HEDONIC HOUSING PRICES & AGRICULTURAL POLLUTION: AN EMPIRICAL INVESTIGATION ON SEMIPARAMETRIC MODELS

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HEDONIC HOUSING PRICES AND AGRICULTURAL POLLUTION: AN EMPIRICAL INVESTIGATION ON SEMIPARAMETRIC MODELS[1]

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Abstract : The objective of this paper is to assess the impact on property values of agricultural pollution using alternative semiparametric hedonic price models. The proposed model specifications are made up of two parts : a partially linear component for house characteristics and a non (semi) parametric form to represent the non linear influence of agricultural pollution. A general-to-specific search procedure is adopted to select the best model specification. An application of these semiparametric models to rural townships indicates that pollution resulting on livestock operations have a significant nonlinear impact on house prices.
Keywords : Hedonic pricing, semiparametric models, agricultural pollution.
JEL : C14, R21, R32, Q0

1 Introduction

Intensive agriculture activities generate negative externalities that are increasingly significant over time and space. Thus, growing concerns on the impacts of intensive livestock operations in rural areas with denser and more urbanized population are representative of such a phenomenon. Agricultural economists have attempted to quantify such effects, using hedonic models of house prices. In such a framework, negative agricultural externalities (pollution) are measured by relevant indicators that are supposed to be inversely related to the prices of houses. Then, estimating the first order derivatives of the hedonic price function with respect to the pollution indicators yields estimates of the prices of these environmental attributes and, indirectly, an

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estimate of consumers' willingness to pay for these "disamenities". Although well grounded from a theoretical point of view, the hedonic price model, when implemented empirically, raised several problems associated with the identification of the underlying structural model parameters. The true nature of the relationships between house prices and its various attributes, which thus might be complex and nonlinear, would be rather be represented by nonparametric models than the traditional parametric specifications (Ekeland *et al.*, 2004).

Up to now, the study of the relationships between agricultural pollution and house prices has been conducted using parametric model specifications (see, for instance, Herriges et al., 2003, Huang *et al.*, 2003; and Palmquist *et al.*, 1997), and to the authors' knowledge, nonparametric and/or semiparametric models have never been employed to address this problem of agricultural pollution in housing price models[2]. The objective of this paper is to fill this gap by using a partially linear semi parametric hedonic price function in order to assess the impact of agricultural pollution on the prices of residential houses in a livestock-intensive region of France.

Three alternative specifications - a fully nonparametric one, a nonparametric additive one, and a single index one - are used to capture different possible forms of nonlinearity associated with these pollution variables in a hedonic price function. We also consider the parametric counterpart of the three aforementioned non- and semi-parametric model specifications. Indeed, the performances of non- and semi-parametric models are usually investigated by comparing their goodness of fit to the parametric model "benchmark". This work differs from previous studies in two respects. First the "true" model benchmark is the fully nonparametric model, and second specification tests are performed in order to compare these specifications (fully parametric, non parametric additive and single index) with respect to this former model benchmark.

The empirical application deals with a set of transaction prices of residential houses sold in 1996 and 1997 in Brittany, France, the leading French region for a number of livestock products and vegetable products.

In the hedonic price model, we specify the prices of residential houses as a function of its physical characteristics, of the two environmental indicators but also of variables representing the economic structure of rural townships where the residential houses are located. All the explanatory variables but the two former environmental indicators enter the hedonic price function in a linear fashion. This makes up the linear part of the hedonic price function. The two pollution indicators enter the hedonic price function in a nonparametric or semi parametric way and this constitutes the nonlinear part of the model.

[2]Non and semiparametric methods have been applied in the hedonic pricing literature dealing with other problems than agricultural pollution : see for instance Stock (1991), Pace (1993 and 1998), Anglin and Gençay (1996), Yatchew (1998), Iwata *et al.* (2000), Martins-Filho and Bin (2005).

The empirical strategy to estimate our housing price model follows a general-to-specific specification search involving three stages. In the first stage, the parameters involved in the linear part of the hedonic price models are estimated using Robinson's approach of partially linear model. In the second stage, the four - parametric, nonparametric, nonparametric additive and single index - specifications of the nonlinear part of the hedonic price function are estimated using the estimated residuals of the first stage estimation procedure. The three specifications (parametric, nonparametric additive and single index) are thus compared to the more general one, i.e. the fully nonparametric one.

The specification tests only select the nonparametric additive specification. Willingness to pay for pollution reduction is then computed for this selected model specification using the estimation procedure of derivatives for additive separable models, proposed by Severance-Lossin and Sperlich (1999). The main result is that the pollution resulting from livestock operations in rural townships is a more crucial environmental issue than the pollution due to intensive crop practices, although both affect significantly, and in a nonlinear way, house prices

2 Semiparametric house price models

In this section is presented a discussion of the different specifications for the hedonic price function. This function can be defined as follows. Suppose that each house can be viewed by economic agents as a bundle of different amounts of a vector of characteristics. All these characteristics are observed by the economic agents when making their choices. Hereafter, we assume that the econometrician only observe some of these characteristics we denote by X when considering characteristics of the house and its surrounding (e.g. number of rooms, state of repair, age of the house, population of the city, stock of existing houses, $\ldots$) and by Z when considering environmental characteristics defining the impact of agricultural pollution. The hedonic price function specifies how the price of a house varies as the characteristics vary, i.e.

$$Y = m(X, Z, \xi) \tag{1}$$

where ξ denote the vector of unobserved (by the econometrician) characteristics of the house. For ease of simplicity, we assume that this vector is unidimensional.

Rosen (1974) provided a theoretical equilibrium framework in which the interactions of consumers and suppliers determine the hedonic price function and where differentiating the hedonic price function with respect to a given characteristic enables to derive the marginal willingness to pay for that characteristic. Rosen also proposed a two-step parametric procedure for estimating the demand for each characteristic in the case where the hedonic price function has the following additive structure:

$$Y = m(X, Z) + \xi \tag{2}$$

and where a parametric functional form of $m(.,.)$ is chosen.
Since Brown and Rosen (1982), the lack of identification of the marginal willingness to pay or bid functions has been a discussed issue in the hedonic model literature. Only recently, Ekeland, Heckman and Nesheim (2004) showed that the main source of the identification problems underlined in this literature lies on the commonly used linearization strategies made to simplify estimation problems. They emphasized that the hedonic price model is generically nonlinear. In the same way, Bajari and Benkard (2004) showed that, given data on a single market, the hedonic price function and the distribution of the unobserved product characteristic are identified if the unobserved product characteristic is independent of the observed ones. Thus, the hedonic price function may have a general non-additive structure.
Armed with these observations, it would seem appropriate to consider nonparametric regression estimators as natural candidates to estimate the hedonic price function (1). But, unfortunately in this process, we would face two problems. First, the characteristic ξ cannot be observed. As in Bajari and Kahn (2005), we take the view that in $Y = m(X, Z) + \xi$, the additive error term to the hedonic price function is interpreted as a vertical product characteristic observed by the consumer but not by the econometrician[3]. Then, a second problem crops up: the curse of dimensionality given that the vectors X and Z may involve a large number of characteristics. Since many housing characteristics are discrete and since our main interest in this work hinges on measuring the impact of environmental variables on house prices, we assume a partially linear specification given by

$$Y = \beta' X + m(Z) + \xi \tag{3}$$

Expression (3) is the conceptual model that is estimated empirically in this paper using parametric and nonparametric estimation procedures. For this purpose, the following four alternative empirical model specifications are proposed and estimated.

[3] We could use Matzkin's (2003) nonparametric estimation procedure that directly deals with a non additive structure. But this procedure supposes that all the observed characteristics are continuous and many housing characteristics in our dataset are discrete.

Parametric specification	Nonparametric specification
(M1) $Y = \beta' X + \gamma' Z + \xi$	**(M2)** $Y = \beta' X + m(Z_1, \cdots, Z_L) + \xi$
Nonparametric Additive specification	Single index specification
(M3) $Y = \beta' X + \sum_{l=1}^{L} g_l(Z_l) + \xi$	**(M4)** $Y = \beta' X + G(\gamma' Z) + \xi$

These four empirical models differ from each other according to the way that the function $m(z)$ is defined. Although model (M1) is similar to a typical linear regression, the remaining model specifications, (M2), (M3) and (M4), include non- parametric and semi- parametric elements with their own specific characteristics.

3 Specification search procedure

To estimate these four empirical models requires to device a method able to estimate the coefficients β and the function $m(z)$. To do so, we estimate this former unknown function, using $Y - \beta X$ as the dependent variable. Even though β has to be estimated, our estimation approach follows a two-stage procedure. In the first stage, we estimate the less restrictive available model specification, that is the specification proposed by Robinson (1988), where the function $m(.)$ is left unspecified. In the second stage, we investigate the four empirical specifications of the function, $m(.)$ defined earlier. Specification tests aimed at selecting the proper specification of the function m(.) are then developed and presented.

3.1 Estimating the linear part of the hedonic price function

The first stage leading to the estimation of β is based on the procedure proposed by Robinson (1988). It is motivated by observing that, if we subtract on both sides of (3) the conditional expectation relative to z, we obtain :

$$Y - E(Y|Z = z) = \beta' \Big(X - E(X|Z = z) \Big) + \xi \tag{4}$$

The estimation procedure can be described as follows :

1. Regress both y_i and x_i on z_i nonparametrically to obtain residuals $\widetilde{Y}_i \equiv y_i - E(Y|Z = z_i)$ and $\widetilde{X}_i \equiv x_i - E(X|Z = z_i)$.

2. Then perform OLS on these residuals to get an estimate of β in (4).

Robinson (1988) showed that, under regularity conditions, this procedure yields to a $\sqrt{n}$-consistent and asymptotically normal estimator $\widetilde{\beta}$ for β, and that there exists a consistent estimator of its limiting covariance matrix.

As a nonparametric estimator of $E(Y|Z = z_i)$ (or $E(X|Z = z_i)$), we use the local polynomial estimator (See Fan and Gijbels, 1996).

3.2 Estimating the nonlinear part of the hedonic price function

Once β is estimated, we use $W = Y - \widetilde{\beta}X$ for dependent variable in all of the models proposed, and only specify the function $m(z)$ according to models **M1-M4**. We turn now to the description of the three non and semiparametric models **M2-M4** and to the way we can get estimates of these models.

3.2.1 Fully nonparametric model (M2)

This model is used as benchmark for our investigation on the ability of semi-parametric model to estimate hedonic functions for real datasets. The function $m(z)$ is estimated using the second stage of Robinson's procedure based on a nonparametric regression of $Y - \widetilde{\beta}\, X$ on Z leading to an estimate of $m(\cdot)$. As a nonparametric estimator of $m(z)$, we use a local polynomial estimator.

3.2.2 Additive model (M3)

The additive house price model is of the form :

$$m(Z) = \sum_{l=1}^{L} g_l(Z_l) \tag{5}$$

where $\left(g_l(.)_{l=1}^{L}, \text{ resp.}\right)$ is a set of L unknown functions satisfying the identifiability condition $E(g_l(Z_l)) = 0$ for every $l = 1, \ldots, L$. Additive models are usually estimated using the Hastie and Tibshirani's (1990) backfitting algorithm[4].

3.2.3 Single-index model (M4)

A single-index house price model rests on the assumption that all the information conveyed by the independent variables can be summarized into a single index $\gamma' Z$ where γ is a vector of unknown coefficients, linked to the endogenous variable through an unknown link function $G(.)$ as :

$$m(z) = G(\gamma' Z) \tag{6}$$

The main idea underlying these models is to avoid the *curse of dimensionality*, by reducing the dimension of the regressor space to one, through the

[4] see, for instance, Pace, 1998, Iwata *et al.*, 2000, and Martins-Filho and Bin, 2005

index. There is a cost being paid in terms of identification since for any arbitrary δ and ν, equation (6) is equivalent to $m(z) = G^*\Big(\nu + \delta(\gamma' Z)\Big)$, and thus size and scale normalization are needed.

3.3 Third stage: Specification tests

As stressed at the beginning of this paper, one of the contribution of this work is to adopt specification tests whereby the various empirical specifications of the function $m(z.)$ are tested and compared to the "true" model benchmark model that is the full non-parametric specification. In our case, the "true" non-parametric model specification is represented by model (M2) while the three remaining ones, (M1), (M3) and (M4) represent the alternative model specifications. We have performed the following three tests of *parametric vs nonparametric* using Horowitz and Spokoiny (2001), *additive vs nonparametric* using Gozalo and Linton (2001) and *single index vs nonparametric* using Fan and Li (1996). The results of these tests on our empirical application are given in table 3.

4 Data

The variables used in the hedonic regression analysis fall into three broad categories: *(i)* the price and the physical attributes of the home and the lot, *(ii)* the characteristics of the surrounding township, and *(iii)* the environmental "disamenities". A summary of the variables is given in Table 1.

To measure consumer's willingness to pay for environmental "disaminities" generated by agriculture would require to dispose of, not only personal and confidential information on consumers' views on such issues, but also of detailed information on the location of livestock operations relative to the consumers' residential houses. Collecting such quantitative information is so sensitive that it is impossible to undertake relevant surveys to generate the relevant data. Given this situation, agricultural pollution is measured by two aggregate indicators. The first one ($NITRO$) is the per hectare of arable land amount of nitrogen emissions of livestock operations in the rural township where the residential house is located. The second indicator considered ($TMEAD$) is the proportion of permanent pasture land converted into tilled land. A high value associated with this variable would indicate a degradation of country's landscape.
Deriving the first order derivatives of house prices with respect to these variables will give an estimate of the prices of these two environmental attributes and indirectly an estimate of consumers' willingness to pay for these two agricultural "disamenities".

Table 1: Variables and Descriptive Statistics

Variable	Description	Units	Min	Max	Mean	Std. Dev.
PRICE	Market Price	Euro	15400	162 583	76 494	33 933
AGE	Age	Year	0	298	47.835	42.018
REPAIR	State of repair	= 1 if good	0	1	0.687	0.464
ROOMS	Number of rooms	#	1	7	4.429	1.353
LOT	Lot size	#	102	21 880	1 793	2 551
COUNTY	County location	= 1 if *"Ille et Vilaine"*	0	1	0.478	0.499
VACANT	Vacant Housing	Percent	0.000	20.000	6.275	3.157
POP	County population	# (x1000)	0.104	4.972	2.047	1.215
AVINC	Average income	Euro	571	2 854	1 082	250
TMEAD	Temporary meadows	Percent	0.010	70.143	29.420	9.972
NITRO	Nitrogen concentration	kg/ha	0.000	339.48	45.169	51.118

N=2092 observations *1 Euro = 6.55957 FF*

5 Empirical results

In the hedonic price models, we specify the prices of residential houses as a function of its physical characteristics, of the two environmental indicators but also of variables representing the economic structure of rural townships where the residential houses are located. All the explanatory variables but the two former environmental indicators enter the hedonic price models in a linear fashion. This makes up the linear part of the hedonic price function. The two pollution indicators enter the hedonic price function in a nonparametric or semiparametric way and this constitutes the nonlinear part of the model. The four partially linear house price models we estimate are defined as :

$$\begin{aligned} \ln Price_i &= \alpha + \beta_1 AGE_i + \beta_2 REPAIR_i + \beta_3 ROOMS_i + \beta_4 LOT_i \\ &\quad + \beta_5 COUNTY_i + \beta_6 VACANT_i + \beta_7 POP_i + \beta_8 AVINC_i + \cdots \end{aligned}$$

Parametric specification (**M1**)
$\cdots + \gamma_1 TMEAD_i + \gamma_2 NITRO_i + \xi_i$

Nonparametric specification (**M2**)
$\cdots + m(TMEAD_i, NITRO_i) + \xi_i$

Additive specification (**M3**)
$\cdots + g_1(TMEAD_i) + g_2(NITRO_i) + \xi_i$

Single index specification (**M4**)
$\cdots + G(\gamma_1 TMEAD_i + \gamma_2 NITRO_i) + \xi_i$

In the following, we report the results of the specification search procedure, the estimated values of the parameters involved in the linear part of the hedonic price function (first stage), a 2D-graphical comparison of the four specifications of $m(z)$ (second stage), followed by the specification test results (third stage). Marginal willingness-to-pay for pollution reduction is then computed for the selected model specification.

Table 2: Estimates of the first step and of the linear and Single index models

	Variable	Partial linear	
		estimates	*standard error*
First step estimates	Age	-0.002	*0.0002*
	Repair	0.359	*0.0174*
	Rooms	0.140	*0.0057*
	Lot	0.029	*0.0028*
	County	0.091	*0.0169*
	Vacant	-0.017	*0.0032*
	Pop	0.016	*0.0074*
	Avinc	0.050	*0.0061*

	Variable	**Fully parametric model estimates** *(standard error)*	**Single Index model estimates**
Second step	Constant	0.889	—
		(0.0253)	—
estimates	Tmead	-0.003	**-0.003**
		(0.0007)	
	Nitro	-0.0006	-0.003
		(0.0001)	

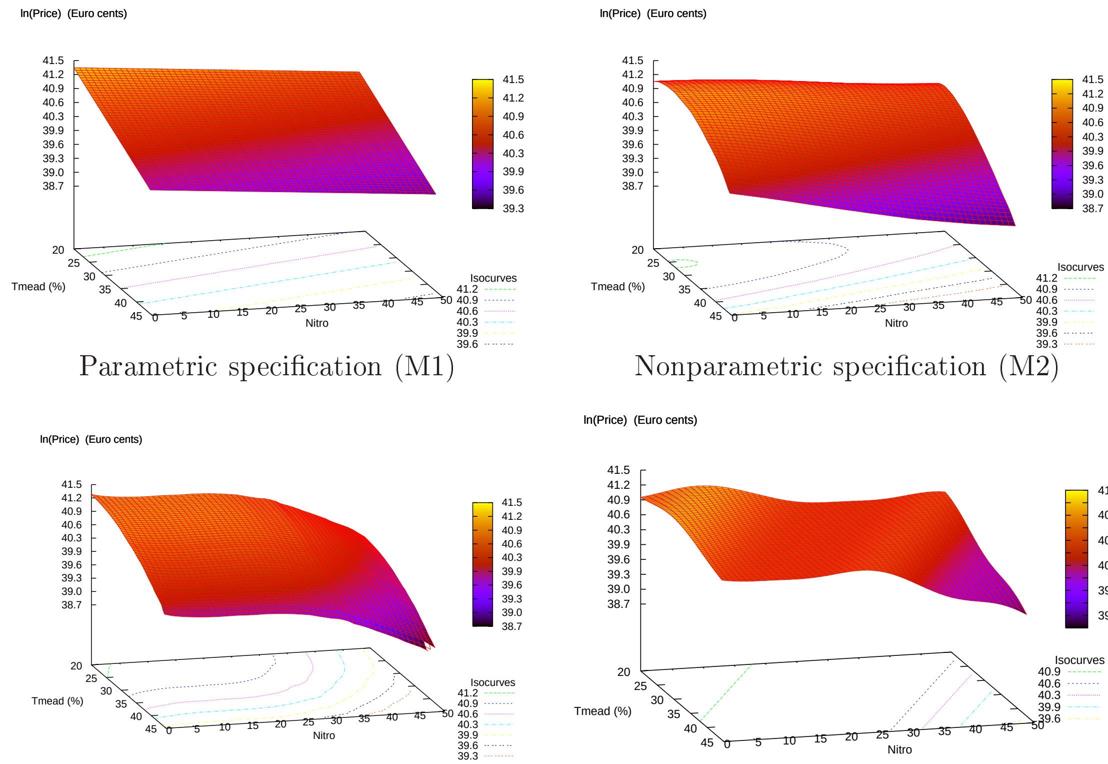
For comparison purpose, the coefficient in the Single index model γ_{Tmead} has been normalized to its corresponding value in the linear model.

5.1 Linear part

The estimates of the parameters β involved in the linear part of the first step estimation are reported in Table 2. In the lower part of this table are also reported estimates of the parameters involved in the fully parametric and single index specifications of $m(z)$.

All the estimated parameters belonging to the linear part of the housing price models[5] are significant and have the expected signs and magnitudes. Examining first the influence of the physical characteristics of the houses on their prices, we note that older houses are characterized by prices declining at a rate of 0,2% per year. Undertaking major renovations to a residential house in Brittany leads to a 35% appreciation in its price, *ceteris paribus*. A larger number of rooms or a bigger lot size are factors contributing to increase the values of the houses. Variables defining the township where the houses are located have signs that are conformed to our expectations. Hence, the prices of any houses located in the rural townships of the most urbanised county of Brittany (Ile-et-Vilaine) experience an average increase by 9.1% of their prices. By contrast, residential houses located in rural towhnships with higher housing vacancy rates would experience lower prices while opposite effects would take place with rural municipalities that either are more populated or have households with higher average incomes.

[5]As the price of houses are expressed in a logarithmic form, the estimated coefficients could be interpreted as the percentage variation in the price of the house resulting from one unit change in the explanatory variables.



Parametric specification (M1) Nonparametric specification (M2)

Nonparametric additive specification (M3) Single index specification (M4)

Figure 1 :*Estimation of* $m(z_1, z_2)$ *for the four specifications*

Looking at the bottom part of Table 5.1, we note that the environmental indicators have the expected influence of the prices of the houses. Their estimated coefficients are statistically significant and negative. Thus, one percent point increase in the share of permanent pasture converted into tillable land results in a 0.3% decline in the price of houses. A similar interpretation could be made for the influence of the (livestock) nitrogen emissions on the propery values. Although the magnitudes of these two coefficients look quite small at first glance, their true economic significance will come to the fore when corresponding WTP are estimated and discussed further in this paper. For comparative purposes we report at the bottom part of Table 2 the parameter estimates of the index model. As expected, these two coefficients are negative. No straightforward interpretation can be provided due to the existence of the nonparametric function $G(.)$.

5.2 Nonlinear part of the hedonic price function

Like in any empirical study of nonparameteric models, this one reports the role and importance of nonlinearities in the form of a graphical analysis. Hence, we develop the estimated response surfaces linking housing prices to the two pollution indicators for the four specifications of the function m(z) in Figure 1. We have restricted the representation of these curves to an area where the density of the joint distribution of the environmental variables z_1 and z_2 was high, *i.e.* where the values of $TMEAD$ belong to the $[20\%, 45\%]$ interval and those of $NITRO$ are located in $[0, 50kg/ha]$ range.

A visual inspection of the four estimated surfaces suggests that the responses of the house prices to the two environmental indicators look very similar in terms of shape and steepness for the specifications (M2) and (M3). On the other hand, the fully parametric specification of the hedonic price function seems to be unable to capture all the features of our data sample. The same pattern would also apply to the partially linear specification involving a single index in the nonlinear part of the hedonic price function.

5.3 Specification tests

Each specification test presented in section 3 was performed to compare the more general nonparametric model with the restricted specifications. All these tests require the choice of bandwidths, which is fully explained in a technical appendix at the end of the paper. In the absence of theoretical guidance for some of these tests we also report some sensitivity analysis of the test statistics to the bandwidths in the same appendix.

Table 3: A summary of the specification tests results

H_0:	Test Statistic	p-value
Parametric specification	$T^* = 6.107$	0.001
Nonparametric additive specification	$\tau_0 = 1.573$	0.116
Single index specification	$T_c = 5.3289$	0.001

Table 3 summarizes the main results of the three specification tests. The results show that the nonparametric additive model is clearly not rejected, while the two others are. This result is consistent with the informal graphical finding that the parametric and single index specifications fail to capture important nonlinear features of the data and that the nonparametric additive specification fits the data satisfactorily.

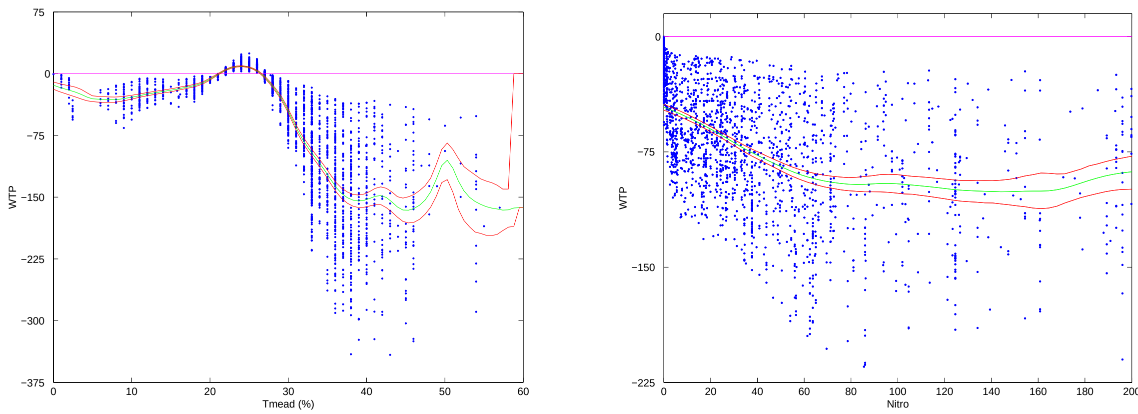
5.4 Marginal prices

Based on the former specification test diagnosis, we now report the willingness to pay estimates for pollution reduction for the nonparametric additive model (M3). These computed values are derived using the estimator developed by Severance-Losin and Sperlich's (1999).

In the figures 2a and 2b[6], we report the estimated values of the willingness to pay for each housing transaction, as well as a nonparametric estimation

[6]It is important to note that WTP estimates presented in both figures 5 and 6 are

of the mean willingness to pay function and its 95% confidence bounds. In figure 3a and 3b are reported the same mean willingness to pay function expressed as a percentage of the corresponding housing prices.



2.a: WTP for landscape degradation (Tmead) *2.b: WTP for livestock nitrogen emission (Nitro)*

Note: In both figures, dots represents WTP estimated for each observation of the data sample, while lines represent nonparametric estimation of the WTP function with 95% confidence bounds.

An inspection of figures 2 and 3 clearly indicates that the relationships linking the willingness to pay to the pollution indicators are highly nonlinear for specific ranges of the values taken by z_1 and z_2. Up to a certain threshold that is significantly different from zero, the derivative of the hedonic price function with respect to the "landscape degradation" indicator "TMEAD" is rather small relative to average observed house prices, but exhibiting a marked and sharp decline when the share of permanent pasture converted into tillable land increases from 20 to 40%. Then the willingness to pay tends to flatten when this indicator takes values greater than 40%. In addition, the examination of figures 2.a and 3.a clearly shows that the relationship landscape degradation exhibit variations in the degree of curvature, which change with the values taken by the indicator TMEAD.

On the other hand, a different pattern seems to take place for WTP estimates associated with livestock nitrogen emissions (NITRO). An examination of figures 2.b and 3.b reveals that the relationship between the mean WTP function and this variable is steep and convex for small values of nitrogen emissions until it reaches 80kgs per hectare of arable land. Then, the mean WTP function for nitrogen emissions tends towards an asympotic value that is equal to 7% of the residential house prices.

It is interesting to compare these WTO estimates obtained with the nonparametric model specification with simlar ones obtained with a parametric

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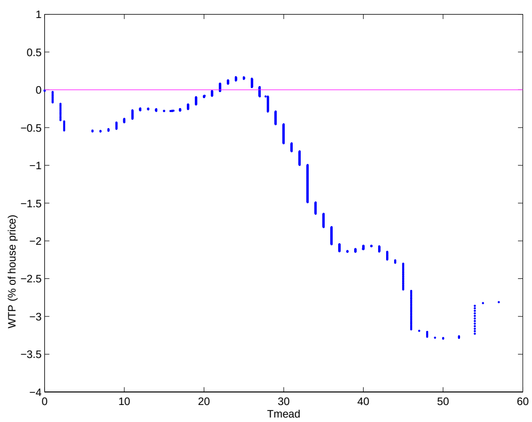
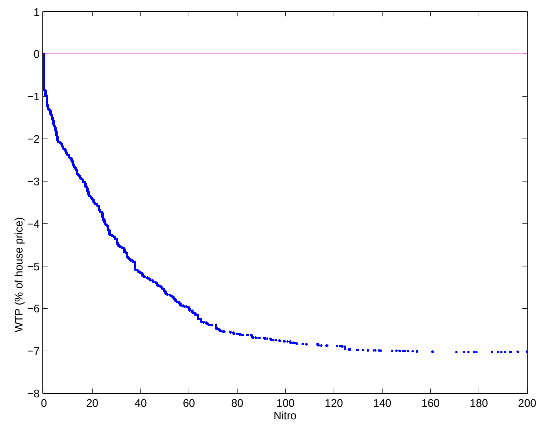
computed assuming the following units of measurements of the environmental indicators: TMEAD: 10% and NITRO: 100kgs/ha. Thus, parameter estimates presented in Table 2 associated with TMEAD and NITRO must be interpreted with these new units of measurment in mind.

specification. If we perform this exercise with model specifications (M1) and (M3) estimated in this work, we note that the WTP estimates obtained with the two model specifications are comparable and very similar for large values of the two environmental indicators. Let us take for instance the case of the landscape degradation indicator: WTP estimate in model (M1) is constant and equal to 3% for the house prices (assuming a 10 percent point change in the share of pasture land converted into tillable land), while the estimate obtained with model (M3) is equal to 3.5% when TMEAD is greater than 50%. Similar conclusions can be reached for WTP estimates for livestock nitrogen emissions.



3.a : WTP for landscape degradation



3.b : WTP for livestock nitrogen emission

Figure 3 : WTP expressed as a percentage of house prices

Note: In both figures, dots represents WTP estimated for each observation of the data sample

6 Concluding remarks

The main objective of this paper has been to show the relevance of semiparametric models to study the relationship between agricultural pollution and property values. For this purpose, semiparametric hedonic price models are estimated in a livestock intensive region of France in order to study the influences of landscape degradation and livestock nitrogen emissions on the house prices. Using appropriate specification tests, we conclude that a nonparametric additive form is the most appropriate specification to explain the nonlinear relationships between property values and agricultural pollution. Results on the willingness to pay estimates for agricultural pollution seem reasonable and conform with a priori expectations, being in line with estimates obtained with a parametric (semi-log) model specification.

Although the application of these semiparametric models to an agricultural-related hedonic pricing case looks promising to capture complex nonlinearities, it is still too early to give a definitive appreciation on its merits. Further works and applications to other agricultural related situations are needed. In this vein, it would be fruitful to analyse and quantify the role of positive and negative agricultural amenities in a common (semiparametric) model framework (Ready and Abdalla, 2005) and to compare it to a more conventional parametric modeling approach.

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