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# The impact of hazardous industrial facilities on housing prices: A comparison of parametric and semiparametric hedonic price models ☆

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ABSTRACT

The willingness of households to pay for prevention against industrial risks can be revealed by real estate markets. By using very rich microdata, we study housing prices in the vicinity of hazardous industries near three important French cities. We show that the impact of hazardous plants on the housing values strongly differs among these three areas, even if the areas all surround chemical and petrochemical industries. We compare the results from both standard parametric and more flexible, semiparametric models of hedonic property. We show that the parametric model might structurally lead to important biases in the estimated value of the impact of hazardous plants on housing values.



## 1. Introduction

Real estate markets can demonstrate their households' willingness to pay to reduce their exposure to hazardous industrial facilities. Indeed, hazardous industrial activities generate strong negative externalities: neighboring populations partly bear the cost of a potential industrial accident; and they can also endure day-to-day nuisances associated with the ordinary course of these activities. However, these facilities also generate positive externalities (Greenstone et al., 2010): they provide, directly and indirectly, employment; and through local taxes, they can contribute to the economic development of the municipalities. Measuring the impact of the distance from the hazardous facilities on the housing values reveals to what extent the facilities' activities are perceived as disamenities.

We estimate the impact of the distance from the hazardous facilities on the housing values by using hedonic price models. The first-order derivative of the hedonic price function with respect to the distance from the hazardous plants provides an estimate of the buyers' willingness to pay to live far from these plants. We study housing prices in the vicinity of three important French cities (Bordeaux, Dunkirk, and Rouen). These three industrial areas all have hazardous chemical and petrochemical industries in addition to other unhazardous industries.

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But, each has different socioeconomic characteristics and different perceptions of industrial risk. This case study relies on a rich dwelling-level micro-database in which each dwelling's address is precisely geocoded. We collect detailed data relative to the dwellings' extrinsic characteristics such as their proximity to a central business district, shops, and public utilities; and their exposure to industrial risk and to other risks or pollutions. The dwellings' price and intrinsic characteristics come from notarial data.

Our first contribution is to study the impact of hazardous chemical and petrochemical industries on housing prices with rich microdata. Indeed, our unique database is much richer than those used by studies on the impact of similar industrial risks on housing prices. The impact of risk exposure on real estate prices is estimated for oil facilities by Boxall et al. (2005) and Flower and Ragas (1994), for the chemical industry by Carroll et al., (1996), and for industrial areas with chemical or petrochemical facilities by Sauvage (1997) and Travers et al. (2009). These studies use data with few (or without) extrinsic characteristics of the dwellings.[2]

Our second contribution is to apply our database to two models to compare the estimated impacts of the distance from hazardous plants on housing prices: a standard parametric model and a semiparametric model. The semiparametric regression is a conditionally parametric regression based on a log-linear specification and that allows implicit prices to vary with respect to space and time of sale, while keeping some smoothness in their distribution. This variation enables to relax and to test the assumption of the fixed parameters. This assumption is tested by comparing the conditionally parametric regression with the baseline log-linear model, which corresponds to a nested model under the null hypothesis of fixed coefficients. We find that the fixed-parameter assumption is rejected, which confirms the need for flexible forms and the use of semiparametric models. This study is the first to compare parametric and conditionally parametric regression models in the analysis of industrial risks, although this comparison has been used for other amenities, such as light rail access (Redfearn, 2009). Other semiparametric models have been compared with parametric models in the analysis of industrial facilities by McMillen and Thorsnes (2003), or for agricultural pollution by Bontemps et al. (2008). Anglin and Gencay (1996) also show that semiparametric hedonic models outperform parametric ones. McMillen (2010), McMillen and Redfearn (2010), Redfearn (2009), and Sunding and Swoboda (2010) specifically compare parametric models with a conditionally parametric regression and recommend its use. Redfearn (2009) shows that implicit prices vary spatially and temporally and that assuming fixed implicit prices is a misspecification of the hedonic model. This misuse of parametric models has important consequences in our case study. Even though the signs and orders of the magnitude of the effects are similar in the two models for the very wide majority of coefficients, the estimated impacts of the distance from highly hazardous plants on housing prices significantly differs between the two models. The parametric model leads to an important bias (here an overestimation) in the estimated value of this impact near Bordeaux and Rouen.

Using the semiparametric model, we show that the impact of hazardous plants on housing values strongly differs among the three industrial areas, even if they all surround chemical and petrochemical industries. The gunpowder factory near Bordeaux is a former military plant that was not necessarily perceived as hazardous by the neighboring population. We find that its proximity is even valued, probably because its neighborhoods are green and very quiet places. Thus, in this case, we capture the unobserved amenities that are spatially correlated with the distance from the plant. For Dunkirk and Rouen, chemical plants are clearly identified as hazardous by local populations. However, for Dunkirk, we find no significant impact of the distance from these plants on housing prices, likely because these industrial risks are overshadowed by the nuclear plant in Gravelines (located 18 km from Dunkirk). For Rouen, highly hazardous plants are perceived as disamenities: on average, households are willing to pay around 1.2% of their dwelling price to move 100 more meters away from these plants. This marginal willingness to pay decreases with respect to the distance from the plants, because the marginal gains (in terms of exposure reduction) of going further away from the hazard's source are likely to decrease.

Our results have practical implications. They show that parametric hedonic models can lead to an important bias in the estimated value of the marginal willingness to pay. Further, our results show that this estimated willingness to pay has a limited external validity: it strongly differs among industrial areas, even among chemical and petrochemical industries; it also depends on the distance from these facilities. Thus, even when assuming that households are aware of the full extent of the industrial risks,[3] our findings call for the careful use of a population's willingness to pay for prevention against industrial risks in the cost–benefit analyses of prevention measures. Until now, most cost–benefit analyses have used the parameters taken from the estimation of parametric hedonic models and on other study areas than the ones under consideration in these analyses. This use can lead to a significant bias in the estimation of the efficient prevention level.

The paper is organized as follows. The parametric and semiparametric models are presented in Section 2. In Section 3, we describe the three industrial areas, the delimitation of the study areas, and the data. Section 4 contains the results from the parametric and semiparametric models. Section 5 concludes.

## 2. Model

### 2.1. Hedonic property models

Hedonic property models enable the estimation of the implicit price of the distance from highly hazardous plants (the first-order derivative of price with respect to this distance). This implicit price is equal to the households' (buyers' or sellers') marginal willingness to move one more meter away from these plants. Indeed, in the framework formalized by Rosen (1974), a dwelling is defined by its distance $d$ from a highly hazardous plant and several other characteristics $X$, which determine its price $P(d, X)$. When choosing their locations, households equalize their marginal willingness to pay for increasing each characteristic by one unit with the marginal, or implicit, price of this characteristic.[4] Thus, the estimation of the hedonic price function provides an estimation of the implicit price of the distance $d$ from highly hazardous plants $\partial P(d, X)/\partial d$, which can be interpreted as the households' marginal willingness to pay to move one more meter away from highly hazardous plants.

Unless making very specific assumptions, the hedonic price function is not linear and has no known explicit form (see Freeman (2003) for a review of hedonic price methods). For this reason, we first perform the following parametric models: linear, log-linear, log–log, and linear with Box–Cox transformations of the price and continuous regressors while allowing these Box–Cox coefficients to be different (Grislain-Letrémy and Katossky, 2013). For each of these specifications, we add fixed

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2 See Table 8 in Appendix A.1 for a review of all these studies and their data.

3 Currie et al. (2013)'s findings do not contradict perfect, or at least unbiased, information about hazardous industrial activities in the housing market, even in the presence of scientific uncertainty about health risks.

4 Specifically, a household of income $y$ chooses its location by maximizing its utility $U(z, d, X)$, where $z$ denotes the amount of composite consumer good (which comprises all consumer goods except land), under its budget constraint $y = z + P(d, X)$. The location choices by households maximize their utilities by equalizing their marginal rates of substitution between each characteristic ($d$ or $x_k$) and money with the implicit price of this characteristic ($\partial P(d, X)/\partial d$ or $\partial P(d, X)/\partial x_k$):

$$\frac{U_d(z, d, X)}{U_z(z, d, X)} = \frac{\partial P(d, X)}{\partial d}, \quad \forall k, \frac{U_{x_k}(z, d, X)}{U_z(z, d, X)} = \frac{\partial P(d, X)}{\partial x_k}. \tag{1}$$