STIMULATING ORGANIC FARMING VIA PUBLIC SERVICES AND AN AUCTION-BASED SUBSIDY

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Abstract

In order to stimulate organic farming governments generally use a mix of temporary hectare payments and provision of public services for stimulating the development of the organic sector. In this paper a conceptual model is developed for determining a socially optimal hectare payment for any given level of public services. Farm heterogeneity, due to the variability of soil quality and management skills, is explicitly taken into account. Using an n-th price auction mechanism farmers indicate what their reservation subsidy is for a given level of public input provision. The outcome of this problem is utilized in the government's optimization problem. We found that the level of per hectare socially optimal subsidy increases significantly with the elasticity of the social welfare function and decreases significantly with the degree of farmers' heterogeneity in suitability of growing organic crops (OC) as well as with the level of complementary governmental services. The total area planted for OC is also quite sensitive to these parameters. The effects of the deadweight loss parameter and the degree of risk aversion on per hectare subsidy and on total organic acreage are relatively small.

Keywords: auctions, organic farming, policy mix
JEL classification: Q28, Q12

1. Introduction

In recent years organic farming received considerable attention in European countries. In their search for a more sustainable agriculture, producers, consumers and policy makers rediscovered organic farming. The consumption and the number of producers increased rapidly in most countries, although total shares are still modest. Policy makers in a number of European countries came up with ambitious goals that the organic sector should attain. In the Netherlands for example, the government stated that in 2010 ten percent of total farmland should be used for organic farming (Ministry of Agriculture, Nature and Food Quality, 2004:11). In order to meet this objective the Dutch government also tries to stimulate the development of the organic sector with a mixture of different policy instruments. These policy instruments can be classified into two main categories: direct payments and the provision of public services. Direct payments are usually on a hectare basis and are given in the first years after switching to organic farming or during the period that a farm is still in transition. In the past these payments were meant as a compensation for losses in production during the first years of organic production. Starting from 2005 the emphasis in providing these subsidies is more on rewarding the positive externalities that arise from using organic methods. The public services provided consist among others of generic marketing activities, dissemination of information, publicly funded research, supporting market integration etc. See Marshall (1991) for an overview of different technical support measures with a public good nature. These services are typical public inputs. Individual farmers benefit from them, but individual organic farmers would never pay for them given the non-excludability and non-rivalry in using these inputs.

Over the years the Dutch government made remarkable shifts in this policy mix. In 1994 a direct income payment per hectare for organic crop farmers in transition was introduced. The year 2002 was the last year this income support was given and support per hectare was also lower in this year. The reason for abolishing the hectare payment scheme was that the government wanted to stimulate the organic sector, but not via subsidies. Market perspectives should guide farmers in their switching decisions. When the growth in the number of organic farms stagnated in 2003, the government decided to use the income support instrument again in 2004. In 2005 a new hectare-based direct income support system was introduced. With the reduction in direct income support, provision of public services became relatively more important over time. In 1998 the Dutch government started advertisement campaigns for organic products. Currently, more than half of the budget for stimulating organic farming is allocated to research, education and information dissemination.

Both types of the above mentioned instruments have the same objective: stimulating the growth of the organic sector. Using farm level data from Sweden, Lohr and Salomonsson (2000) confirmed that direct payments and provision of public services are substitutes in the utility function of farmers considering switching to organic farming. In their paper they focus on farm-level decisions without taking risk explicitly into account. In a study on individual switching decisions Pietola and Oude Lansink (2001) did account for uncertainty in organic revenues. However, they only focused on the role of direct payments as a means of stimulating organic farming. Both aforementioned papers focus explicitly on farm-level decisions without taking the role of the government into account.

In this paper a conceptual model is developed for determining a socially optimal per-hectare subsidy for any given level of public services. Farm heterogeneity, due to the variability of soil quality and management skills, is explicitly taken into account. Using an *n*-th price auction mechanism farmers indicate what is their reservation subsidy. The farm-level reservation subsidies are utilized by the government in its optimization problem. The structure of this auction mechanism motivates farmers to reveal their true reservation subsidies for switching to organic farming. The sensitivity of the socially optimal subsidy and of its associated level of organic farming to various parameters is also examined. The theoretical developments are applied to data from the province of Flevoland in the Netherlands. The empirical findings show that he level of per hectare socially optimal subsidy increases significantly with the elasticity of the social welfare function and decreases significantly with the degree of farmers' heterogeneity in suitability of growing organic crops (OC) as well as with the level of complementary governmental services. The total area planted for OC is also quite sensitive to these parameters. The effects of the deadweight loss parameter and the degree of risk aversion on per hectare subsidy and on total organic acreage are relatively small.

The rest of the paper is organized as follows. In section two the conceptual framework is developed. In this section the farmers' decision problem and the government optimization problem are defined. Also the *n*-th price auction as a mechanism for truthfully revealing reservation subsidies for switching is explained. Section 3 presents the data from the province of Flevoland in the Netherlands and the calibration of the empirical model. The results on optimal subsidy levels and its impact on the total area planted for organic crops are presented in section 4. Section five gives concluding remarks.

2. Conceptual Framework

2.1 The farmer's problem

Assume an agricultural area of A hectares (ha), owned by a large number of farmers (M), each cultivating an area of a hectares, ($aM = A$). Based on observed behaviour of farmers we assume that all the land of a specific farm is utilised either for traditional crops (**TC**) or for organic crops (**OC**), for a predetermined time horizon of T years.[1] We start the analysis with the assumption that currently (t=0) each one of the farmers grows TC, yielding an annual profit of W^0 euros per farm, which is assumed to be fixed over time.

The farmers vary with respect to skills and suitability of land for growing OC. Formally, we assume that the specific characteristics of the m^{th} farm(er) (hereafter farmer's type) is denoted by $\theta_m \in [\underline{\theta}, \overline{\theta}], m = 1, ..., M$, with cumulative distribution given by $F(\theta_m)$, $(F(\underline{\theta}) = 0,$ and $F(\overline{\theta}) = 1)$, and a strictly positive and differentiable density function $f(\theta_m)$. The vector of farmers' types is given by $\Theta = (\theta_1, \theta_2, ..., \theta_M)$. The farmer's type is private information and is not known to the government and to other farmers.

The farmer considers the option to substitute the TC by OC. The profit associated with OC varies over time and is assumed to be random, due to combined variability in yields and prices. Padel & Lampkin (1994: 216) note that there is evidence for greater variability in crop yields with OC. Lack of opportunities to intervene with fertiliser or pesticides increases the risk of crop failure. Besides production risks, OC are also more prone to market risks. The small scale of organic markets could lead to greater fluctuations in demand and supply. Moreover, higher prices for OC may lead to a drop in demand in times of economic depression. In the absence of public intervention, the expected profits per farm associated with the OC are lower than W^0 in the first few years of the planning horizon, and then it gradually increases until it exceeds W^0 before the end of this horizon.

The government is interested in increasing the total area planted with OC because of the environment friendly production methods applied. It encourages farmers to switch to OC via a combination of two policy instruments. The first instrument is a direct compensation payment of $s(\Theta)$ per ha planted with OC. Direct payments are paid to farmers only during the first $\hat{t} < T$ years of the time horizon. This subsidy is equal for all farmers that decide to grow OC since differentiated subsidies are politically infeasible. The level of the subsidy is a function of the distribution of the types of farmers. The second instrument is public services of *G* euros for the whole organic sector. Examples of services relevant for our analysis include information gathering and disseminating, lowering transaction costs associated with the switch of activities, assisting in advertisement and marketing plans and more. Reduction of farm-level risks associated with the adoption of OC is a main contribution of these public services. Only farmers who choose to switch from TC to OC can benefit from these public services *G*.

Let $\Pi^1_{t,m}(\theta_m, s(\Theta), G) = \theta_m \cdot \pi^1_t(G) + a \cdot s(\Theta)$ be the profit per farm for OC in year *t* with mean and variance given by

$$\overline{\Pi}^1_{t,m} = \begin{cases} \theta_m \cdot \overline{\pi}^1_t(G) + a \cdot s(\Theta), & \text{if } t \leq \hat{t} \\ \theta_m \cdot \overline{\pi}^1_t(G), & \text{if } \hat{t} < t \leq T, \end{cases} \tag{1}$$

and

$$\mathrm{Var}(\Pi^1_{t,m}) = \theta_m^2 V_{\pi_t}(G), \tag{2}$$

respectively. Expected profit increases in both *s* and *G*, while the variance decreases in G. Recognising that a decision to switch to OC is a typical long-term decision and that there is variability in OC profits, it is assumed that farmers maximise the stream of utility of expected profits. We assume that each one of the farmers is risk averse with utility function $U_m(\cdot)$ defined on wealth which is increasing, twice differentiable and strictly concave ($U_m' > 0, U_m'' < 0$). Since the paper does not focus on the role of risk and risk aversion, and in order to make the analysis more tractable, it is useful to approximate the expected utility from farm-level profits by a certainty equivalent profit defined by:

$$\Pi^{1,\mathrm{CE}}_{\mathrm{t,m}} = \overline{\Pi}^1_{t,m} - 0.5 \cdot \gamma \cdot Var(\pi^1_t) \tag{3}$$

where $\gamma = -U_m''/U_m' > 0$ is the Arrow-Pratt coefficient of absolute risk aversion. The annual equivalent of the present value of the stream of future certainty equivalent profits for this case is given by

$$\mathrm{W}^1_{\mathrm{m}}(\theta_m, s(\Theta), G) = \theta_m \cdot [\overline{\pi}^1(G) - 0.5\theta_m \cdot \gamma V_\pi(G)] + aH(r) \cdot \sum_{t=1}^{\hat{t}} \frac{s(\Theta))}{(1+r)^t}, \tag{4}$$

where $\overline{\pi}^1(G) = H(r) \cdot \sum_{t=1}^{T} \frac{\overline{\pi}^1_t(G)}{(1+r)^t}$, $V_\pi(G) = H(r) \cdot \sum_{t=1}^{T} \frac{V_{\pi_t}(G)}{(1+r)^t}$, *r* is the annual real interest rate, and $H(r) = \frac{r(1+r)^T}{(1+r)^T - 1}$ is a capital recovery factor. Given the level of the policy instruments, $s(\Theta)$ and *G*, $W^1_{\mathrm{m}}(\bullet)$ is assumed to increase in the farmer's type, namely:

$$\frac{\partial W_{\mathrm{m}}^{1}(\bullet)}{\partial \theta_m} = \bar{\pi}^{1}(G) - \theta_m \cdot \gamma V_{\pi}(G)] > 0 \tag{5}$$

It can be easily verified that $W_{\mathrm{m}}^{1}(\bullet)$ increases in both, *G* and *s*.

In the absence of governmental intervention, (s =*G*=0), it is assumed that $W^{0} > W_{\mathrm{m}}^{1}(\bullet)\ \forall m$ and for every $\theta_m \in [\underline{\theta}, \bar{\theta}]$. In other words, without governmental intervention none of the farmers in the region will quit growing TC and start growing OC instead. This assumption is in line with the observation that even with past policies promoting organic farming thus far only a small number of farmers switched to OC.

For a given level of *G*, there exists a level of the annual-equivalent direct hectare payment $\tilde{s}_m(G)$, further denoted as reservation subsidy of the m^{th} farmer, under which she is indifferent between the two types of crops:

$$\tilde{s}_m(G) = \frac{1}{a} \cdot \{W^{0} - \theta_m \cdot [\bar{\pi}^{1}(G) - 0.5\theta_m \cdot \gamma V_{\pi}(G)]\} \tag{6}$$

Differentiating (6) with respect to the type of the farm, yields

$$sign\{\partial \tilde{s}_m / \partial \theta_m\} = -sign\{\partial W_{\mathrm{m}}^{1}(\bullet) / \partial \theta_m\} < 0 \tag{7a}$$

(see (5))[2] . Since $\bar{\pi}_t^{1}(G)$ increases in *G* and $V_{\pi}(G)$ decreases in G, it can be easily verified that

$$\partial \tilde{s}_m / \partial G < 0, \tag{7b}$$

indicating that the two policy instruments are substitutes.

Given the levels of the policy instruments, $s(\Theta)$ and *G*, the farmer's decision can be stated formally as follows

$$\begin{cases} \text{If } W_{\mathrm{m}}^{1}(\bullet) \geq W^{0} & \text{then } I^{m}(s,G) = 1 \\ \text{If } W_{\mathrm{m}}^{1}(\bullet) < W^{0} & \text{then } I^{m}(s,G) = 0, \end{cases} \tag{8}$$

where $I^{m}(s,G)$ is an indicator function which is equal to 1 if the farmer decides to stop growing TC and switch to OC and equal to 0 if she decides not to adopt OC.

For a given level of *G*, the total land area in the region that is planted for OC, is dependent on the actual level of *s*. For a formal formulation of this dependency it is convenient to use a graphical presentation. Based on (6) and (7a) and (7b), the set of reservation subsidies $\tilde{s}$ as a function of θ is depicted in Figure 1 for two levels of public services. With actual annual subsidy of s^{*} €/ha all the farmers of type $\theta^{*}(s^{*}, G)$ and higher will start growing OC, while all other farmers will keep growing TC. Rewriting equation (6) for the "marginal farmer" with type $\theta_m = \theta^{*}(s^{*}, G)$ and $\tilde{s}_m = s^{*}$ allows for performing comparative statics, yielding:

$$\frac{\partial \theta^{*}}{\partial G} < 0,\ \frac{\partial \theta^{*}}{\partial s^{*}} < 0,\ \frac{\partial^{2} \theta^{*}}{\partial s^{*2}} > 0,\ \frac{\partial^{2} \theta^{*}}{\partial s^{*} \partial G} > 0, \text{ and } \frac{\partial^{2} \theta^{*}}{\partial s^{*} \partial \gamma} < 0. \tag{9}$$

The sign of $\frac{\partial \theta^*}{\partial \gamma}$ is indeterminate.

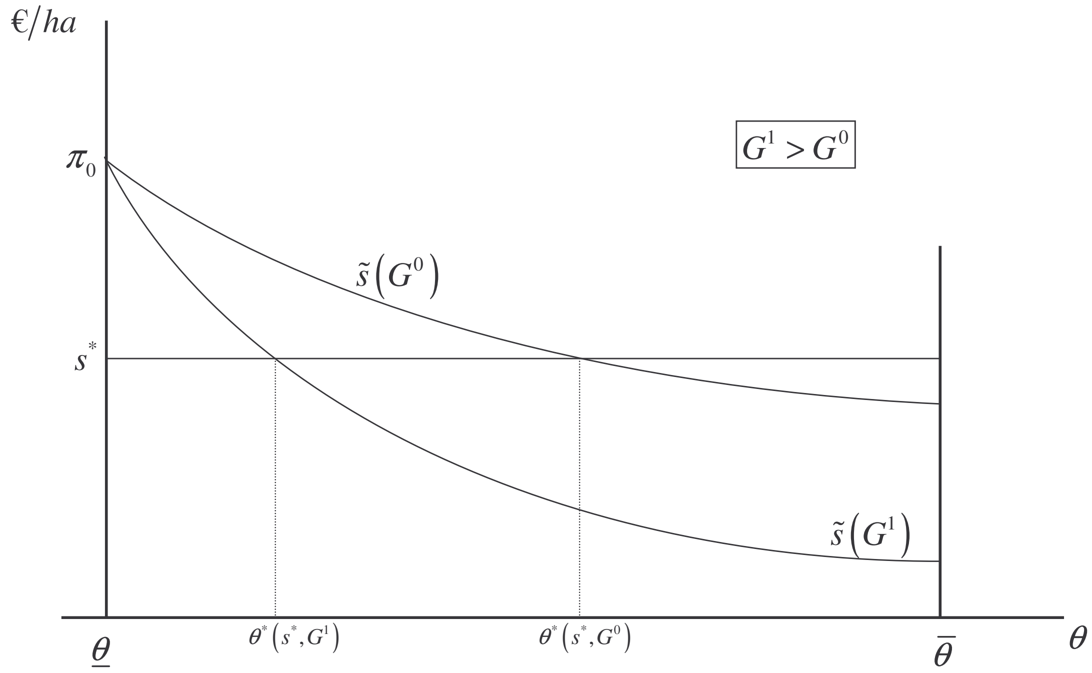

Figure 1. Type-dependent reservation subsidies for different levels of G and type-thresholds as functions of s^*.

The total land areas planted for OC and for TC are given by equations (10a) and (10b), respectively:

$$TA^{OC}(s^*, G) = A[1 - F(\theta^*(s^*, G))] \tag{10a}$$

$$TA^{TC}(s^*, G) = AF(\theta^*(s^*, G)) = A - TA^{OC} \tag{10b}$$

2.2 An optimal auction for revealing reservation subsidies for switching

The government's job is to determine the levels of the public-input (*G*) and the (annual-equivalent) direct payment, s^*, that maximises its objective function (see below). However, $\theta_m \in [\underline{\theta}, \overline{\theta}]$ is a private information of the m^{th} farmer and cannot be observed by the government (and neither by all other farmers). So, the government does not know which levels of *s* and *G* lead to a certain production of OC. Given the information asymmetry, farmers may have an incentive not to reveal their true type in order to obtain higher direct payments. So, the governmental support program should be designed as such that it provides an incentive to farmers who decide to join the program and grow OC, to report their reservation subsidy and (therefore indirectly their type) truthfully. In their study on conservation contracts Latacz-Lohmann and Van der Hamsvoort (1997) proposed using an auction as such a mechanism. The design of such an auction is extremely important. See Klemperer (2002) for an overview of issues. A sealed-bid auction is less prone to collusion among participants then an open auction.

The second-price sealed-bid multiple object (Vickrey) auction and related forms have the advantage over first-price auctions that they are less susceptible to over- or underbidding because of the separation of the bid and the price (e.g., Krishna (2002), chapter 12). In other words, participants have an incentive to reveal their true values, in our case their true reservation subsidy for switching.

Note that in the discriminatory first-bid sealed auction proposed by Latacz-Lohmann and Van der Hamsvoort (1997), where each participant receives his personal bid, farmers will not report their true reservation subsidies because of this tendency of overbidding. Shogren et al. (2001) indicate that a remaining problem with second-price auctions is that participants that expect their bids to be far from the auction outcome will not bid in a serious way. As a solution to this they propose the so-called n^{th}-price auction.

The auction mechanism used in our setting is based on this n^{th}-price auction and results in a uniform subsidy for all farmers that will participate in the end. This is because application of a system with differentiated subsidies per unit of land is expected to be politically infeasible and rejected as a non-equitable policy instrument. In this auction, the government offers multiple identical contracts to all farmers in the region. Specifically, each farmer who considers switching to organic farming is asked to report the level of her "reservation subsidy," $\tilde{s}_m(G)$, for a few predetermined levels of public services, *G*. If the actual subsidy chosen by the government, $s^*(\Theta, G)$ is strictly greater than $\tilde{s}_m(G)$, farmer *m* is required to plant all of her land to OC instead of TC, and the government is required to pay her the uniform subsidy $s^*(\Theta, G)$. The reservation subsidy of the first unsuccessful bid is greater than or equal to $s^*(\Theta, G)$. In other words, $s^*(\Theta, G)$ is lying strictly above the highest successful bid and below the lowest unsuccessful bid. The difference with the n^{th}-price sealed bid auction discussed by Shogren et al. (2001) is that the n^{th}-price is not determined randomly but is the outcome of the government optimisation problem (see below). However, since the farmers do not and cannot know the outcome of the government optimisation problem for them it's equal to a random n^{th}-price auction.[3]

Shogren et al. (2001) proved that in the n^{th}-price sealed bid auction it is optimal for all participants to bid their true reservation value. This proof is adopted for our analysis and can be summarised as follows. Define AS_m as the surplus of the auction:

$$AS_m = \begin{cases} W_m^1\left(s^*(\Theta, G)\right) - W^0 & \text{if} \quad \tilde{s}_m(G) < s^*(\Theta, G) \\ 0 & \text{if} \quad \tilde{s}_m(G) \geq s^*(\Theta, G) \end{cases} \tag{11}$$

In other words, if the farmer's subsidy bid is strictly lower than the outcome of the auction, the farmer is in the program and earns a surplus. If the subsidy bid is higher than or equal to the final subsidy level, the farmer remains growing TC and his surplus is zero. Now what happens if a farmer overbids? In that case there is a chance that the final subsidy chosen by the government ($s^*(\Theta, G)$) will be higher, but only if the overbidding farmer is the first unsuccessful bid (she is then the one effectively raising the subsidy), which implies that the farmer will not participate, hurting herself. If the overbidding farmer is not the first unsuccessful bid the final subsidy is the same and it doesn't affect AS_m. The final subsidy can never be lower due to overbidding. What happens in the case of underbidding? Then there is a positive probability that the farmer is in the program, receiving a subsidy that is lower than her reservation subsidy, so the farmer would make a loss. If there is a higher first unsuccessful bid, the farmer will still receive this level, so underbidding would not affect the surplus. So, there is no reason for the farmer to overbid or underbid. In other words, truthful revelation is a strong dominating strategy for each farmer.

2.3 Optimal Governmental Choice

The government wishes to maximise social surplus from agricultural production of traditional and organic crops. For a given level of *G*, the government's optimisation problem can be formally stated as

$$\underbrace{\max}_{s^*(\Theta)} SW = M \cdot \int_{\theta^*(s^*,G)}^{\bar{\theta}} \theta_m \cdot [\bar{\pi}^1(G) - 0.5\theta_m \cdot \gamma V_\pi(G)] f(\theta_m) d\theta_m$$
$$+ TA^{TC}(s^*,G) \cdot (W^0 / a) + J[TA^{OC}(s^*,G)] - \delta \cdot G$$
$$- \delta \cdot TA^{OC}(s^*,G) \cdot s^* \qquad (12)$$

where the threshold-type $\theta^*(s^*,G)$ is determined by the type of the farmer with the highest successful bid (threshold-farmer), δ is the marginal deadweight loss from distortionary taxes of raising the government payments and $J[\cdot]$ is an increasing, strictly concave and twice differentiable money-metric social value function defined on total area planted for OC. For the ease of analysis, it is further assumed that θ_m is uniformly distributed, i.e. $f(\theta_m) = \dfrac{1}{\Delta\theta}$ where $\Delta\theta = \bar{\theta} - \underline{\theta}$.

Utilising Leibniz rule for differentiation of integrals, recalling that $aM = A$, and assuming an internal solution, the first order condition is:

$$\partial SW / \partial s^* = (\Delta\theta)^{-1} \cdot A \cdot \frac{\partial\theta^*(s^*,G)}{\partial s^*} \{[\frac{1}{a}[W^0 - \theta^*(s^*,G) \cdot [\bar{\pi}^1(G) - 0.5\theta^*(s^*,G) \cdot \gamma V_\pi(G)]]$$
$$+ \delta s^* - J^{'}(\bullet)\} - \delta \cdot TA^{OC}(s^*,G) = 0$$

where J' is the partial derivative of J. Noting from equation (6) and Figure 1 that

$$s^*(G) = \frac{1}{a} \cdot \{W^0 - \theta^* \cdot [\bar{\pi}^1(G) - 0.5\theta^* \cdot \gamma V_\pi(G)]\}$$

and noting from (9) and (10a,b) that

$$\frac{\partial TA^{OC}}{\partial s^*} = -\frac{\partial TA^{TC}}{\partial s^*} = -(\Delta\theta)^{-1} \cdot A \cdot \frac{\partial\theta^*(s^*,G)}{\partial s^*} > 0, \qquad (13)$$

the above first order condition can be rewritten as:

$$\partial SW / \partial s^* = \frac{\partial TA^{OC}(s^*,G)}{\partial s^*} \cdot [J^{'}(TA^{OC}(s^*,G)) - (1+\delta)s^*] - \delta \cdot TA^{OC}(s^*,G) = 0 \qquad (14)$$

or

$$\partial SW / \partial s^* = \frac{\partial TA^{OC}(s^*,G)}{\partial s^*} \cdot [J^{'}(TA^{OC}(s^*,G)) - s^*] - \frac{\partial[\delta \cdot TA^{OC}(s^*,G) \cdot s^*]}{\partial s^*} = 0 \qquad (14a)$$

It can be easily verified that the second order condition, $\partial^2 SW / \partial s^{*2} < 0$ is satisfied. Note that the condition in (14) can be satisfied only if $J^{'}(TA^{OC}(s^*,G)) > (1+\delta)s^*$, as we assume hereafter.

The first term on the right hand side of (14a) is the marginal benefits to society from a marginal increase in the subsidy per hectare planted for OC. Specifically, it is equal to the increase in the number of hectares enrolled in the program, $\dfrac{\partial TA^{OC}(s^*,G)}{\partial s^*}$, times the net marginal benefits of an additional hectare planted for OC. The latter is equal to the marginal increase in the social value function, $J^{'}(TA^{OC}(s^*,G))$, minus $s^*(G)$ which equals the marginal loss of farm income due to the substitution of TC by OC (see (6)). The second term on the right hand side of (14a) is the marginal increase in the total dead-weight loss from distortionary taxes of raising tax revenues to support the government payment.

2.4 Comparative statics

Let s^* be the subsidy level that solves (14). In this subsection we conduct analyse the comparative statics of the model via complete differentiation of (14) with respect to G, $\Delta\theta$, δ, and γ and utilisation of (9) and (13). The results are detailed below where (-) and (+) represents negative and positive signs, respectively:

$$sign\left\{\frac{\partial s^*}{\partial G}\right\} = sign\left\{\underbrace{\frac{\partial[\partial TA^{OC}/\partial s^*]}{\partial G}}_{(-)}\underbrace{[J^{'}(\cdot)-(1+\delta)s^*]}_{(+)}+\underbrace{\frac{\partial TA^{OC}}{\partial s^*}}_{(+)}\underbrace{[\underbrace{J^{''}(\cdot)}_{(-)}\underbrace{\frac{\partial TA^{OC}}{\partial G}}_{(+)}]}_{(-)}-\delta\cdot\underbrace{\frac{\partial TA^{OC}}{\partial G}}_{(+)}\right\}<0 \quad (15a)$$

To evaluate the impact of $\Delta\theta \equiv \overline{\theta}-\underline{\theta}$ note that it can be increased by either increasing $\overline{\theta}$ by $\varepsilon(>0)$, decreasing $\underline{\theta}$ by $\varepsilon(>0)$ or making both changes simultaneously. We choose to apply the third alternative, which implies a mean preserving spread in the distribution of farmers' types. Specifically, we assume that $\theta \in [\underline{\theta}-\varepsilon, \overline{\theta}+\varepsilon] \rightarrow \Delta\theta = \overline{\theta}-\underline{\theta}+2\varepsilon.$ The mean, the variance and the cumulative density function of θ are given by $E\theta = (\underline{\theta}+\overline{\theta})/2,\ Var(\theta) = (\overline{\theta}-\underline{\theta}+2\varepsilon)/12$ and $F(\theta) = (\theta-\underline{\theta}+\varepsilon)/(\overline{\theta}-\underline{\theta}+2\varepsilon)$, respectively. An increase in ε increases $\Delta\theta$ and the variance but does not affect the mean. It can be easily verified that $\text{sign}\{\frac{\partial F}{\partial\varepsilon}\} = sign\{\overline{\theta}+\underline{\theta}-2\theta\}$ is positive (negative) if $\theta^* \le E\theta$ ($\theta^* > E\theta$). If $\theta^*(s^*, G)$ is smaller than the mean of θ, (implying that in the optimal solution, more than 50% of the total area is planted to OC), the sign of $\partial TA^{OC}/\partial\varepsilon$ becomes positive and the impact of ε on $\tilde{s}^*$ is positive. However, if θ^* is larger than $E\theta$, the sign of $\partial TA^{OC}/\partial\varepsilon$ is indeterminate and the impact of ε on $\tilde{s}^*$ becomes indeterminate:

$$sign\left\{\frac{\partial s^*}{\partial \varepsilon}\right\} = sign\left\{\underbrace{\frac{\partial[\partial TA^{OC}/\partial s^*]}{\partial \varepsilon}}_{(+)}\underbrace{[J^{'}(\cdot)-(1+\delta)s^*]}_{(+)}+\underbrace{\frac{\partial TA^{OC}}{\partial s^*}}_{(+)}\underbrace{[\underbrace{J^{''}(\cdot)}_{(-)}\underbrace{\frac{\partial TA^{OC}}{\partial \varepsilon}}_{(?)}]}_{(?)}-\delta\underbrace{\frac{\partial TA^{OC}}{\partial \varepsilon}}_{(?)}\right\} \quad (15b)$$

$$= \begin{cases} \text{Indeterminate if } \theta^* > E\theta \\ >0 \qquad\qquad \text{if } \theta^* \le E\theta \end{cases}$$

The impacts of marginal dead-weight loss is

$$sign\left\{\frac{\partial s^*}{\partial \delta}\right\} = sign\left\{-\frac{\partial TA^{OC}}{\partial s^*}\cdot s^* - TA^{OC}\right\}<0 \qquad (15c)$$

The impact of the absolute measure of risk aversion depends, among other things, on the sign of $\partial TA^{OC}/\partial\gamma$, which is expected to be negative. Assuming that this sign is indeed negative, we get

$$sign\left\{\frac{\partial s^*}{\partial \gamma}\right\} = sign\left\{\underbrace{\frac{\partial[\partial TA^{OC}/\partial s^*]}{\partial \gamma}}_{(+)}\underbrace{[J^{'}(\cdot)-(1+\delta)s^*]}_{(+)}+\underbrace{\frac{\partial TA^{OC}}{\partial s^*}}_{(+)}\underbrace{[\underbrace{J^{''}(\cdot)}_{(-)}\underbrace{\frac{\partial TA^{OC}}{\partial \gamma}}_{(-)}]}_{(+)}-\delta\underbrace{\frac{\partial TA^{OC}}{\partial \gamma}}_{(-)}\right\} > 0 \quad (15d)$$

3. Data and calibration of the empirical model

The theoretical model developed in section 2 is applied using data from the province of Flevoland in the Netherlands. The area consists of about 80000 ha of land used for arable farming, which is about 75% of the total agricultural land in the area. The soil type in the region is clay which is suitable for organic farming. So, agronomic conditions do not prevent farmers from switching. In the region there are already a number of organic arable farms.

To calibrate the model, data of specialized arable farms covering the period 1990-1999 are used. These data are obtained from the Dutch farm accounting data network (FADN) operated by WUR-LEI. The dataset consists of 110 traditional farms having 473 observations in total and 22 organic farms with 90 observations. These observations are used to calculate mean ($\bar{\pi}^1(G)$) and variance ($V_\pi(G)$) used in the model. The values for *A, a* and W^0, were also directly calculated using the data at hand. The Arrow-Pratt coefficient of absolute risk aversion (γ) is based on an estimated unit-free coefficient of relative risk aversion of 0.20 using the same data for traditional arable farmers (Oude Lansink, 1999). Dividing by the average profits per organic farm (1.77), gives a measure of of 0.113. The deadweight loss parameter (δ) is based on a study by Alston and Hurd (1990) who argue that the marginal social welfare cost of spending is between 0.20 and 0.50. We took the average value of 0.35. The parameter values are reported in Table 1.

The application additionally requires the specification of the governmental social-value function $J(TA^{OC})$ and the calibration of a few parameters. Recalling that *J* is assumed to be an increasing, strictly concave and twice differentiable function of $J = (TA^{OC})^\alpha$ where $0 < \alpha < 1$, is the elasticity of the social-value function from the area planted for OC.

In the absence of data on the parameters $\underline{\theta}$, $\bar{\theta}$ and α we calibrated them as follows:

1. First, based on our data set we assumed the **lowest** level of the certainty equivalent profits per-farm (without a subsidy) in the region to be 0.4x10^5 € per farm. Namely, (see (4)) $\underline{\theta}\cdot[\bar{\pi}^1(G)-0.5\underline{\theta}\cdot\gamma V_\pi(G)]=0.4$. Substituting for $\bar{\pi}^1(G)$, γ and $V_\pi(G)$ (Table 1), yields $\underline{\theta}=0.3$.
2. Second, given $\underline{\theta}$, we utilized the actual level of subsidy in 1999 ($s^* = 227$ € /ha) and equation (6) to calculate its corresponding level of θ^*. Then, given θ^*, we utilized the actual area in the region planted for OC in 1999 ($TA^{OC} = 5097$ ha) and equation (10a), ($TA^{OC}(s^*,G) = A[1-F(\theta^*(s^*,G))]$), to calibrate for $\bar{\theta}(=0.90)$. The remaining parameter to be calibrated is α
3. Finally, we utilized the specification of the governmental social-value function J, substituted $J' = \alpha(TA^{OC})^{\alpha-1}$ into the first order condition for optimal subsidy in (14) to calibrate for $\alpha(=0.433)$.

The calibrated values are also reported in Table 1.

Table 1. Basic parameter values.

Parameter	Description	Units	Value
A	Total size of arable land in the province of Flevoland	Hectares	80,000
a	Average size of arable farm in the area	Hectares	48.5
W^0	Average annual profits of traditional farms	10^5 € of 1999	1.25
$\bar{\pi}^1(G)$	Annual equivalent of stream of future certainty equivalent profits	10^5 € of 1999	1.358
$V_\pi(G)$	Average variance of profits		0.724
γ	Arrow-Pratt coefficient of absolute risk aversion		0.113
δ	Deadweight loss parameter		0.35
$\underline{\theta}$	Lower bound for type		0.30
$\bar{\theta}$	Upper bound for type		0.90
α	Coefficient of exponential function for J		0.433

4. Results

This section describes the results of the sensitivity analysis performed with the empirical model. This analysis shows the changes in the optimal solution of the government's problem if one of the parameters changes while the others are kept constant. This indicates the relative importance of differences in specific model parameters. The results of the sensitivity analysis are given in table 2. The direction of the results are in line with the comparative statistics of section 2.4. Therefore, interest is more on the size of the effects caused by different values for individual model parameters. Note that in calculating total social welfare (*SW*) the deadweight loss associated with public expenditure on *G* is not taken into account. The reason for this is that there is no data available on yearly expenditure on *G*.

Table 2. Results of sensitivity analysis.

Scenarios	Area of OC planted TA^{OC} (ha)	Subsidy per ha $\tilde{s}$ (€/ha)	Total subsidy $TA^{OC}\cdot\tilde{s}$ (10^5 €)	Deadweight loss (10^5 €)	SW from OC* (10^5 €)	SW from TC** (10^5 €)	Total SW*** (10^5 €)
Base-case	5097	227.00	11.57	4.05	158.60	1930.48	2089.08
$\alpha = 0.5$	9861	321.95	31.75	11.11	320.28	1807.70	2127.98
$\alpha = 0.65$	41,186	951.69	391.96	137.19	1702.04	1000.37	2702.41
$\gamma = 0.25$	3831	279.42	10.70	3.75	121.23	1963.11	2084.34
$\delta = 0.50$	4495	215.01	9.66	4.85	141.50	1946.00	2087.50
$\bar{\pi}^1(G)\uparrow 10\%$ $V_\pi(G)\downarrow 10\%$	10,724	104.54	11.21	3.92	329.54	1785.47	2115.01
$\bar{\pi}^1(G)\uparrow 5\%$ $V_\pi(G)\downarrow 10\%$	7770	156.98	12.20	4.27	238.49	1861.59	2100.08
$\bar{\pi}^1(G)\uparrow 10\%$ $V_\pi(G)\downarrow 5\%$	10,660	105.59	11.26	3.94	327.52	1787.10	2114.62
$\underline{\theta} = 0.20$ $\bar{\theta} = 1.00$	9508	112.62	10.71	3.75	295.29	1816.80	2112.09
$\underline{\theta} = 0.40$ $\bar{\theta} = 0.80$	2042	418.52	8.55	2.99	68.47	2009.23	2077.70

* Social welfare from OC is calculated as $M\cdot\int_{\theta^*(\tilde{s},G)}^{\bar{\theta}}\theta\cdot[\bar{\pi}^1(G)-0.5\theta\cdot\gamma V_\pi(G)]f(\theta)d\theta-\delta\cdot TA^{OC}(G,\tilde{s})\cdot\tilde{s}+J[TA^{OC}(G,\tilde{s})]$

** Social welfare from TC is calculated as $TA^{TC}(G,\tilde{s})\cdot(W^0/a)$

*** Actual social welfare should be somewhat lower since the calculation does not take the deadweight loss on *G* into account.

The second and third rows of table 2 show that different values of α, the elasticity of the social welfare function with respect to area planted with OC, have a significant impact on the socially optimal outcome. With an elasticity of 0.5 instead of the original 0.433 that reflects the current valuation of OC by the government, the optimal per hectare subsidy goes up by 41.8%, to 321.95 and the area planted with OC nearly doubles. Since more utility is derived from OC and the deadweight loss of the higher subsidy increases only slightly, social welfare goes up about 2%. When α is set to 0.65, the optimal subsidy and area planted increase dramatically. Not surprisingly, total social welfare is high despite the relatively large deadweight loss. Also note that total subsidy is about 34 times as high as in the base scenario. From this two simulations we can learn that the optimal subsidy level depends very much on the social valuation of OC by the government.

A higher degree of risk aversion among farmers has some mixed effects as shown by the results for $\gamma = 0.25$, which is more than twice the base Arrow-Pratt coefficient[4]. Since farmers are more risk averse, they consider the risky OC as less attractive reflected by higher reservation subsidies $\tilde{s}$. These overall higher reservation subsidies lead to a higher subsidy of 279 set by government and a total acreage of 3831, which is of course lower than the base acreage. Note that because of the higher subsidy per hectare and less hectares converted, total subsidies do not decrease much. Also the welfare effects are low.

A higher deadweight loss parameter δ leads to a lower optimal subsidy level as expected from equation (15c). The effects are however relatively small, with the subsidy only 12 euros less per hectare and only 500 hectares less converted to OC. Social welfare levels are also not affected much, so we can say that the level of deadweight loss does not have a big impact on the results.

It is assumed that $\bar{\pi}_t^1(G)$ increases in *G* and $V_\pi(G)$ decreases in G. But, lack of yearly data on *G* it was not possible to quantify the relationships between *G* and $\bar{\pi}_t^1(G)$ and $V_\pi(G)$ empirically, e.g. using regression techniques. However, in order to examine how changes in *G* can affect the optimal social outcome, we increased $\bar{\pi}_t^1(G)$ by 10% and decreased $V_\pi(G)$ by 10%. Interestingly, the results are rather sensitive to this change. The final subsidy is more than halved and the area planted with OC more than doubled. In order to know whether these dramatic effects are due to the increase in $\bar{\pi}_t^1(G)$ or the decrease in $V_\pi(G)$, we did analysed two more scenarios. In the first, $\bar{\pi}_t^1(G)$ only rose by 5% and $V_\pi(G)$ still decreased by 10%. In the second we turned the effects the other way around. From these two scenarios it follows that changes in $V_\pi(G)$ do not have a big effect on the results. Shifts in optimal subsidy and area planted are mainly due to changes in average profits.

Finally, we applied a mean-preserving spread on the uniform distribution of θ. First, we widened the range of θ, implying more heterogeneity in suitability of growing OC. This results in a bigger spread in the set of reservation subsidies. The optimal subsidy is now only 112.62, but more than nine and half thousand hectares are grown with organic crops. Less heterogeneity in the types has the opposite effect as shown by the last row of table 2. With an optimal subsidy of 418.52 euros per hectare, still only 2042 hectares are grown with organic. The small acreage for OC leads to low social welfare from OC and low overall social welfare. From these results it follows that suitability of growing organic crops has a big impact on switching decisions.

5. Concluding Remarks

This paper develops a model to determine the optimal mix of a direct income support policy and providing public services both aimed at stimulating organic farming. Direct income support has a positive effect on the income of farmers that grow organic crops, whereas the public services both raise income and reduce the variability of yearly revenues. Heterogeneous suitability for growing organic crops is explicitly taken into account. An important element is the inclusion of a n^{th}-price auction that induces farmers to truthfully reveal their reservation subsidy for switching to organic crops. The theoretical model is applied using data from the province of Flevoland in the Netherlands.

Conclusions that can be drawn from the analysis are that the optimal direct per hectare subsidy is decreasing in the provision of general services, decreasing in the spread of types of farmers, decreasing in the marginal deadweight loss and increasing in the elasticity of the social welfare function as well as in the absolute measure of risk aversion.

We believe that the suggested mechanism to elicit the truthful revelation of farmers' reservation subsidies for various levels of complementary public services is simple to apply and can be operated at low costs. Moreover, the information acquired by the government will enables her to improve the decision making process relative to the current situation under which subsidy levels are set in an ad-hoc fashion.

Obviously, the analysis is partial and includes a few caveats and simplified assumptions. Quantifying the relationships between the mean and variance of profits from growing OC and the provision of public services, identifying and estimating the parameters of the distribution of farmers' types and explicitly accounting for variable land size, are directions into which the current analysis can be profitably extended.

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Endnotes

[1] The option to switch back and forth between crops is rejected a priori since this would lead to repeated losses in yields and investments made.

[2] To guarantee that $\partial \tilde{s}_m / \partial \theta_m$ is negative for the whole range of θ_m 's values we assume that $\bar{\theta} \leq \bar{\pi}^1(G) / \gamma V_\pi(G)$.

[3] Since there are many/multiple farmers participating it is impossible for any farmer to know all the bids of the other farmers in order to mimic the government optimization problem.

[4] Since the values for $\underline{\theta}$ and $\bar{\theta}$ were calibrated using $\gamma = 0.113$, we also did a sensitivity analysis with higher γ and recalibrated values for $\underline{\theta}$ and $\bar{\theta}$. Although the results differed in size, the directions were similar.