A goal-frame approach on the adoption of organic farming practices

Giorgos N. Diakoulakis* and Athanasios Kampas

Department of Agricultural Economics & Rural Development, Agricultural University of Athens

*Corresponding author: Giorgos N. Diakoulakis, gi_di@aua.gr

Abstract: Building around the Goal-Framing Theory, this article explores farmer's adoption choices of organic farming practices under the presence of land subsidies and price premiums. The main results are: (i) even though land subsidies induce organic production, they reduce the fraction of organic farming practices been adopted; (ii) price premiums can induce both organic farming and the adoption of a higher fraction of organic farming practices, provided that they are high enough; (iii) land subsidies and price premiums are likely to induce over-compliance if the adoption target is relatively low; (iv) it is more likely to observe over–compliance among farmers who in the absence of financial incentives exhibit normative goal preferences; (v) land subsidies should be accompanied by additional interventions that foster normative behaviour (e.g., educational programs, environmental campaigns, etc.). Such a necessity is reduced once price premiums coexist. Finally, a payment scheme is proposed, as well.

Keywords: organic farming, farmers' behaviour, goal-driven choices, land subsidies, price premiums

JEL: D91, Q18, Q58

1 Introduction

During the last decades, organic production has attracted attention from both scholars and social planners as a solution to environmental-related problems (Kotschi and Müller-Sämann, 2004). The International Federation of Organic Agriculture Movements (IFOAM) defines organic production as "[. . .] a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. It combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved." (Luttikholt, 2007).

To facilitate the adoption of organic production environmental agencies have implemented several policy measures that can be classified as: (i) agri-environmental schemes, (ii) certification schemes, and (iii) payments for environmental services (PES) (Ottaviani, 2011). Among them, a widely used incentive vehicle that falls into the PES scheme is (per-hectare) land subsidies (Feinerman and Gardebroek, 2007). Beyond that, consumers are willing to pay a price premium for organic goods (Connolly and Klaiber, 2014), on the basis that they perceive organic products as being differentiated (healthier and more safe products) in comparison to conventional ones (Endres, 2007).

The motivational efficiency of land subsidies and price premiums is often attributed to the fact that economic incentives primarily correspond to, and influence, a self-centered rationality (Ostrom, 2000). Notwithstanding, it is well known that humans' decisions are often guided by a variety of non-selfish motives. With respect to pro-environmental behaviour, there is a burgeon of literature supporting the notion that (altruistic, biospheric and moral) values (e.g., Karp, 1996; Nordlund and Garvill, 2002; De Groot and Steg, 2009) and norms (e.g., Cialdini et al., 1990; Goldstein et al., 2008; Farrow et al., 2017) guide pro-environmental choices.

Recently, Lindenberg and Steg (2007, 2013) provide a framework, namely the Goal-Framing Theory (thereafter, GFT), for explaining individuals' pro-environmental choices that combines selfish and non-selfish motives under a goal-based integrated framework. The psychological mechanism underlined in the GFT is that human behaviour is a modular process comprising by hardwire and softwire subroutines that make humans sensitive to a narrow spectrum of both internal and external information, and that goals are a fundamental creator of such subroutines (Lindenberg, 2008).

In this article, we develop a theoretical model to explore farmer's behaviour regarding the adoption of organic farming practices. Particularly, we try to answer two important questions. First, whether financial incentives, namely land subsidies and price premiums, can induce the adoption of organic farming practices. Second, whether such incentives foster compliance -or even overcompliance- with an environmental target.

The vast majority of the current literature either treats farmer's behaviour as a binary one diversifying between organic and conventional farming (e.g., MacRae et al., 1990; Lohr and Salomonsson, 2000; Kaufmann et al., 2009; Theocharopoulos et al., 2012), or it investigates the effects of (both) monetary and non-monetary incentives on the adoption of a particular farming practice, like crop management (e.g., Miranowski, 1984; Cutforth et al., 2001; Theocharopoulos et al., 2012), waste recycling and composting (e.g., Kashmanian and Rynk, 1998; Matter et al., 2015; Paul et al., 2017; Chen et al., 2020; Xiong et al., 2022), and pest management (e.g., Falconer and Hodge, 2000; Sexton et al., 2007; Lefebvre et al., 2015; Despotović et al., 2019).

Our analysis differentiate from the current one in that we are interested on how *many* of the available organic farming practices the farmer chooses to adopt rather that how *much* of a particular practice she chooses to implement. Answering such a question is vital for the social planner because it will allow her to design policies for meeting the overall objective of organic farming as it stated by Lampkin and Padel (1994) "[...] to create integrated, humane, environmentally and economically sustainable agricultural production systems, which maximise reliance on farm-derived renewable resources and the management of ecological and biological process(es) and interactions, so as to provide acceptable levels of crop, livestock and human nutrition, protection from pests and diseases, and an appropriate return to the human and other resources employed".

To do so, our theoretical model utilises the GFT by assuming that the motivational driver of farmer's choices is the activation of her overarching goals. The rationale is the following: First, there are empirical evidence indicating that farmers exhibit multiple goals when they determining their farming choices (e.g., Patrick et al., 1983; Van Kooten et al., 1986; Sumpsi et al., 1997; Wallace and Moss, 2002; Sintori et al., 2009; Duesberg et al., 2013). Thus, a goal-driven behavioural theory seems to be an appropriate framework for explaining adoption choices. Second, there is not a unique socio-psychological theory that can consistently explain farmers' behaviour across various domains. For instance, Borges et al. (2014), Senger et al. (2017), and Bagheri et al. (2019) utilise the Theory of Planned Behavior (TPB, Ajzen, 1991) for explaining farmers' choices, whereas Rezaei et al. (2019) and Savari et al. (2021), and Johansson et al. (2013) and Rezaei-Moghaddam et al. (2020) analysis is built around the Norm Activation Model (NAM, Schwartz, 1977), and the Value-Belief-Norm Theory (VBN, Stern et al., 1999), respectively. Thus, we believe that integrated frameworks, like the GFT, might be a more appropriate approach compared to conventional ones (e.g., TPB, NAM or VBN), because they can combine the influence of both selfish and non-selfish motives in a sold manner.

The key policy implications can be summarised on the followings. First, land subsidies can induce the transition from conventional to organic farming only when the targeted adoption rate of the available organic farming practices is low enough. Importantly, land subsidies always undermine farmer's environmental performance compared to the status quo (i.e., no land subsidy is offered). The policy implication is if the social planner wants to facilitate the adoption of organic that land subsidies should be implemented together with a behavioural intervention that maintain (or increase) farmer's willingness to behave in a normative manner.

Second, price premiums always induce farmer's environmental performance compared to the status quo (i.e., no price premium is in place). The policy implication is twofold. From one side, the necessity of having an additional behavioural intervention is reduced. Importantly, if the targeted adoption rate of the available organic farming practices is low, then price premiums are able to induce overcompliance, regardless of how strong were farmer's initial preferences for acting normatively.

Finally, even though a menu of financial incentives (i.e., both land subsidies and price premiums are in place) is more likely to induce organic production, farmer's environmental performance is somewhere in between the previous two polar cases. Hence, land subsidies should be implemented only if price premiums by themselves cannot induce organic production.

The structure of this article is as follows. Section 2 presents our model's basic assumption and farmer's characteristics. Section 3 explores farmer's behaviour when either land subsidies or price premiums or both are in place. Section 4 summarises and concludes.

2 Setting the basic assumptions

2.1 Specifying the properties of the conventional and organic farming

Consider a situation where a single farmer owns a piece of a land that it is normalised to one, and which it is conserved for agricultural production. The agricultural good can be produced either by conventional or organic farming.

Specifically, if the farmer adopts a conventional farming system, then she produces $q = q(\mathbf{x})$, where $\mathbf{x}$ is a vector of inputs and $q(\cdot)$ is a strictly positive and concave production function (i.e., $q(\mathbf{x}) \geq 0$, with equality if $\mathbf{x} = \emptyset$, $q_x > 0$ and $q_{xx} < 0$ for any $x \in \mathbf{x}$). On the contrary, if she adopts an organic farming system, then she produces $y = y(k)$, where $k \in [0, 1]$ shows the fraction of the organic farming practices been adopted that ranges from no adoption (i.e., $k = 0$) to full adoption (i.e., $k = 1$). Furthermore, $y(k)$ is assumed to be a weakly positive and concave production function (i.e., $y(k) \geq 0$, with equality if $k = 0$, $y' \geq 0$ and $y'' \leq 0$). The rationale is the followings. First, the inputs that are necessary for organic production might be conditional on the practices been adopted. For instance, crop rotation may require a different set of inputs if it used solely or in combination with any other practice, like organic fertilisation. Thus, it seems reasonable to express organic production as a function of the organic farming practices been adopted instead of its necessary inputs, per se. Second, there is a lack of evidence on whether the adoption of more organic farming practices increases the productivity of an organic farming system and whether such a productivity increment, if any, comes at a positive rate.

Furthermore, the cost of conventional production is $\mathbf{wx}$, where $\mathbf{w}$ is a vector of the unit cost of inputs. Respectively, the cost of organic farming is $c = c(k)$, where $c(k)$ is assumed to be a positive and convex cost function (i.e., $c(k) \geq 0$, with equality if $k = 0$, $c' > 0$ and $c'' > 0$). The rationale is that the adoption of organic farming practices increases the cost of organic farming practices because many of them can be quite labour and/or machinery intensive. However, one should note that extensive adoption of organic farming practices does not necessarily mean that organic production becomes more costly compared to conventional one. For instance, Klonsky (2012) stresses that the difference between the cost of organic and conventional production depends on both the type of the agricultural good (e.g., the type of the crop) and the practice been adopted. In this article, we are not interested in which organic farming practice the farmer adopts per se, but rather on their fraction. Thus, $c(k) \gtreqless \mathbf{wx}$.

2.2 Specifying farmer's characteristics

Lindenberg (2008) argues that humans' behaviour is determined by overarching goals and more specific, by the degree of these goals are activated. In the context of pro-environmental behaviour, Lindenberg and Steg (2007, 2013) state that human choices are guided by three overarching goals: a gain goal (i.e., to increase her profits, wealth, etc.), a hedonic goal (i.e., to feel good by, for instance, exerting less effort) and a normative goal (i.e., to act appropriately). With that context, if the farmer adopts a conventional farming system, then her goal-based utility is given by:

$$u(\mathbf{x}; \alpha_i) = (1 - \alpha_i)[pq(\mathbf{x}) - \mathbf{wx}] \tag{1}$$

whereas if she adopts organic farming, then her goal-based utility is:

$$v_i(k; \alpha_i) = (1 - \alpha_i)\pi_i(k) + \alpha_i h(k) \tag{2}$$

Here, the subscript $i = \{0, j\}$ refers to the state of nature regarding the presence (i.e., $i = j$) or absence (i.e., $i = 0$) of a financial incentive, S_j, that favours organic farming, $p > 0$ is the market price of the conventional agricultural good, $\pi_i(k)$ denotes farmer's profits from organic farming, and $h(k)$ is a 'psychological' utility that reflects farmer's inner satisfaction from the adoption of organic farming practices. For instance, organic farming might be a social demand due to its environmental benefits and therefore, $h(k)$ reflects farmer's satisfaction from acting pro-socially. Alternatively, the farmer knows that by adopting organic farming practices contributes to the environmental quality. In such a case, $h(k)$ reflects farmer's satisfaction from complying with her personal (pro-environmental) values and (environmental) morality. In this article, $h(k)$ is assumed to be a strictly positive and concave function (i.e., $h(k) \geq 0$, with equality if $k = 0$, $h' > 0$ and $h'' < 0$).

Furthermore, α_i is a parameter that reflects the activation of the normative goal. Particularly, if $\alpha_i = 0$, then $v_i = \pi_i(k)$. In such a case, the farmer completely forgone any psychological benefits associated with organic farming and instead, she determines her production choices purely from a profit point of view. On the contrary, if $\alpha_i = 1$, then $v_i = h(k)$. That is, the farmer completely forgone any profits associated with organic farming and instead, she determines her choices purely from her inner satisfaction. However, this latter case seems to be unrealistic, because farmers by nature always consider the profitability of their production choices. Thus, for the rest of our analysis we assume that $0 \leq \alpha_i < 1$.

Moreover, Lindenberg and Steg (2007, 2013) argue that the strength of someone's goals (i.e., the degree of activation) depends on both the values she endorses and on situational factors. It is widely accepted in the scholarly literature that financial incentives may undermine humans' non-selfish preferences (Wiersma, 1992; Deci et al., 1999), because they may reduce theirs self-determination and/or self-esteem (e.g., Tang and Hall, 1995; Frey and Oberholzer-Gee, 1997), or their self-regulation (Deci et al., 1999), or because they swift theirs attention (i.e., frame shifting) to selfish outcomes (Rode et al., 2015). To account for such a *crowding-out* *effect*, we assume -given farmer's values- that $\alpha_i < \alpha_0$.

3 Exploring farmer's behaviour

Let us assume a social planner who wishes to facilitate the adoption of organic farming by providing a land subsidy, $S_L \geq 0$ (Feinerman and Gardebroek, 2007). Such payment reflects society's acknowledgment for the provision of environmental benefits and belongs to a family of transfers known collectively as green payments (Horan and Claassen, 2007), or payments for environmental services (Engel et al., 2008).

Beyond regulatory policies, consumers are willing to pay a price premium, $S_P \geq 0$, for organic goods, on the basis that they perceive organic products as being healthier and more safe products in comparison to conventional ones (Endres, 2007). The price premium is only paid for goods certified as organic and sold under the analogous label. An independent third body, upon routinely inspecting farmer's compliance with organic farming prerequisites, issues such a certification. The fixed cost of such a certification denoted by $z > 0$ is assumed to be borne by farmers. In its simplest case, such an eco-certification involves the identification of some traits in the production process, which are (imperfectly) correlated with the product's 'environmental friendliness' (Mason, 2011). The complex issues of random monitoring, uncertainty in signals and probabilistic certification are ignored in our analysis (for a thorough analysis, see Hamilton and Zilberman (2006), and Mason et al. (2012)).

Hence, in each state of nature farmer's utility-maximisation problem can be defined as:

$$\max_{0 \leq k \leq 1} \; v_i(k;\alpha_i) \text{ s.t. } k \geq \bar{k} \text{ and } v_i \geq u(\mathbf{x}^*;\alpha_i),\; \mathbf{x}^* = \arg\max \; u(\mathbf{x};\alpha_i) \tag{3}$$

where $k \geq k_T$ is an *adoption constraint* imposed by the social planner and $v_i \geq u(\mathbf{x}^*;\alpha_i)$ is farmer's *incentive rationality constraint*. In other words, $k_T \in (0, 1]$ shows the minimum fraction of organic farming practices the farmer has to adopt in order to get the payment S_j.

3.1 The benchmark case: no financial incentives are provided

We begin our analysis by exploring farmer's behaviour when there is not any financial incentive that favours organic farming (i.e., $i = 0$). In such a case, farmer's profits from organic production are:

$$\pi_0 = py(k) - c(k) \tag{4}$$

Thus, we can show (see Appendix for the proof) that:

Lemma 1. *Let's assume that exists $\hat{k} \in (0,1]$ that solves $\pi_0'(\hat{k}) = 0$. Then, a farmer with $\alpha_0 \in [0,1)$ adopts $k_0^* \in [\hat{k}, 1]$ fraction of organic farming practices, with $k_0^* = \hat{k}$ if $\alpha_0 = 0$, where k_0^* solves $v_0'(k_0^*; \alpha_0) = 0$, and $\left(\partial k_0^* \middle/ \partial a_0\right) > 0$.*

In words, Lemma 1 states in the absence of any financial incentive that favours organic production, any farmer is willing to adopt organic farming practices. Particularly, Lemma 1 emphasises that the more norm-oriented a farmer is, the higher fraction of organic farming practices she tends to adopt.

However, a farmer does not produce organically unless her incentive rationality constraint is satisfied. Formally, by using Eq. (1), Eq. (2) and Lemma 1 we propose that:

Proposition 1. *Let's define the set*

$$\mathbb{A} = \left\{ (k, \alpha_0) : \frac{\alpha_0}{1-\alpha_0} \geq \frac{pq(\mathbf{x}^*) - \mathbf{wx}^* - \pi_0(k)}{h(k)} \right\}$$

Then, for a farmer with a profile $\{\alpha_0\} \mapsto k_0^*$ organic production weakly dominates conventional one if and only if $(k_0^*, \alpha_0) \in \mathbb{A}$.

Proposition 1 stays that in the absence of any financial incentive that favours organic farming, there will be a class of farmers that are willing to produce organically. Thus, for the rest of our analysis we explore how land subsidies and price premiums affect both farmers with $(k_0^*, \alpha_0) \in \mathbb{A}$ and $(k_0^*, \alpha_0) \notin \mathbb{A}$.

3.2 Exploring the impact of a land subsidy on farmer's behaviour

We now turn to the case where only land subsidies are in place $j = L$ and consequently, the farmer is characterised by a profile $\{\alpha_0, \alpha_L\} \mapsto \left(k_0^*, k_L^*\right)$, with $\alpha_L \in [0, \alpha_0)$. In addition, her profits from organic production are given by:

$$\pi_L = py(k) - c(k) + S_L \tag{5}$$

By using Eq. (2), Eq. (5) and Lemma 1 it is straightforward to show (see Appendix for the proof) that:

Lemma 2. *Given farmer's profile $\{\alpha_0, \alpha_L\}$, the optimal fraction of organic farming practices, k_L^* is: (i) $\hat{k} \leq k_L^* < k_0^*$, with $k_L^* = \hat{k}$ if $\alpha_L = 0$, provided that $\alpha_0 > 0$; (ii) $k_L^* = k_0^* = \hat{k}$, provided that $\alpha_0 = 0$.*

Lemma 2 stresses the followings two policy implications. First, land subsidies cannot induce by themselves the adoption of organic farming practices to those farmers who in the no-incentivised state behave in a pure profit-maximisation fashion. Second, farmers who in the no-incentivised state exhibit normative preferences now choose to adopt organic farming practices to a lesser degree. Importantly, if farmer's normative preferences are 'sensitive' to land subsidies (i.e., $\alpha_L \to 0$), then in the land subsidy state every farmer behaves as been purely profit-maximiser.

The rationale of these observations is the following: A land subsidy induces profit-seeking behaviour because it activates the gain goal. Furthermore, the farmer knows that adopting a higher fraction of organic farming practices increases her satisfaction but at the same time it turns to be too costly. However, the activation of the gain goal undermines the influence of that psychological benefit on her overall utility, making less likely for that psychological benefit to 'cancel-off' any cost associated with the adoption of organic farming practices. Consequently, the farmer realises that she can be better-off by adopting a lower fraction of organic farming practices than before.

Furthermore, the social planner knows that a farmer will not produce organically unless her incentive rationality constraint is satisfied. That is, by using Eq. (1), Eq. (2) and Eq. (5) we can easily show that a land subsidy, S_L, weakly dominates organic production if and only if:

$$S_L \geq S_L^*(k;\alpha_L) \equiv pq(\mathbf{x}^*) - \mathbf{w}\mathbf{x}^* - \pi_0(k) - \left(\frac{\alpha_L}{1-\alpha_L}\right)h(k) \tag{6}$$

The primarily objective of the social planner is to induce at least compliance with the adoption target, k_T, and so, Eq. (6) points that a farmer with a profile $\{\alpha_0, \alpha_L\}$ requires (at least) a payment of $S_L^*(k_T;\alpha_L)$, with $\left(\partial S_L^*/\partial\alpha_L\right) < 0$. Thus, an important policy question concerns the volume of that target.

The answer is given by Lemma 2. Specifically, if the social planner wants to induce organic production for any farmer with $0 \leq \alpha_0 < 1$, then she need to impose $k_T \leq k_0^*(0) = \hat{k}$. The rationale is the following. First, the social planner knows that a farmer with $\{0,0\} \mapsto \left(\hat{k},\hat{k}\right)$, whereas a farmer with $\{\alpha_0, 0\} \mapsto \left(k_0^*,\hat{k}\right)$. In other words, both farmers who before and/or after the introduction of a land subsidy choose to behave in a pure profit-maximisation fashion will never comply with a target of $k_T > \hat{k}$. Second, the social planner also knows that farmers with $\{\alpha_0,\alpha_L\} \mapsto \left(k_0^*, k_L^*\right)$ and that for $\alpha_L > 0$ Lemma 2 points that $k_L^* > \hat{k}$. In other words, under a target of $k_T \leq \hat{k}$ a farmer who continues to exhibit normative preferences after the introduction of a land subsidy has the tendency to overcomply. Additionally, we can show (see Appendix for the proof) that $S_L^*\left(k_L^*;\alpha_L\right) < S_L^*(\hat{k};0)$ and so, such a farmer is willing to produce organically under a payment of $S_L^*(\hat{k};0)$ because she is over-compensated.

The following proposition summarises the above discussion:

Proposition 2. *An environmental program of the form of* $\langle k_T \leq \hat{k}; S_L^*(k_T;0)\rangle$ *induces organic production for any farmer. Particularly,*

(i) if $\{0,0\} \mapsto \left(\hat{k},\hat{k}\right)$ *or* $\{\alpha_0,0\} \mapsto \left(k_0^*,\hat{k}\right)$*, then the farmer complies with* $k_T = \hat{k}$ *and*

over-complies with $k_T < \hat{k}$*;*

(ii) if $\{\alpha_0, \alpha_L\} \mapsto \left(k_0^*, k_L^*\right)$*, then the farmer always over-complies.*

Few important policy implications emanate from the Proposition 2. First, such a program is likely to induce opportunistic behaviour because the farmer has a strong incentive to falsify the 'sensitivity' of her normative goal preferences to land subsidies in order to receive a higher payment. Second, the social planner should keep in mind that environmental payment schemes that rely solely on land subsidies always underperform compared to the status quo (i.e., absence of the scheme), even though some participants tend to over-comply with the program's target. This observation emphasises the necessity of behavioural interventions (e.g., green nudges) as a complementary policy mechanism that can either maintain or even foster farmer's normative goal preferences to the status quo level.

3.3 Exploring the impact of a price premium on farmer's behaviour

We now turn to the case where only price premiums are in place $j = P$ and consequently, the farmer is characterised by a profile $\{\alpha_0, \alpha_P\} \mapsto \left(k_0^*, k_P^*\right)$. Additionally, her profits from organic production are:

$$\pi_P = (p + S_P)y(k) - c(k) - z \tag{7}$$

where $z > 0$ denotes the certification cost.

By using Eq. (2), Eq. (7) and a similar procedure we used for proving Lemma 1 we can show (see Appendix for the proof) that:

Lemma 3. *Given farmer's profile* $\{\alpha_0, \alpha_P\}$*, the optimal fraction of organic farming practices is:*

(I) provided that $\alpha_0 = 0$*, we have that* $k_P^* \geq k_0^*(0)$*, with equality if* $y'(k_P^*) = 0$

(II) provided that $0 \leq \alpha_P < \alpha_0$ *we have that:*

- *if* $y'(k_P^*) = 0$, *then* $k_P^* < k_0^*$*;*
- *if* $y'(k_P^*) > 0$, *then* $k_P^* < k_0^*$ *if also* $0 < S_P \leq S_P^+$, *whereas* $k_P^* > k_0^*$ *if* $S_P \geq S_P^-$, *with*

$$S_P^+ : \frac{\pi_0'(k_P^*)}{h'(k_P^*)} > \frac{\pi_0'(k_0^*)}{h'(k_0^*)} \quad \text{and} \quad S_P^- : \frac{\pi_0'(k_P^*)}{h'(k_P^*)} < \frac{\pi_0'(k_0^*)}{h'(k_0^*)}$$

Lemma 3 provides interesting policy implications. Contrary to the case of land subsidies, price premiums induce the adoption of organic farming practices for farmers who in the first place behave in a pure profit-maximisation fashion (i.e., $\alpha_0 = 0$), provided that such a choice increases the productivity of organic production. However, this observation does not necessarily holds for those who in the status quo scenario produce organically (i.e., $\alpha_0 > 0$). Specifically, Lemma 3 points that those types of farmers has an incentive to adopt more of the available organic farming practices if consumers are willing to pay (at least) a price of S_P^-.

The rationale is the following. First, we have assumed that price premiums do not initiate any normative learning process and therefore, farmers who initially behave in a pure-profit maximisation fashion they maintain the same attitude even after the introduction of a price premium. Hence, such a type of farmer tends to increase the adoption of organic farming practices because she knows that a positive marginal productivity implies that adopting more of the organic farming practices is profitable. However, such a profit increment is not always beneficial for a farmer who initially exhibits normative goal preference. Once price premiums are in place, such a type of farmer requires a (minimum) payment from consumers such that to cover any 'psychological utility' loss associated with her reduced tendency to acting normatively.

Likewise, Eq. (1), Eq. (2) and Eq. (7) indicates that organic production weakly dominates conventional one if:

$$S_P \geq S_P^*(k; \alpha_P) \equiv \frac{pq(\mathbf{x}^*) - \mathbf{w}\mathbf{x}^* - \pi_0(k) + z}{y(k)} - \left(\frac{\alpha_P}{1 - \alpha_P}\right)\frac{h(k)}{y(k)} \tag{8}$$

Hence, by using Eq. (8) and Lemma 3 we can show (see Appendix for the proof) that:

Lemma 4. *A farmer with a profile $\{\alpha_0, \alpha_P\} \mapsto (k_0^*, k_P^*)$ produces organically under a payment of $S_P^*(k_T; \alpha_P)$, with $k_T \in (0, k_P^*]$. Particularly, if $k_T < k_P^*$ the farmer over-complies.*

The policy implication of Lemma 4 is that under a payment of $S_P^*(k_P^*; 0)$ any farmer produces organically, regardless whether initially or after the introduction of the price premium she exhibits normative goal preferences. Importantly, Lemma 3 highlights that if $k_T = k_P^*(0)$ and $S_P^*(k_T; 0) \geq S_P^-$, then any farmer chooses to adopt more organic farming practices than she would do on the status quo.

3.4 Exploring the impact of both land subsidies and price premiums on farmer's behaviour

In the previous sections we assume that only one of the two financial incentives are in place. In reality, however, land subsidies and price premiums coexist. Thus, it is important to explore how a menu of financial incentives ($j = M$), $S = (S_L, S_P)$, affect farmer's behavior.

In such a case, a farmer is expected to has a profile $\{\alpha_0, \alpha_M\} \mapsto (k_0^*, k_M^*)$. Additionally, farmer's profits will be given by:

$$\pi_M(k) = (p + S_P)y(k) - c(k) + S_L - z \tag{9}$$

One can easily observe that only the price premium is a part of farmer's optimality condition. Thus, provided that $y'(k_M^*) > 0$ Lemmas 2 and 3 imply that a farmer with a profile $\{0, 0\}$ would choose $k_L^* = \hat{k} < k_M^* < k_P^*$. In other words, a menu of financial incentives still motivates a farmer who initially behaves in a pure-profit maximisation fashion to adopt more organic farming practices compared to the status quo.

On the contrary, a farmer with a profile $\{\alpha_0, \alpha_M\}$, with $\alpha_M \in [0, \alpha_0)$, would choose $k_M^* < k_P^*$, whereas $k_M^* \gtrless k_L^* = k_0^*$ depends on whether a payment S_M^- is feasible. Importantly, note that

$S^-_M > S^-_P$.[1] Hence, under a menu of financial incentives a farmer is more likely to reduce the adoption of organic farming practices compared to the case where only price premiums are in place.

Furthermore, by using Eq. (1), Eq. (2) and Eq. (9) we can show that a menu (S_L, S_P) weakly dominates organic production if

$$S_L \geq pq(\mathbf{x}^*) - \mathbf{wx}^* - \pi_0(k) - S_P y(k) + z - \left(\frac{\alpha_M}{1-\alpha_M}\right) h(k) \tag{10}$$

Particularly, by using Eq. (8) and Eq. (10) we argue (see Appendix for the proof) that:

Lemma 5. *Given that $S_P < S^*_p(k;\alpha_P)$, with $k \leq k^*_M$. Then the menu (S_L, S_p) weakly dominates organic farming iff $S_L \geq h(k)\left(\frac{\alpha_P - \alpha_M}{(1-\alpha_P)(1-\alpha_M)}\right) - \varepsilon y(k)$, where $\varepsilon > 0$ is infinitesimal.*

Consequently, by using Lemmas 2–5 we propose:

Proposition 3. *Given that consumers' willingness to pay for organic goods is $S_P \geq 0$, a social planner should offer a land subsidy, S_L to a farmer with a profile $\{\alpha_0, \alpha_L, \alpha_P, \alpha_M\} \mapsto \left(k^*_0, k^*_L, k^*_P, k^*_M\right)$ according to the following scheme:*

(i) If $S_P \geq S^*_P(k_T;\alpha_P)$, with $k_T \leq k^*_P$, then $S_L = 0$.

(ii) If $0 < S_p < S^*_P(k_T;\alpha_P)$, with $k_T \leq k^*_M < k^*_P$, then $S_L \geq h(k_T)\left(\frac{\alpha_P - \alpha_M}{(1-\alpha_P)(1-\alpha_M)}\right) - \varepsilon y(k_T)$.

(iii) If $S_P = 0$, then $S_L \geq S^*_L(k^*_0;\alpha_0)$, provided that $\alpha_0 = 0$ and $S_L = 0$ otherwise.

The implication of the recommendations (i) and (iii) of Proposition 3 is straightforward. Specifically, (i) states that the social planner should offer nothing, provided that consumers' willingness for organic goods can cover the 'utility loss' associated with organic farming. The recommendation (iii) states that the social planner should pay something only to those farmers who behave in a pure-profit maximisation fashion in the first place.

[1] Note that a differentiation of S^-_P with respect to k^*_P yields that S^-_P decreases as k^*_P increases. However, $k^*_M < k^*_P$ and therefore, $S^-_M > S^-_P$.

The implication of the recommendation (ii) of Proposition 3 comes straightforward from Lemma 5 and it is the most interesting one, mainly for two reasons. First, it states that the social planner should always pay the farmers provided that consumers' willingness to pay for organic goods is low. Specifically, the level of the land subsidy should account for the differential on farmer's normative goal preferences between the absence and the presence of a menu of financial incentives.

Second, this observation highlights that the social planner can be benefited by implementing behavioural interventions that target consumers instead of farmers. The reason is that for a behavioural intervention that targets farmers to be efficient the social planner has to know how 'sensitive' are farmer's normative goal preferences. However, such an information maybe quite difficult to be obtained. On the contrary, the necessity of aquiering such an information for behavioural interventions that target consumers is limited. The reason is that price premiums positively affect adoption choices, regardless how 'sensitive' are farmer's normative goal preferences to such an incentives.

4 Results and conclusion

In this article we theoretically explored the influence of land subsidies and price premiums on farmer's choices towards the adoption of organic farming practices, when these incentives are implemented both in isolation and in combination. Our main results can be summarised on the followings:

First, land subsidies can induce -by themselves- the transition from conventional to organic production, but they reduce the adoption of organic farming practices. In this article we have assumed that land subsidies undermine farmer's normative goal preferences because they frame a profit-seeking behaviour. Thus, this result emphasises that if social planner's primarily objective is to induce the adoption of organic farming practices, then land subsidies should never been used in isolation. Additional incentives should be provided, like price premiums and/or behavioural interventions targeted in enhancing normative behaviour.

Second, price premiums cannot only induce -by themselves- the transition from conventional to organic production, but most importantly they can foster the adoption of organic farming practices. Specifically, Lemma 3 stresses that price premiums always induce the adoption of organic farming practices to those farmers who initially do not exhibit normative goal preferences. Such an effect can also be occurred to farmers who initially cared for normative actions, provided that price premiums are high enough.

Third, our analysis indicates that over-compliance is more likely to be occurred as long as two conditions are met: the adoption target is low and farmers continue to exhibit normative goal preferences after the introduction of the payment scheme. Satisfaction of these two requirements means that for those farmers compliance is perceived as sub-optimal, increasing their incentives to over-comply.

Finally, some limitations should be spelled-out. Our theoretical analysis on adoption choices is time-independent. However, time is an important factor on pro-environmental behaviour and so, how farmer's goal preferences are formatting throughout an environmental program is an interesting topic. Furthermore, our analysis is restricted to the behaviour of a single farmer. An interesting topic is how financial incentives affect the population of farmers and specifically, whether such a population consists of solely profit-maximising individuals or not. Last but not least, normative goal preferences might be context-specific, meaning that farmers' normative goal preference may be conditional on the type of the agricultural good they produce. For instance, those associate with livestock may exhibit stronger normative goal preferences due to animal rights considerations. We leave the exploration of these topics for future research.

References

Ajzen, Icek (1991) "The theory of planned behavior," *Organizational Behavior and Human Decision Processes*, 50 (2), 179–211.

Bagheri, Asghar, Abolmohammad Bondori, Mohammad Sadegh Allahyari, and Christos A Damalas (2019) "Modeling farmers' intention to use pesticides: An expanded version of the theory of planned behavior," *Journal of Environmental Management*, 248, 109291.

Borges, João Augusto Rossi, Alfons GJM Oude Lansink, Claudio Marques Ribeiro, and Vanessa Lutke (2014) "Understanding farmers' intention to adopt improved natural grassland using the theory of planned behavior," *Livestock Sciences*, 169, 163–174.

Chen, Tianming, Shiwen Zhang, and Zengwei Yuan (2020) "Adoption of solid organic waste composting products: A critical review," *Journal of Cleaner Production*, 272, 122712.

Cialdini, Robert B, Raymond R Reno, and Carl A Kallgren (1990) "A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places.," *Journal of Personality and Social Psychology*, 58 (6), 1015–1026.

Connolly, Cristina and H Allen Klaiber (2014) "Does organic command a premium when the food is already local?" *American Journal of Agricultural Economics*, 96 (4), 1102–1116.

Cutforth, Laurence B., Charles A. Francis, Gary D. Lynne, David A. Mortensen, and Kent M. Eskridge (2001) "Factors affecting farmers' crop diversity decisions: An integrated approach," *American Journal of Alternative Agriculture*, 16 (4), 168–176.

De Groot, Judith IM and Linda Steg (2009) "Mean or green: which values can promote stable pro-environmental behavior?" *Conservation Letters*, 2 (2), 61–66.

Deci, Edward L, Richard Koestner, and Richard M Ryan (1999) "A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation.," *Psychological Bulletin*, 125 (6), 627–668.

Despotović, Jelena, Vesna Rodić, and Francesco Caracciolo (2019) "Factors affecting farmers' adoption of integrated pest management in Serbia: An application of the theory of planned behavior," *Journal of Cleaner Production*, 228, 1196–1205.

Duesberg, Stefanie, Deirdre O'Connor, and Áine Ní Dhubháin (2013) "To plant or not to plant—Irish farmers' goals and values with regard to afforestation," *Land Use Policy*, 32, 155–164.

Endres, A Bryan (2007) "An Awkward Adolescence in the Organics Industry: Coming to Terms with Big Organics and Other Legal Challenges for the Industry's Next Ten Years," *Drake Journal of Agricultural Law*, 12, 17–59.

Engel, Stefanie, Stefano Pagiola, and Sven Wunder (2008) "Designing payments for environmental services in theory and practice: An overview of the issues," *Ecological Economics*, 65 (4), 663–674.

Falconer, K and I Hodge (2000) "Using economic incentives for pesticide usage reductions: responsiveness to input taxation and agricultural systems," *Agricultural Systems*, 63 (3), 175–194.

Farrow, Katherine, Gilles Grolleau, and Lisette Ibanez (2017) "Social norms and pro-environmental behavior: A review of the evidence," *Ecological Economics*, 140, 1–13.

Feinerman, Eli and Cornelis Gardebroek (2007) "Stimulating organic farming via publicly provided services and an auction-based subsidy," *European Review of Agricultural Economics*, 34 (2), 141–159.

Frey, Bruno S and Felix Oberholzer-Gee (1997) "The cost of price incentives: An empirical analysis of motivation crowding-out," *The American Economic Review*, 87 (4), 746–755.

Goldstein, Noah J, Robert B Cialdini, and Vladas Griskevicius (2008) "A room with a viewpoint: Using social norms to motivate environmental conservation in hotels," *Journal of Consumer Research*, 35 (3), 472–482.

Hamilton, Stephen F and David Zilberman (2006) "Green markets, eco-certification, and equilibrium fraud," *Journal of Environmental Economics and Management*, 52 (3), 627–644.

Horan, Richard D and Roger Claassen (2007) "Targeting green payments under a budget constraint," *Land Economics*, 83 (3), 319–330.

Johansson, Maria, Johan Rahm, and Mats Gyllin (2013) "Landowners' participation in biodiversity conservation examined through the Value-Belief-Norm Theory," *Landscape Research*, 38 (3), 295–311.

Karp, David Gutierrez (1996) "Values and their effect on pro-environmental behavior," *Environment and Behavior*, 28 (1), 111–133.

Kashmanian, Richard M and Robert F Rynk (1998) "Creating positive incentives for farm composting," *American Journal of Alternative Agriculture*, 13 (1), 40–45.

Kaufmann, Peter, Sigrid Stagl, and Daniel W Franks (2009) "Simulating the diffusion of organic farming practices in two New EU Member States," *Ecological Economics*, 68 (10), 2580–2593.

Kotschi, Johannes and Karl Müller-Sämann (2004) *The Role of Organic Agriculture in Mitigating Climate Change – a Scoping Study*: IFOAM.

Lampkin, Nicolas H and Susanne Padel (1994) *The economics of organic farming: an international perspective*: Wallingford (United Kingdom) CAB International.

Lefebvre, Marianne, Stephen RH Langrell, and Sergio Gomez-y Paloma (2015) "Incentives and policies for integrated pest management in Europe: a review," *Agronomy for Sustainable Development*, 35 (1), 27–45.

Lindenberg, Siegwart (2008) "Social rationality, semi-modularity and goal-framing: What is it all about?" *Analyse & Kritik*, 30 (2), 669–687.

Lindenberg, Siegwart and Linda Steg (2007) "Normative, gain and hedonic goal frames guiding environmental behavior," *Journal of Social Issues*, 63 (1), 117–137.

——— (2013) "Goal-framing theory and norm-guided environmental behavior," in *Encouraging sustainable behavior*, 37–54: Psychology Press.

Lohr, Luanne and Lennart Salomonsson (2000) "Conversion subsidies for organic production: results from Sweden and lessons for the United States," *Agricultural Economics*, 22 (2), 133–146.

Luttikholt, Louise WM (2007) "Principles of organic agriculture as formulated by the International Federation of Organic Agriculture Movements," *NJAS-Wageningen Journal of Life Sciences*, 54 (4), 347–360.

MacRae, Rod J, Stuart B Hill, John Henning, and Alison J Bentley (1990) "Policies, programs, and regulations to support the transition to sustainable agriculture in Canada," *American Journal of Alternative Agriculture*, 5 (2), 76–92.

Mason, Charles F et al. (2012) "The economics of eco-labeling: Theory and empirical implications," *International Review of Environmental and Resource Economics*, 6 (4), 341–372.

Mason, Charles F (2011) "Eco-labeling and market equilibria with noisy certification tests," *Environmental and Resource Economics*, 48 (4), 537–560.

Matter, Anne, Mehedi Ahsan, Michelle Marbach, and Christian Zurbrügg (2015) "Impacts of policy and market incentives for solid waste recycling in Dhaka, Bangladesh," *Waste Management*, 39, 321–328.

Miranowski, John A. (1984) "Impacts of Productivity Loss on Crop Production and Management in a Dynamic Economic Model," *American Journal of Agricultural Economics*, 66 (1), 61–71.

Nordlund, Annika M and Jörgen Garvill (2002) "Value structures behind proenvironmental behavior," *Environment and Behavior*, 34 (6), 740–756.

Ostrom, Elinor (2000) "Collective action and the evolution of social norms," *Journal of Economic Perspectives*, 14 (3), 137–158.

Ottaviani, Daniela (2011) "The role of PES in agriculture," in *Payments for Ecosystem Services and Food Security*, 9 – 29: FAO.

Patrick, George F, Brian F Blake, and Suzanne H Whitaker (1983) "Farmers' goals: uni-or multi-dimensional?" *American Journal of Agricultural Economics*, 65 (2), 315–320.

Paul, Jacky, Jorge Sierra, François Causeret, Loïc Guindé, and Jean-Marc Blazy (2017) "Factors affecting the adoption of compost use by farmers in small tropical Caribbean islands," *Journal of Cleaner Production*, 142, 1387–1396.

Rezaei-Moghaddam, Kurosh, Nasim Vatankhah, and Abdolazim Ajili (2020) "Adoption of pro-environmental behaviors among farmers: application of Value–Belief–Norm theory," *Chemical and Biological Technologies in Agriculture*, 7 (1), 1–15.

Rezaei, Rohollah, Leila Safa, Christos A Damalas, and Mohammad Mahdi Ganjkhanloo (2019) "Drivers of farmers' intention to use integrated pest management: integrating theory of planned behavior and norm activation model," *Journal of Environmental Management*, 236, 328–339.

Rode, Julian, Erik Gómez-Baggethun, and Torsten Krause (2015) "Motivation crowding by economic incentives in conservation policy: A review of the empirical evidence," *Ecological Economics*, 117, 270–282.

Savari, Moslem, Abas Abdeshahi, Hamidreza Gharechaee, and Omid Nasrollahian (2021) "Explaining farmers' response to water crisis through theory of the norm activation model: Evidence from Iran," *International Journal of Disaster Risk Reduction*, 60, 102284.

Schwartz, Shalom H (1977) "Normative influences on altruism," in *Advances in experimental social psychology*, 10, 221–279: Elsevier.

Senger, Igor, Joao Augusto Rossi Borges, and Joao Armando Dessimon Machado (2017) "Using the theory of planned behavior to understand the intention of small farmers in diversifying their agricultural production," *Journal of Rural Studies*, 49, 32–40.

Sexton, Steven E, Zhen Lei, David Zilberman et al. (2007) "The economics of pesticides and pest control," *International Review of Environmental and Resource Economics*, 1 (3), 271–326.

Sintori, Alexandra, Stelios Rozakis, Kostas Tsiboukas et al. (2009) "Multiple goals in farmers' decision making: The case of sheep farming in Western Greece," in *83rd Annual Conference, March 30-April 1, 2009, Dublin, Ireland* (51075), Agricultural Economic Society.

Stern, Paul C, Thomas Dietz, Troy Abel, Gregory A Guagnano, and Linda Kalof (1999) "A value-belief-norm theory of support for social movements: The case of environmentalism," *Human Ecology Review*, 81–97.

Sumpsi, JoseMaria, Francisco Amador, and Carlos Romero (1997) "On farmers' objectives: A multi-criteria approach," *European Journal of Operational Research*, 96 (1), 64–71.

Tang, Shu-Hua and Vernon C Hall (1995) "The overjustification effect: A meta-analysis," *Applied Cognitive Psychology*, 9 (5), 365–404.

Theocharopoulos, Athanasios, Katerina Melfou, Evangelos Papanagiotou et al. (2012) "Analysis of decision making process for the adoption of sustainable farming systems: The case of peach farmers in Greece," *American-Eurasian Journal of Sustainable Agriculture*, 6 (1), 24–32.

Van Kooten, G Cornelis, Richard A Schoney, and Keith A Hayward (1986) "An alternative approach to the evaluation of goal hierarchies among farmers," *Western Journal of Agricultural Economics*, 40–49.

Wallace, Michael T and Joan E Moss (2002) "Farmer decision-making with conflicting goals: a recursive strategic programming analysis," *Journal of Agricultural Economics*, 53 (1), 82–100.

Wiersma, Uco J (1992) "The effects of extrinsic rewards in intrinsic motivation: A meta-analysis," *Journal of Occupational and Organizational Psychology*, 65 (2), 101–114.

Xiong, LX, XY Li, JJ Ning, YR Dong, and Y Yan (2022) "The effects of dynamic incentives on the recycling of livestock and poultry manure in a multiscenario evolutionary game," *Environment, Development and Sustainability*, 1–33.

Appendix

Proof of Lemma 1

For an interior solution (i.e., $k \in (0,1]$, the first-order condition of Eq. (3) is $v_0' = 0$, which by using Eq. (2) we obtain:

$$v_0'(k;\alpha_0) = 0 \Leftrightarrow (1-\alpha_0)\pi_0'(k) + \alpha_0 h'(k) = 0 \tag{A1}$$

Note that $h' > 0$ for all $k \in (0,1]$. Thus, if $\pi_0' > 0$, then $k^* = 1$ for all $\alpha_0 \in [0,1)$. In other words, any farmer regardless how profit-oriented is would choose to adopt all the available organic farming practices. However, this is not realistic and so, it must be that $\pi_0'(k) \leq 0$ for all $k \in (0,1]$.

Let's assume that exists $\hat{k} \in (0,1]$, such that $\pi_0'(\hat{k}) = 0$. In addition, $\pi_0'' = py'' - c'' < 0$ for all $k \in (0,1]$. Hence, it turns out that $\pi_0'(k) \leq 0$ for any $k \in [\hat{k},1]$. Consequently, Eq. (A1) points that a farmer optimal choice, k_0^*, is:

$$k_0^*(\alpha_0) : \ \frac{\alpha_0}{1-\alpha_0} = -\frac{\pi_0'(k_0^*)}{h'(k_0^*)} \tag{A2}$$

By using Eq. (A2) it is straightforward to show that an $\alpha_0 = 0$ yields that $\pi_0'(k_0^*) = 0 \Rightarrow \pi_0'(k_0^*) = \pi_0'(\hat{k}) \Rightarrow k_0^*(0) = \hat{k}$. Additionally, by differentiating both sides of Eq. (A2) with respect to α_0 we have that:

$$\frac{\partial k_0^*}{\partial \alpha_0}\left(\frac{\pi_0''\left[\pi_0' - h'\right] - \pi_0'\left[\pi_0'' - h''\right]}{[\pi_0' - h']^2}\right) = 1 \Rightarrow \frac{\partial k_0^*}{\partial \alpha_0} > 0 \tag{A3}$$

because $\pi_0' \leq 0$, $h'' < 0$, $h' > 0$, and $\pi_0'' < 0$. Thus, $k_0^* \in [\hat{k},1]$.

Proof of Lemma 2

By using a similar procedure with the proof of Lemma 1, we have that farmer's optimal choice when land subsidies are in place, k^*_L, is:

$$k^*_L(\alpha_L) : \frac{\alpha_L}{1-\alpha_L} = -\frac{\pi'_L(k^*_L)}{h'(k^*_L)} \tag{A4}$$

However, Eq. (5) point that $\pi'_L(k) = \pi'_0(k)$ and so, optimal condition becomes:

$$\frac{\alpha_L}{1-\alpha_L} = -\frac{\pi'_0(k^*_L)}{h'(k^*_L)} \tag{A5}$$

We know that $\alpha_L < \alpha_0$. In addition, recall that $\left(\partial k^*_0 \big/ \partial \alpha_0\right) > 0$. Thus, a comparison between Eq. (A2) and Eq. (A5) implies that $k^*_L < k^*_0$, with $\left(\partial k^*_L / \partial \alpha_L\right) > 0$. Moreover, if $\alpha_L = 0$, then $k^*_L = \hat{k}$. Thus, it turns out that for $\alpha_L \in [0, \alpha_0)$ we have that $k^*_L \in [\hat{k}, k^*_0)$.

Proof of $S^*_L(k^*_L; \alpha_L) < S^*_L(\hat{k}; 0)$

Recall that the land subsidy that marginally dominates organic production is:

$$S^*_L(k; \alpha_L) = pq(\mathbf{x}^*) - \mathbf{wx}^* - \pi_0(k) - \left(\frac{\alpha_L}{1-\alpha_L}\right)h(k) \tag{A6}$$

where $\left(\partial S^*_L / \partial \alpha_L\right) < 0$. A differentiation of S^*_L with respect to k yields that:

$$\frac{\partial S^*_L}{\partial k} = -\pi'_0(k) - \left(\frac{\alpha_L}{1-\alpha_L}\right)h'(k) \tag{A7}$$

which by using Eq. (A1) and Eq. (A5) we have that for $k = k^*_L$ Eq. (A7) becomes $\left(\partial S^*_L / \partial k\right) = 0$. In addition,

$$\frac{\partial^2 S^*_L}{\partial k^2} = -\pi''_0(k) - \left(\frac{\alpha_L}{1-\alpha_L}\right)h''(k) \tag{A8}$$

Note that $\pi_0'', h'' < 0$ and consequently, $\left(\partial^2 S_L^* / \partial k^2\right) > 0$. Hence, S_L^* has a minimum at k_L^*, i.e., $S_L^*(k_L^*;\alpha_L) \leq S_L^*(k;\alpha_L)$ for any $k \in (0,1]$. Consequently, $S_L^*(k_L^*;\alpha_L) \leq S_L^*(\hat{k};\alpha_L)$.

Furthermore, recall that $\left(\partial S_L^* / \partial \alpha_L\right) < 0$, which implies that $S_L^*(\hat{k};\alpha_L) < S_L^*(\hat{k};0)$. Thus, by combining these two results we obtain that $S_L^*(k_L^*;\alpha_L) < S_L^*(\hat{k};0)$.

Proof of Lemma 3

For an interior solution the first-order condition of Eq. (3) is $v_P' = 0$, which by using Eq. (2) and Eq. (7) we obtain:

$$\begin{aligned} v_P'(k;\alpha_P) = 0 \Leftrightarrow (1-\alpha_P)\pi_P'(k) + \alpha_P h'(k) = 0 \Leftrightarrow \\ (1-\alpha_P)\pi_0'(k) + (1-\alpha_P)S_P y'(k) + \alpha_P h'(k) = 0 \Leftrightarrow \\ k_P^*(\alpha_P) : \ \frac{\alpha_P}{1-\alpha_P} = -\left(\frac{\pi_0'(k_P^*) + S_P y'(k_P^*)}{h'(k_P^*)}\right) \end{aligned} \tag{A9}$$

The following cases can be distinguished:

$\alpha_0 = 0 \Longrightarrow \alpha_P = 0$. In such a case, Eq. (A9) points that $\pi_0'[k_P^*(0)] + S_P y'[k_P^*(0)] = 0$. Furthermore, we know that $\pi_0'(\hat{k}) = 0$. Thus, a comparison between $k_P^*(0)$ and $\hat{k}$ yields that $\pi_0'[k_P^*(0)] + S_P y'[k_P^*(0)] = \pi_0'(\hat{k})$. Consequently, if $y'[k_P^*(0)] = 0$, then $k_P^*(0) = \hat{k}$. On the contrary, if $y'[k_P^*(0)] > 0$, then $\pi_0'[k_P^*(0)] - \pi_0'(\hat{k}) = -S_P y'[k_P^*(0)] < 0 \Rightarrow \pi_0'[k_P^*(0)] < \pi_0'(\hat{k})$. Note that $\pi_0'' < 0$ and so, it must be that $k_P^*(0) > \hat{k}$.

$\alpha_0 > 0 \Longrightarrow 0 \leq \alpha_P < \alpha_0$. In such a case, Eq. (A2) and Eq. (A9) point that (we suppress the arguments of k_P^* and k_0^*):

$$\begin{aligned} \frac{\pi_0'(k_P^*) + S_P y'(k_P^*)}{h'(k_P^*)} + \frac{\alpha_P}{1-\alpha_P} = \frac{\pi_0'(k_0^*)}{h'(k_0^*)} + \frac{\alpha_0}{1-\alpha_0} \Leftrightarrow \\ \frac{\pi_0'(k_P^*) + S_P y'(k_P^*)}{h'(k_P^*)} - \frac{\pi_0'(k_0^*)}{h'(k_0^*)} = \frac{\alpha_0}{1-\alpha_0} - \frac{\alpha_P}{1-\alpha_P} \end{aligned} \tag{A10}$$

Note that $0 \leq \alpha_P < \alpha_0$ and so, the RHS of Eq. (A10) is positive. Thus, it must be:

$$\frac{\pi_0'(k_P^*) + S_P y'(k_P^*)}{h'(k_P^*)} - \frac{\pi_0'(k_0^*)}{h'(k_0^*)} > 0 \Leftrightarrow \frac{\pi_0'(k_P^*)}{h'(k_P^*)} - \frac{\pi_0'(k_0^*)}{h'(k_0^*)} > -\frac{S_P y'(k_P^*)}{h'(k_P^*)} \tag{A11}$$

Here, we have the following sub-cases:

(i) $y'(k_P^*) = 0$: In that case, it must hold

$$\frac{\pi_0'(k_P^*)}{h'(k_P^*)} > \frac{\pi_0'(k_0^*)}{h'(k_0^*)} \tag{A12}$$

One should recall that $\pi_0' \leq 0$ for any $k \in (0, 1]$ and so, $\pi_0'' h' - h'' \pi_0' < 0$. Therefore, we obtain that $k_P^* < k_0^*$.

(ii) $y'(k_P^*) > 0$: In that case, Eq. (A11) can be satisfied if its LHS is positive or negative. Particularly, let's assume that exist S_P^+ and S_P^- such that the LHS of Eq. (A11) is positive and negative, respectively. Furthermore, by rearranging Eq. (A9) and differentiating it with respect to S_P we obtain that:

$$\begin{aligned} \frac{\alpha_P}{1-\alpha_P} h'' \frac{\partial k_P^*}{\partial S_P} = -\pi_0'' \frac{\partial k_P^*}{\partial S_P} - y' - S_P y'' \frac{\partial k_P^*}{\partial S_P} \Leftrightarrow \\ \frac{\partial k_P^*}{\partial S_P} \left[\frac{\alpha_P}{1-\alpha_P} h'' + \pi_0'' + S_P y'' \right] = -1 \end{aligned} \tag{A13}$$

Note that the sign of $[\cdot]$ is negative and therefore, $(\partial k_P^* / \partial S_P) > 0$. Additionally,

$$\frac{\partial}{\partial S_P} \left[\frac{\pi_0'(k_P^*)}{h'(k_P^*)} - \frac{\pi_0'(k_0^*)}{h'(k_0^*)} \right] = \frac{\partial k_P^*}{\partial S_P} \left(\frac{\pi_0'' h' - h'' \pi_0'}{h'^2} \right) < 0 \tag{A14}$$

Thus, for any $0 < S_P \leq S_P^+$ the LHS of Eq. (A11) remains positive and so, Eq. (A12) implies that for any $0 < S_P \leq S_P^+$ we have that $k_P^* < k_0^*$. The opposite holds for any $S_P \geq S_P^-$. Specifically, Eq. (A14) states that the LHS of Eq. (A11) decreases as the price premium increases, making more likely the condition of Eq. (A11) to be satisfied. Thus, for any $S_P \geq S_P^-$ Eq. (A12) implies that $k_P^* > k_0^*$.

Proof of Lemma 4

By using Eq. (1), Eq. (2) and Eq. (7) we have that the farmer's incentive rationality constraint can be expressed as:

$$\phi(k;\alpha_P) \equiv v_P(k;\alpha_P) - u(\mathbf{x}^*;\alpha_P) \geq 0 \tag{A15}$$

A differentiation of ϕ with respect to k yields that $\phi' = v'_P$ and $\phi'' = v''_P < 0$. Thus, ϕ has a maximum at k^*_P, i.e., $\phi(k^*_P;\alpha_P) \geq \phi(k;\alpha_P)$. Furthermore, Eq. (8) implies that any payment $S^*_P(k;\alpha_P)$ yields $\phi(k;\alpha_P)$=0. Consequently, for any feasible payment $S^*_P(\bar{k};\alpha_P)$, with $\bar{k} \in (0, k^*_P]$, we have that $\phi(k^*_P;\alpha_P) \geq \phi(\bar{k};\alpha_P) \Rightarrow \phi(k^*_P;\alpha_P) \geq 0$.

Proof of Lemma 5

Recall that $S^*_P(k;\alpha_P)$ is the value of the price premium that induces organic production without any further intervention. In addition, recall that once a menu of financial incentives is in place, then a farmer chooses to adopt k^*_M. Thus, if $S^*_P(k^*_M;\alpha_P) \leq S_P < S^*_P(k^*_P;\alpha_P)$, then the social planner can simply reduce the adoption target to $k_T = k^*_M$.

The problem for the social planner is if $S_P < S^*_P(k_T;\alpha_P)$, with $k_T \leq k^*_M$. Specifically, let's assume that $S_P = S^*_P(k;\alpha_P) - \varepsilon$, where $\varepsilon > 0$ is infinitesimal. Then, by using Eq. (8) and Eq. (10) we have that:

$$\begin{aligned}
S_L &\geq pq(\mathbf{x}^*) - \mathbf{w}\mathbf{x}^* - \pi_0(k) - \left[S^*_P(k;\alpha_P) - \varepsilon\right]y(k) + z - \left(\frac{\alpha_M}{1-\alpha_M}\right)h(k) \\
S_L &\geq \left(\frac{\alpha_P}{1-\alpha_P}\right)h(k) - \varepsilon y(k) - \left(\frac{\alpha_M}{1-\alpha_M}\right)h(k) \\
S_L &\geq \left(\frac{\alpha_P - \alpha_M}{(1-\alpha_P)(1-\alpha_M)}\right)h(k) - \varepsilon y(k)
\end{aligned} \tag{A16}$$