# Making the Principal Agent Nexus Applicable to Nature Provision by Farmers: On Information, Mechanism Design and Transaction Costs

Ernst-August Nuppenau

Justus-Liebig-University

Giessen, Germany

# Content

# Motivation



- Many attempts have been made to develop schemes that improve the environment of rural areas by paying farmers for ecosystem services.
- These payments shall address changes in farm practices (see below a review and references for specific aspects in mechanism design in agriculture) and be cost minimal
- Policy makers are especially searching for feasible incentive schemes and mechanisms that
  - (i) optimally link environmental services to precondition being observable,
  - (ii) presumably offer less intensive agriculture as goal,
  - (iii) find appropriate types of payment schemes based on indicators,
  - (iv) address heterogeneity of farmers and environments; and
  - (v) are suited for diverse landscapes
- The problem of hidden information and moral hazards concerns applicants.

# Objectives

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

- It is the objective to modify the principal/agent approach of Laffont and Tirole for an application in nature provision.
- We address specific problems in nature provision which emerge in terms of complexity in nature provision.
- A further objective of the paper to provide the theoretical background for an empirical design of a flexible and adjustable payment scheme.
- In particular, the proposal seeks to minimize social costs of the principal, i.e. government, in exchange for environmental services provided by farmers.
- This proposal will recognize revelation mechanisms, incentive compatibility and transaction costs simultaneously in the design of payment programs.

# Type the problem

- The theory of incentive in procurement and regulation with heterogeneity of agents, information deficits and possibilities for discrimination requires rules to be linked to the products (nature in our case being, in particular, also diverse).
- Especially, the application of the theory of incentives in procurement and regulations in environmental economics proves that standard findings (Pigouvian taxes or subsidies) should be only considered as a special case conditional on rules in a wider context.
- Why not auctions?

  - Auctions need a clear description of the product to be auctioned and work with point pollution.

  - This work draws parallel lines between the economics of negative externalities in non-point pollution and economics of positive externalities in nature provision by farmers.

  - Much of this work draws back on Xepapadeas.

# hidden information in nature provision

- Kreps
- Varian
- Slangen
- Ozanne and White
- Canton et al.
- Hansen and Romstad
- Moxey et al.
- Metepenningen et al.

# reformulation of nature provision as information problem

For practical applications modeling of the economics of nature provision with diverse farmers is faced with the problems of:

- (i) selection,
- (ii) hidden information,
- (iii) choice of farm practices, and
- (iv) information diversity.

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Three informational aspects in nature provision at farm level have to be quantified:

(i) The product “nature“, itself as to be accomplished;

(ii) changes in “farm practices“ (to be attained, if more nature in agriculture shall prevail) must be made transparent; and

(iii) “farm characteristics“ (as by which criterion farmers can we distinguished) are to be addressed.

**plus transaction costs**

- For example, we uses n as yard stick. Giving weights “w” to individual variables a general yardstick “n“ can be derived on the basis of

  $n = w_{11}\, n_1 + w_{12}\, n_2 + w_{13} n_3$ ($n_i$ are species)

- A set of variables shall be again be composed of variables such as effective soil quality $i_1$, already prevalent nature elements (for example, hedgerows of ditch side strips) $i_2$, and initial or effective or really achievable manure surplus $i_3$. To make the approach operational, these variables are again condensed in an index:

  $i = w_{21}\, i_1 + w_{22}\, i_2 + w_{23}\, i_3$ (i information)

- Then practices as mineral injection into soils (artificial fertilizer $x_1$), manure $x_2$ and herbicide application $x_3$ are the most prominent. We bring them together in another index of practice or intensity of farming $\chi$:

  $\chi = w_{31}\, x_1 + w_{33}\, x_1 + w_{33}\, x_3$

It gives:

$[n, \iota, \chi]' = A_1{*}x + A_2{**}\iota$ or $h_1 n = -h_1 n_o + h_2 I + h_3 \chi + h_4\, \iota$

# objective function of farmer

$$B(\iota)=B(l(\iota),n(\iota),\iota)=\max\ \pi\ w(l(\iota),n(\iota),\iota)=\max[p[l(\iota)-a_{2,0}-a_{2,1}n(\iota)]-C(l(\iota),n(\iota),\iota)]L$$

- I. Decision variables:
- $B(\iota)$ = benefit of farmers
- $\pi w$ = profit without payment but reallocation in favor of nature provision
- $l(\iota)$ = share of land allocation in environmental friendly agriculture as percentage
- $n(\iota)$ = nature provision (see annex)
- II. Distribution variable:
- $\iota$ = information characteristic of farm
- III. Coefficients:
- p = gross margin after reallocation:
- p1 = product price of conventional products
- a1 = yield in conventional production
- k1 = specific costs conventional in production
- p2 = product price of environmental friendly products
- a2 = yield environmental friendly production
- k2 = specific environmental friendly in production
- a2,0 = intercept of linear yield decline function due to nature provision
- a2,1 = proportional factor of linear yield decline function due to nature provision
- C(.) = cost function
- L = total land

# - government objective function

sum (integral over heterogenous farmers) with Distribution function f(i):

$$W(\iota) = \int [B(l(\iota), n(\iota, h4)) - \lambda [s(\iota) + c(\iota)]] f(\iota) d\iota$$

with additionally:
s(i) : subsidy
c(i) : transactions costs

# - constraints:

$$N = \int n(\iota) f(\iota)\, d\iota \quad \text{and} \quad L = \int l(\iota)\, f(\iota)\, d\iota$$

Nature Land

# Truth Telling Mechanism

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

The "truth-telling" and incentive criteria of mechanism design will be accomplished by the redesign of the optimization of the principal according to the agent's optimal choice on the criteria "$\iota$" that he wants to reveal. Laffont and Tirole (1993) have proved that in general a condition or constraint, such as

$$\int\int \psi''(C(\iota) - h4\iota)\, dC(\iota)\, d\iota \geq 0$$

guarantees that truth-telling prevails.

It translates into a dynamic constrain of the feature of a differential equation

-Technically, a control problem can be expressed with a Hamilton function.

- It is a generalization of a Lagrange approach.

$$H(\iota)=[(1-\lambda)B(l(\iota),n(\iota),\iota)+\lambda[\pi s(\iota)-c(\iota,h4)]-$$

$$\beta^{N*}n(\iota)-\beta^{L*}l(\iota)]f(\iota)-\nu_1(\iota)B_n(n(\iota))-\nu_2(\iota)h_1^{-1}h_{4,0}n(\iota)$$

optimality conditions and derivatives to

$$\frac{\delta H}{\delta n}=-\dot{\nu}_2 \qquad \frac{\delta H}{\delta l}=0 \qquad \frac{\delta H}{\delta h_4}=0 \qquad \frac{\delta H}{\delta \pi}=-\dot{\nu}_1 \qquad \frac{\delta H}{\delta \nu_1}=\dot{\pi} \qquad \frac{\delta H}{\delta \nu_2}=\dot{n}$$

where $\nu_1$ and $\nu_1$ are “dynamic” shadow prices for nature and land

… (13.1)

… (13.2)

… (13.3)

system (13.4)

… (13.5)

… (13.6)

of four differential equations in l, n, $v_1$, and $v_2$

# Application

Three major elements appear in data development for an empirical foundation.

- The ecological, agronomic, and statistical problems in the formulation of equation (1) have to be solved. The corresponding theoretical aspects are discussed in the appendix. This can be done on base of pilot studies and empirically approved yardsticks which are feasible.
- The coefficients of the objective function, in particular, the cost function must be calculated. This can be done the base of sampling from the same pilot studies or on the base of farm models that are generalized by certain techniques, in order to be representative for the farmers involved.
- The distribution function of farmers with regard to the index of the characteristic must be evaluated which can be done only by broader sampling with the majority of farmers.

# Summary

- It has been shown how the theory of incentive in procurements and regulation, which is a special branch of the principal/agent theory, can be applied to nature provision by farmers.
- The paper developed an appropriate formulation of the agents' and principal's objectives in nature provision, to synchronize countervailing interests of farmers and the government
- A delivery of numerically applicable formula for the derivation of subsidies on nature provision