The role of transaction costs and bargaining power in wildlife and landscape services production: A micro-econometric model for Dutch dairy farms

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Abstract
In this paper a theoretical and empirical model is developed for analysing the decisions of individual farmers whether or not to produce wildlife and landscape services, how much of these services to produce and form an environmental co-operative in order to reduce transaction costs or to build up bargaining power. The model is applied for Dutch dairy farmers as the main users of agricultural land in the Netherlands. Simulations show that the reduction of transaction costs makes it attractive for farmers to form an environmental co-operative in case of a fixed price for wildlife and landscape services. Therefore more wildlife and landscape services are produced and more farmers are involved compared to a situation with individual supply. If demand is no longer perfectly elastic an increase in wildlife and landscape services production leads to lower prices offsetting part of the production and profit increase caused by lower transaction costs. However, if the environmental co-operative acts like a monopolist its bargaining position leads to a decrease in the production of wildlife and landscape services and higher prices.

Keywords: wildlife and landscape management, micro-econometrics, transaction costs, co-operation

1. Introduction

The literature on producing wildlife and landscape services focuses on the decision whether or not to produce these services. It can be divided along two main streams. The first main stream of literature concerns the decision of individual farmers to participate in agri-environmental contracts which define the production of wildlife and landscape services. Brotherton (1989) analyses the participation in hypothetical schemes with help of a survey among farmers. The predicted proportion of farmers participating in contracts is compared with actual participation. Morris and Potter (1995) conducted a survey among farmers in SouthEast England. Their objective was to compare farm characteristics of adopters and non-adopters of agri-environmental schemes. Beedell and Rehman (2000) raise the question: Are some farmers more conservation minded? They use social-psychology models to analyse this question. Crabtree et al (1998) use a logit model to predict the probability of entry into a farm woodland incentive scheme in the UK. They use census data to analyse the decision to enter a contract and compare the use of census data to the use of small-scale surveys. Also van Wenum and Wossink (2001) use a logit/probit approach to analyse to participation in real and contingent participation to analyse optimal bid offers in the Netherlands. Hanley et al. (1998) use a LP-model in which the combine economic and ecological aspects of the conservation of heather moorland in Northern Scotland. Dorward (1999: 484) uses a programming approach from to incorporate transaction costs in the analysis of contract choice. He analyses hypothetical data and calculates the minimum necessary payments needed to achieve ecological targets based on opportunity costs. Hanley et al. (1999) conduct a cost benefit analysis to judge the efficiency of agri-environmental contracts. Slangen (1997) and Weaver (1998) analyse agri-environmental contracts from an information economics/principal agent point of view. They are searching for optimal contracts. The approaches of Falconer and Whitby (1999) and Falconer (2000) are approaches based on institutional economics. The participation in contracts and the transaction cost of participating are analysed with help of a survey for different countries within Europe.

The second main stream is directed to groups of farmers preserving wildlife and landscape. MacFarlane (1998: 594) concludes for linking farmers' land together to create localised, but meaningful, "conservation estates" where management practices can extend with a level of coherence across cadastral boundaries. Hodge (2001: 108-109) argues that there is scope for the creation of new organisations within which common management decision may be taken. Slangen and Polman (2002) mention the idea of environmental co-operatives saving on transaction costs when contracting for wildlife and landscape collectively. Also Falconer (1999: 9; 2000: 391) pays attention farmer networks and collective options for contract entry. She argues that transactional economies of scale might also be achieved by making collective agreements.

Lacking in the literature are empirical farm models analysing the combined and linked decisions of individual farmers whether or not to produce wildlife and landscape services, how much to produce and to form an environmental co-operative. Moreover, the literature has concentrated on the role of (ecological) scale advantages and transaction costs reduction as the main arguments to form an environmental co-operative paying no attention to the possible bargaining power (countervailing power) of an environmental co-operative.

Objective of this paper is to develop a theoretical and empirical model for analysing the decisions of individual farmers whether or not to produce wildlife and landscape services, how much of these services to produce and form an environmental co-operative in order to reduce transaction costs or to build up bargaining power. The model is applied for Dutch dairy farmers as the main users of agricultural land in the Netherlands.

To reach the objective a micro-econometric model for Dutch dairy farming, which includes the production of wildlife and landscape services, is specified and estimated. The model is then applied to a small group of farms to analyse whether or not and to what extent they will produce wildlife and landscape services under different circumstances. Analysed circumstances are: (1) no co-operation; (2) co-operation where co-operation leads to a reduction in transaction costs and (3) co-operation where co-operation leads to a reduction in transaction costs but also to a higher price for wildlife and landscape services produced because of an improved bargaining position compared to individual supply.

Section 2 describes the theoretical model used. Section 3 discusses the empirical model, data and estimation. Simulations and results are given in section 4. Section 5 summarises the main results and provides some conclusions.

2. Theoretical Model

In this section a theoretical micro-economic model for farmers concluding contracts for the production of wildlife and landscape services is developed. This model includes individual decisions to conclude contracts and the decision to form co-operatives as intermediary organisation for concluding contracts. Before the decision whether or not to co-operate is discussed a theoretical model of wildlife and landscape services production is developed.

Model of wildlife and landscape services production

Here a micro-economic model of wildlife and landscape services production in dairy farming is presented. It is assumed that dairy farming is characterised by joint production of multiple outputs. Given the milk quota system it is assumed that milk production is fixed in the short run. Moreover, production of wildlife and landscape services is assumed fixed in the short run because contracts have to be concluded for a period of five years. Inputs are assumed variable or fixed in the short run (quasi-fixed inputs). It is assumed that farmers maximise profit given the level of prices and quantities of quasi-fixed outputs (milk and wildlife and landscape services) and quasi-fixed inputs. The short term, dual profit function $\pi_h(p, z_h)$ for farmer *h* is given by

$$\pi_h(p, z_h) = \max_y \{p.y_h \mid T(z_h, y_h), p > 0\} \qquad h = 1,\dots,H \qquad (1)$$

where π_h profit for farmer h; y_h vector of (variable) netputs for farmer h (if an individual netput $y_{hi} > 0$ it is an output, if $y_{hi} < 0$, it is an input); z_h vector of quasi-fixed netputs for farmer h (if a specific netput $z_{hk} > 0$, it is a quasi-fixed input, whereas if $z_{hk} < 0$, it is a quasi-fixed output), p vector of netput prices, *T* technology set.

It is assumed that the profit function is continuous and twice differentiable. Furthermore, profits are non-negative, non-decreasing in output prices, non-increasing in input prices and convex and linear homogenous in prices. Supply and demand functions are given by (Hotellings' lemma):

$$y_{hi}(p, z_h) = \frac{\partial \pi_h(p, z_h)}{\partial p_i} \qquad h = 1,\dots,H \text{ and } i = 1,\dots,I \qquad (2)$$

The shadow prices of the quasi-fixed inputs and quasi-fixed outputs are given by:

$$\frac{\partial \pi_h(p, z_h)}{\partial z_{hk}} = s_{hk}(p, z_h) \qquad h = 1,\dots,H \text{ and } k = 1,\dots,K \qquad (3)$$

Here, $s_h(p, z_h)$ is the vector of shadow prices for the quasi-fixed inputs and quasi-fixed outputs z_h. The shadow price for wildlife and landscape services is equal to the marginal cost of production and differs over individual farms.

The above model shows the profit, netputs and shadow prices if farmers already produce wildlife and landscape services (or this production is zero). Next we investigate what would happen if wildlife and landscape services are no longer fixed. In other words would the farmer in that case produce these services or not and how many services would be produced?

No co-operation

Suppose the farmer is faced with the choice whether or not to produce wildlife and landscape services. Production will be positive if profit in case of producing these services is higher than without this production. The optimal level of production will be determined in the point where the marginal cost of producing wildlife and landscape services equals the price.

We assume that the demand for wildlife and landscape services by the government is either completely price elastic; the price is given (w_1), or depends on the price (demand is price elastic). If demand is price elastic demand is given by:

$$z_1^d = f(w_1) \qquad (4)$$

where w_1 price (compensation paid) for wildlife and landscape services and z_1^d demand for wildlife and landscape services.

Wildlife and landscape management contracts involve transaction costs (Falconer and Whitby, 1999: 67; Hanley et al., 1999: 72; Hodge, 1991: 375; etc.). The transaction costs we deal with in this paper are the transaction costs paid by farmers. Examples are the costs of negotiating with the government, administration of the contract, and monitoring and administrating results. These costs have to be distinguished from the public transaction costs like administrative costs of operating the contract for the government (Falconer, 1999: 71-73). Private transaction costs can be separated in fixed costs and variable costs. Fixed transaction costs depend only on the decision to contract. Examples are the cost of gaining information on possible contracts, administrative tasks, and management decisions like for what price do contracts fit in the farming business. Variable transaction costs depend on the level of production and are here assumed to be constant per unit of wildlife and landscape services produced. Examples of variable transaction costs are the costs of auditing, monitoring and reporting species.

The possibility to produce wildlife and landscape services results in the following profit maximisation problem on farm level:

$$\pi_h(p, z_h^e, w_1, c_h, C_h) = \max_{z_1}\{g_h(p, z_h) + w_1 z_{h1} - c_h z_{h1} - C_h\} \qquad h = 1,\ldots,H \qquad (5)$$

where

$$g_h(p, z_h) = \max_{y_h}\{p y_h\} \qquad h = 1,\ldots,H \qquad (6)$$

The first order condition equals:

$$\frac{\partial \pi_h(p, z_h^e, w_1, c_h, C_h)}{\partial z_{h1}} = w_1 - c_h + \frac{\partial g_h(p, z_h)}{\partial z_{h1}} = 0 \qquad h = 1,\ldots,H \qquad (7)$$

where z_{h1} production of wildlife and landscape services by farmer h, z_h^e quasi-fixed inputs and outputs, except wildlife and landscape services, for farmer h, C_h fixed transaction costs for farmer h (only dependent on the decision to contract), c_h variable transaction costs for farmer h per unit of wildlife and landscape production. Here $g_h(p, z_h^e, z_{h1})$ is the restricted profit function which is defined as the cost of producing wildlife and landscape services. In the profit maximising optimum (equation 7) the price equals the marginal costs (including the variable transaction costs per unit of production) of producing wildlife and landscape services.

From the first order condition the supply function of wildlife and landscape services can be derived:

$$z_{h1} = f(p, w_1, z_h^e, c_h, C_h) \qquad \text{h = 1,…,H} \qquad (8)$$

However wildlife and landscape services are only produced if profit increases. So

$$\pi_h > \pi_h^e \qquad (9)$$

where π_h^e is the with zero wildlife and landscape services production.

Co-operating where co-operation leads to a reduction in transaction costs

Here we assume that farms co-operate in order to reduce (fixed) transaction costs. Co-operation takes the form of forming an environmental co-operative. Although forming a co-operative leads to extra fixed transaction costs (membership fees for the co-operative, administration of the co-operative and enforcement costs) there can be an overall reduction compared to the situation where farmers have to sign an individual contract because fixed transaction costs like negotiation costs for a contract, search costs, etc. can be shared. In the model we assume that the fixed transaction costs for a member of the co-operative equal the fixed transaction costs in case of no co-operation divided by the number of members of the co-operative. The profit maximisation problem for an individual farmer is equal to the profit maximisation problem in equation (6) but C_h is replaced by $C_h^{new} = C_h / N$. Notice that the first order condition (equation 7) does not change. So if the farmer would produce wildlife and landscape services in case there is no co-operation he still produces the same amount of services after forming of the environmental co-operative. However, given that fixed transaction costs are now lower it could be the case that more farmers produce wildlife and landscape services (equation 9). This result is independent from the situation if the price is given or not. However, if the price is variable and more farmers start producing wildlife and landscape services the price will go down affecting the decision whether or not to join the co-operative and the amount of services produced.

Co-operation with an improved bargaining position

Besides a reduction in fixed transaction costs a co-operative could provide bargaining power (countervailing power). When there is one co-operative to contract for wildlife and landscape, that co-operative is unlikely to take the price as given. The co-operative will recognise its influence over the price, and chooses that level of price and output that maximises overall profits. In other words the co-operative will act like a monopolist. For the government it can be attractive to deal only with the co-operative instead of a group of individual farmers because dealing with a single party leads to a reduction in transaction costs. So, the co-operative maximises total profit of its members not only deciding on what amount to produce but also taken into account the effect of production on the price. Moreover, the number of participants is variable because this number affects production, price and profit. Substituting the demand function in equation 5 and leads to the following first order condition:

$$w_1 = \frac{c_h - \dfrac{\partial g_h(p, z_h)}{\partial z_{h1}}}{1 - \dfrac{1}{\left|\varepsilon^d\right|}} \qquad \text{h = 1,…,H} \qquad (10)$$

Equation (10) indicates that the price is a mark-up over marginal cost, where the mark-up depends on the elasticity of demand. Here we assume a constant elasticity demand curve, hence $\left|\varepsilon^{d}\right|$ is constant. In case of a monopoly the farmers will be able to achieve an extra profit compared to the case in which they only co-operate to reduce fixed transaction costs. When $\left|\varepsilon^{d}\right|$ goes to infinity the mark-up goes to zero and the price will be equal to the price in the situation of no bargaining power. The farmer faces a flat demand curve (infinitely elastic demand). For $\left|\varepsilon^{d}\right|<1$ the marginal revenue is negative, so it can not possibly equal marginal cost.

3. Empirical model

In this section we derive the shadow price equations for wildlife and landscape services production of individual farms in a representative sample of Dutch dairy farming. These shadow price equations are used to derive optimal supply of wildlife and landscape services. The shadow price equations are derived from a micro-econometric profit model. Micro econometric profit models have been applied frequently in the agricultural economics literature (see Shumway, 1995, for an overview). This also holds for the dairy sector in the Netherlands (Boots et al, 1997; Helming et al, 1993). Models of Dutch dairy farming have to take into account that individual dairy farms have operated under a quota constraint since 1984.

Dairy farming is modelled by assuming that the farm produces three outputs; milk (z_0), which is subject to a supply constraint, wildlife and landscape (z_1), subject to a supply constraint in form of long term contracts, and a composite of other outputs (e.g. beef) (q_1). Three variable inputs are used; purchased feed (q_2), dairy cattle ($q3$) and a composite of other inputs (q_4). Furthermore, four quasi-fixed inputs are distinguished; labour (z_2), land (z_3), buildings (z_4), and machinery (z_5). The model also includes a time trend (z_6) representing technology.

The symmetric normalised quadratic (SNQ) form is used as the empirical specification (Kohli, 1993; Oude Lansink and Stefanou, 1997) of the restricted profit function. The SNQ is a flexible functional form that allows for negative profit and for curvature conditions (convexity in prices) to be imposed globally. Another advantage is that the estimation results do not depend on the choice of a numeraire netput (as is the case for the also frequently used normalised quadratic). The SNQ profit function (for all farmers h) takes the following form:

$$\begin{aligned}\pi_{ht}(v_{it},z_{kht}) = {} & \sum_{i=1}^{4}\alpha_{ih}v_{it} + \frac{1}{2}w^{-1}\sum_{i=1}^{4}\sum_{j=1}^{4}\alpha_{ij}v_{it}v_{jt} + \sum_{i=1}^{4}\sum_{k=0}^{6}\gamma_{ik}v_{it}z_{kht} \\ & + \frac{1}{2}w\sum_{k=0}^{6}\sum_{n=0}^{6}\beta_{kn}z_{kht}z_{nht}\end{aligned} \qquad (11)$$

where $\pi_{ht}(v_{it},z_{kht})$ profit of farmer h in year t, v_{it} price of netput i in year t, z_{kht} quasi-fixed input or quasi-fixed output k of farmer h in year t. Symmetry is maintained by requiring $\alpha_{ij}=\alpha_{ji}$ and $\beta_{kn}=\beta_{nk}$. Linear homogeneity in prices is imposed by the term $w=\sum_{l=1}^{4}\theta_l v_{lt}$, where θ_l are non-negative constants determined as the average shares of netput l (l=1,..,4) in total costs plus revenues. Additional restrictions $\sum_{j=1}^{4}\alpha_{ij}\bar{v}_j = 0 \quad (\forall i = 1,..,4)$ have to be imposed, in order to identify all parameters α_{ij}. Here, $\bar{v}_j$ is an arbitrary point of observation.

Netput equations (i=1,..,4 and for all farmers h) are derived using Hotelling's lemma

$$q_{iht} = \alpha_{ih} + w^{-1}\sum_{j=1}^{4}\alpha_{ij}v_{jt} - \frac{1}{2}\theta_i w^{-2}\sum_{l=1}^{4}\sum_{j=1}^{4}\alpha_{lj}v_{lt}v_{jt} + \sum_{k=0}^{6}\gamma_{ik}z_{kht} + \frac{1}{2}\theta_i\sum_{k=0}^{6}\sum_{n=0}^{6}\beta_{kn}z_{kht}z_{nht} \qquad (12)$$

Shadow price equations (k=0,..,6 and for all farmers h) are derived taking the first order derivative of the profit function with respect to the quantities of fixed outputs and inputs:

$$s_{kht} = \sum_{i=1}^{4}\gamma_{ik}v_{it} + w\sum_{n=0}^{6}\beta_{kn}z_{nht} \qquad (13)$$

Notice that shadow prices between farms only depend on differences in the level of quasi-fixed inputs. Assuming the production of wildlife and nature services variable the supply function can be derived by taking the inverse of the shadow price equation (13) and replacing the shadow price by the market price. The supply function is given by:

$$z_{1ht} = \frac{-\sum_{i=1}^{4}\gamma_{i1}v_{it} - \sum_{n=0,2}^{6}\beta_{1kn}z_{nht} + w_1}{w\beta_{11}} \qquad (14)$$

Data and Estimation

Data on specialised dairy farms covering the period 1991/92 - 1999/00 come from a stratified sample of farms keeping accounts on behalf of the Dutch Agricultural Economics Research Institute (LEI) farm accounting system. The stratification is based on economic farm size, age of the farmer, region, and type of farming. Annual data of participating farms are available. The data set used for estimation contains 6203 observations on 1237 farms. In the sample (very) small farms and non-specialised farms are not represented. Data is used from Dutch dairy farms that have more than 50 per cent of their Dutch standard gross margin from dairy farming[1]. The farms usually remain in the panel for about five years, so the data set forms an incomplete (or unbalanced) panel[2]. Data for the average farm in 1999/00 are given in Table A.1 in the Appendix.

If prices at the farm level are available in the FADN, they are used to calculate price indices[3]. If prices are not present in the FADN, price indices are borrowed from CBS/LEI-DLO (2000). In this study we used implicit quantity indices. Implicit quantity indices are obtained as the ratio of value to price

[1] See CBS/LEI Landbouwcijfers 2000 for norms on gross margins for different products

[2] The authors thank Stijn Reinhard for providing the methods for aggregating data.

[3] Prices in the paper are given in euros. However, the research was done in guilders.

index and therefore output is in prices of a specific year, 1991 is the base year. The price index used in this study is the average of the multilateral Törnqvist price index over the farms for every year. This price index varies over the years but not over the farms, implying that differences in the composition of a netput over quality are reflected in the quantity (cf. Reinhard, 1999: 25).

In the model two supply-constrained outputs, one unconstrained output, three variable inputs and five quasi-fixed inputs are distinguished. The first constrained output is "milk" which consist of milk revenues. The second constrained output is wildlife and landscape services. The variable wildlife and landscape services is based on the decrease in production of grass expressed in kilo fodder unit milk per ha (kFUM) (energy content of fodder). The price we use in the simulations is based on the financial compensation for wildlife and landscape services. The compensation is based on (Heinen, 1997: 3):

- the decrease in production of grass expressed in kilo fodder unit milk per ha (kFUM) (energy content of dairy fodder) ;
- the increase in labour input in hours per ha;
- the change in operating costs (e.g. lower fertiliser expenditures) is deducted.

The contracts differ in the reduction of the production of grass because they differ in prescriptions for providing wildlife and landscape services. For example, in the Netherlands there are five contracts for nesting periods possible that differ in the date the nesting period ends: June 1, June 8, June 15, June 22, and June 30. The starting date is the same for all these contracts: April 1. When the nesting period gets longer the decrease in kFUM will be larger. Hence the more "wildlife and landscape services" will be produced. The financial compensation per kFUM can change every year, also for contracts that were concluded in previous years. The compensation for wildlife and landscape management contracts does not differ in labour input required.

The unconstrained or 'other output' is an aggregate of revenues from marketable crops, beef and veal, pigs, poultry and other farm revenues. The three variable inputs are 'purchased feed' for cattle, 'Dairy cattle' and 'other input'. Purchased feed contains purchased concentrate and roughage. Dairy cattle contain the utilisation livestock. The price index of livestock is calculated as the multilateral Törnqvist price index of the revaluation of the livestock. The value of livestock is known at the start-balance and the end-balance of each year. The difference between the start balance of year t and the and-balance of year t-1 is due to revaluation of the cattle. The other input is a composite of costs of feed for animals other that dairy cattle, seeds, fertilisers, pesticides, contract work, veterinary services, fuel, energy, other cattle and other variable inputs.

Quasi-fixed inputs are 'labour', 'land', 'buildings', and 'machinery'. Labour consists of total family labour measured in hours. Land is measured as the total area farmland in hectares. A multilateral Törnqvist price index is used to aggregate the price indices of the components of capital stock. The characteristics of the data are summarised in Table A1.

The system of equations (12) is estimated with additive error terms included prior to estimation. Every farm is assumed to have a farm-specific intercept, reflecting differences in farm characteristics (e.g. management quality and soil quality). A fixed-effects model explicitly accounts for this assumption. The necessary transformation for such a model can also be applied to an incomplete panel, like our data set (see Thijssen, 1992). The profit function is not estimated along with the netput equations, since the intercepts of the netput equations appear as slope coefficients in the profit function. Including the profit function during estimation requires direct estimation of all farm-specific intercepts. Note that all parameters of the profit function are, however identified in the netput equations.

Endogenous variables are q_i (i=1,..,4). We assume that the error terms are uncorrelated to the quasi-fixed factors. Error terms may be correlated across equations. Therefore, the estimation technique used is SUR (Johnston and Dinardo, 1997, 318-320). The covariance matrix of residuals used in estimating the system is corrected for the difference in the number of observations (Judge et al., 1988, p.462). The estimation results can be found in Table A.2 in the Appendix and show that about half of the parameters are significantly different from zero at the 5 per cent significance level.

4. Simulations and results

4.1 Supply equation wildlife and landscape services

Table 1 gives the results of the estimation of the supply equation of nature (equation 16).

Table 1: Supply equation wildlife and landscape services for dairy farms in the Netherlands

	s_1	v_1	v_2	v_3	v_4	z_0	z_2	z_3	z_4	z_5	z_6
Supply	2844	-1762	-2029	-136	-1091	-0.82	532	20	-3	6	-40

Source: own calculations

Supply of wildlife and landscape increases if the price of (w_1) wildlife landscape services increases. The coefficients for the prices of the netputs are negative. So other output is a substitute for wildlife and landscape services. Higher feed prices makes the production of wildlife and landscape services less attractive because a higher production leads to less roughage production on the farm and more purchased feed demand. The supply of wildlife and landscape services are negatively related to the quota level, so an increase in milk production leads to a decrease in the supply of wildlife and landscape services. The estimates for land, labour, and machinery imply that larger amounts of these quasi-fixed inputs on the farm result in higher supply of wildlife and landscape services. Larger amounts of buildings result in a lower supply of wildlife and landscape. One could conclude that the main inputs for the production of wildlife and landscape are land and labour.

4.2 Simulations

The simulations are elaborated in this section. The base simulation (see Table 2) represents a situation where wildlife and landscape services are produced for a situation in which the price is fixed and the government concluded contracts with individual farmers. Farmers supply wildlife and landscape services only if profit increases. Farmers supply services till the point where marginal costs equal the price the government offers. The price the government is equal for every farm and equals €0,40. Moreover, we assume fixed transaction costs and the variable transaction costs equal between farmers. So the base simulation does not represent the actual situation but represents the situation where all efficiency gains from producing wildlife and landscape are realised. The simulations are performed using equations 9, 10, 12, 14 and an equation to calculate profit. Because these equations are mutually dependent a search algorithm (in GAMS) was used to solve the set of equations. Profits are calculated as the value of the netputs plus the revenue form wildlife and landscape production minus the transaction costs.

In the first simulation farms co-operate in order to reduce fixed transaction costs. It is expected that this leads to more farms participating in the production of wildlife and landscape services. However, the price, and therefore marginal costs, does not change which implies that the level of production of farms already participating in the base run does not change. The second simulation is identical to the first except that in this situation we no longer assume a perfectly price elastic demand but a downward sloping constant elasticity (the price elasticity of demand equals 4) of demand function for wildlife and landscape services of the government. The third simulation is identical to the second simulation but farms co-operate not only to reduce fixed transaction costs but also to achieve bargaining power.

During the simulations input and output prices are held constant. This seems realistic because wildlife and landscape services production is relatively small compared to milk production. Farms are selected for an area where farmers are concluding contracts in practice. It the simulation model, the effects are determined for the 12 individual farms in the sample for the year 1999/00 all located in the areas Krimpenerwaard, Alblasserwaard, and Vijfherenlanden in the province of South-Holland. Given the regional differences in wildlife and landscape environmental co-operatives act regionally therefore we did not take a representative sample for the Netherlands.

The simulations describe the effects on the level of production of wildlife and landscape services on farm level, farm profits per unit of wildlife and landscape services produced (only for farms involved in production), the number of farmers involved in wildlife and landscape services production, transaction costs, feed and cattle input. Results of the simulations are presented in table 2.

Table 2: Wildlife and landscape services production under different scenarios

		Co-operation		
	Base run: no co-operation	Scenario I: reducing transaction costs, fixed price	Scenario II: reducing transaction costs, elastic demand	Scenario III: bargaining power
Wildlife and landscape services (Kfum/%)	139	+90%	+37%	-5%
Price (€)	0.40	0.40	0.37	0.40
Profit per unit wildlife and landscape services (€)	0.07	0.12	0.09	0.19
Number of producers	3	8	7	7
Private transaction cost per unit (€)	18	10	9	8
Share transaction cost in total compensation (%)	14	4	6	6
Feed input	971	+5%	+2%	-0.5%

In a situation where farmers can collectively conclude contracts fixed transaction costs are shared among the members of the co-operative. Because of the savings on the fixed transaction costs 5 extra farmers will conclude contracts. Further, wildlife and landscape services production increases with 90%. The profit for per unit of nature increases to € 0.12. This can be explained by the reduction of the private transaction costs for participating farmers. The input of feed increases if the farmer produces wildlife and landscape services. The extra need for feed can be explained by decrease in the available amount of roughage due to the production of wildlife and landscape services.

In the second simulation the government has an elastic demand for wildlife and landscape services and the farmers and the government negotiate on the contract without one of the parties posses monopoly power. Under this simulation the farmers the price, production, profit and number of participating farmers are lower compared to a situation with a fixed price but higher than in the base run. A reduction in transaction costs leads to extra farmers participating and therefore to extra production. This increase in production leads to lower prices which partly offset the increases caused by the reduction in transaction costs.

In the third simulation the environmental co-operative has monopoly power. In case of monopoly farmers are able to set a mark-up above their marginal cost. In case of a monopoly farmers produce less wildlife and landscape services compared to all other runs. However, the profit per unit of wildlife and landscape services produced is higher. The price is approximately equal to the price of the base run. The results in this simulation depend on the assumption that the government only does business with the environmental co-operative in specific area and not with individual farmers. At the given market price some farmers would like to produce wildlife and landscape services joining the co-operative but they cannot because that would reduce overall profit of the co-operative.

4.3 Transaction costs

This section contains a sensitivity analysis on transaction costs. The analysis concerns fixed transaction costs at three alternative levels: no transaction costs, the benchmark transaction costs and relatively high transaction costs. The results for the analysis are given in table 3.

Table 3: Sensitivity analysis: different transaction costs for individual supply

	Wildlife and landscape services (Kfum)	Profit (€)	Number of farmers involved
Base run	139	2890	3
Transaction costs			
No transaction costs	+91%	+1%	8
High transaction costs (double)	-100%	-0.3%	0

Decreasing transaction costs make it more attractive for farmers to produce wildlife and landscape services. An increase in transaction costs decreases the production and profit of wildlife and landscape services. Higher (lower) transaction costs makes contracting for wildlife and landscape management less (more) interesting for farmers and therefore make forming an environmental co-operative more (less) attractive.

5. Summary and conclusions

Objective of this paper is to develop a theoretical and empirical model for analysing the decisions of individual farmers whether or not to produce wildlife and landscape services, how much of these services to produce and form an environmental co-operative in order to reduce transaction costs or to build up bargaining power. The model is applied for Dutch dairy farmers as the main users of agricultural land in the Netherlands.

Reduction of fixed transaction costs make it attractive for farmers to form an environmental co-operative in case of a fixed price for wildlife and landscape services. Therefore more wildlife and landscape services are produced. However price and therefore marginal costs do not change which implies that the amount of wildlife and landscape services produced is not affected by formation the co-operative. So if a farmer already produced wildlife and landscape services before the co-operative exists his production does not change but his profit does. If demand is no longer perfectly elastic (price is endogenous) an increase in wildlife and landscape services production leads to lower prices offsetting part of the production and profit increase caused by lower fixed transaction costs. However, if the environmental co-operative acts like a monopolist an improved bargaining position leads to a decrease in the production of wildlife and landscape services and higher prices but also to a smaller amount of farmers producing wildlife and landscape services.

The results of our study are obviously subject to some qualifications. First the model is a short-term model. Changes in technology are for example not accounted for. Moreover, welfare analysis is not possible because the model does not contain consumer benefits and public transaction costs. Extending the model in this direction could be worthwhile in future research. Notwithstanding these qualifications the model presented is a powerful tool to study wildlife and landscape services production and motives to form environmental co-operatives.

References

Beedell, J. and T. Rehman (2000) Using Social-psychology Models to Understand Farmers' Conservation Behaviour. *Journal of Rural Studies* 16: 117-127.

Boots, M. (1997) *Micro-economic Analysis of Alternative Policies for Dutch Dairy Farming.* Thesis, Wageningen University.

Brotherton, I. (1989) Farmer Participation in Voluntary Land Diversion Contracts: Some Observations from Theory. *Journal of Rural Studies* 5(3): 299-304.

CBS/LEI-DLO (2000) *Landbouwcijfers.* Landbouw-Economisch Instituut/Centraal Bureau voor de Statistiek, 's-Gravenhage/Voorburg.

Crabtree, B., N. Chalmers, N. Barron (1998) Information for Policy Design: Modelling Participation in a Farm Woodland Incentive Contract. *Journal of Agricultural Economics* 49(3): 306-320.

Dorward, A. (1999) A Risk Programming Approach for Analysing Contractual Choice in the Presence of Transaction Costs. *European Review of Agricultural Economics* 26: 479-492.

Falconer, K. (1999) *Developing Co-operative Approaches to Agri-environmental Policy: a Transactions Cost Perspective on Farmer Participation in Voluntary Approaches*. Paper presented at the 64th EAAE seminar on 'Co-operative Strategies to Cope with Agro-Environmental Problems', Humboldt University, Berlin, October 29-29, 1999.

Falconer, K. (2000) Farm-level Constraints on Agri-environmental Contract Participation: a Transactional Perspective. *Journal of Rural Studies* 16: 379-394.

Falconer, K. and M. Whitby (1999) The Invisible Costs of Contract Implementation and Administration. In: G. Van Huylenbroeck and M.Whitby, *Countryside Stewardship: Farmers, Policies, and Markets*. Elsevier Science, Oxford: 67-88.

Hanley, N. H. Kirkpatrick, I. Simpson, and D. Oglethorpe (1998) Principles for the Provision of Public Goods from Agriculture: Modelling Moorland Conservation in Scotland, *Land Economics* 74(1): 102-113.

Hanley, N., M. Whitby, and I. Simpson (1999) Assessing the Success of Agri-environmental Policy in the UK. *Land Use Policy* 16: 67-80.

Heinen, J. (1997) *Grondslagen voor de Berekening van Beheersvergoedingen in de Regeling Beheersovereenkomsten en Natuurontwikkeling (RBON)*, LBL-publicatie nummer 80, Utrecht

Helming, J., A.J. Oskam, and G.J. Thijssen (1993) A Micro-economic Analysis of Dairy Farming in the Netherlands. *European Review of Agricultural Economics* 20(3): 343-363.

Hodge, I. (1991) Incentive Policies and the Rural Environment. *Journal of Rural Studies* 7(4): 373-384.

Hodge, I. (2001) Beyond Agri-environmental Policy: Towards an Alternative Model of Rural Environmental Governance. *Land Use Policy* 18: 99-111.

Johnston, J. and DiNardo, J. (1997) *Econometric methods*. McGraw-Hill, New York , 4th edition.

Judge, G.G., R.C. Hill, W.E. Griffiths, H. Lútkepohl and T. Lee (1988) *Introduction to the Theory and Practice of Econometrics.* Wiley, New York.

Kohli, U. (1993) A Symmetric Normalized Quadratic GNP Function and the U.S. Demand for Imports and Supply of Exports. *International Economic Review* 34(1): 243-255.

MacFarlane, R. (1998) Implementing Agri-environment Policy: a Landscape Ecology Perspective. *Journal of Environmental Planning and Management* 41(5): 575-596.

Morris, C. and C. Potter (1995) Recruiting the New Conservationists: Farmers' Adoption of Agri-Environmental Contracts in the U.K. *Journal of Rural Studies* 11(1): 51-63.

Oude-Lansink and S. Stefanou (1997) Asymmetric Adjustment of Dynamic Factors at the Firm Level. *American Journal of Agricultural Economics* 79: 1340-1351.

Reinhard, S. (1999) *Econometric Analysis of Economic and Environmental Efficiency of Dutch Dairy Farms.* Thesis, Wageningen University.

Shumway, C.R. (1995) Recent Duality Contributions in Production Economics. *Journal of Agricultural and Resource Economics* 20: 178-194.

Slangen, L.H.G. (1997) How to Organise Nature Production by Farmers. *European Review of Agricultural Economics* 24: 508-529.

Thijssen, G.J. (1992) *Micro-economic Models of Dutch Dairy Farms.* Dissertation Wageningen University.

Van Wenum, J. and A. Wossink (2001) *Wildlife conservation by farmers: analysis of actual and contingent participation,* AAEA Conference 2001, Chicago: 29 pages.

Weaver, R.D. (1998) Private Provision of Public Environmental Goods: Policy Mechanisms for Agriculture. In: Dabbert, S. A. Dubgaard, L. Slangen and M. Whitby, *The Economics of Landscape and Wildlife Conservation*. CAB International, Oxon/NewYork:159-172.

Appendix

Table A1: Data for the average specialised farm in 1999/00

Variable	Unit	Whole sample	
		Mean	Standard deviation
Output:			
• Milk	1000 '91 NLG	373	190
• Wildlife and landscape	1000 '91 NLG	7	10
• Other output	1000 '91 NLG	65	75
Variable input:			
• Feed input	1000 '91 NLG	87	58
• Cattle input	1000 '91 NLG	6	3
• Other	1000 '91 NLG	57	39
Quasi fixed inputs:			
• Labor	hours	4192	1370
• Land	ha	42	19
• Capital buildings	1000 '91 NLG	403	178
• Capital machinery	1000 '91 NLG	185	96
Other Characteristics			
• Soil type		Mainly peaty, other soil type is clay	

Source: FADN

Table A 2: Estimation results

parameter	estimate	t-ratio	parameter	estimate	t-ratio
γ_{10}	-0.2003	8.70	α_{22}	9.1895	2.61
γ_{11}	8.0099	5.33	α_{23}	-0.3603	-9.31 E-5
γ_{12}	1.2708	6.42	α_{33}	24.8803	2.40 E-3
γ_{13}	0.0680	6.51	β_{00}	-0.0001	-1.36
γ_{14}	0.0966	4.26	β_{01}	0.0035	1.10
γ_{15}	-0.6195	-1.07	β_{02}	0.0006	1.85
γ_{16}	1.0741	2.64	β_{03}	-0.001	-3.44
γ_{20}	-0.2208	-18.29	β_{04}	0.0003	6.17
γ_{21}	-0.5852	-0.70	β_{05}	0.0003	-0.17
γ_{22}	0.5789	5.51	β_{06}	0.0037	3.23
γ_{23}	-0.0219	-3.79	β_{11}	-1.7309	-4.69
γ_{24}	-0.0105	-0.84	β_{12}	0.02155	0.73
γ_{25}	-0.7135	-2.12	β_{13}	0.0067	3.63
γ_{26}	1.3815	5.94	β_{14}	-0.0037	-0.96
γ_{30}	-0.0117	-21.17	β_{15}	0.2133	1.36
γ_{31}	0.0222	0.53	β_{16}	-0.0124	-0.14
γ_{32}	-0.0322	-6.52	β_{22}	0.0056	1.69
γ_{33}	-0.0007	-2.48	β_{23}	0.0005	2.11
γ_{34}	-0.0004	-0.58	β_{24}	-0.0015	-4.37
γ_{35}	-0.0480	-2.63	β_{25}	0.0195	1.27
γ_{36}	0.0529	4.90	β_{26}	-0.0165	-1.61
γ_{40}	-0.0419	-5.88	β_{33}	0.00003	2.03
γ_{41}	4.0726	8.10	β_{34}	-0.0002	-5.96
γ_{42}	-0.9008	-14.47	β_{35}	-0.0012	-1.10
γ_{43}	-0.0021	-0.60	β_{36}	0.0011	1.46
γ_{44}	-0.0223	-2.94	β_{44}	0.0001	1.50
γ_{45}	-0.3837	-1.85	β_{35}	0.0037	1.26
γ_{46}	-0.3920	-2.52	β_{46}	-0.0024	-1.48
α_{11}	0.0487	0.0125	β_{55}	-0.0085	-0.29
α_{12}	-0.6087	-0.1998	β_{56}	-0.0646	-1.23
α_{13}	0.4379	2.61	β_{66}	-0.0384	-0.80
Observations	6203				
Farms	1237				
Period	1986/87-1999/00				