Stimulating organic farming via publicly provided services and an auction-based subsidy

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Summary
Governments generally use a mix of temporary hectare payments and provision of public services to stimulate the organic crop 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 results of this auction are used to determine the government’s optimal policy choices.

Keywords: auctions, organic farming, policy mix

JEL classification: Q28, Q12

1. Introduction
Organic farming has received considerable attention in European countries in recent years. In their search for a more sustainable agriculture, producers, consumers and policymakers have rediscovered organic farming. Consumption and the number of producers have increased rapidly in most countries, although market shares are still modest. Policymakers in a number of European countries have set ambitious goals for the organic sector. In the Netherlands, for example, the government has stated that, by 2010, 10 per cent of total farmland should be used for organic farming (Ministry of Agriculture, Nature and Food Quality, 2004: 11). EU governments believe that organic products respond to consumer concerns and therefore market development should be stimulated. As well as better quality food of a perceived higher level of food safety, organic production methods also deliver public goods...
related to the environment, rural development and animal welfare and should therefore be supported by the society (European Commission, 2004).

In order to stimulate the development of the organic sector, the Dutch government has used 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 per 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 compensation for production losses during the early years of organic production. Since 2005, the emphasis on providing these subsidies has been more on rewarding the positive externalities arising from organic methods. The public services provided include generic marketing activities, dissemination of information, publicly funded research, support for market integration and so on [see Marshall (1991) for an overview of different technical support measures with a public good nature]. These services are typical public inputs. Individual organic farmers benefit from them, but individual farmers would never pay for them given their non-excludability and non-rivalness. The provision of the aforementioned public services is also supported by the European Action Plan for Organic Food and Farming (European Commission, 2004) when it states that further growth of the organic sector should be supported by improving information provision, embedding organic support in rural policies and harmonising standards and requirements within the EU. Both direct payments and public services have the same objective: stimulating the growth of the organic sector. With direct payments, more farms may switch, which would lead to a larger scale of organic production. These sectoral economies of scale could lead to potentially lower consumer prices, which would further increase the organic sector. As indicated in the European Action Plan, growth of the sector could also be stimulated by better facilities, justifying the provision of public services. Lampkin et al. (2000) stressed that both direct producers support and public support policies are essential for the growth of the organic sector.

Over the years, the Dutch government has made remarkable shifts in this policy mix. A direct income payment per hectare for organic crop farmers in transition, introduced in 1994, was paid for the last time (at a lower rate) in 2002. The government’s reason for abolishing this area-based payment scheme was that it wanted to stimulate the organic sector, but not via subsidies. In line with the European Action Plan for Organic Food and Farming (European Commission, 2004), the view was that market perspectives should guide farmers in their switching decisions. However, after the growth in the number of organic farms stagnated in 2003, the government decided in 2004 to use the income support instrument again. In 2005, a new hectare-based direct income support system was introduced. With the reduction in direct income support, the provision of public services became relatively more important over time. In 1998, the Dutch government started advertising campaigns for organic products. Currently, the greater part of
the budget for stimulating organic farming is allocated to research, education and information dissemination.

Using Swedish farm-level data, 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, but their paper does not take risk into account. In a study of individual switching decisions, Pietola and Oude Lansink (2001) did account for uncertainty in organic revenues. However, they focused only on the role of direct payments as a means of stimulating organic farming. Both these papers study farm-level decisions without explicitly taking the optimal role of the government into account. Häring et al. (2004) showed how direct payments and provision of public services fit into the second pillar of the EU Common Agricultural Policy and how different policies affect both organic and non-organic farms.

The model developed in this paper determines 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 their reservation subsidy is. The structure of this auction mechanism motivates farmers to reveal their true reservation subsidies for switching to organic farming. The farm-level reservation subsidies are used by the government in determining its optimal policy settings. The sensitivity of the socially optimal subsidy and of its associated level of organic farming to various parameters is also examined. The theoretical approach is applied using data from the province of Flevoland in the Netherlands.

The rest of the paper is organised as follows. In Section 2, the conceptual framework is developed; here, the farmer’s decision problem and the government’s optimisation 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 Dutch province of Flevoland and the calibration of the empirical model. Section 4 gives the results of a sensitivity analysis indicating how optimal subsidy levels and total area planted change when key model parameters are different. Section 5 presents our concluding remarks.

2. Conceptual framework

2.1. The farmer’s problem

Assume an agricultural area of $A$ ha, owned by a large number of farmers ($M$), each cultivating an area of $a$ ha ($aM = A$). On the basis of the observed behaviour of Dutch farmers in recent years, we assume that all the land of a specific farm is utilised either for traditional crops (TCs) or for organic crops (OCs), for a predetermined time horizon of $T$ years. The option to switch back and forth between crops is excluded a priori, since this would lead to repeated losses in yields and investments made.
assumption that currently \((t = 0)\) each farmer grows TCs, 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 their land for growing OCs. Formally, we assume that the specific characteristics of the \(m\)th farm(er) (hereafter called ‘farmer type’) are denoted by \(\theta_m \in [\theta, \bar{\theta}], m = 1, \ldots, M\), with cumulative distribution given by \(F(\theta_m), [F(\theta) = 0\) and \(F(\bar{\theta}) = 1]\), and a strictly positive and differentiable density function, \(f(\theta_m)\).

The vector of farmer types is given by \(Q = (u_1, u_2, \ldots, u_M)\). Farmer type is private information and is not known to the government or to other farmers.

The farmer considers the option of switching from TCs to OCs. The profit associated with OCs varies over time and is assumed to be random, due to combined variability in yields and prices. Padel and Lampkin (1994a: 216) reported evidence of greater variability in crop yields with OCs. Lack of opportunity to intervene with fertiliser or pesticides increases the risk of crop failure. Lammerts van Bueren et al. (2002) showed that, in the Netherlands, yield variability is indeed higher for OCs relative to TCs. Besides production risks, OCs are also more prone to market risks, since the small scale of organic markets can lead to greater fluctuations in demand and supply. Moreover, higher prices for OCs may lead to a drop in demand in times of economic depression. In the absence of public intervention, the expected profit per farm associated with OCs is lower than the certain and fixed\(^3\) profit from TCs, \(W^0\), in the first few years of the planning horizon, but then it gradually increases to levels in excess of \(W^0\) before the end of this horizon (Padel and Lampkin, 1994b: 304).

The government is interested in increasing the total area planted with OCs because of the environment-friendly production methods used. It uses a combination of two policy instruments to encourage farmers to switch to OCs. The first instrument is a direct compensation payment of \(s(Q)\) per hectare planted with OCs. 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 who decide to grow OCs since individually differentiated subsidies are assumed to be politically infeasible.\(^4\) The level of the subsidy is a function of the distribution of the

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\(^2\) In principle, farm heterogeneity can also be attributed to the variability of farm size. For the sake of simplicity and without loss of generality, we assume here that, in the relevant range of agricultural plots, production exhibits constant return to scale with land regardless of crop planted and that all farms are of an equal size.

\(^3\) The assumption that farmers do not vary with respect to growing TCs is made for simplicity and its removal will not affect our main results and conclusion. However, as pointed out by an anonymous referee, the government could use the available information from the variability of TCs (even if the variability is low) to infer something about the farmer’s type.

\(^4\) Note that in the Netherlands, there is some differentiation in hectare subsidies over sectors. For example, arable farmers receive lower subsidies per hectare than horticultural firms. However, within a given sector, subsidies per hectare are, in principle, uniform. At the individual level, subsidies vary over time, i.e. they are higher in the first year than in subsequent years. Our analysis takes this into account by focusing on annual equivalent subsidies based on the whole subsidy period. A third issue is that there is an upper limit to the total amount of subsidies a farm can receive. For farms that switch a large area of land, this might effectively reduce the subsidy per hectare. This feature does not play a role in our analysis, since we assume each farm cultivates a hectares of land.
types of farmers. The second instrument is public services defined in terms of expenditure ($G$ euros) for the whole organic sector. Examples of services relevant for our analysis include information gathering and dissemination, lowering transaction costs associated with the production switch, assisting in advertisement and marketing plans and so on. A major contribution of these public services is the reduction of farm-level risks associated with adopting OCs. Only farmers who choose to switch from TCs to OCs can benefit from the public services provided by $G$. In the absence of direct payments, the random profit per farm of farmer $m$ in year $t$ is given by $\theta_m \pi_t^1 (G)$, with mean and variance equal to $\theta_m \bar{\pi}_t^1 (G)$ and $\theta_m^2 V_{\pi_t} (G)$, respectively. With subsidy, the profit per farm for OCs, for the first $t \leq \hat{t}$ years of the time horizon, is $\Pi_{t,m}^1 (\theta_m, s(\Theta), G) = \theta_m \pi_t^1 (G) + as(\Theta)$, with mean and variance given by

$$\Pi_{t,m}^1 = \begin{cases} \theta_m \bar{\pi}_t^1 (G) + as(\Theta), & \text{if } t \leq \hat{t} \\ \theta_m \pi_t^1 (G), & \text{if } \hat{t} < t \leq T, \end{cases}$$

(1)

and

$$\text{Var}(\Pi_{t,m}^1) = \theta_m^2 V_{\pi_t} (G),$$

(2)

respectively, where $\bar{\pi}_t^1$ is the expected value of $\pi_t^1$. Expected profit increases in both $s$ and $G$, while its variance decreases in $G$. Recognising that a decision to switch to OCs is a typical long-term decision and that there is variability in OC profits, it is assumed that farmers maximise the future stream of the utility of expected profits. We assume that each farmer is risk-averse, with utility function $U_m(\cdot)$ defined on wealth that 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\(^5\) and in order to make the analysis more tractable, we approximate the expected utility from farm-level profits by a certainty-equivalent profit defined by:

$$\Pi_{t,m}^{1,CE} = \Pi_{t,m}^1 - 0.5 \gamma \text{Var}(\pi_t^1),$$

(3)

where $\gamma = -U_m''/U_m'$ 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

$$W_m^1 (\theta_m, s(\Theta), G) = \theta_m [\bar{\pi}_1^1 (G) - 0.5 \theta_m \gamma V_{\pi_t} (G)] + aH(r) \sum_{i=1}^{\hat{t}} \frac{s(\Theta)}{(1 + r)^t},$$

(4)

where
\[
\tilde{\pi}^1(G) = H(r) \sum_{t=1}^{T} \frac{\pi^1_t(G)}{(1 + r)^t}, \quad V_\pi(G) = H(r) \sum_{t=1}^{T} V_{\pi_t}(G)/(1 + r)^t,
\]
r is the annual real interest rate and \(H(r) = r(1 + r)^T/(1 + r)^T - 1\) is a capital recovery factor that produces an annuity value when multiplied by a present value. Given the level of the policy instruments, \(s(\Theta)\) and \(G\), \(W_{m1}(\cdot)\) is assumed to increase in the farmer’s type, namely:
\[
\frac{\partial W_{m1}(\cdot)}{\partial \theta_m} = \tilde{\pi}^1(G) - \theta_m \gamma V_\pi(G) > 0. \tag{5}
\]
It can be easily verified that \(W_{m1}(\cdot)\) increases in both \(G\) and \(s\).

In the absence of government intervention, \((s = G = 0)\), it is assumed that \(W^0 > W_{m1}(\cdot) \forall m\) for every \(\theta_m \in [\theta, \bar{\theta}]\). In other words, without government intervention, no farmer in the region will quit growing TCs and start growing OCs 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 have switched to OCs in the Netherlands.

For a given level of \(G\), there exists a level of the annual-equivalent direct hectare payment, \(\tilde{s}_m(G)\), further denoted as the reservation subsidy of the \(m\)th farmer, under which the farmer is indifferent between the two types of crops:
\[
\tilde{s}_m(G) = \frac{1}{a} \left\{ W^0 - \theta_m [\tilde{\pi}^1(G) - 0.5 \theta_m \gamma V_\pi(G)] \right\} \tag{6}
\]
Differentiating equation (6) with respect to the type of the farm yields
\[
\text{sign} \left\{ \frac{\partial \tilde{s}_m}{\partial \theta_m} \right\} = -\text{sign} \left\{ \frac{\partial W_{m1}(\cdot)}{\partial \theta_m} \right\} < 0 \tag{7a}
\]
(see equation (5),7)

Since \(\tilde{\pi}^1(G)\) increases in \(G\) and \(V_\pi(G)\) decreases in \(G\), it can be easily verified that
\[
\frac{\partial \tilde{s}_m}{\partial G} < 0, \tag{7b}
\]
indicating that the two policy instruments are substitutes.

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6 \(\tilde{\pi}^1(G)\) and \(V_\pi(G)\) are the annuitised values (over years 1, 2, \ldots, \(T\)) that correspond to the present values of \(\sum_{t=1}^{T} V_{\pi_t}(G)/(1 + r)^t\) and \(\sum_{t=1}^{T} \tilde{\pi}^1_t(G)/(1 + r)^t\), respectively.

7 \(\frac{\partial \tilde{s}_m}{\partial \theta_m} = \frac{1}{a} \tilde{\pi}^1(G) - \theta_m \gamma V_\pi(G)\). To guarantee that this derivative is negative for the whole range of \(\theta_m\) values \([\bar{\theta}, \hat{\theta}]\), we assume that \(\tilde{\theta} \leq \tilde{\pi}^1(G)/\gamma V_\pi(G)\). This implies that the more suitable a farm is for growing OCs (higher type), the lower its reservation subsidy for switching.
Given the levels of the policy instruments, $s(\Theta)$ and $G$, the farmer’s decision can be stated formally as follows:

If $W_m^1(\cdot) \geq W^0$ then $I^m(s, G) = 1$
If $W_m^1(\cdot) < W^0$ then $I^m(s, G) = 0$,  \hspace{1cm} (8)

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

For a given level of $G$, the total land area in the region that is planted to OCs depends on the actual level of $s$. For a formal description of this dependency, it is convenient to use a graphical presentation. On the basis of equations (6), (7a) and (7b), the set of reservation subsidies $\tilde{s}$ as a function of $\theta$ is depicted in Figure 1 for two levels of public services. With an actual annual subsidy of $s^*$ euros per hectare, all the farmers of type $\theta^*$ ($s^*, G$) and higher will start growing OCs, while all other farmers will keep growing TCs. Rewriting equation (6) for the ‘marginal farmer’ of type $\theta_m = \theta^*(s^*, G)$ and $\tilde{s}_m = s^*$ allows us to perform comparative statics, yielding:

$$\frac{\partial \theta^*}{\partial G} < 0, \quad \frac{\partial \theta^*}{\partial s^*} < 0, \quad \frac{\partial^2 \theta^*}{\partial s^*^2} > 0, \quad \frac{\partial^2 \theta^*}{\partial s^* \partial G} > 0, \quad \frac{\partial^2 \theta^*}{\partial G^2} < 0. \hspace{1cm} (9)$$

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

The total land areas planted to OCs and to TCs are given by equations (10a) and (10b), respectively:

$$TA^\text{OC}(s^*, G) = A[1 - F(\theta^*(s^*, G))] \hspace{1cm} (10a)$$
$$TA^\text{TC}(s^*, G) = AF(\theta^*(s^*, G)) = A - TA^\text{OC} \hspace{1cm} (10b)$$

![Figure 1](image-url: https://example.com/figure1)  

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

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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. However, in the current study, we focus on the determination of the (direct) per-hectare subsidy \(s^*\) by assuming that the level of public services, \(G\), has been predetermined already (via some political process that is exogenous to our analysis). Thus, \(G\) is hereafter treated as an exogenous parameter in our analysis.

The parameter \(u_m\), \([u, \bar{u}]\) is private information of the \(m\)th farmer and cannot be observed by the government (nor by any other farmer). So, the government does not know \textit{a priori} which level of \(s\) leads to a certain production of OCs. Given the information asymmetry, farmers may have an incentive not to reveal their true type in order to obtain higher direct payments. To overcome this problem, the government’s support programme should be designed such that it provides an incentive to farmers who decide to join the programme and grow OCs, to report their reservation subsidy truthfully (which will also reveal their types). In their study on conservation contracts, Latacz-Lohmann and Van der Hamsvoort (1997) proposed using an auction as a truth-revealing mechanism. The design of such an auction is extremely important; for example, a sealed-bid auction is less prone to collusion among participants than an open auction.\(^8\)

The second-price sealed-bid multiple object (Vickrey) auction and related forms have the advantage over first-price auctions in that they are less susceptible to over- or underbidding because of the separation of the bid and the price [see, for example, 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), in which each participant receives his personal bid, farmers will not report their true reservation subsidies because of this tendency to overbidding. Shogren \textit{et al.} (2001) indicated that a remaining problem with second-price auctions is that participants who 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 \textit{nth} price auction.

The auction mechanism used in our setting is based on this \textit{nth} price auction and results in a uniform subsidy for all farmers who end up participating. This is because the application of a system with individually differentiated subsidies per unit of land is expected to be politically infeasible. 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 his ‘reservation subsidy’, \(\hat{s}_m(G)\), for a predetermined level of public services, \(G\). If the actual subsidy chosen by

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\(^8\) See Klemperer (2004: 1–148) for an overview of issues.
the government, \( s^* (\Theta, G) \), is strictly greater than \( \tilde{s}_m (G) \), farmer \( m \) is required to plant all his land to OCs instead of TCs, and the government is required to pay him 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, \( s^* (\Theta, G) \) lies 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’s optimisation choice. However, since the farmers do not and cannot know the government’s optimal solution, for them it is equal to a random \( n \)th price auction.9

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. In the context of our analysis, this proof can be summarised as follows. Define \( AS_m \) as the surplus of the auction:

\[
AS_m = \begin{cases} 
W^1_m(s^*(\Theta, G)) - W^0 & \text{if } \tilde{s}_m(G) < s^*(\Theta, G) \\
0 & \text{if } \tilde{s}_m(G) \geq s^*(\Theta, G)
\end{cases}
\]  

(11)

In other words, if the farmer’s subsidy bid is strictly lower than the outcome of the auction, the farmer is in the programme and earns a surplus. If the subsidy bid is higher than or equal to the final subsidy level, the farmer remains growing TCs 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, which implies that the farmer will not participate, thereby hurting himself. If the overbidding farmer is not the first unsuccessful bid, the final subsidy is the same and it does not affect \( AS_m \). The final subsidy can never be lower due to overbidding. In the case of underbidding, there is a positive probability that the farmer is in the programme, receiving a subsidy that is lower than his 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. Therefore, there is no reason for the farmer to overbid or underbid. In other words, truthful revelation is a strong dominating strategy for each farmer.10

2.3. Optimal government choice

The government wishes to maximise the social surplus from the production of traditional and OCs. For a given level of \( G \), the government’s optimisation

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9 Since many farmers are participating, it is impossible for any farmer to know all the bids of the other farmers in order to mimic the government’s optimisation choice. Moreover, the government’s objective function in equation (12) is not fully observed by the farmers.

10 An anonymous referee pointed out that the auction described here resembles a uniform price auction with uncertain supply. Klemperer (2004: 105) indicated that, with many units auctioned, both auctions are analogous. Back and Zender (2001) showed that in a uniform price auction with many goods, the uncertainty about the final number of goods auctioned reduces the danger of collusion among bidders.
problem can be formally stated as\(^{11}\)

\[
\max_{s^*(\theta)} \text{SW} = M \int_{\theta'(s^*, G)} \theta_m[\tilde{\pi}(G) - 0.5\theta_m \gamma V_\pi(G)] f(\theta_m) d\theta_m \\
+ TA^{TC}(s^*, G) \left( \frac{W^0}{a} \right) + J[TA^{OC}(s^*, G)] - \delta G - \delta TA^{OC}(s^*, G)s^*
\]

(12)

where the threshold-type \(\theta^*(s^*, G)\) is determined by the type of the farmer with the highest successful bid (threshold-farmer), \(\delta\) is the marginal deadweight loss from distortionary taxes that fund the government payments and \(J[\cdot]\) is an increasing, strictly concave and twice differentiable money-metric social value function defined on total area planted to OCs. For ease of analysis, it is further assumed that \(\theta_m\) is uniformly distributed, that is,

\[
f(\theta_m) = \frac{1}{\Delta \theta}, \quad \Delta \theta = \bar{\theta} - \underline{\theta}.
\]

Utilising Leibniz’s rule for differentiating integrals, recalling that \(aM = A\), and assuming an internal solution, the first-order condition is:

\[
\frac{\partial \text{SW}}{\partial s^*} = (\Delta \theta)^{-1} A \frac{\partial \theta^*(s^*, G)}{\partial s^*} \\
\times \left\{ \left[ \frac{1}{a} [W^0 - \theta^*(s^*, G)[\tilde{\pi}(G) - 0.5\theta^*(s^*, G)\gamma V_\pi(G)] \right] + \delta s^* - J'(\cdot) \right\} \\
- \delta \cdot TA^{OC}(s^*, G) = 0,
\]

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

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

and from equations (9) and (10a) and (10b)) that

\[
\frac{\partial TA^{OC}}{\partial s^*} = - \frac{\partial TA^{TC}}{\partial s^*} = - (\Delta \theta)^{-1} A \frac{\partial \theta^*(s^*, G)}{\partial s^*} > 0,
\]

(13)

\(^{11}\) Currently, the formulation of the government’s objective function is based on the assumption that farm areas are identical (see footnote 2). Assuming that the farm-level area cultivated with OCs is not fixed but depends on the level of \(s^*\) would complicate the analysis significantly. At the farm level, it requires formulating an optimisation model that yields a derived demand function for land allocated to OCs as a function of \(s^*\); the farm-level derived demand functions are then substituted into the government’s objective function, thus increasing analytical complexity. However, doing so would not add much to our conceptual and empirical analyses.
the above first-order condition can be rewritten as:

\[ \frac{\partial SW}{\partial s^*} = \frac{\partial \text{TAOC}(s^*, G)}{\partial s^*} [J'(\text{TAOC}(s^*, G)) - (1 + \delta)s^*] - \delta \text{TAOC}(s^*, G) = 0 \]  \hspace{1cm} (14a)

or

\[ \frac{\partial SW}{\partial s^*} = \frac{\partial \text{TAOC}(s^*, G)}{\partial s^*} \left[ J'(\text{TAOC}(s^*, G)) - s^* \right] - \frac{\partial [\delta \text{TAOC}(s^*, G)s^*]}{\partial s^*} = 0 \]  \hspace{1cm} (14b)

The functional forms and the parameter values for \( J \) and \( f(\theta) \) are not observed by farmers and thus none of them can solve the optimisation problem in equation (12) to obtain equation (14a).

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

The first term on the right-hand side of equation (14b) is the marginal benefit to society from an increase in the subsidy per hectare planted to OCs. Specifically, it is equal to the increase in the number of hectares enrolled in the programme, \( \partial \text{TAOC}(s^*, G)/\partial s^* \), times the net marginal benefit of an additional hectare planted to OCs. The latter is equal to the marginal increase in the social value function, \( J'(\text{TAOC}(s^*, G)) \), minus \( s^*(G) \), which equals the marginal loss of farm income due to the substitution of TCs by OCs [see equation (6)]. The second term on the right-hand side of equation (14b) is the marginal increase in the total deadweight loss due to raising tax revenues to support the government payment.

2.4. Comparative statics

Let \( s^* \) be the subsidy level that solves equation (14a). In this subsection, we analyse the comparative statistics of the model via complete differentiation of equation (14a) with respect to \( G, \Delta \theta, \delta \) and \( \gamma \) and utilisation of equations (9) and (13). The results are detailed below where \((-)\) and \((+)\) represent expressions having negative and positive signs, respectively:

\[
\text{sign} \left\{ \frac{\partial s^*}{\partial G} \right\} = \text{sign} \left\{ \frac{\partial [\partial \text{TAOC}/\partial s^*]}{\partial G} \right\} \left[ J'(\cdot) - (1 + \delta)s^* \right] \left( - \right) (-) \\
+ \frac{\partial \text{TAOC}}{\partial s^*} \left[ J''(\cdot) \frac{\partial \text{TAOC}}{\partial G} \right] - \delta \frac{\partial \text{TAOC}}{\partial G} \left( + \right) (+) \left( + \right) < 0 \]  \hspace{1cm} (15a)
To evaluate the impact of $\Delta \theta \equiv \bar{\theta} - \theta$, note that it can be increased by either increasing $\bar{\theta}$ by $\varepsilon(>0)$ or decreasing $\theta$ 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 $\theta \in [\theta - \varepsilon, \bar{\theta} + \varepsilon] \rightarrow \Delta \theta = \bar{\theta} + 2\varepsilon$. The mean, the variance and the cumulative density function of $\theta$ are given by $E\theta = (\bar{\theta} + \theta)/2$, $\text{Var}(\theta) = (\bar{\theta} - \theta + 2\varepsilon)^2/12$ and $F(\theta) = (\bar{\theta} - \theta + \varepsilon)/(\theta - \bar{\theta} + 2\varepsilon)$, respectively. An increase in $\varepsilon$ increases $\Delta \theta$ and the variance, but does not affect the mean. It can easily be verified that $\text{sign}\{\partial F/\partial \varepsilon\} = \text{sign}\{\bar{\theta} + \theta - 2\varepsilon\}$ is positive (negative) if $\theta^* \leq E\theta (\theta^* > E\theta)$. If $\theta^* (s^*, G)$ is smaller than or equal to the mean of $\theta$, (implying that in the optimal solution, at least 50 per cent of the total area is planted to OCs), the sign of $\partial TA_{OC}/\partial \varepsilon$ becomes negative and the impact of $\varepsilon$ on $s^*$ is indeterminate. However, if $\theta^*$ is larger than $E\theta$, the sign of $\partial TA_{OC}/\partial \varepsilon$ is positive and the impact of $\varepsilon$ on $s^*$ is negative:

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

$$
= \left\{ \begin{array}{ll}
< 0 & \text{if } \theta^* > E\theta \\
\text{indeterminate} & \text{if } \theta^* \leq E\theta
\end{array} \right.
$$

The impacts of marginal deadweight loss is

$$
\text{sign}\left\{\frac{\partial s^*}{\partial \delta}\right\} = \text{sign}\left\{-\frac{\partial TA_{OC}}{\partial s^*s^* - TA_{OC}}\right\} < 0 \quad (15c)
$$

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

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

\[\frac{\partial TA^{OC}}{\partial s^*} \left[ J''(\cdot) \frac{\partial TA^{OC}}{\partial \gamma} - \delta \frac{\partial TA^{OC}}{\partial \gamma} \right] \]

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

3. Data and calibration of the empirical model

The theoretical model developed in Section 2 is applied using data from the Dutch province of Flevoland. The area consists of about 80,000 ha of land used for arable farming, which is about 75 per cent 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. There are already a number of organic arable farms in the region.

To calibrate the model, data on specialised arable farms covering the period 1990–1999 are used. These data come from the Dutch farm accounting data network operated by WUR-LEI. The data set consists of 110 traditional farms (473 observations) in total and 22 organic farms (90 observations). These observations are used to calculate the mean \[\bar{p}_t(G)\] and variance \[V_{p}(G)\] 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 \((\gamma)\) is based on a unit-free coefficient of relative risk aversion of 0.20 estimated using the same data for traditional arable farmers (Oude Lansink, 1999). Dividing by the average profit per organic farm \((\bar{p}_t = 1.77, \forall t)\) gives a measure of 0.113. Assuming a real interest rate of \(r = 0.4\) and planning horizon of \(T = 10\) years, the annual equivalent of the present value of the stream of future \(\pi_t^1 s\) is

\[\bar{\pi}^1(G) = 1.77 \left[ \frac{1.04^{8} - 1}{0.004 \times 1.04^{8}} \right] / 1.04^2 \left[ \frac{0.04 \times 1.04^{10}}{1.04^{10} - 1} \right] = 1.358.\]

The deadweight loss parameter \((\delta)\) is based on a study by Alston and Hurd (1990), who argued 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 also requires the specification of the government’s social-value function \(J(TA^{OC})\) and the calibration of a few parameters. Recalling that the social-value function \(J\) is assumed to be an increasing, strictly concave and twice differentiable function of \(TA^{OC}\), we choose the functional form \(J = (TA^{OC})^\alpha\), where \(0 < \alpha < 1\) is the elasticity of this function.
In the absence of data on the parameters $u$, $u\bar{\bar{u}}$ and $a$, we calibrated them as follows:

1. First, on the basis of our data set, we assumed the lowest level in the region of the certainty-equivalent profit per farm (without subsidy) to be $\mathbf{E}0.4 \times 10^5$ per farm. In other words, $\mathbf{u}[p^\mathbf{G}1] = 0.4$. [equation (4)]. Substituting for $p^\mathbf{G}1$, $g$ and $V_p^\mathbf{G}$ (Table 1) yields $u = 0.3$.

2. Second, given $u$, we used the actual level of subsidy in 1999 ($s/C_3 = \mathbf{E}227/\text{ha}$) and equation (6) to calculate its corresponding level of $u/C_3$. Then, given $u/C_3$, we used the actual area in the region planted to OCs in 1999 ($TAOC = 5,097 \text{ha}$) and equation (10a) to calibrate $u = 0.90$.

3. The final parameter to be calibrated is $a$. The issue here is what value $a$ must take in order for the model to produce the current policy. Therefore, given all other parameters, we used the specification of the government’s social-value function $J$ and substituted $J^0 = a(TAOC)^{a-1}$ into the first-order condition for the optimal subsidy [equation (14a)] to calibrate for $a = 0.433$. The calibrated values are also reported in Table 1.

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

1. First, on the basis of our data set, we assumed the lowest level in the region of the certainty-equivalent profit per farm (without subsidy) to be $\mathbf{E}0.4 \times 10^5$ per farm. In other words, $\mathbf{u}[p^\mathbf{G}1] = 0.4$. [equation (4)]. Substituting for $p^\mathbf{G}1$, $g$ and $V_p^\mathbf{G}$ (Table 1) yields $\theta = 0.3$.

2. Second, given $\theta$, we used the actual level of subsidy in 1999 ($s^* = \mathbf{E}227/\text{ha}$) and equation (6) to calculate its corresponding level of $\theta^*$. Then, given $\theta^*$, we used the actual area in the region planted to OCs in 1999 ($TAOC = 5,097 \text{ha}$) and equation (10a) to calibrate $\bar{\theta} (=0.90)$.

3. The final parameter to be calibrated is $\alpha$. The issue here is what value $\alpha$ must take in order for the model to produce the current policy. Therefore, given all other parameters, we used the specification of the government’s social-value function $J$ and substituted $J^\alpha = a(TAOC)^{a-1}$ into the first-order condition for the optimal subsidy [equation (14a)] to calibrate for $\alpha (=0.433)$.

Note that this calibration procedure implicitly assumes that policies in Flevoland are optimal and reflect true social preferences, so that the actual and the optimal per-hectare subsidies coincide. In the absence of exact estimates of this value, this is the best we can do. We are fully aware that if these policies are not optimal, as might be expected, the true value of $\alpha$ will be somewhat different. Therefore, we do not claim that the $\alpha$ value we use is the exact and true value representing social welfare. For this reason, we also performed sensitivity analysis on $\alpha$ in the remainder of the paper. We like to stress that this supporting assumption of current optimal policies does not necessarily imply that the ability distribution of farmers is already known and that the government has already been able to solve equation (13). The optimal policy might have been approximated via a trial and error process reflected by ongoing changes in organic policies.
4. Results

This section describes the base-case results and the results of the sensitivity analysis performed with the empirical model. The sensitivity analysis shows the changes in the government’s optimal choice if one of the parameters changes while the others are kept constant. This indicates the relative importance of changes in specific model parameters. The results are given in Table 2.

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 are no data available on yearly expenditure on $G$.

The second and third rows of Table 2 show that different values of $a$, the elasticity of the social-value function with respect to area planted to OCs, have a significant impact on the socially optimal outcome. With an elasticity of 0.5 instead of the base value 0.433 (which reflects the current valuation of OCs by the government), the optimal per hectare subsidy goes up by 41.8 per cent, to 321.95, and the area planted to OCs nearly doubles. Since more utility is derived from OCs and the deadweight loss of the higher subsidy increases only slightly, social welfare goes up about 2 per cent. When $a$ is set equal 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 higher than in the base scenario. From these two simulations, we learn that the optimal subsidy level depends very much on the social valuation of OCs by the government.

A higher degree of risk aversion among farmers has mixed effects, as shown by the results for $\gamma = 0.25$, which is more than twice the base Arrow–Pratt coefficient.13 Since farmers are more risk-averse, they consider the risky OCs to be less attractive, which is reflected by higher reservation subsidies $\tilde{s}$. These overall higher reservation subsidies lead to a higher subsidy of 279 set by the government and a total acreage of 3,831, which is of course lower than the base acreage. Note that because of the higher subsidy per hectare and fewer hectares converted, total subsidies do not decrease much. Although the welfare effect is low, the decrease of more than 23 per cent in social welfare associated with the OCs is almost fully compensated by the increase in social welfare associated with TCs.

A higher deadweight loss parameter, $\delta$, leads to a lower optimal subsidy level, as expected from equation (15c). The effects are, however, relatively small, with the subsidy only €12 less per hectare and only 500 ha less converted to OCs. 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 $\bar{\pi}^1_i (G)$ increases in $G$ and $V_\pi (G)$ decreases in $G$. But, due to the lack of yearly data on $G$, it was not possible to quantify the relationships between $G$, $\bar{\pi}^1_i (G)$ and $V_\pi (G)$ empirically, e.g. using regression techniques.

---

13 Since the values for $\bar{u}$ and $\bar{\theta}$ were calibrated using $\gamma = 0.113$, we also did a sensitivity analysis with higher $\gamma$ and recalibrated value for $\bar{\theta}$. Although the results differed in size, the directions were similar.
<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Area of OCs planted ([T_A^{OC} \text{ (ha)}])</th>
<th>Subsidy per hectare ([\tilde{s}, (\text{€/ha})])</th>
<th>Total subsidy ([TA^{OC} \tilde{s}, (\text{€ 10^5})])</th>
<th>Deadweight loss ((\text{€ 10^5}))</th>
<th>SW from OCs(^a) ((\text{€ 10^5}))</th>
<th>SW from TCs(^b) ((\text{€ 10^5}))</th>
<th>Total SW(^c) ((\text{€ 10^5}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base-case</td>
<td>5,097</td>
<td>227.00</td>
<td>11.57</td>
<td>4.05</td>
<td>158.60</td>
<td>1,930.48</td>
<td>2,089.08</td>
</tr>
<tr>
<td>(\alpha = 0.5)</td>
<td>9,861</td>
<td>321.95</td>
<td>31.75</td>
<td>11.11</td>
<td>320.28</td>
<td>1,807.70</td>
<td>2,127.98</td>
</tr>
<tr>
<td>(\alpha = 0.65)</td>
<td>41,186</td>
<td>951.69</td>
<td>391.96</td>
<td>137.19</td>
<td>1,702.04</td>
<td>1,000.37</td>
<td>2,702.41</td>
</tr>
<tr>
<td>(\gamma = 0.25)</td>
<td>3,831</td>
<td>279.42</td>
<td>10.70</td>
<td>3.75</td>
<td>121.23</td>
<td>1,963.11</td>
<td>2,084.34</td>
</tr>
<tr>
<td>(\delta = 0.50)</td>
<td>4,495</td>
<td>215.01</td>
<td>9.66</td>
<td>4.85</td>
<td>141.50</td>
<td>1,946.00</td>
<td>2,087.50</td>
</tr>
<tr>
<td>(\hat{\pi}^1(G) \uparrow 10 \text{ per cent})</td>
<td>10,724</td>
<td>104.54</td>
<td>11.21</td>
<td>3.92</td>
<td>329.54</td>
<td>1,785.47</td>
<td>2,115.01</td>
</tr>
<tr>
<td>(V_{\pi}(G) \downarrow 10 \text{ per cent})</td>
<td>7,770</td>
<td>156.98</td>
<td>12.20</td>
<td>4.27</td>
<td>238.49</td>
<td>1,861.59</td>
<td>2,100.08</td>
</tr>
<tr>
<td>(\pi^1(G) \uparrow 5 \text{ per cent})</td>
<td>10,660</td>
<td>105.59</td>
<td>11.26</td>
<td>3.94</td>
<td>327.52</td>
<td>1,787.10</td>
<td>2,114.62</td>
</tr>
<tr>
<td>(V_{\pi}(G) \downarrow 10 \text{ per cent})</td>
<td>9,508</td>
<td>112.62</td>
<td>10.71</td>
<td>3.75</td>
<td>295.29</td>
<td>1,816.80</td>
<td>2,112.09</td>
</tr>
<tr>
<td>(\theta = 0.20)</td>
<td>2,042</td>
<td>418.52</td>
<td>8.55</td>
<td>2.99</td>
<td>68.47</td>
<td>2,009.23</td>
<td>2,077.70</td>
</tr>
<tr>
<td>(\theta = 1.00)</td>
<td>58,920</td>
<td>363.50</td>
<td>31.85</td>
<td>11.19</td>
<td>325.68</td>
<td>1,811.74</td>
<td>2,133.62</td>
</tr>
<tr>
<td>(\theta = 0.40)</td>
<td>2,042</td>
<td>418.52</td>
<td>8.55</td>
<td>2.99</td>
<td>68.47</td>
<td>2,009.23</td>
<td>2,077.70</td>
</tr>
</tbody>
</table>

\(^a\)Social welfare from OCs is calculated as \(M_{\pi(G)}^\theta [\pi^1(G) - 0.5\theta \Psi_\pi(G) f(\theta) d\theta - \delta TA^{OC}(G,s^*) s^* + J[TA^{OC}(G,s^*)]].\)

\(^b\)Social welfare from TCs is calculated as \(TA^{TC}(G,s^*) (W^{\pi}(a)).\)

\(^c\)Actual social welfare should be somewhat lower since the calculation does not take the deadweight loss due to \(G\) into account.
However, in order to examine how changes in $G$ can affect the optimal social outcome, we increased $\bar{\pi}_1^t (G)$ by 10 per cent and decreased $V_{\pi} (G)$ by 10 per cent. Interestingly, the results are rather sensitive to these changes: the final subsidy is more than halved and the area planted to OCs more than doubled. In order to know whether these dramatic effects are due to the increase in $\bar{\pi}_1^t (G)$ or the decrease in $V_{\pi} (G)$ we analysed two more scenarios. In the first, $\bar{\pi}_1^t (G)$ rose by only 5 per cent and $V_{\pi} (G)$ still decreased by 10 per cent. 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 $\theta$. First, we widened the range of $\theta$, implying more heterogeneity in the suitability of growing OCs. This results in a bigger spread in the set of reservation subsidies. The optimal subsidy is now only 112.62, but more than 9, 500 ha are sown with OCs. Less heterogeneity in the farmer types has the opposite effect, as shown in the last row of Table 2. With an optimal subsidy of €418.52 per hectare, still only 2,042 ha are grown with OCs. The small acreage for OCs leads to low social welfare from OCs and low overall social welfare. From these results, it follows that the suitability of growing OCs has a big impact on switching decisions.

5. Concluding remarks

This paper develops a model to determine the socially optimal hectare subsidy for a given level of public expenditure aimed at stimulating organic farming. Direct income support has a positive effect on the income of farmers who grow OCs, whereas the public services both raise income and reduce the variability of yearly revenues. Analysing the optimal subsidy level and how to achieve it is important given the modest number of farmers who have switched to organic farming in the Netherlands in recent years under the existing policy regimes. Heterogeneity in suitability for growing OCs is explicitly taken into account. An important element is the inclusion of an $n$th price auction that induces farmers to reveal truthfully their reservation subsidy for switching to organic crops. The theoretical model is applied using the data from the Dutch province of Flevoland.

The empirical findings show that the level of socially optimal per-hectare subsidy increases substantially with the elasticity of the social welfare function. The optimal subsidy decreases significantly with the degree of farmers’ heterogeneity with respect to the suitability of growing OCs as well as with the level of complementary governmental services. So, the optimal subsidy and public services are policy substitutes. The total area planted to OCs is quite sensitive to these three 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 sensitivity of the results with respect to the elasticity of the social welfare function
indicates that governments really should have a good answer to questions regarding what organic farming is worth to society. Marshall (1991) argued in favour of support for organic farming because of the positive externalities generated by this sector. Higher valuation of these externalities would increase socially optimal subsidies strongly as the results suggest. Also the European Commission (2004) indicated that organic farming should be supported because it provides public goods. The strong effect of the level of government services on the optimal subsidy level is also a noteworthy finding. In most European countries, organic policies have been modified over time, with current policies often being a mix of direct subsidies and provision of public services. A shift towards public services should therefore be accompanied with a review of existing subsidy levels.

We believe that the suggested auction mechanism for eliciting the truthful revelation of farmers’ reservation subsidies for various levels of complementary public services is simple to apply and can be operated at low cost. Moreover, the information acquired by the government will enable it to improve the decision-making process relative to the current situation in which subsidy levels are set in an economically suboptimal way.

Obviously, the analysis is partial and includes some simplified assumptions. Hence, results should be interpreted cautiously. Quantifying the relationships between the mean and variance of profits from growing OCs 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 a few directions in which the current analysis could be profitably extended.

References


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