric information level of biodiversity protection action x_1^{B*} in period 1, which discourages the regulator to facilitate her action in period 2, than by setting x_1^G in period 1 and inducing the regulator to facilitate her action in period 2. Rearranging the terms of condition (30), we get $U_1^{B^*} - U_1^B(x_1^G) \ge \delta(U_2^{sB^*} - U_2^{nB^*})$. It implies that, due to deviation from the symmetric information level of biodiversity protection action in period 1, the *brown*-type farmer's loss in period 1 must be greater than the discounted value of her gain in period 2.

Now, from (31), it is evident that $x_1^{G^*} = x_1^{B^*} = x_2^{nG^*} = x_2^{nB^*}$, $U_1^{G^*} = U_2^{nG^*} \equiv \widetilde{U}^G$ (say), $U_1^{B^*} = U_2^{nB^*} \equiv \widetilde{U}^B$ (say), where $x_2^{ni^*}$ is the no facilitation level of biodiversity protection action of the type i farmer in period 2. Therefore, we can rewrite conditions (29) and (30), respectively, as follows.

$$U_1^G(x_1^G) \ge (1+\delta)\,\widetilde{U}^G - \delta\, U_2^{sG^*} \implies \Psi(x_1^G) \ge \Delta^{\mathrm{G}} \quad (29a)$$

and $$U_1^B(x_1^G) \le (1+\delta)\,\widetilde{U}^B - \delta\, U_2^{sB^*} \implies \Psi(x_1^G) \le \Delta^{\mathrm{B}}, \quad (30a)$$

where $\Psi(x_1^G) = \pi(x_1^G) + g(x_1^G) - C(x_1^G)$, $\Delta^{\mathrm{G}} = (1+\delta)\,\widetilde{U}^G - \delta\, U_2^{sG^*} - \vartheta^G\, t$ and

$\Delta^{\mathrm{B}} = (1+\delta)\,\widetilde{U}^B - \delta\, U_2^{sB^*} - \vartheta^B\, t$. We depict conditions (29a) and (30a) in Figure 2, considering that $\Delta^{\mathrm{G}} < \Delta^{\mathrm{B}}$ is satisfied, which the regulator can always ensure by choosing monetary transfers t and t_s appropriately (see Appendix for details). The bell-shaped curve in Figure 2 plots $\Psi = \Psi(x_1^G)$. Of the two flat lines, the height of the top one represents Δ^{B}, while the height of the bottom one represents Δ^{G}.[10] It is evident that any $x_1^G \in [\,\underline{x}_1^G,\ \overline{x}_1^G\,]$ satisfies condition (29a), whereas condition (30a) is satisfied if x_1^G belongs to outside the interval $(\,\underline{x}_1^B,\ \overline{x}_1^B\,)$, as shown in Figure 2. Therefore, if $x_1^G \in (\,\underline{x}_1^G,\ \underline{x}_1^B]$ or $x_1^G \in [\,\overline{x}_1^B,\ \overline{x}_1^G\,)$, both conditions (29a) and (30a) are satisfied. That is, by setting any $x_1^G \in \left(\,\underline{x}_1^G,\ \underline{x}_1^B\right] \cup [\,\overline{x}_1^B,\ \overline{x}_1^G\,)$ in period 1 the green-type farmer can credibly signal her true identity to the regulator. Clearly, there are many possible actions of the *green*-type farmer in period 1 which can credibly signal her true identity to the regulator. Among them, $x_1^G = \overline{x}_1^B$ deserves special attention. The reason is, the *green*-type farmer is likely to choose x_1^G from the upper interval $[\,\overline{x}_1^B,\ \overline{x}_1^G\,)$, in which $\overline{x}_1^B$ corresponds to minimum deviation from her symmetric information level of action $x_1^{G^*}$; i.e., $x_1^G = \overline{x}_1^B$ gives highest payoff and conveys the information credibly. Therefore, we propose that the green-type farmer will choose $x_1^G = \overline{x}_1^B$ in period 1 in order to credibly signal her true identity. For the *brown*-type farmer, on the other hand, it is optimal to choose her symmetric information level of biodiversity protection action $x_1^B = x_1^{B^*}$ in period 1.[11]

Given the regulator's prior beliefs, if expected social welfare of period 2 is less than the reservation level of social welfare ($E(W) < \underline{W}$) , there exists a separating equilibrium. In the separating PBE, the green-type farmer undertakes much greater biodiversity protection action ($\overline{x}_1^B$) in period 1 compared to her optimal choice action under symmetric information ($x_1^{G^*} < \overline{x}_1^B$), whereas the brown-type farmer does not deviate from her optimal choice of action under symmetric information ($x_1^{B^*}$). The regulator facilitates biodiversity protection action of only the green-type farmer in period 2.

Pooling Equilibrium. In this case the farmer undertakes a common biodiversity protection action in period 1 regardless of her type, *green* or *brown*, such that the regulator cannot update his beliefs and he finds expected social welfare is at least as large as the reservation social welfare, $E(W) = \rho\, W_G + (1-\rho) W_B \geq \underline{W}$. Since it is optimal for the

[10] Note that $\Psi(0) = 0$, $\Psi'(0) > 0$ and $\Psi'' = \pi'' + g'' - C'' < 0$, i.e., $\Psi(x_1^G)$ is strictly concave in x_1^G, and both Δ^{G} and Δ^{B} are independent of x_1^G.

[11] We establish that $(x_1^G = \overline{x}_1^B,\ x_1^B = x_1^{B^*})$ is a PBE in the Appendix.

regulator to facilitates biodiversity protection action although he cannot update its belief, the *green*-type farmer has now no incentive to deviate from her symmetric information level of biodiversity protection action in period 1, $x_1^{G^*}$. But, the *brown*-type farmer would like to mimic the *green*-type farmer, and set $x_1^{G^*}$ for sure in period 1, so that the regulator cannot update his belief and facilitate biodiversity protection action in period 2.

Formally, for the pooling equilibrium, the *green*-type farmer's incentive compatibility constraint remains same as (29), but the *brown*-type farmer's incentive compatibility constraint (30) is now reversed as follows.

$$IC^{B'}: \qquad U_1^B(x_1^G) + \delta U_2^{sB^*} > U_1^{B^*} + \delta U_2^{nB^*} \Longrightarrow \Psi(x_1^G) > \Delta^{\mathrm{B}}, \qquad (30')$$

From Figure 2, it is evident that both (29) and $(30')$ are satisfied, if $x_1^G \in (\underline{x}_1^B, \ \overline{x}_1^B)$. That is, there exists a plethora of pooling equilibrium. However, since the *green*-type farmer's optimal action under symmetric information $x_1^{G^*} \in (\underline{x}_1^B, \ \overline{x}_1^B)$ and it is in the *brown*-type farmer's interest to mimic of the *green*-type farmer's behaviour in order to masquerade her true identity, the *brown*-type farmer will also choose $x_1^{G^*}$ in period 1. Further, note that we have $x_1^{G^*} = x_1^{B^*}$. It implies that in the pooling equilibrium, each type farmer chooses her symmetric information level of biodiversity protection action in period 1: $x_1^G = x_1^B = x_1^{G^*} (= x_1^{B^*})$. In other words, in the pooling equilibrium, there will not be any deviation in the choice of biodiversity protection action in period 1 by a farmer regardless of her type – *green* or *brown*.

Therefore, given the regulator's prior beliefs, if expected social welfare of period 2 is greater than or equal to the reservation level of social welfare ($E(W) \geq \underline{W}$), there exists a pooling PBE in which a farmer sticks to her optimal choice of biodiversity protection action under symmetric information in period 1, regardless of her type, and the regulator always facilitates the farmer's biodiversity protection action in period 2.[12]

6. Application: unpaid agri-environmental measures in England

The main application of the model developed in section 4 is to the role of social norms in the voluntary provision of public goods in the rural setting and how this interacts with green payment schemes. From the point of view of our framework of the trade-off between social social preferences, endogenous norms and monetary reward, of particular interest is the growth initiatives to promote the voluntary uptake of unpaid environmental

[12] See Appendix for details.

land management during a period characterised by a movement towards green payment policies, in the European Union in particular[13].

6.1. The Campaign for the Farmed Environment (CFA)

Our first main example is in the UK where in 2009 the farming organisations launched the Campaign for the Farmed Environment (CFA) to improve the environmental conditions of agricultural habitats and landscapes throughout lowland England.

The Campaign is to be reflected upon against the background of the Environmental Stewardship Scheme (ESS) which is the main representation of a government-led green payment scheme in England since 2005. The ESS established a right for all farmers to receive payment for the provision of countryside goods[14], whatever their counterfactual position (Hodge and Reader, 2010). It represented a clear shift away from previous programs targeted spatially on particular types of area. Thus, the ESS allows all farmers to participate. The implication is that the provision of countryside goods can be enhanced both by reducing the intensity of production in more intensively farmed areas, such as by the introduction of buffer strips and the management of linear features such as hedgerows, as well as by supporting farming in less intensively managed areas where the existing farming practices deliver environmental benefits.

The literature on the ESS has many references to problems that are consistent with our focus on different types of motivations. The main issue is that there is no incentive for farmers to do more than the minimum necessary since the payment is for the implementation of the specific conservation practices, not for the ecological result. Worse, the prescription of management practices and designation of specific areas for agri-environmental work fails to allow farmers to develop or demonstrate skilled performance (Burton et al. 2008). Thus, farmers might well be interested in conservation as such and have their own ideas but might not engage because current schemes are top-down[15]. In addition, there is a lot of anecdotal

[13] Agri-environmental schemes became a mandatory part of the policy toolkit in EU Member States as part of Pillar II (Rural Development Policy) in 2005. These schemes now constitute a central element of the Common Agricultural Policy in terms of agricultural area covered and expenditures. Over 2007-2013, the annual average spending from EU's Fund for Rural Development was €3.3 billion. Farmers self-select from a menu of conservation options and enrol in 5 year contracts.

[14] The scheme's primary objectives are to: conserve wildlife (biodiversity); maintain and enhance landscape quality and character; protect the historic environment; protect natural resources (water and soil), and promote public access and understanding of the countryside.

[15] As explained by one of the farmers interviewed by Emery and Franks (2012): *"A lot of the schemes that come in you think 'well that's completely impractical, it's not going to work', if you actually had a farmer on the committee or something it would enable to stop that scheme happening before it even went down the road".*

evidence that the scheme is associated with high private transaction costs that are not covered by the payments (because these are calculated based on profit foregone).

The CFE began as an industry-led approach initially for maintaining the environmental benefits provided by former set-aside[16]. More specifically the CFA promotes the on-farm environmental action through one or more of three options: choosing key in-field target options in the ES; retaining former set-aside and any other areas of uncropped land (unpaid), and putting areas of land outside the ES into Campaign voluntary measures (unpaid). Communications include a website, Campaign leaflets and brochures, and CFE led events, as well as a visible presence at a wide range of national, regional and local events operated by partner organizations. The delivery of program as such is at the local (county) level through local county coordinators (LCC) working with local liaison groups (LLG) made up of farmers and representatives of partner organizations. Farmers' CFE activities involve paperwork. Initially these activities were recorded on-line on the CFE webpage.

There is a wide range of survey data being collected in the evaluation of the CFE (see e.g., Powell et al., 2012). The most recent data show that during the 2013/14 crop year, 44% of holdings in England had land within one of the 22 CFE-listed unpaid voluntary measures. This totalled to 450 thousand hectares (with an additional 9800 skylark plots and 7400 km of fenced watercourses). Overall 38 % of holdings were not involved in any agro-environmental schemes in 2014. Given that an attribute of conservation management on farm land is that it involves some sacrifice of financial profit the CFE results strongly suggest other non-monetary motives.

Powell et al. (2012) discuss results from a survey with local county coordinators (LCCs) that asked for their views on what makes farmers get involved in the CFE. This resulted in four main categories of reasons that confirm the importance of peer pressure, the concern to be seen to be doing the right thing, and the influence of opinions of other farmers. The level of environmental interest was also clearly important. The interviewed LCCS indicated that the desire to avoid further regulation was a key reason some farmers were getting involved, while payments (from ELS) were a driving force for few farmers. Access to advice and learning what others are doing was seen as a more important factor.

The survey of the LCCs also investigated farmers' reasons for not getting involved in the CFE. A key reason was the financial and regulatory uncertainty due to the next (2015)

[16] Set-aside became compulsory in 1992 for large arable farmers as part of the MacSharry reform of the Common Agricultural Policy. It was originally set at 15% and reduced to 10% in 1996. Following the 2005 CAP reform this restriction was removed. Set-aside accounted for some 500,000 ha in England alone in 1995/1996, or to 11% of all eligible arable land (Firbank et al. 1998).

CAP reform. Confusion over the message CFE is trying to achieve was also identified as a reason as well as the high cereal prices. But many LCCs indicated as most important an unwillingness among some farmers to engage as a primary reason; i.e., avoiding form-filling and for some a desire to avoid more inspections, interference, and ‘being told what to do’ by outside agencies.

Interesting to note is the development in the area under unpaid measures since the start of the Campaign. There number of measures for which this can be analyzed is limited because CFE-listed unpaid practices have changed since 2009. From the survey data collected since 2011 it follows that overall areas have tended to fall with the exception of overwintering stubble and selective use of spring herbicides. Additional survey results suggest that the 2012/13 area of stubble was 93% (+/-25 %) higher than planned due to adverse weather conditions (Defra, 2013).

Thus the decrease in hectares suggests the interest in the CFA is waning but this does not necessarily mean a reduced interest in unpaid conservation per se. In the latter context it is interesting to note that in the farmer survey over 2012/13, 29% of the respondents in the same survey recorded land under some form of unpaid environmental management outside the Campaign that ‘fully meets or closely resembles the essential management requirements’ of CFE’. Obviously this is self-reported data but the 29% strikes as remarkable. It could mean that the CFA recognition has lost its esteem effect since many farmers started participating. Alternatively it could mean that it is specific measures that create esteem for the farmer and that these measures are not covered by the current CFA which has now less prescriptive requirements than at the start.

6.2. Chlorpyrifos—*Stop the Drift* Campaign

Chlorpyrifos is an important insecticide to control key insect pests and it is widely used in the UK. Changes to the risk assessment by the UK regulator – the Chemicals Regulation Directorate (CRD) – applied to the use of chlorpyrifos products next to water courses meant the existing safeguard of a 5 metre no-spray buffer zone was no longer considered sufficient protection for aquatic organisms. To pass the new assessment the buffer would have to be 75 metres or more.

In response, a new stewardship initiative, ‘Chlorpyrifos: Say NO to Drift’ was launched by the three major UK approval holders in October 2011. The aim of this initiative was to achieve 100 percent uptake of low-drift nozzles[17] and an extended no-spray buffer zone of 20 metres by all UK farmers applying the insecticide with a conventional boom sprayer. Support for the campaign was of crucial importance because without it would be unlikely that chlorpyrifos products could have been retained in the UK market.

An independent assessment of the uptake of the campaign recommendation was conducted by the Pesticide Usage Survey team of the Food & Environment Research Agency (FERA). Data from the regular pesticide usage survey by this agency showed that chlorpyrifos is applied to over 125,000 hectares of crops throughout Great Britain each year. For the assessment a postal questionnaire was sent to over 2,200 arable, grassland and fodder, orchard, soft fruit and outdoor vegetable holdings in 2012 with a response rate of 22 percent.

The survey results showed a high awareness (average 90%) of the “Say No to Drift Campaign” with 99% of orchard, 97% of arable, 93% of outdoor vegetables, 83% of soft fruit and 75% of grassland & fodder farms being aware of the campaign (Table 1a). The postal responses also showed a high level of low-drift nozzle usage in 2012 with significant increases in the use of low-drift nozzles between 2011 and 2012 as a result of the campaign. Orchards in particular showed the most significant change in the use of low-drift nozzles (Table 1b).

Following on from the postal survey additional data were collected as part of the visit pesticide usage surveys on orchards (266 holdings) & soft fruit (269 holdings). Holdings sampled in the orchard survey accounted for 41% of the total area of all orchards grown in England & Wales, and holdings sampled for the soft fruit survey comprised 47% of the England & Wales area grown. As with the postal survey there was a high awareness of the Campaign and for both surveys a very positive approach to the aims of the Campaign. The results of the visit survey show that in 2011 8% of orchard holdings were using low-drift nozzles for chlorpyrifos applications but following the campaign in 2012 this figure had increased to 76%, with 85% of holdings indicating they would use low-drift nozzles in 2013. Approximately 42% of those questioned indicated that they were using extended buffer zones for all chlorpyrifos applications in 2012 and a further 5% said they would be in 2013. The figures were similar for the visit survey to soft fruit holdings. The main reason why the use of low-drift nozzles and extended buffer strips were not as large in soft fruit compared to

[17] Low-drift nozzles were not considered in the standard pesticide registration process. UK rated 3* low-drift nozzles have been proven to reduce drift by at least 75% compared to conventional types.

orchard crops was because many of the soft fruit crops are grown in plastic tunnels where drift is not so much of an issue.

A supplementary postal survey was proposed for late summer 2013. However, in order to prevent participants from reaching survey fatigue the postal survey did not go ahead.

7. Concluding Remarks

Economists rely on rational choice theory, which assumes people are rational and self-interested, to design biodiversity conservation policy (e.g., payment for ecosystem services, EU's agri-environmental schemes, and REDD). Yet, there is ample evidence that farmers deviate systematically from rational choice. Conservation policy may fail then to achieve the desired goal. It is unclear, though, how economic incentives induce changes in motivational structure, how social norms affect pro-environmental behavior, and how social preferences interact with a financial incentive.

In this paper we examined the non-separability of self-interest and endogenous social preferences—in particular, reputational concern conditional on social norm (i.e., average opinion regarding biodiversity protection on private land)—and how this could affect standard economic incentive mechanism designed to encourage biodiversity protection on private land. We show that conservation policy without complete knowledge of farmers' motivations may not be effective and efficient. A financial reward for biodiversity protection provided to a 'green' farmer (with social preferences) may crowd-out private initiative; a 'brown' farmer (social reputation seeker) may also forgo payment but in this case to buy social reputation. A regulator's challenge, under asymmetric information, is to design an efficient voluntary incentive mechanism that specifies a menu of monetary-transfer-to-effort that gets the best out of both types of farmers. Our results show that (a) social reward or 'status incentive' can keep the 'early birds' interested in the program and that (b) a decision maker can protect biodiversity on farmland at a lower cost by allowing farmers who are merely interested in social reputation to purchase a 'socially responsibility reward'.

We also address how to separate and induce 'leaders' in protecting farmland biodiversity by developing a two period signal extracting problem. If a regulator wants to induce only green type farmers, one potential problem is that a brown type farmer can successfully mimic the green type which would incur a social loss. In a two-period model, a farmer chooses biodiversity protection action in period one, which becomes common knowledge at the end of the period, and receives monetary compensation from the regulator. In period two, the regulator then selects a green type farmer to facilitate her biodiversity protection action and offers monetary compensation. Results show that, under perfect

Bayesian equilibrium, the regulator can separate out the types—a green farmer over-protects in period one whereas a brown farmer chooses the optimal action.

Our claim about the cost-effectiveness of the proposed mechanism depends crucially on (i) the relationship between the norms and policy instruments, and (ii) the possibility of an exogenous shift of the average opinion. It is important to understand whether the proposed policy instrument and existing social norm are conflicting or complement to each other (e.g., see Acemoglu and Jackson 2013). Our mechanism works well if there is a well-accepted social-norm that farmland biodiversity protection is the right thing to do. Otherwise, non-participation will not influence the social costs of disesteem and participation will not ensure esteem or leadership value. In addition, successful implementation of our mechanism depends on whether a policy maker can influence or shift average opinion and, if yes, then the welfare implication of such a move. Public displays, education, mass-awareness, campaign can be useful means of establishing and influencing a norm. It is unclear though whether the costs and benefits of such initiatives will balance out. Future research could explore such possibilities and their welfare impact in more details.

References

Acemoglu, D. and Jackson, M.O., 2014. Social norms and the enforcement of laws (No. w20369). National Bureau of Economic Research.

Ahnström, J., Höckert, J., Bergea, H.L., Francis, C.A., Skelton, P., Hallgren, L. (2008). "Farmers and nature conservation: what is known about attitudes, context factors and actions affecting conservation", *Renewable Agriculture and Food Systems* 24(1): 38-47.

Akerlof, G. (1980). "A theory of social custom, of which unemployment may be one consequence", *Quarterly Journal of Economics* 94(4): 749-775.

Allcott, H. (2011). "Social norms and energy conservation", *Journal of Public Economics* 95(9-10): 1082-1095.

Andreoni, J., Petrie, R. (2004). Public goods experiments without confidentiality: a glimpse into fund-raising. *Journal of public Economics*, *88*(7), 1605-1623.

Ariely, D., Bracha, A., Meier, S. (2009). "Doing good or doing well? Image motivation and monetary incentives in behaving prosocially", *The American Economic Review* 99(1): 544-555.

Arrow, K. J (1986). "Rationality of self and others in an economic system." *Journal of Business,* S385-S399.

Baliga, S., Maskin, E., (2003). Mechanism design for the environment. In: Maler, K.G., Vincent, J.R. (Eds.), Handbook of Environmental Economics, vol. 1. North-Holland, Amsterdam, pp. 305–324.

Banerjee, P., Shogren, J.F., (2010). "Regulation, Reputation, and Environmental Risk", *Economics Letters* 106: 45-47.

______ (2012). "Material Interests, Moral Reputation, and Crowding out Species Protection on Private Land", *Journal of Environmental Economics and Management* 63(1): 137-149.

Batáry, P., Dicks, L.V., Kleijn, D., Sutherland, W.J. (2015). "The role of agri-environmental schemes in conservation and environmental management", *Conservation Biology* 29(4): 1006-1016.

Batson, D., (1967). "Altruism and Prosocial Behavior", in: D. Gilbert, S. Fiske, G. Lindzey (Eds.), Handbook of Social Psychology, Vol. 2, McGraw Hill, New York, pp. 282–316.

Bénabou, R., Tirole, J., (2006). "Incentives and prosocial behaviour", *American Economic Review* 96 (5): 1652–1678.

_______(2011). "Laws and social norms", NBER Working Paper.

Besley, T., Ghatak, M., (2008). "Status Incentives", *American Economic Review* 98(2): 206-11.

Bowles, S., Hwang, S., (2008). "Social preferences and public economics: mechanism design when social preferences depend on incentives", *Journal of Public Economics* 92 (8–9): 1811–1820.

Bowles, S., Polanía-Reyes, S. (2012). Economic incentives and social preferences: substitutes or complements? *Journal of Economic Literature* 50(2): 368-425.

Bowles, S. (1998). "Association Endogenous Preferences: The Cultural Consequences of Markets and Other Economic Institutions", *Journal of Economic Literature,* 36 (1): 75-111.

______ (2008). "Policies designed for self-interested citizens may undermine the moral sentiments: evidence from economic experiments", *Science* 320: 1605–1609.

Brennan, G. and Pettit, P. (2004) The Economy of Esteem, Oxford: Oxford University Press.Bryan, J. H., and Test, M. A., (1967). "Models and Helping: Naturalistic Studies in Aiding Behavior", *Journal of Personality and Social Psychology*, 6 (4): 400-4007.

Bryan, J. H., Test, M. A. (1967). Models and helping: naturalistic studies in aiding behavior. *Journal of personality and social psychology*, *6*(4p1), 400.

Burton, R.J.F., Kuczera, C., Schwartz, G., (2008). "Exploring farmers' cultural resistance to voluntary agri-environmental schemes", *Sociologica Ruralis* 48: 16-37.

Burton, R.J.F., Paragahawewa, U., (2011)."Creating culturally sustainable agri-environmental schemes". *Journal of Rural Studies* 27: 95-104.

CapeNature, (2016). Conservation Stewardship, http://www.capenature.co.za/care-for-nature/stewardship/, last accessed on June 11, 2016.

Cappelen, A. W., Reme, B., Sørensen, E. Ø., Tungodden, B. (2015). "Leadership and Incentives", *Management Science*.

Chouinard, H.H., Paterson, T., Wandschneider, P.R., Ohler, A.M., 2008. "Will Farmers Trade Profits for Stewardship? Heterogeneous Motivations for Farm Practice Selection", *Land Economics* 84(1): 66-82.

Colman, D. (1994). "Ethics and externalities: Agricultural stewardship and other behaviour", *Journal* of Agricultural Economics 45(3): 299-311.

Crocker, T.D., Shogren, J.F., Turner, P.R. (1998) "Incomplete beliefs and nonmarket valuation", *Resource and Energy Economics* 20:139–162.Defra (2013).

Campaign for the Farmed Environment (CFE) – Survey of land managed voluntarily in 2012/13 farming year (England), available from https://www.gov.uk/government/statistics/campaign-for-the-farmed-environment.

De Snoo, G.R., Herzon, I., Staats, H., Burton, R.F.J., Schindler, S., Van Dijk, J., Lokhorst, A.M., Bullock, J.M., Lobley, M., Wrbka, T., Schwarz, G., Musters, C.J.M. (2012). "Toward effective nature conservation of farmland: making farmers matter", *Conservation Letters* 6: 66-72.

Driver, A., Sink, K.J., Nel, J.N., Holness, S., Van Niekerk, L., Daniels, F., Jonas, Z., Majiedt, P.A., Harris, L., Maze, K., (2012). National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis Report. Pretoria.

Emery, S.B., Franks, J.R. (2012). " The potential for collaborative agri-environment schemes in England: Can a well-designed collaborative approach address farmers' concerns with current schemes?", *Sociologica Ruralis* 28(3): 218–231.

Fehr, E., Holger, H., Wilkening, T. (2013). "The Lure of Authority: Motivation and Incentive Effects of Power", *American Economic Review*, 103 (4): 1325-1359.

Firbank, L.G. (1998). Agronomic and environmental evaluation of set-aside under the EC Arable Area Payments Scheme, vols. 1–4. Institute of Terrestrial Ecology/Ministry of Agriculture, Fisheries and Food, London.

Fischer, P., Huddart, S. (2008). "Optimal Contracting with Endogenous Social Norms", *American Economic Review* 98(4): 1459-1475.

Frey, S.B. (1997). Not Just for the Money: an Economic Theory of Personal Motivation. Edward Elgar, Cheltenham.

Frey, S.B., R. Jegen, R., (2001). "Motivation crowding theory", Journal of Economic Surveys 15 (5): 589-611.

Genius, M., Koundouri, P., Nauges, C., Tzouvelekas, V. (2013). "Information Transmission in Irrigation Technology Adoption and Diffusion: Social Learning, Extension Services, and Spatial Effects", *American Journal of Agricultural Economics* 96(1): 328-344.

Greiner, R., Gregg, D. (2011).“Farmers’ intrinsic motivations, barriers to the adoption of conservation practices and effectiveness of policy instruments: Empirical evidence from northern Australia”, *Land Use Policy* 28(1); 257-265.
Griskevicius, V., Tybur, J.M. and Van den Bergh, B. (2010). “Going Green to Be Seen: Status, Reputation, and Conspicuous Consumption”, *Journal of Personality & Social Psychology* 98(3): 392-404.
Hanley, N., Banerjee, S., Lennox, F.D., Armsworth, P.R., (2012). How should we incentivize private landowners to ‘produce’ more biodiversity? *Oxford Review of Economic Policy* 28 (1): 93-113.
Hermalin, B.E,. (1998). “Toward an economic theory of leadership: leading by example”, *The American Economic Review* 88(5): 1188-1206.
Hodge, I. and Reader, M., (2010). “The introduction of Entry Level Stewardship in England: Extension or dilution in agri-environment policy?”, *Land Use Policy* 27 (2): 270-282.
Howley, P. (2015). “Measuring the non-pecuniary benefits from farming: Implications for farmers' decision-making”, American Journal of Agricultural Economics 97(4): 1072-1086.
Kahneman, D. , Tverksy , A. (Eds) (2000). Choices, Values and Frames, Cambridge UK: Cambridge University Press.
Kosfeld, M., Rustagi, D. (2015). Leader punishment and cooperation in groups: Experimental field evidence from commons management in Ethiopia. *American Economic Review*, *105*(2), 747-783.
Kuhfuss, L., Preget, R., Thoyer, S., Hanley, N., Le Coent, P., Desole, M. (2015). Nudges, Social Norms and Permanence in Agri-Environmental Schemes, http://purl.umn.edu/204233
Laffont, J.J., (1995). “Regulation, moral hazard and insurance of environmental risks”, *Journal of Public Economics* 58: 319–336.
Lokhorst, A.M. , Staats, H., van Dijk, J., van Dijk, E., de Snoo, G. (2011). “What’s in it for me? Motivational differences between farmers’ subsidised and non-subsidised conservation practices”, *Applied Psychology* 60(3); 337-353.
Lokhorst , A.M., Hoon, C., le Rutte, R., de Snoo, G., (2014). There is an I in nature: The crucial role of the self in nature conservation, *Land Use Policy* 39: 121-126.
Lindbeck, A., Nyberg, S. and Weibull, J.W., (1999). “Social norms and economic incentives in the welfare state”, *Quarterly Journal of Economics* 114 (1): 1-35.
OECD (Organisation for Economic Co-operation and Development) (2010). Agricultural Policies in OECD Countries 2010 - at a glance. OECD, Paris.
_____ (2013). Providing Agri-environmental Public Goods through Collective Action, OECD Paris. www.oecd-ilibrary.org/agriculture-and-food/providing-agri-environmental-public-goods-through-collective-action_9789264197213-en
Potters, J., Sefton,M., Vesterlund, L. (2007). “Leading-by-example and signaling in voluntary contribution games: an experimental study”, *Economic Theory* 33: 169-182.
Powell, J., Kambites, C., Reed, M., Gaskell, P., Lewis, N., and Curry, N. (2012). The Campaign for the Farmed Environment: evaluation of partnership, local and wider impacts, Report to Defra. CCRI: Gloucester.
Rode, J., Gomez-Baggethun, E., Krause, T., (2015). “Motivation crowding by economic incentives in conservation policy: A review of the empirical evidence”, *Ecological Economics* (in press).
Rogge, E., F. Nevens, H. Gulinck, H. (2007). “Perception of rural landscapes in Flanders, looking beyond aesthetics”, *Landscape and Urban Planning* 82: 159-174.

Sauer, J., Wossink, A., (2013). “Marketed outputs and non-marketed ecosystem services: the evaluation of marginal costs”, *European Review of Agricultural Economics* 40(4): 573-604.
Selinske, M., (2013). Do fulfilled motivations lead to satisfaction? An assessment of stewardship landowners in the Western Cape, South Africa. Department of Life Sciences, Imperial College, London.
Smith, R., Shogren, J.F., (2002). “Voluntary incentive design for endangered species protection”, *Journal of Environmental Economics and Management* 43: 169–187.
Thaler, R., Sunstein, C. (2008) Nudge: Improving decisions about health, wealth and happiness, New Haven, CT: Yale University Press.
Van Vught, M., Roberts, G., Hardy, C. (2007) Cooperative altruism: Development of reputation-based cooperation in groups, In: R. Dunbar and L. Barrett (Eds) Handbook of evolutionary psychology(oo. 531-540), Oxford UK: Oxford University Press.
Vesterlund, L., (2003). “Informational value of sequential fundraising”, *Journal of Public Economics* 87: 627–657

Figure 1

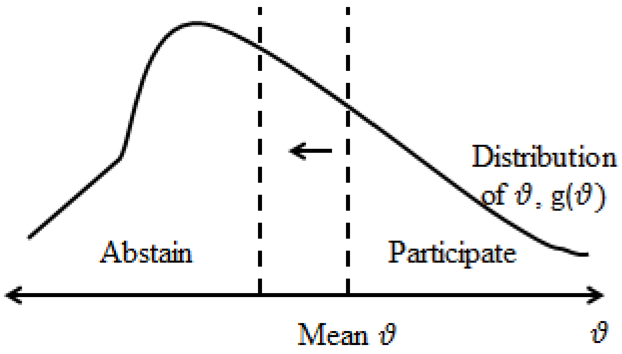

Figure 1 The density function of intrinsic satisfaction from doing the 'right thing'.

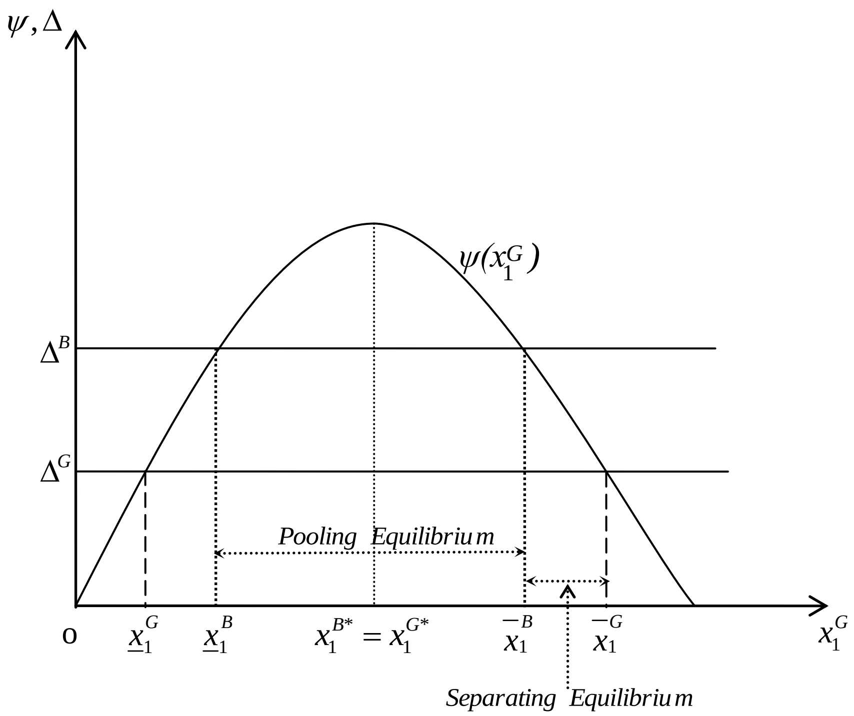

Figure 2: Separating and Pooling Equilibrium Biodiversity Protection Actions

Table 1a – Summary data collected as part of the postal and visit surveys – Chlorpyrifos "Say No to Drift Campaign" – Responses and awareness

	Responses	Awareness of campaign (%)	Awareness of reasons behind the campaign (%)	Awareness of campaign requirements (%)
Arable - postal	139	97%	64%	80%
Fodder & grassland –	118	75%	49%	57%
Orchards – postal	91	99%	50%	88%
Soft fruit – postal	60	83%	31%	73%
Vegetables – postal	86	93%	49%	76%
Orchards - visit	144	99%	54%	97%
Soft fruit - visit	98	87%	59%	94%

Source: FERA

Table 1b – Summary data collected as part of the postal and visit surveys – Chlorpyrifos "Say No to Drift Campaign" – Use of low-drift nozzles and extended buffers

	Use of low-drift nozzles (all chlorpyrifos applications)		Use of extended buffer zones (all chlorpyrifos applications)	
	2011	2012	2012	Future use
Arable – postal	70%	90%	69%	71%
Fodder & grassland –	50%	68%	65%	68%
Orchards - postal	6%	70%	57%	60%
Soft fruit - postal	20%	58%	50%	53%
Vegetables – postal	58%	74%	48%	51%
Orchards - visit	8%	75%	42%	47%
Soft fruit - visit	6%	37%	31%	33%

Source: FERA

Appendix

We provide a detailed explanation of PBEs.

Separating Equilibrium. Let us now establish that ($x_1^G = \overline{x}_1^B,\ x_1^B = x_1^{B^*}$) is a PBE. Note that a PBE consists of a strategy profile and a set of beliefs such that (a) given the beliefs, the strategies form a sub-game perfect Nash equilibrium and (b) given these strategies the beliefs satisfy the Bayes rule. In general, we can specify a PBE in the following manner. The *green*-type farmer will choose x_1^G with probability μ^G and x_1^B with probability $(1 - \mu^G)$, and the *brown*-type farmer will choose x_1^G with probability $(1 - \mu^B)$ and x_1^B with probability μ^B. Further, the regulator will be required to update his beliefs via the Bayes rule and decide whether to facilitate biodiversity protection action in period 2 or not, based on expected social welfare corresponding to his updated beliefs.

Let $\beta(x_1)$ be the updated probability the regulator attaches to the farmer being *green*-type after he observes the farmer's period 1 action x_1. In the case of separating equilibrium, we have seen that the optimal biodiversity protection actions are as follows: $x_1^G = \overline{x}_1^B$ and $x_1^B = x_1^{B^*}$; and $\mu^G = 1$ and $\mu^B = 1$. Then by Bayes rule, $\beta(\overline{x}_1^B) = \frac{\rho\ \mu^G}{\rho\ \mu^G + (1-\rho)\ (1-\mu^B)} = 1$ and $\beta(x_1^{B^*}) = \frac{\rho\ (1-\mu^B)}{\rho\ (1-\mu^G) + (1-\rho)\ \mu^B} = 0$. The signals are fully revealing and, thus, the regulator will facilitate the green-type farmer's biodiversity protection action. We can specify the out-of-equilibrium beliefs of the regulator as, $\beta(x_1) = \begin{cases} 1, & \text{if } x_1 \geq \overline{x}_1^B \text{ and} \\ 0, & \text{if } x_1 < \overline{x}_1^B. \end{cases}$

Finally, it is also evident from Figure 2 that for the existence of separating equilibrium, the condition $\Delta^G < \Delta^B$ must be satisfied. Otherwise, if $\Delta^G \geq \Delta^B$, separating equilibrium does not exist. However,

$$\Delta^G < \Delta^B \Leftrightarrow (1+\delta)\ \widetilde{U}^G - \delta\ U_2^{sG^*} - \vartheta^G\ t < (1+\delta)\ \widetilde{U}^B - \delta\ U_2^{sB^*} - \vartheta^B\ t$$

$$\Leftrightarrow\ \delta\, U_2^{sB^*} - \delta\, U_2^{sG^*} < (1+\delta)\left(\widetilde{U}^B - \widetilde{U}^G\right) - (\vartheta^B - \vartheta^G)\ t$$

$$\Leftrightarrow \delta\left(U_2^{sB^*} - U_2^{sG^*}\right) < (1+\delta)\,(\vartheta^B - \vartheta^G)t - (\vartheta^B - \vartheta^G)t, \text{ since } \widetilde{U}^B - \widetilde{U}^G = t(\vartheta^B - \vartheta^G)$$

$$\Leftrightarrow \left(U_2^{sB^*} - U_2^{sG^*}\right) < (\vartheta^B - \vartheta^G)t$$

$$\Leftrightarrow \left(U_2^{sB^*} - \vartheta^B t_s\right) - \left(U_2^{sG^*} - \vartheta^G t_s\right) < (\vartheta^B - \vartheta^G)(t - t_s) \tag{32}$$

Now, note that, for any given x_2, $\left[U_2^{sG}(x_2) - \vartheta^G t_s\right] - \left[U_2^{sB}(x_2) - \vartheta^B t_s\right] = \left(\frac{1}{\vartheta^G} - -\frac{1}{\vartheta^B}\right)[f(x_2) - g(x_2)] > 0$. Moreover, we have both $\left[U_2^{sG}(x_2) - \vartheta^G t_s\right]$ and $\left[U_2^{sB}(x_2) - \vartheta^B t_s\right]$ are strictly concave in x_2, $\vartheta^B > \vartheta^G$, and as seen before $x_2^{sG*} > x_2^{sB*}$. It implies that $\left(U_2^{sB^*} - \vartheta^B t_s\right) - \left(U_2^{sG^*} - \vartheta^G t_s\right) < 0$, i.e., the LHS of (32) is negative and, thus, the condition (32) is satisfied unless t_s is very large compared to t. Therefore, by choosing t and t_s appropriately, the regulator can ensure truthful revelation of the farmers' types through credible signalling by the green-type farmer, which is in the best interest of the regulator. In other words, existence of the separating equilibrium will always be ensured by the regulator.

Pooling Equilibrium. To establish that this a PBE, we can specify $\mu^G = 1 - \mu^B = 1$ and $\mu^B = 0$. Then by Bayes rule, $\beta\left(x_1^{G^*}\right) = \frac{\rho\,\mu^G}{\rho\,\mu^G + (1-\rho)\,(1-\mu^B)} = \rho = \beta\left(x_1^{B^*}\right)$ and $1 - \beta\left(x_1^{G^*}\right) = 1 - \rho = 1 - \beta\left(x_1^{B^*}\right)$. That is, the regulator cannot update his prior beliefs by observing $x_1^G = x_1^B = x_1^{G^*}\ (= x_1^{B^*})$. The out-of-equilibrium beliefs of the regulator can be specified as $\beta(x_1) = 1$ if $x_1 > x_1^{G^*}$, and $\beta(x_1) = 0$ if $x_1 < x_1^{G^*}$. Further note that, unlike as in the case of separating equilibrium, it is not necessary to satisfy the condition (32) for the existence of separating equilibrium. This is because, $x_1^G = x_1^B = x_1^{G^*}\ (= x_1^{B^*})$ satisfy both (29) and $(30')$ even when $\Delta^G \geq \Delta^B$, i.e., when positions of the two flat lines in Figure 2 reverse or coincide.