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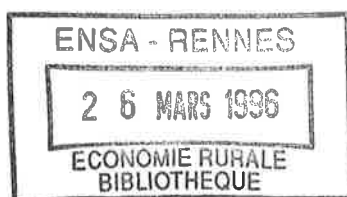
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HEDONIC PRICING OF AGRICULTURE  
AND FORESTRY EXTERNALITIES



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SUMMARY

In the French agricultural sector, the ever-increasing use of factors of industrial origin and the specialization of farmers are responsible for a double blow to the environment. One can observe the simultaneous appearance of negative externalities (such as water pollution and erosion) and the cancellation of positive external factors (landscape degradation and loss of biodiversity...). The quest for profit in the forest sector leads to similar effects, although they are perhaps less pronounced. Environmental policies raise the problem of the choice of pollution or amenity level. A solution can be found in the comparison of the costs of producing the public goods here considered, and the benefit that society can expect to reap from it. Environmental benefits or damages comprise a strong non-market component, which explains the errors of management, and the recreational, esthetic, and ecological losses incurred.

In this study, the hedonic price method (HPM) was used to identify and evaluate some of the external effects of agricultural and sylvicultural activities, basing the study on the renting price of rural self-catering cottages, or gîtes, in Brittany. The 600 gîtes sampled were described using three main categories of attributes: intrinsic, geographic and environmental. The environmental variables describe the use of the soil by agriculture and forestry, in the commune where the gîte is located. We limited ourselves to estimate the hedonic price function which links the price of the gîte to its attributes. Seemingly in accordance with most hypotheses, fodder crops and intensive livestock farming cause the renting-price of gîtes to decrease, whereas permanent grassland seems to have the opposite influence. The effects of forestry and cereal farming, insignificant, need to be confirmed and explained. When we compare homogeneous data, the implicit prices of the variables responsible for the external effects are clearly higher than the subsidy or tax which have been considered, notably in the case of nitrogen pollution caused by breeding. Affined and confirmed, implicit prices could be used to calculate the losses incurred by the tourism sector, or, on a more ambitious level, to evaluate the policies leading to the intensification of fodder farming and animal breeding. Nevertheless, the study includes numerous methodological limitations linked to the specificity of gîtes, to the definition of environmental indicators, to the imprecise nature of the data, and to the linear form of the hedonic price function. Improvements which can be made to the rural applications of the HPM are mentioned in the conclusion.

**Keywords** : hedonic pricing, externality, valuation, benefit, damage, agriculture, forestry, environment, tourism.

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# 1. Introduction

## ***Nature of externalities***

Vermersch (1992) and Rainelli and Vermersch (1992) discussed the environmental consequences of seeking Pareto optimality in the French agricultural sector. On the one hand, technical progress, the regulation of agricultural prices, and the evolution of the relative prices of production factors have been responsible for an ever-increasing use of factors of industrial origin, relatively to land (intensification). On the other hand, the existence of short-term economies and the absence of diversification economies have caused producers to specialize. At the same time, agricultural productions have concentrated in the regions where they are strongest : cereal crops in the north central France, dairy and intensive livestock farming in the West, whereas more and more farms are closing in other regions, most specifically in the southern half of France. The result is a double blow to the environment, which is perceptible on the national level, as well as on a regional level, and even on the level of the single farm. The first is well known and is characterized by the appearance of negative externalities: the harmful effects on the health of humans and on ecosystems caused by the discharge of pesticides, and nutrients of either chemical or animal origin, the denaturation of the countryside by livestock buildings, the odor of animal manure, the erosion linked to farming of certain crops, etc... The second blow to the environment concerns the cancellation of positive services or externalities brought on by agriculture; for example, one can mention the problems of the loss of biodiversity and of aesthetic and recreational services which are brought on by the destruction of hedgerows and the suppression of wetlands, but also by the abandoning of farmland.

Phenomena of the same order, even if they are not so pronounced, characterize the recent evolution of French forests (IFEN, 1994). Since the Second World War, the productive function of the forest has been favored, to the detriment of its ecological and recreational functions. In order to make up for the imbalance between the supply of and demand for forest products, we have reforested using essentially conifers, fast-growing species which guarantee a higher profitability. Even if only a part of the surface-area of the forest is concerned, intensive management like that practiced in agriculture is accompanied by similar environmental consequences. The question is mainly one of the loss of positive external factors : the homogenization of plant populations, whether it be by their age or by their species, reduces landscape quality and biodiversity, which in turn reduces the recreational functions of these areas. On the other hand, the potential negative externalities seem less important and more unknown : repercussions of the use of fertilizers and of phytocides, choice of species and water acidification, etc...

## ***French policies and evaluation***

In the forest domain, environmental policies are essentially regulatory, notably with the creation of natural reserves, biotope designation, protective forests. But there are also more specific measures allowing for an agriculture/forest zoning policy in mountain areas, whose goal is to limit the expansion of the forest in order to avoid

rural desertification and the closing in of landscape. Agricultural environmental policies, which appeared more recently because of a later realization of the scope of the problems, concern externalities and instruments which are more numerous and varied. The recourse to regulation can be illustrated by the policies of classified installations and the nitrate directive which aim to curb of the negative externalities linked to intensive livestock farming, or by the dispositions of the landscape law which preside over land development and land reallocation. At the same time, reflection on the use of economic incentives is progressing rapidly, taking into account both the curbing of negative externalities (programs designed to control agricultural pollution : livestock buildings improvements and nitrogen-pollution tax, Bonnieux et Rainelli, 1995), and the production of positive services (agri-environmental contracts : local operations designed to protect rare and fragile biotopes, to fight against the effects of farm closings, or to manage the fauna and the flora).

The conception of such policies raises the problem of the choice of the objectives of depollution or amenity level. The general answer is to set norms such as 50mg of nitrate per liter of water meant for human consumption. But we know as well that the economic response must also be found by comparing the real costs of depollution at the source, and the benefits reaped by society from the improvements of uses of water (water which has different functions : drinkable, productive, recreational, and ecological, Amigues et al, 1995). A recent report from the Finance Commission of the French General Assembly speaks of the possibility of imposing cost-benefit analysis of environmental regulations, similar to what already exists in the United States (Brard, 1995). What's more, such an approach would clear up the debate over the way economic incentives will be designed.

### ***Hedonic prices and rural amenities***

In this study, the hedonic price method (HPM) was used to detect certain external damages or benefits of agriculture and forestry. The HPM allows us to monetarize non-market environmental assets, by examining the differences of housing price due to variations in the quality of the environment. The hypothesis put forth is that the increase of the value of homes brought on by the increased quality of the environment would represent the Willingness to pay (WTP), for an improved environment. We seek to emphasize a relationship between housing prices and their attributes of livability, of location, and of environmental quality. This relationship, the hedonic price function, allows us to obtain the implicit price of the environment and, with other information concerning consumers, to trace the demand for a healthy environment, and then the welfare changes caused by environmental policies. The theoretical and practical questions raised by the environmental application of the HPM have been gathered in various surveys (Freeman, 1979 ; Follain and Jimenez, 1985 ; Johansson, 1987 ; Bartik and Smith, 1987 ; Palmquist , 1991 ; Freeman, 1993 ; Desaignes and Point, 1993 ; Le Goffe, 1995). The empirical applications of the HPM involve essentially the valuation of urban assets, such as noise and air-quality (Soguel, 1994 ; Nelson, 1978). Several studies have emphasized the positive effects of trees (Anderson and Cordell, 1988) and of city parks (More et al, 1988) on property value. The rural applications are very limited : the results concern forests

and natural areas, but nothing in-depth has been done on agriculture (Garrod and Willis, 1992 and 1993 ; Delache and Jacques, 1994).

In our article, the hedonic approach was applied to the renting-price of rural self catering cottages, or gîtes. The study was limited to Brittany, in Western France. Here, the environmental effects are partially internalized since the gîte owners, who are often farmers, benefit from the price-differentials resulting from the environmental quality that they themselves have been instrumental in creating. However, we hope to transpose these findings to other rural properties in which welfare changes do not necessarily give rise to monetary compensation. Our research had three main objectives:

- to identify the agricultural or sylvicultural elements which effectively result in welfare changes.
- to found the public policies of pollution control and of providing of amenities, in particular those requiring economic incentives, the rate of which must be debated.
- to examine the methodological problems raised by the HPM and its application to the countryside.

## **2. The Data**

### ***Selecting the properties***

In the last twenty years, hedonic studies on housing have been carried out essentially in Anglo-Saxon countries, and particularly in the United States, where there is a more simplified access to computerized files of transactions, classifying the price and the characteristics of both lodging and of house-buyers. In France, this type of access is not possible. In order to study housing transactions, nevertheless, it is possible to resort to specific or existing surveys. If the homes surveyed are main residences, we are dealing with numerous local markets which are influenced by the work market in particular. The need to carry out our study in a large geographical area, in order to have at our disposal a sufficient variety of the effects of agriculture, would have led us to group separate markets. According to Palmquist (1991), such a grouping leads to a biased estimation of the coefficients of the hedonic price function. This problem does not exist when one deals with rented accommodations, such as gîtes, the market of which is more regional, or even national. Moreover, compared to a main residence, the demand (and thus the price) for rented accommodations is undoubtedly more influenced by environmental attributes , and less so by the need to be near certain tertiary sectors, one's job, or road systems.... This « hedonic » attitude of the consumer choosing rented accommodations is favorable to the detecting of environmental effects in the price, at the same time eliminating other parasitic variation factors. As gîtes are necessarily located outside of towns, it is fair to think that their agricultural and forest settings influence the price of rent. Finally, a centralized file of gîtes exists. It is available in regional catalogues,

with information classified according to season, to the size of the accommodations, the quality of services, etc<sup>1</sup>...

The sample retained assembles roughly 600 gîtes dispersed nearly equally between the departments of Finistère, Côtes d'Armor, and Morbihan<sup>2</sup>. 45 percent of the gîtes are located in the north of Brittany, and 55 percent in the south. We chose to limit the sample to a region whose countryside is sufficiently homogeneous; in fact, a national study would have involved a risk of confusion of environmental effects with the specificities of the regions involved (relief, geology, rural architecture, patrimony, etc...). Nevertheless, the gîtes were selected in such a way as to create a sufficient variability in the use of the soil, notably in connection to the intensive or extensive nature of the agriculture, as well as to the degree of forest cover.

### ***Prices of the gîtes***

The information concerning the gîtes is taken from the 1995 catalogues. The weekly renting prices were recorded for the high, middle, and low touristic seasons (table 1)<sup>3</sup>. We of course dealt with the price listed and not with equilibrium prices. This makes the assimilation of implicit prices to marginal WTP a difficult affair. The study of the rate of occupancy of the gîtes does, however, lead us to make a distinction between the renting seasons. Whereas the rate of occupancy is nearly 100 percent in the high season, it is much lower in the middle season and especially in the low season. This is a common phenomenon which can be observed for all forms of tourist accommodations in Brittany (Bonnieux and Rainelli, 1991). The process of determining the price of gîtes is thus most likely different according to the season. In the high season, the proprietor takes into account the rate of occupancy and adjusts his price from one year to the next, in order to fill his gîte at the highest price. On the other hand, the need to make a profit does not allow for too great a reduction in the price of rent, during the middle and low seasons. As the demand during these seasons is lower, there is a resulting partial rate of occupation. In order to take into account the process of price-adjustment, which most certainly takes place in the high season, we limited ourselves to gîtes which have existed for at least 8 years. The idea was that renting price of the gîte, which was set arbitrarily the first year of its existence, has had the time to adjust, notably to the demand for environmental amenities. As these environmental attributes are not listed in the gîte catalogues, we must beware of a lack of consumer information, which might cast doubt on the application of the method. The customer surveys performed by Breton gîte associations contain two elements which help assuage that misgiving. First of all, a majority of gîtes are rented through the intermediary of connections. Second, the gîte clientele is a very faithful one; a vast majority of vacationers plan on coming back to the department and using the same system of accommodation. It is thus

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<sup>1</sup> Gîtes de France.

<sup>2</sup> The total number of gîtes in the three departments is approximately 3000, which means that our survey represents 20 percent of the gîtes.

<sup>3</sup> High season : July and August ; middle season : June and September ; low season : from October to May.

probable that a significant portion of the clientele are already familiar with the gîte environment, either indirectly or directly (regular customers).

### ***Attributes of the gîtes***

The gîtes are characterized by three main categories of attributes : intrinsic, geographic, and environmental. Table 1 gives statistics describing the attributes later chosen in the hedonic models. The intrinsic attributes of the gîtes are the number of people they can lodge, the gîte-catalogue rating (rating given according to the quality and comfort), and the separation from other buildings<sup>4</sup>. The geographical situation of the gîte can be classified according to several distances (various were tested) which are likely to influence the welfare of its users. We chose the distance from Paris to give an indication of the average cost of reaching the gîtes for the French clientele, and of east/west location as well. The proximity of the sea is a well-known factor of influence on the price of holiday accommodations, and recreational users of the coastline make up the bulk of the Breton clientele. Finally, the climatic factor was taken into account by locating the gîtes in the north or the south of Brittany.

Defining environmental attributes raises difficult questions, often discussed in writings on the topic (Freeman, 1993). In our study, the most obvious approach would have been to index the renting price of gîtes according to the environmental parameters which are influenced by agriculture and by the forest. Thus, we would have needed data concerning water-quality (content of nutrients and of pesticides), the biodiversity of the aquatic and terrestrial ecosystems, different elements of the landscape, etc... These data are not readily available, for one thing, and for another thing, it can sometimes be difficult to determine the specific role farming plays in the evolution of these parameters. Lacking trustworthy indicators to measure external influences, we adopted a global approach measuring the use of the soil by agriculture and by the forest. Each gîte was described according to the proportion of the surface area of its commune dedicated to forest, permanent grassland, cereal and fodder crops; these are the main uses of the soil in Brittany. We completed the data on plant production with statistics about the density of livestock compared to the surface area of the commune. With this approach, the agricultural and silvicultural variables synthesize several environmental influences, which become impossible to isolate. In this way, the existence of fodder crops implies the use of species (corn) and/or farming practices which are potentially harmful to the environment, the systematic recourse to fertilizers and pesticides, the frequent destruction of hedgerows, and a high density of dairy cattle. On the contrary, permanent grassland characterize more extensive systems which have a greater respect for hedgerows, the soil and water-quality. At the same time, a high density of either pigs or poultry causes problems of noxious odors, the degradation of the landscape by livestock buildings, the pollution of the air and water by animal manure. This is the reason for which these monogastric species have been grouped on the basis of the nitrogen contained in their manure.

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<sup>4</sup> A distinction is made among gîtes which are adjacent to other accommodations, non-adjacent gîtes located in a group of buildings sharing one courtyard, and gîtes which are completely independent.

Table 1 - Descriptive statistics of prices and attributes of the gîtes used in the hedonic models (n=580)

Variable	Average	Standart Deviation	Median	Minimum	Maximum
High season price (FF/week)	1959	473	1920	880	4100
Middle season price (FF/week)	1340	339	1300	500	3670
Low season price (FF/week)	1148	285	1100	400	3420
Lodging capacity (Number of persons)	4.8	1.4	5	2	11
Gîte rating (stars)	2.1	0.7	2	1	3
Adjacent gîte (1=yes, 0=no)	0.47				
Shared courtyard (1=yes, 0=no)	0.27				
Distance from the sea (km)	20.8	17.0	17.0	0.2	72
Distance from Paris (km)	501	54	493	395	621
Geographical location ( 1=north, 0=south)	0.46				
Pigs (head/ha TSA)	3.2	3.1	2.1	0.0	15.0
Poultry (head/ha TSA)	47.9	52.5	31.9	0.0	433.0
Monogastric animals (ANU <sup>1</sup> /ha TSA)	0.56	0.44	0.46	0.0	2.61
Fodder crops (%TSA)	32.4	10.7	33.3	4.0	69.9
Permanent Grassland (%TSA)	9.5	5.1	8.1	0.6	30.1
Cereal crops (%TSA)	18.2	8.8	16.4	3.6	93.6
Forests (%TSA)	7.8	7.0	5.5	0.0	43.3

TSA = Total Surface Area

<sup>1</sup> Animal Nitrogen Unit ; 1 pig = 0.1 ANU ; 1 poultry = 0.005 ANU

### 3. The Model

Most of the hedonic studies applied to the environment in the last twenty years have been based on the work of Rosen (1974), dealing with the theoretical model of markets of differentiated goods. According to this model, the characteristics constituting the differentiated good come to play simultaneously in the utility function of the consumer and in the cost function of the producer. The hedonic price function represents the geometrical place of equilibrium between the supply of and the demand for the different goods. Following the example of Freeman (1993), we will confine ourselves to the demand of a housing market with environmental attributes. The utility of the consumer  $U$  is a function of the characteristics of his accomodations, and of the consumption of other goods, represented by the vector  $X$  (price vector  $P_x$ ). Thus  $I$ ,  $L$ , and  $Q$ , respectively, are the vectors of the intrinsic,



location, and environmental characteristics of the lodging, which are also arguments for hedonic price function  $P$ . The program of the consumer is :

$$\text{Max } U(X, I, L, Q)$$

$$\text{Subject to budget constraint : } PxX + P(I, L, Q) = R$$

Solving this equation with  $q_j$  being one of the environmental attributes, and  $x_j$  being one of the other good consumed leads us to the optimal solution which checks:

$$\frac{\partial U / \partial q_j}{\partial U / \partial x_i} Px_i = \partial P / \partial q_j$$

In equilibrium, the consumer chooses his level of characteristic  $q_j$  by matching his marginal bid for  $q_j$  to the implicit marginal market-price of  $q_j$ . As a result, in a market in which consumers maximize their utility, the implicit marginal price observed at a given level of a characteristic, obtained by the derivation of the hedonic price function, supplies the consumer's marginal WTP for this characteristic. The hypothesis of a market in equilibrium, which implies that consumers constantly reexamine their choice and that all differentiated goods find a taker, was discussed by Freeman (1979 and 1993) concerning the housing market. The second step then consists in identifying the demand function, thus opening the way to calculating the welfare changes due to environmental policies.

The Breton gîte market probably satisfies the hypothesis of uniqueness (see above), and perhaps the hypothesis of equilibrium in the high season, all the more so since, unlike the situation of the market for main residences, the consumer is free to reexamine his choice, practically without incurring mobility expenses. As this was an exploratory study, and as we lacked information about the clientele of gîtes, we confined ourselves to the first step, which leads to the hedonic price function and to the implicit price of environmental attributes, without identifying the demand. This will cause several problems for the calculation of the welfare changes due to environmental policies. The hedonic price function is specified empirically as follows:

$$P_i = P(I_i, L_i, Q_i)$$

where  $P_i$  is the price of weekly rent for gîte  $i$  (a model was estimated for each season), and where  $I_i$ ,  $L_i$ , and  $Q_i$  designate the vectors of the intrinsic, local, and environmental attributes of gîte  $i$ . Lacking a simple analytical solution of the Rosen model, the theory gives few indications about the specification of the functional form of the hedonic equation, which, however, is known for affecting implicit prices (Graves et al, 1988; Cropper et al, 1988).

In our study the choice of attributes was guided by the desire to reconcile two antagonistic constraints. It was important first to not omit any key characteristics, in order to not bias our estimations (Bateman, 1993). But it was also important to avoid

the multicollinearity brought on by a multiplication of variables. For this reason, we linked the agricultural indicators to neighboring environmental effects : wheat, barley and corn in cereals, temporary grasses and corn fodder in fodder crops, pigs and poultry in monogastrics. The different functional forms found in literature were tested : linear, log-linear, log-log, Box-Cox. It seems important to seek out flexible forms : the transformation of Box-Cox of the dependent variable  $p(\lambda) = (p^\lambda - 1) / \lambda$  thus allows us to obtain rising implicit marginal prices, constant or lowering with the level of the characteristic, according to the value of  $\lambda$  (Bateman, 1993). We should note on this point that the identification of the demand is impossible when the hedonic price function is linear.

#### 4. The Results

The best results were obtained for the weekly price in the high season, with 65% of variation explained by the model (table 2). The functional form we chose was linear; we could not improve the signification of the coefficients and the  $R^2$  by testing more complex flexible functional forms. It is also profitable to express the agricultural variables according to the total surface area of the commune, rather than in utilized agricultural area. A graphic test of heteroscedasticity proved negative. The attributes which play a role, and the sign of implicit prices seem to be generally in keeping with the hypotheses and with the empirical intuitions. Among the intrinsic attributes tested, three had an influence on the price of gîtes. The first important attribute was lodging capacity ; renting price went up by approximately FF200 per extra person accomodated. Next came the rating, with an increase of FF180 per each extra star. Finally, the separation of the gîte from other buildings is also taken into account : a completely independent gîte will rent for FF120 more than a gîte adjacent to other buildings, and FF80 more than an independent gîte sharing a courtyard with other gîtes. On the other hand, the further the gîte is from Paris, the more expensive it is (FF1.4 per kilometer), whereas we had expected the opposite effect because of travel expenses. A possible interpretation of this effect lies in the consumer's desire for a certain « Breton » character (landscapes, homes, place names) which are more frequent the further west one goes. There may also be a question of a relief which is much more impressive in the west. Finally, we remarked a FF90 price difference between the north and the south, with, as expected, the south being more expensive.

We maintained five environmental attributes in the model, of which only two are clearly significant. It appears that the price of gîtes is negatively influenced by intensive fodder and livestock farming, with robust signs and coefficients when one modifies the model. The result is approximately FF5 per point for the fodder crops and FF120 per additional ANU<sup>5</sup> per hectare for monogastric animals, which represents in both cases a range of FF300 renting price between the extremes gîtes, the average price of which was FF2000. We deteriorate the accuracy of our estimations when we attempt to disassociate the pigs and poultry, or, conversely, when we attempt to include monogastrics animals and cattle in the same index. The implicit

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<sup>5</sup> Animal Nitrogen Unit calculated on the basis of nitrogen excreted.

index. The implicit prices of the proportions of permanent grassland and of forests, even if not significant, have a fairly robust sign. Whereas the price of gîtes increases with the proportion of permanent pasture, it is diminished by forest cover, but these are only trends. The influence of cereal crops is less robust.

When we now look at the models for the middle and low seasons, the percentage of variation explained by the model is clearly lowered. In the middle season, we can find almost the same significant attributes as in the high season, with the same signs, but the influence of north-south location disappears. The effects have diminished, more or less proportionally to the average renting prices, except for the rating and the distance from the sea, where we can remark a clear drop. In the low season, the renting prices of gîtes are influenced essentially by their intrinsic attributes and the distance from the sea. The density of monogastric animals is now the only significant environmental attribute. Nevertheless, the sign of the variables is maintained all year long.

Table 2 - Estimation of the hedonic functions (linear models)<sup>1</sup>

Variable	High season	Middle Season	Low season
Constant	363 (1,9)	371 (2,1)	467 (2,7)
Lodging Capacity	196 (22,6)	134 (17,1)	112 (15,0)
Gîte Rating	180 (9,5)	73 (4,3)	62 (3,7)
Adjacent gîte	-118 (-3,9)	-77 (-2,8)	-71 (-2,8)
Shared courtyard	-85 (-2,5)	-46 (-1,5)	-71 (-2,5)
Distance from the sea	-8,2 (-9,4)	-4,4 (-5,5)	-3,8 (-4,8)
Distance from Paris	1,4 (4,9)	0,7 (2,9)	0,3 (1,3)
Geographical location	-92 (-3,5)	-4 (-0,2)	-50 (-2,2)
Monogastric animals	-120 (-3,3)	-83 (-2,5)	-71 (-2,2)
Fodder crops	-4,7 (-3,5)	-2,5 (-2,1)	-0,7 (-0,6)
Permanent grassland	4,8 (1,8)	2,0 (0,8)	1,1 (0,5)
Cereal crops	3,4 (1,6)	3,7 (2,0)	2,7 (1,5)
Forests	-3,2 (-1,5)	-2,7 (-1,4)	-1,6 (-0,9)
R <sup>2</sup>	0,65	0,45	0,42
Adjusted R <sup>2</sup>	0,64	0,44	0,41

<sup>1</sup> Weekly Prices for 1995 in French francs.

## 5. Discussion

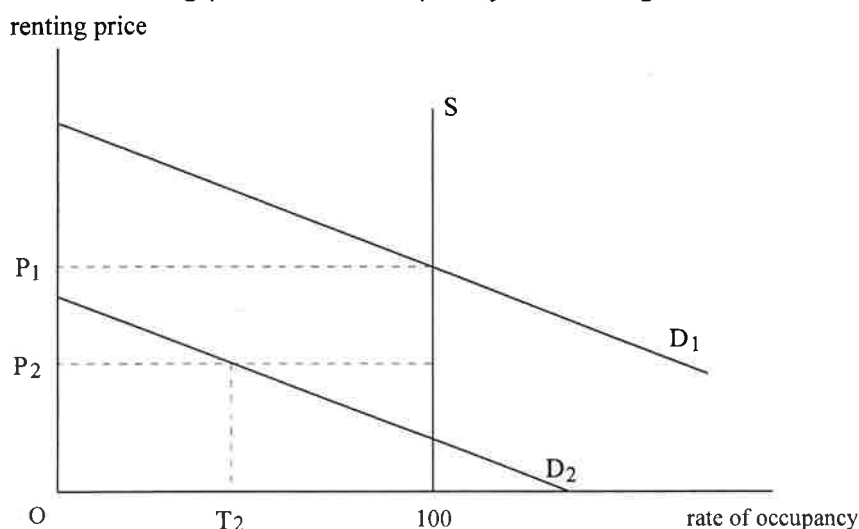
One important limitation of this study comes from the fact that the environmental attributes and the prices were available for different years, respectively 1988 and 1995. Did agriculture and forestry evolve significantly during that period ? The answer can be found by comparing agricultural statistics for Brittany for 1988 and 1993. We can remark a drop of 6 percent in the number of bovines, most probably due to milk quotas and the increase of productivity. This drop is logically accompanied by a global decrease in the land used for fodder (fodder crops : -10 %, permanent grassland : -8 %), even though the amount of land reserved for corn fodder increased by 10 percent. At the same time the amount of land used for cereal farming increased by 11 percent, and the number of monogastric animals increased rapidly (pigs: 12 %; poultry : more than 20 %). It is difficult to say to what point this evolution influenced our results. We can assume that the intensification of crop-farming and especially of animal breeding occurred more frequently in areas where the practice of intensive farming was already more widespread, thus widening the differences between the communes. Following this hypothesis, the implicit price associated with the density of monogastric animals, for example, would be overestimated.

The environmental influences all turned out generally as we expected, except perhaps the influence of the forestry, which was negative, but not significantly so. In an attempt to explain its influence, we decided to study the characteristics of the Breton forest. In Brittany, the forest is mainly private property, and since World War II, reforestation has been done with mainly conifers, resulting in a proportion of this species which is higher than the average for France. This situation is not favorable for the recreational use of the forest ; it can be likened to the reduction of housing prices caused by conifers, observed by Garrod and Willis (1993). More generally, we can rethink our choice of indexing external factors according to variable of the use of the soil. Over and beyond the aspects which have already been discussed (global or indirect character), it is probable that the aesthetic function of the countryside is not as well taken into account as its ecological function. First of all, architectural elements, which, along with the agricultural or silvicultural uses of the soil, form the rural French countryside, have been badly thought out. Secondly, it is probable that the willingness to pay for the aesthetic function of the countryside is determined by a global conception of its various elements. It seems then that the contingent valuation method would be the most adapted for dealing with these types of problems.

In evaluating the damages caused by the Amoco Cadiz oil-spill, Bonnieux and Rainelli (1991), proposed an interpretation of the equilibrium of the tourist market in Brittany. We can use their example to attempt to explain the differences between the models according to the renting season for gîtes. Figure 1 represents the demand for a gîte during the high season (D1), for the off-season (D2), as well as the supply of the gîte in term of maximum lodging capacity (S). During the high season, the gîte owner adjusts his price P1 in such a way as to obtain a maximum rate of occupancy. During the off-season (middle and low seasons), the price P2 brings about a rate of

occupancy  $T_2$  which explains the gap between  $P_2$  and the equilibrium price. Information from Breton gîte associations indicates that the rate of occupancy during the off-season varies in individual cases, notably according to the distance from the sea. This additional, unknown factor of variation in the off-season models, might explain the drop of  $R^2$  and the lesser signification of the variables, notably environmental ones, compared to the high-season model.

Figure 1 - Renting price and occupancy rate of a gîte for different seasons



$D_1$  : high-season demand

$D_2$  : off-season demand

Knowing implicit prices allows us to envision a cost-benefit analysis of intensification of fodder and livestock farming, comparing the losses in the tourism sector and the non-market damages incurred by local residents (differences in housing prices), to the increase in added value brought on to the considered activities<sup>6</sup>. This exercise, however, presents numerous difficulties, several of which will be dealt with. The first difficulty comes from the linear form of the hedonic equation ; a more elaborated form could not be obtained, most likely because of the imprecise nature of the data (non-equilibrium prices, prices and attributes gathered in different years, global and indirect environmental attributes...). This constraint imposes unchanging implicit prices, whereas we should rather expect an increase of marginal damages with the intensification of farming. This lack of realism is compounded by the impossibility of estimating the demand function for environmental attributes (a double problem, since we had no data concerning gîte clientele). As we could not estimate the welfare change, we are reduced to resorting to the differential in the renting price of gîtes, which, according to Bartik and Smith (1987), overestimate the welfare change. A third difficulty lies in the transfer of our findings to residents, who are much more numerous than tourists and who are present all year long. To what extent can we assimilate the WTP of tourists during the high season, which is the only element we can claim to reach from the implicit price, to the average WTP of year-long residents ? Taking into account the difficulties

<sup>6</sup> We should also measure the market damages involving water-treatment, fish farming, etc...

involved in applying the HPM to main residences in rural areas, the use of the contingent valuation method seems the appropriate way to answer the question. However, we must assume that the tourist, who is more "hedonic" than the year-long resident, and who does not benefit from the social external factors of agriculture (notably in terms of employment), is much more sensitive to the attributes of the environment surrounding his accommodations.

We also attempted to compare the level of implicit prices (marginal damages or benefits) during the high season to the rate of the economic incentives which have been, or will soon be, brought into play. Two cases were considered : the annual subsidy of FF3,000 per ha allotted for converting arable land into permanent grassland (agri-environmental contract for water-protection), and the annual increase of the nitrogen pollution tax brought on by the increase of animal density (+1 ANU per ha). The subsidy per ha and the additional tax per ANU were compared, respectively, with the benefit of the increase of permanent grassland, and the damage caused by the increase in monogastric density. In each case, the benefit per ha or damage per ANU is obtained by spreading the implicit annual price over all of the resident Breton households, and dividing it by the appropriate surface area or livestock. The benefit per ha of permanent grassland is FF9,000, and the damage per ANU is 20 times higher than the additional tax linked to increase of animal density. For the reasons mentioned earlier (evolution of agriculture between 1988 and 1995, calculation of the welfare changes based on price differentials, transfer tourist-resident), values are overestimated. On the contrary, we did not take into account certain damages to the tourism sector that should be added. Finally, we should remark that the damage linked to intensive livestock farming involves a large number of harmful elements (odors, degradation of the landscape, water pollution), whereas the tax punishes only nitrogen pollution.

## 6. Conclusion

This study has shown that the HPM, a method traditionally reserved for the urban domain, can contribute to the valuation of the externalities of agriculture and forestry. It is one of the first studies to furnish figures for agriculture, even if they are debatable. Before quantification, our study permitted the identification of the main agricultural variables whose effects to the environment are well-known, but influence on welfare had, to our knowledge, never been proven in housing markets. Fodder crops and intensive livestock farming (pigs and poultry) generate negative externalities, whereas permanent grassland seem to create positive services. The effects of the forest and of cereal-farming on the price of gîtes, which are, respectively, positive and negative, need to be confirmed and explained. When we compare homogeneous data, the implicit price of the variables responsible for external effects is clearly superior to the subsidy or tax considered, notably in the case of nitrogen pollution caused by breeding. Affined and proven, the implicit prices could be used to evaluate the loss to the tourism sector, and, on a more ambitious level, to evaluate the non-market losses to residents caused by the intensification of fodder farming and animal breeding.

Nevertheless, the study comports certain methodological limitations which inform us of the improvements which need to be made on concerning rural applications of the HPM. These limits stem from the specificity of gîtes (incomplete information concerning consumers, institutional nature of prices, tourist-resident transfer), the difficulty of indexing external factors (global and indirect agricultural variables) and the impossibility of estimating a ratio of demand (lack of data and linear functional form).

It seems that the development of rural applications of the HPM will require the acquisition of data-bases recording the selling or renting prices of property on the market. In order to control the factors of variation linked to employment and the size of the market, it would be interesting to consider studies including second homes, or perhaps homes of the rural zones around large cities. In addition to the classic model, models of discrete choice or studies of multiple sales should be experimented with (Bartik and Smith, 1987). In addition, in order to confirm the global valuations indexed according to agricultural variables, it would be useful to further elaborate the environmental variables. This objective calls for the creation of data-bases recording water-quality, biodiversity, landscape.... The recourse to geographical information systems should prove to be useful in the latter case (Bateman, 1994). In the forest domain, data concerning the composition of species and the structure of tree populations should also permit us to explain observed effects.

We should also plan on gathering information about housing consumers. This information, unfortunately, is absent from our exploratory study. It is a question of measuring the preference for certain environmental criteria (perception, sensitivity, hierarchy...), in order to interpret hedonic equations. We must then obtain the socio-economic characteristics which are essential to successfully identify the demand function ; the identification must be made from multiple markets (Palmquist, 1984). Finally, future, specific surveys, should put into play the contingent valuation method, in order to confirm the WTP resulting from the HPM, which also causes comparison difficulties (Bonnieux and Weaver, 1995).

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