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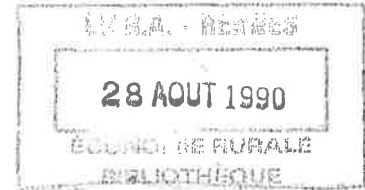
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ECONOMY AGAINST ECOLOGY :

MODELLING MANURE UTILIZATION IN FRANCE

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Some environmentalists believe that nature has intrinsic value whether humans are around to sense and experience it or not, therefore they do typically recommend the elimination of pollution. Economists tend to deal with pollution in a different way because they consider it occurs only when one or more individuals suffer a loss of welfare. So pollution being a negative externality there is an optimal level of pollution. The search for this efficient level raises difficult problems because we need to know the private benefit of the polluter and the external cost.

Damage functions are very difficult to estimate in practice since they involve components which do not have observable prices, so specific valuation methodologies are needed. Moreover the identification of damage categories is opening the way for disputes about their relevance because preferences for environmental assets are very contingent. But as suggested by Baumol and Oates (1988, pp.240-243) there is good reason to believe that the demand for environmental quality will rise with income. This position is consistent with the recent emergence of the environmental movement which developed a consciousness about the value of environmental assets. As a consequence the economist will have to put higher values on social costs since it can be expected that willingness to prevent environmental stress is going to increase in the future. Therefore it can be argued it is possible to reconcile ecology and economy.

The development of intensive livestock farming creates detrimental effects which include amenity losses due to noise, bad smell and aesthetic changes. But up to now they are considered as being small compared with the contamination and eutrophication of ground and surface waters, due to run-off and the leaching of animal wastes. There is now in France a great concern with the nitrate contamination because nitrate concentration in drinking water is above the permit level of 50 mg/l in several areas.

This paper is restricted to the nitrate component of pollution due to liquid manure and focuses on nitrogen excess at the farm level. This relevant variable is reviewed in the first point which is mainly descriptive, since using microdata farms are classified according to the level of nitrogen excess. There clearly exists a threshold for nitrogen excess above which farm operators are polluters. But the point is why they do not respect agronomical standards and so pollute the environment ? To deal with this problem an econometric model of farmers'behaviour in face of manure and mineral fertilizers is developed in the second point. It is based upon a Tobit specification in order to take this threshold effect into account. The third point is devoted to the econometric estimation on panel data for the years 1982-86 and the discussion of the results emphasizes technical and allocative inefficiencies.

1- Nitrogen excess from intensive animal production at the farm level

Due to the changes in society, with urbanization and the increase in purchasing power, the meat demand has considerably increased in the last decades. On the supply side, a converging set of technological advances, mainly in poultry and pig production, has made it possible to respond to the needs that arose. These advances have been adopted in France in the sixties by the most dynamic farmers generally settled in small holdings located in regions without employment opportunity.

During the seventies cheap import of feedstuffs contributed to the possibilities for development in intensive stock-keeping. But the intensification at the European level has led to overproduction and to lower profit margins, so that the scale of operations has enlarged leading to considerable animal wastes per unit of land in some cases. The pollution effects of the intensification has been increased by a parallel development towards regional specialization to such an extent

that more than one-half of French pig production is now located in only one region, namely Brittany.

According to the number and the type of livestock it is possible to estimate the availability of fertilizer components of animal origin per farm. But otherwise artificial fertilizers are bought and we have to take the total amount of nutrients into account. If the application rate in cultivated land of total nitrogen from animal or mineral origin, is more important than the extraction, which depends on the type of crops and yields, damage to environment ensues. We can assume that these damages are proportional to the excess of nitrogen.

In fact, the effects of nitrogen surplus are more complicated because groundwater pollution depends on the nitrogen cycle in the soils. Furthermore the effects of on-site manure spreading are related to the nature and the state of the soil. Soils can be distinguished as being nil, poor, average and good. This classification has to be compared with weather conditions, which ultimately leads to three kinds of surface : those on which slurry spreading is unsuitable at any time of year, those on which it is unsuitable only in winter, and those on which slurry can be spread at any time of year. So the relationship between a certain amount of fertilizers and the consequent damage is not a simple one.

The nitrogen excess is estimated from the French farm accountancy data network, a representative sample of full time farms giving detailed informations on 6500 units. A panel with 489 intensive animal farms is selected from 1982 to 1986. Intensive animal farming is defined by a ratio of stock-keeping per hectare (number of animals corresponding to one cow one year over than 1.5), and the total nitrogen is expressed in kg of mineral nutrient. Some holdings do not produce crops and they have only animals and they export manure. But export flows of manure are unknown therefore farms with less than 5 ha are excluded from the sample and are not taken into account in results reported below.

As indicated in table 1 along the five years surpluses reach high values since the grand mean of total animal and mineral nitrogen excess per ha equals 176 kg varying from a minimum of 170 kg in 1985 to a maximum of 181 kg in 1986. But the dispersion of these results is very important as shown by the standard-deviation.

	1982	1983	1984	1985	1986	Total
mean	189	172	176	170	181	176
standard-deviation	487	404	405	392	571	457

It is possible to compare the grand mean of 176 kg with results reported by other authors, as for instance Becker, 1989, p.191 who did similar calculations for Lower-Saxony in FRG. For the same period, he obtains surpluses varying from 324 to 347 kg/ha, twice the French result.

The importance of the variance concerning the French results may be explained by differences between types of farming. This point is clear in table 2 where the distribution of holdings by type of farming according to the difference between total supply of nitrogen and total plant fixation is given.

Table 2. Distribution of holdings by type of farming according to the nitrogen availability (cumulated data)

	deficit units	balanced units	excess units	all %	units number
Mixed farming (arable land+ cattle and dairy)	14 %	8 %	78 %	100	1623
Arable farming (cereals+sugar beets+oilseeds)	9 %	10 %	81 %	100	728
Intensive livestock (pig and poultry)	8 %	7 %	85 %	100	78
All farms	12 %	9 %	79 %	100	2429

For all types of farming, deficit units account for 12 % ; balanced units for 9 % and excess units for 79 %. The break-down by type of farming in table 2 shows that excess units are more numerous among intensive livestock farms (85 %) than in mixed farms (78 %). Reversely there is a lack of nitrogen in 14 % of the mixed farms, against 8 % in intensive livestock farms. Arable farming occupies a medium range in both cases.

Table 3 provides other data concerning the distribution of farms according to the level of nitrogen availability. It is assumed that 30 kg of nitrogen per ha is an agricultural threshold below which there is no utilization by the crops. So this level corresponds to a negative excess.

Table 3. Farm distribution according to nitrogen excess (in %)

N-Excess (in kg/ha)	82	83	84	85	86
> 500	4.5	4.1	4.5	4.5	4.9
> 300	7.6	7.8	9.2	8.2	7.4
> 200	21.2	19.2	17.1	19.6	15.9
> 100	50.9	51.5	53.2	50.1	48.9
> 50	72.4	72.6	72.2	72.0	71.1
> 30	79.0	81.0	80.2	77.9	76.9
< 30	21.0	19.0	19.8	22.1	23.1

The figures in table 3 show a steady rate of farms, about one-half, for which there is an important excess, over 100 kg/ha, while the number of high polluting units, for which excess is greater than 200 kg/ha, has declined from 21.2 % in 1982 to 15.9 % in 1986. But the rate of very high polluting farms, for which the difference between total supply and utilization by plants exceeds 500 kg per ha still remains stable 4.1 % to 4.9 %. Moreover there is an increase of the number of units below 30 kg per ha from 21.0 in 1982 up to 23.1 in 1986.

2. Farmer behaviour and manure utilization

Manure spreading involves costs but generate benefits for the farmer since organic nitrogen can be substituted for bought fertilizers. Sometime those benefits are not enough to balance spreading costs so the free disposal hypothesis is not met, but usually manure spreading is a profitable process at the farm level.

For a given level of output the total amount of available organic nitrogen is fixed but usually too small to fulfill plant requirements. Thus the cost minimizer has to determine the optimal level of mineral nitrogen he has to purchase. Therefore nitrogen excess is not consistent with a cost minimizing behaviour because it shows technical and allocative inefficiencies. Moreover nitrogen excess creates social costs because a fraction of nitrogen spreaded is not assimilated by the crops.

Let us begin, then, by introducing a model similar with one which has been considered to take into account land and family labour fixity (Vermeresch, 1989). The farmer wishes to minimize the cost of production subject to the relevant constraints concerning the technology and predetermined levels for fixed factors. Note that this cost-minimizing hypothesis encompasses the profits maximizing one which is more restrictive.

Formally the problem is :

$$\begin{aligned}
 & (\text{Min } p'_x \cdot x + p'_z \cdot z \\
 & (x, z \\
 & (\\
 & (\text{(a) } (x, z) \in X(y) \qquad [1] \\
 & (\\
 & (\text{(b) } z \in Z_F \subset R^+{}^N \\
 & (
 \end{aligned}$$

The input-vector is divided into two sub-vectors x for variable inputs and z for fixed inputs. The set $X(y)$ contains all input bundles (x, z) which can give y , and z lies in the hyperplan Z_F .

We shall distinguish three categories of fixed inputs : land T , family labour L_f and nitrogen provision through liquid manure N_l .

There is a constraint on land availability :

$(b_1) T \leq \bar{T}$ and the fixed cost of land is $P_T \bar{T}$. If this constraint is binding then it is possible to infer the long-run equilibrium level for land (Brown and Christensen, 1981 ; Guyomard and Vermersch, 1989). For arable farms, there is econometric evidence that this optimal level is greater than T so in the long-run there is a pressure toward an increasing acreage of farm holdings. Therefore land is a quasi-fixed factor because if the constraint (b_1) was relaxed farmers would adapt farm acreage in order to meet farm size optimality, this process would result into more land under cultivation.

The constraint (b_2) relates to the family labour input and it is given by :

$$(b_2) \quad L \geq L_f$$

The quantity L_f of available family labour provides the lower bound for the total amount L of labour input. This constraint is not necessarily binding because some farm operators have to hire wage earners because there is not enough family labour available on the farm : L_f is smaller than the solution of problem [1] for labour. If labour is demanded in amount smaller or equal to L_f then the constraint is binding. The latter case is often observed and involves a low mobility of agricultural labour due to poor job opportunities. Family labour is a semi-fixed input.

Farms can be classified into two categories according to whether or not the family labour constraint is binding. For the first category for which the constraint is effective there is some hired labour on the farm. Therefore given a cost-minimizing behaviour, the optimal level of labour input equals family labour plus hired labour. The basic idea is to use this information to derive the optimal level of input for the second category of farms for which the constraint is not binding.

A Tobit specification can be used to handle these two categories of farms - Vermersch (1989) has estimated a tobit model using a sample of arable farms in France. The optimal level of labour has been calculated for each farm. Very often, there is a disequilibrium which is characterized by an excess of family labour. Prices and technology given there is too much family labour on farms.

Regarding manure utilization farms can also be classified into two categories so the Tobit specification can be extended to this new problem. Formally the manure constraint is :

$$(b_3) \quad N \geq N_1$$

N_1 equals nitrogen provision through liquid manure, thus the farmer has to spread this minimum quantity. The total amount effectively spreaded is equaled to N which includes N_1 plus nitrogen N_c provided by chemical fertilizers. Thus N_1 and N_c are substitutable.

There is no opportunity to sell N_1 so the farmer has to use it in the production process. Thus the (b_3) constraint is similar to (b_2) because N_1 is an input whose utilization is subject to technical and allocative inefficiencies. In order to go forward let us introduce an agronomical standard S_r which equals, for a given crop mix, average nitrogen requirements per hectare. S_r is farm specific and above this standard pollution occurs.

For each farm a threshold $S_r \bar{T}$ is easily calculated and can be used to split the sample into two sub-samples which are defined by :

$$(i) \quad N_c + N_1 \leq S_r \bar{T}$$

$$(ii) \quad N_c + N_1 > S_r \bar{T}$$

For case (i) total nitrogen spreaded respects the farm specific threshold therefore the farm operator is assumed

to be a cost-minimizer and the observed amount of nitrogen spreaded is optimal :

$$N^* = N \text{ and } N_c^* = N_c$$

Case (ii) reveals allocative and may be technical inefficiencies because too much nitrogen is spreaded so cost-minimizer would have bought a smaller amount than N_c of chemical fertilizers.

Both cases can be written :

$$N = N_c + N_l = \begin{cases} N_c^* + N_l & \text{if } N_c + N_l \leq S_r \bar{T} \\ N_c + N_l & \text{otherwise} \end{cases} \quad [2]$$

This expression completes model specification. It is a Tobit with a specific threshold for each observation instead of only one for the whole sample.

3- Empirical results

The problem involves two thresholds $S_r \bar{T}$ and N_l . The former is a farm specific agronomical standard whereas the latter equals nitrogen provision through liquid manure.

Following Shephard's lemma, derived factor demand is easily obtained. Then let us consider the following linear specification for nitrogen demand :

$$N_c^* + N_l = a_0 + \sum_i a_i P_i + b \cdot y + \sum_h c_h \cdot Z_h \quad [3]$$

The output is represented by y ; p_i is the price of factor x_i , $i = 1, \dots, 4$ respectively : fuel, chemical fertilizers, capital (building and machinery) and feed. Quasi-fixed factors z_h include family labour and acreage under cultivation.

Table 4 shows Tobit model [2] estimation with the parametrization (3). The data bank is a panel of 500 farms for the period 1982-1986 (see annex). Estimates reported in table 4 has been calculated on the pooled sample whose size is $NT = 500$. In order to assess estimation significance a chi-square statistic is provided.

Table 4. Parameter estimates

Variable	Estimate	Standard error	Chi-square
P1	20.50	15.66	1.71
P2	-179.51	41.63	18.60
P3	3850.82	2080.04	3.43
P4	-29.02	14.41	4.05
y	-0.0011	0.0006	2.76
z1 (family labour)	0.033	0.266	0.015
z2 (acreage)	1.94	0.100	371.77
z3	0.026	0.018	1.98
z4	2.82	0.374	57.0

Moreover between, within and classical quasi generalized least square estimations are also considered. Each calculation has been run for three different cases :

- (i) N_c is the dependent variable
- (ii) $N_c + N_l$ is the dependent variable
- (iii) $N_c + N_l$ is explained by a Tobit model

Table 5. Fertilizer own price elasticity (calculated at the sample mean)

dependent variable	total	average		QGLS
		between	within	
N_c	-0.91 (8.95)	-1.33 (9.74)	-0.75 (11.16)	-0.77 (10.65)
$N_c + N_1$	-0.70 (10.38)	-0.53 (3.72)	-0.43 (6.47)	-0.41 (5.65)
$N_c + N_1$ (Tobit model)	-0.24 (18.6)	-0.10 (14.95)	-0.29 (20.05)	

t-ratio and chi-square (Tobit model) are in parenthesis. Obtained values are consistent with cross-sectional results (annex). They are closed to values published elsewhere (Bonnieux and Rainelli, 1988).

Furthermore, these elasticities generally decrease (in absolute term) with the closeness (proximity) of the nitrogen allocation to an efficient level. As a consequence, nitrogen taxation would induce a process which would remove the observed inefficiencies.

Annex : Data and other results

We have used a panel of farms with more than 1.5 cattle units per hectare (N=100) for five years (1982-1986).

Four variable inputs and two quasi-fixed factors are taken into account : the model is specified with prices for fuel, fertilizer, capital and feed ; acreage under cultivation and family labour are included as fixed inputs. z3 represents materials for which we have no price ; z4 is livestock in cattle units. For the capital input, it is assumed that the service flow from the stock of capital is proportional to this stock and, as in Dormont and Sevestre (1986), the user cost of capital is only the apparent interest rate. The level of output is measured by cash sales.

Table 6. Own price elasticity for nitrogen demand : cross sectional estimates

Nitrogen	1982	1983	1984	1985	1986
N_c (chemical)	-0.99	-0.93	-1.09	-0.69	-0.75
$N_c + N_1$ (total)	-0.33	-0.25	-0.54	-0.28	-0.20
$N_c + N_1$ (total) (Tobit model)	-0.23	-0.31	-0.36	-0.22	-0.40

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