

Does information to buyers affect the sales price of a property? Mandatory disclosure and the hedonic price model – A test on French data

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Abstract – Under the assumption of complete and perfect information, hedonic prices can be interpreted as marginal willingness to pay. This assumption may appear strong, especially in cases of exposure to natural risks. This assumption is tested for the French real estate market: we assess the impact of an informational shock—the implementation of the obligation to inform buyers and tenants (IAL) on 1st June 2006—on real estate prices. If the information available to buyers was perfect, there should not be any impact. A hedonic price model is estimated in difference-in-differences, using notarial data spatially matched with maps of regulated zones covered by flood risk prevention plans. The results do not show an impact of the introduction of the IAL on the average price of the houses concerned. However, for certain categories of properties (ground floor apartments) and certain municipalities (where the housing market is the least tense, such as the so-called “recentred” Robien zone C), the estimated impact is negative and significant, a sign that not all buyers were initially in a situation of complete and perfect information.

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Reminder:

The opinions and analyses in this article are those of the author(s) and do not necessarily reflect their institution's or Insee's views.

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Hedonic price theory (Rosen, 1974) is the reference conceptual framework used to analyse real estate prices. Under the assumptions of agents' rationality and buyers and sellers' complete and perfect information about all of a property's characteristics, hedonic prices can be interpreted as the marginal willingness to pay for those characteristics. However, this assumption can appear strong in some cases because of potential asymmetries of information between buyers and sellers (Pope, 2008a), or indeed a lack of information about certain characteristics. This is particularly true for exposure to environmental risks: in 2013, one inhabitant in five in a municipality exposed to a flood risk said that they were unaware of the risk when they moved in, while half of them said that they were aware but they considered the risk minimal (SOeS survey on the perception of risk exposure, see Pautard, 2014).

This paper attempts to test the assumption of complete and perfect information on the French property markets. To this end, it assesses the impact of an information shock – the implementation, on 1st June 2006, of the obligation to inform buyers and tenants on natural and technological risks (*Information aux acquéreurs et locataires* in French, the IAL) – on the sales price of existing houses and on the perception of natural risks among the inhabitants of exposed zones. Since the coming into force of the IAL, buyers must be informed if the property they wish to acquire is exposed to risks when it is located within the boundaries of a risk prevention plan (PPR) or a seismic zone (see Box).

Studies testing the level of information and risk perception often use major natural disasters as an exogenous information shock insofar as they are the expression of the natural hazard (Montz & Tobin, 1988, 1994; Bin & Polasky, 2004; Harrison *et al.*, 2001; Beron *et al.*, 1997). Nonetheless, properties and their direct environment are also subject to material damage. As such, the estimated impact includes both the adjustment of risk perception and, at least in the short term, a deterioration in the quality of the properties and possibly even the increase in risk exposure if protective structures have been damaged¹.

On the other hand, buyer disclosure mechanisms (such as the sellers' disclosure statement that currently exists in the USA), where the expected impact is to improve the agents' risk perception, do not modify either the specific

characteristics of the property or those of its environment, nor do they alter the level of objective exposure to the risk. When they have not been anticipated, they may therefore be seen as an exogenous change of the quantity and/or quality of the information made available to buyers. The rare studies conducted into their impact conclude that there is a depreciative effect on residential property prices. Pope (2008a) demonstrated the depreciative effect (-2.9%) on the value of houses in the most exposed zones following the introduction of a requirement to inform potential buyers about the noise caused by the Raleigh–Durham airport in North Carolina. Pope (2008b) also studied the impact of the 1996 introduction of the North Carolina Residential Disclosure Statement, a similar mechanism to the IAL. A difference-in-differences analysis points to a 4% depreciation in the price of houses located in federal flood risk zones when compared to houses exposed to less frequent risks, all other things being equal. However, in the United States, contrary to France², insurance premiums take into account risk exposure so that flows from future insurance premiums are capitalized into North American real estate prices (MacDonald *et al.*, 1990; Bin & Landry, 2013). This mechanism therefore has an impact on buyers' risk perception and on their financial planning, so Pope's estimation does not strictly identify the impact of information.

The introduction of the IAL requirement for properties situated within the boundaries of a PPR provided an opportunity for a quasi-natural experiment to identify the impact of a purely informational shock on house prices in the zones concerned and to test the assumption of complete and perfect information on the French real estate markets. A downward adjustment of prices after 1st June 2006 in zones subject to the IAL requirement would indicate that at least a portion of buyers initially underestimated the risk and that the assumption of complete and perfect information was not therefore verified.

This paper only studies the flood risk. The impact of the enforcement of the IAL requirement on the housing prices within zones exposed to the flood risk (flood risk

1. See Mauroux (2015) for an analysis of the theoretical effects of a natural disaster on real estate markets.

2. In France, natural disaster insurance is a mandatory extension of the home insurance cover. However, the insurance premium is not linked to the level of exposure and stands at 12% of the amount of the home insurance premium all over France.

prevention plan or PPRi) is estimated using a difference-in-differences hedonic price model (Parmeter & Pope, 2013). Housing transactions located in municipalities concerned by the IAL requirement but outside the boundaries

of PPRi are used as a counterfactual. It should be noted that, as we do not attempt to estimate the implicit price of exposure to natural risks, the results cannot be interpreted in terms of marginal willingness to pay.

Box – The obligation of information to buyers and tenants (IAL)

Since 1st June 2006, any new buyer or tenant of a property of any kind must be notified by the seller or lessor of the existence of a natural and technological risk affecting the property and the easements to be respected (Articles L. 125-5 and R. 125-23 to 27 of the French Environment Code). The aim of this disclosure requirement (IAL, for *Information des Acquéreurs et des Locataires* in French) is to inform new occupants so that they can adapt their home or the property accordingly to be better prepared for crisis situations in the event of a natural disaster.

The disclosure requirement applies to real estate (built or non-built properties) located within the boundaries of a natural risk (PPRn) or technological risk (PPRt) prevention plan or within an Ia, Ib, II or III seismic zone indicated in Article 4 of the decree dated 14 May 1991^(a).

The risk prevention plans establish risk zones at sub-municipal level based on a map defining the various zones according to their level of exposure to the given risk (avalanches, forest fires, floods, volcanoes, etc.). The PPR plans also include regulations that define, for each zone, the public utility easements and construction/urbanism rules that must be complied with, again according to level of exposure (non-build zones, zones where building is permitted subject to specific adaptations and zones where building is permitted without reservations). Zones are defined to a very fine geographic level (see, for example, the PPR map for the 5th, 6th and 7th *arrondissements* of Paris, Online complement C1).

The owner or lessor of a property concerned must therefore provide a risk disclosure statement based on information that the *département's* prefect provides to the mayor of the municipality in which the property is located (see in Appendix 1 the form provided by the ministry in charge of risk prevention in 2006). This risk disclosure statement is accompanied by a map precisely locating the property and indicating whether or not it is affected by the notified risks and, if so, which ones. Outside these boundaries, the IAL is not mandatory even if the property

is located within the territory of a municipality subject to a PPR.

The risk statement is drawn up by the time of signature of the initial sales agreement at the latest and given to the buyer with the other technical property audits (energy performance, asbestos situation, etc.). It may be updated at the time of sale in case of changes with respect to the risks since the initial sales agreement. It is then appended to the deed of sale and initialled by both parties (seller and buyer). If the seller fails to disclose information and to present a natural and technological risk statement, the buyer (or tenant) may withdraw from the sale or ask a judge to impose a lower price (Article 125-5 of the French Environment Code).

In 2006, 13,999 municipalities out of a total 36,705, i.e. just over one third, were concerned by an IAL requirement (see Table A). 9,926 (or just under a third) were concerned by a PPRn; no PPRt had been approved at that point as the procedure was still very new. The PPRn was still at the prescription stage in 5,593 municipalities and had been approved in 4,333 (source: *Gaspar*). 5,895 municipalities were located in a seismic risk zone, 820 of which were covered by an approved PPRn (1,002 under a prescribed PPRn). The PPRn mainly covered flood risks (70%), ground movement risks (14%) and the shrinkage and swelling of clay soils, i.e. drought (11%).

(a) New seismic zoning (modifying articles 563-1 to 8 of the French Environment Code) came into force on 1st May 2011. The municipalities' seismic zone map is now established by Decree no. 2010-1255 dated 22 October 2010 on the delineation of seismic zones in France. Since 2011, owners and lessors must also inform future occupants if the property has suffered damage following a natural or technological catastrophe and, along with the sales contract, provide a statement listing any insurance claims paid of which they are aware. Since 2013, they must also state the property's situation within the boundaries of a mining risk prevention plan and, if the property is within the boundaries of a PPRt, whether work has been prescribed and, if so, whether it has been done.

Table A
Municipalities subject to a natural risk prevention plan and in a seismic zone in France in 2006

	No PPR	Prescribed PPR	Approved PPR	Total
Outside a seismic zone	22,706	4 591	3,513	30,810
Seismic zone	4,073	1,002	820	5,895
Total	26,779	5,593	4 333	36,705

Note: No PPRt had been approved in 2006 (there were six prescribed PPRt), hence all the approved PPR were PPRn.
Coverage: Whole of France.
Sources: *Gaspar*, CGDD calculations.

The IAL was first analysed by Caumont (2014). He estimated the impact on house prices in the Nord-Pas-de-Calais coast of integrating the coastal flood risk into IAL disclosure requirement in October 2011. However, as the estimations are only conducted on the period following implementation of the IAL (October 2011 and June 2013), the impact of the informational shock is not identified. Here, the impact of enforcement of the IAL requirement on residential property prices is identified using temporal variability (before and after 1st June 2006) and spatial variability (within and outside the PPRi boundaries covered by the IAL requirement) of the information provided to buyers.

Our paper is organized as follows: the first section focuses on the question of complete and perfect information within the framework of the hedonic price model. We then explain the econometric method and identification strategy, as well as the various sources of data used. Next, we turn to the results of estimations of the impact of IAL implementation on residential property prices and test their heterogeneity according to various factors involving risk perception (house's floor), memory of the risk (date of the last official declaration of natural disaster) and tension on real estate markets, and then conduct placebo tests. The final section discusses the results and the limits of the study.

Information and the hedonic price method

Hedonic price theory (Rosen, 1974) is based on the central assumption that a housing unit can be defined as a set of characteristics and its total price is the sum of the implicit prices that the consumer is willing to pay for each of those characteristics ("hedonic prices"). Exposure to risk may be seen as a loss of amenity (a disamenity) for householders. For example, in the event of a natural disaster, the household will not only suffer material damage but also intangible damage (loss of items with sentimental value, stress, etc.). Under the assumption of complete and perfect information, the marginal price should therefore decrease with risk exposure and reciprocally, all other things being equal, the price should increase as household security increases (cf. Pope 2008b, p. 554, Figure 2). This is true even for households that are risk-neutral because they still

bear the damage costs on uninsured properties³. According to the theory, all other things being equal, the depreciation of the price of an insured house exposed to a natural risk, compared to an identical but non-exposed house, is equal to the uninsured damage and a risk premium, which reflects households' risk aversion (Mauroux, 2015).

Nonetheless, this result is only valid under the strong assumption of complete and perfect information available to sellers and buyers on the house price and characteristics. Uninformed buyers, or buyers who are informed but do not perceive the risk⁴, do not adjust their price offer for changes in the level of disamenity since they do not observe it; this is true regardless of their preferences for that particular characteristic. Without this assumption, the hedonic price model is not identified and the results of the estimate can no longer be interpreted as a marginal willingness to pay.

Under information asymmetry, if none of the buyers are informed about the risk, the maximum price at which they are prepared to purchase the property is, all other things being equal, constant regardless of the level of amenity loss. Conversely, if some of the buyers are informed, they will not be prepared to pay more than their maximum bid for significant levels of disamenity. Not all sellers will afford to wait for an uninformed buyer prepared to "over-pay" for the disamenity (this situation is described in Pope 2008b, p. 556, Figure 4). The higher the fraction of informed buyers, the lower the appeal for sellers of waiting for an uninformed buyer to put in an offer for the property, and thus the closer to the value of perfect information the implicit price for the disamenity will be.

To test the assumption of complete and perfect information on real estate markets, the selected strategy is to observe the markets' reaction to an information shock on a the attribute of a house or its environment. If the assumption is verified, this shock should not have any impact on prices.

3. In France, natural disaster insurance policies almost completely cover material damage to insured properties caused by a major event, the coverage rate of the "Cat Nat" (CATAstrophe NATurelle, or natural disaster) insurance scheme being close to 100% and the relatively low franchise (450 euros for a private individual). In the event of a flood, the material damage borne by households mainly corresponds to uninsured property.

4. Buyers may be informed about risk exposure and value security but fail to take the information into account for as much, or they may have misunderstood it (because it might be complex), may not trust the source of information or have perception biases leading them to underestimate the risk (e.g. availability heuristic or gamblers' fallacy: see below).

Conversely, if we observe a price adjustment, this would indicate that households initially had a misguided perception of the given attribute, which would challenge the assumption of complete and perfect information. All other things being equal, we therefore expect the impact of the IAL to be nil among informed populations and to have a negative impact on the price of exposed houses, compared to non-exposed houses, among people who were not previously informed. At market level, the proportion of informed households should increase and, all other things being equal, the price of exposed properties should fall.

Estimation method

Difference-in-differences identification strategy

We assume that potential buyers' preferences and risk aversion are not altered by the IAL. The strategy used to identify the impact of the IAL on house prices is based on two sources of variation. The first is the discrete temporal shift in flood risk information available to potential buyers of a property situated in a municipality covered by a PPRi after the IAL requirement came into force on 1st June 2006. Before then, information on the exposure of a property was available to the public, free of charge, but potential buyers had to bear search costs (time, visits to the council offices, etc.) to obtain it. On 1st June 2006, these search costs were practically cancelled out because potential buyers now receive a risk statement and map showing them the property's position with regard to the regulated zones (see the Box and Appendix 1). The second source of variation is spatial variation in levels of exposure between regulatory PPRi zones and areas outside those zones; this allows us to identify which sellers are required to provide an IAL statement to potential buyers. PPRi zones are subject to regulations precisely because they are the most exposed geographic areas given their closeness to a source of risk, their vulnerability before a concentration of factors, etc. According to the experiment's terminology, properties situated within the boundaries of a PPRi zone have received a "treatment", i.e. the provision of information on risk exposure contained in IAL documents. The other properties in the municipality, located outside the boundaries of the PPRi zones, are not subject to the disclosure requirement. There are nonetheless part of the same local real estate markets and

are affected by the same shocks. They are used as a control group⁵.

The difference-in-differences model identifies the impact of treatment on the treated, under the assumptions that, in the absence of treatment, the two groups would have undergone the same changes (common trend) and that the differences observed before treatment are constant over time (constant group fixed effect)⁶. This implies an assumption whereby the fact of being located within the boundaries of a PPRi has a constant effect on prices over time (no modification in agents' preferences as regards the risk after 1st June 2006), and PPRi and non-PPRi zones do not form two separate markets but are subject to the same trends (no contextual shocks or specific trends). This assumption will be tested by a placebo test.

Identification of the difference-in-differences model is also based on the assumption that the treatment rate goes up from 0 to 100% in the treatment group after the treatment date (sharp design), and remains at 0% in the control group. However, even before the IAL came into force, some households were already aware of risk exposure (thanks to publicly available information). Similarly, after 1st June 2006, we are unable to ascertain whether all future buyers of a property within a PPR zone actually received the risk statement and whether their perception bias⁷ was reduced. The impact of preventive information thus seems to fall under the definition of fuzzy design. Here, we assume that, for a potential buyer, the IAL resulted in an increase of the probability of being informed in risk zones, but we cannot affirm that this probability has risen from 0 to 1. At the aggregate level, we assume that the IAL has increased the number of informed agents and that the hedonic price curve has shifted closer to the perfect information curve, though does not necessarily match it completely.

5. Because seismic zones are defined at municipal level, it is not possible to distinguish, within a single municipality, properties subject to the IAL requirement and those not subject to it to be used as a control group. Municipalities subject to a seismic risk were therefore excluded from the coverage of this study.

6. Another assumption for identification is that being treated is not determined by the result, the variable of interest: because the PPRi zones are based on an administrative decision according to flood risk exposure level, the price of the property sold has no impact on the fact that it is situated (or not situated) in a PPRi zone.

7. We use the term "perception bias" to refer to the difference between the perceived risk (subjective probability) and the objective risk. Savage (1954) introduced the notion of subjective probabilities as an extension of von Neumann and Morgenstern's expected utility model to formalise the fact that the agents do not necessarily base their decisions on objective probability but instead use a perceived probability.

According to Chaisemartin and d'Haultfoeuille (2018), in the presence of fuzzy treatment and if none of the members of the control group is treated at any time, the difference-in-differences estimator of the variable is equal to the difference-in-differences estimator divided by the change in probability of being treated for the treated after treatment. To estimate the effect of treatment on the treated, we need to be able to observe the level of information among buyers of houses in PPRi zones before and after 1st June or, at the very least, ascertain whether buyers were actually provided with risk statements. However, this information is not available in the notarial data and, as far as we know, there is no external survey able to inform us on awareness of environmental risk exposure at a sufficiently detailed geographic level or for the period in question⁸. We are not therefore able to estimate the exact effect of treatment on the treated. However, we may reasonably assume that the level of information has not fallen since the introduction of the IAL; the difference-in-differences estimator would thus provide a lower bound of the effect of treatment on the treated.

In addition, perception biases may also have been reduced for properties located out of PPRi zones. Following enforcement of the IAL requirement, demand for “safe” properties may have increased while supply has remained constant. The economic outcome of interest is thus the impact of the disclosure requirement on households who would not have otherwise been informed. In cases of fuzzy design and unlike the standard case, households can be treated in each group and for each period. Chaisemartin and d'Haultfoeuille (2018) have studied the form of the difference-in-differences estimator in such a case and detailed the conditions of identification. They put forward an alternative estimator, but using it requires knowing how information levels changed in the municipalities subject to a PPR, within and outside the regulated zones before and after June 2006. Under the likely assumption that the probability of being informed increases faster among the treatment group than in the control group, the difference-in-differences estimate is again a lower bound of the impact of treatment on the treated.

Finally, it is rather unlikely that the date of enforcement of the IAL and the rise in the proportion of informed buyers after 1st June were anticipated by the sellers of exposed properties⁹. If that were the case, we would expect

buyers to try and anticipate the sale of properties exposed to a risk. The difference-in-differences model would then underestimate the fall in price consecutive to the disclosure of information.

Choice of functional form

We estimate a conventional hedonic price model (Rosen, 1974 ; Palmquist, 2005) in a difference-in-differences setting (Parmeter & Pope, 2013)¹⁰. We suppose that the implementation of the IAL requirement is a localised shock, in other words, a limited number of housing transactions are affected, meaning that, at least in the short term, the equilibrium on the real estate market is not modified and the hedonic price function remains constant (Bartik, 1988; Palmquist, 2005). Our aim is to estimate the marginal effect of a specific attribute as accurately as possible (Cassel & Mendelsohn, 1985; Cropper *et al.*, 1988); however, this paper does not attempt to estimate the marginal price to obtain marginal willingness to pay estimates for an attribute (safety as regards the flood risk in this case)¹¹.

We have opted for a semi-log model. A model with an additive form for explanatory variables allows to directly interpret the difference-in-differences regression results as the average effect of treatment on the treated (Ai & Norton, 2003; Puhani, 2012).

8. The survey into the perception of exposure to risks conducted in 2007 and 2013 by the SOeS does not provide information on the exact location of the respondents' residence with regard to the regulated zones and does not therefore allow an estimation of the proportion of buyers informed about flood risk exposure in PPRi zones before and after 1st June 2006.

9. Implementing decree 2005-134 dated 15 February 2005 provided that the IAL would become mandatory as from the first day of the fourth month following publication, in the official departmental statute book, of the prefectural decrees establishing the list of natural and technological risks, the municipalities concerned and the documents to which sellers and lessors can refer. The implementing decree provided for a maximum time frame of one year for publication of these lists, meaning an enforcement date of 1st June 2005 at the earliest and 1st June 2006 at the latest. A majority of the prefectural decrees were enacted in early 2006.

10. Endogeneity between price and quantity is a problem that is inherent to the hedonic price method, especially when estimating parameters of the supply function. To control endogeneity, some authors have used an instrumental variables model (Cavailhès, 2005; Travers *et al.*, 2009). Parmeter and Pope (2014) demonstrate that when applied to pseudo-experiments, quasi-experimental methods such as difference-in-differences can be used to solve the endogeneity issue. The variable of interest in this paper is obtained by crossing a characteristic related to the property's location with a date, which is a priori exogenous. It is therefore highly unlikely that the fact of lying within the treatment zone after treatment is endogenous with the price. Here, the differences between the treated zone and the treatment zone are not significant (see Online complement C2). If we were able to identify endogeneity between the price and certain other characteristics of the properties, the risk of contamination between other potentially endogenous X variables and the crossed interaction term would be low.

11. Apart from in cases of infinitesimal, exogenous change, quasi-experiment methods are not the most appropriate (Kuminoff & Pope, 2014; Klaiber & Smith, 2013).

We thus estimate the following difference-in-differences hedonic price model :

$$\text{Log}(p_{ijt}) = \alpha_0 + \sum_k \alpha_k X_{ik} + \alpha_d d_{ic} + \sum_j c_j Z_j + \sum_{t=2}^{12} \beta_t 1_t + \beta_z 1_{Zrisque} + \delta 1_{Zrisque} \times 1_{ApJuin} + \varepsilon_{it}$$

where p_{ijt} is the price (excluding agency and notary fees) of the property sold in the month t in the municipality j , α_0 is a constant, X_k is the vector of the housing unit's intrinsic characteristics, d_{ic} the distance (in km) of the house from the centre of the municipality, Z_j the vector of the municipality's characteristics j and ε_{it} an error term. 1_t is an indicator equal to 1 if sale of the property occurs in month t . These dummies are used to estimate the trend in housing transaction prices over time, supposedly common to all the treated zones and the control zone¹². $1_{Zrisque}$ takes the value 1 if the property lies within a PPRi zone, and otherwise 0, and 1_{ApJuin} is given the value 1 if the transaction was completed after 1st June 2006¹³, and otherwise 0, so that $1_{Zrisque} \times 1_{ApJuin}$ is equal to 1 if the house was subject to the IAL requirement at the time of sale, and 0 otherwise.

The parameter of interest is δ , the estimate of the price adjustment, in percentage, caused by the disclosure of information, all other things being equal, and at an unchanged level of exposure to the risk.

As a robustness check, we also estimate the following simple Box-Cox model (Box & Cox, 1964), allowing greater flexibility in the hedonic price function.

$$p_{it}(\lambda) = \sum_{k \in K_c} \alpha_k X_{ik}(\lambda) + \sum_{k \in K_d} \alpha_k X_{ik}$$

with $Z(\lambda) = \frac{Z^\lambda - 1}{\lambda}$ si $\lambda \neq 0$, $Z(\lambda) = \ln(Z)$ si $\lambda = 0$

where p_{ijt} is the price exclusive of agency and notary fees of the property i sold in month t , λ the transformation coefficient, K_c indicates the continuous explanatory variables and K_d the discrete variables.

Since the variables of interest are the discrete variables, we report the sign of the impact of these variables on the price estimated using the Box-Cox model. This model is not linear and the values calculated on the basis of the coefficients estimated before the treatment variables will no longer be equal to the effect of treatment on the treated (Ai & Norton, 2003; Puhani, 2012). As the transformation function

is an increasing monotonous function, the treatment still has the same sign as the coefficient and is only significant if the coefficient is too. The results of the Box-Cox estimation are therefore used to confirm or invalidate the sign and the significance of the results. Only their sign and significance will be interpreted.

We need to control for two known confounding influences. Firstly, a natural disaster in the year of the transaction will affect both the real estate market and perceptions of natural risks (Mauroux, 2015). It will thus be difficult to ascertain the extent to which the variations observed on markets in 2006 can be attributed to the information provided by the IAL or to material damage suffered by properties or public infrastructures. For this reason, municipalities subject to at least one official natural disaster classification in 2006 are excluded from the estimation sample¹⁴.

Another confounder is the effect of amenity which proximity to the source of risk can imply. For example, flood-risk areas are precisely at risk because they lie close to river banks. Such proximity may be highly valued by home owners due to the landscapes, the view and the recreational possibilities (Longuépée & Zuindeau, 2001; Travers *et al.*, 2008). Exposure to a natural risk, recognised here in the regulated PPRi zones, will be strongly correlated with environmental benefits which it may be impossible to observe. As a result, hedonic price estimates suffer from an omitted variable bias. To identify price variations due to the positive effect of amenity separately from those due to the negative impact of the risk, we need a variable that measures amenity (direct view of a river bank, altitude, distance from the coast, etc.) separately from

12. If the temporal trend is constant over the pre-treatment period ($\beta_2 = \beta_3$) and over the post-treatment period ($\beta_6 = \beta_{12}$), we find ourselves with a "conventional" difference-in-differences model with a before/after indicator.

13. A preferred estimation model would be an event study analysis type model (also known as timing of event) with a crossed interaction term per month, rather than a before/after setting ($\sum_{t=2} \delta_t 1_{inzppr}$ instead of $\delta 1_{Zrisque} \times 1_{ApJuin}$, with δ_t month-by-month treatment impacts). This model relaxes the assumption on uniformity of the effect of treatment on the treated in all observation periods and, thanks to the terms crossed before the treatment date ($\sum_{t=2} \delta_t 1_{inzppr}$), allows to test the absence of a pre-trend between the treated and the control group ($\delta_t = 0$). The number of in PPRi zone transactions is, however, low in certain months, so an estimate of this specification would be based on few observations in the treatment zones. The selected specification increases the statistical power but is based on the assumptions of the absence of pre-trend and that—which cannot be tested—that the treatment effect on the treated is uniform over the whole period after 1st June.

14. With the exception of shrinkage and swelling of clay soils. The consequences of this kind of disaster are often observed several months after the occurrence of a drought, so the date of classification as natural disaster often falls after the date of the event.

the measurement of exposure (Pope 2008a; Pope 2008b; Longuépée & Zuindeau 2001; Déronzier & Terra, 2006). Nonetheless, if the characteristics of the properties concerning these amenities (distance, view, etc.) remain constant over time and between zones, the fixed “housing unit located within the regulated zone” effect will also reflect the effect of amenity on price. Buyers’ preferences for environmental amenities do not really change with the introduction of the IAL requirement so the “before/after” difference in the difference-in-differences model will cancel out any constant effect over time between zones, regardless of whether the variable is observable or not. This is a particularly attractive model for treating omitted variable bias, which is a major issue with the hedonic price method.

Data

This study uses original data spatially matching notarial databases covering real estate transactions in 2006 with the regulated flood risk prevention plans (PPRi) official zoning and municipal data on land use and past natural disaster records.

The data on real estate transactions are taken from notarial databases for the year 2006 (the *BIEN*—notarial economic database—for Île-de-France, and the *Perval* database for other *départements*¹⁵). These very rich databases provide a detailed set of information on each transaction: sales price (exclusive of notarial and negotiating fees), address, plot surface area, number of rooms, type of housing unit, period of construction, with a garage or not, car parking, cellar, etc.). It also provides some information on the seller and buyer (age, nationality, place of residence, etc.).

The study is limited to private sales completed in 2006, involving private individuals and vacant homes (excluding unusual properties such as mills, former railway stations, etc., and excluding life leases), where the price, excluding notarial and agency fees, exceeded €1,500. We only retained standard apartments (with a maximum of nine rooms and a living area of at least 10 m²) and individual houses for which the land surface is indicated (with a maximum of twelve rooms and a living area of at least 20 m²)¹⁶.

The notarial data were spatially matched with maps of the regulated PPRi official zoning

available on the Cartorisque website¹⁷ and the information taken from the Gaspar¹⁸ database on PPRs. To identify the units located within the regulated zones subject to the IAL requirement, the housing transactions in the notarial databases were geopositioned to the cadastral parcel using the *Parcelaire*® database from the IGN. The $I_{Zrisque}$ indicator results from the matching of the coordinates obtained with the PPRi maps. This unique database is used to accurately determine whether or not the property is situated in a regulated PPRi zone and, for transactions after 1st June 2006; whether the housing transaction is subject to the IAL requirement. At the time of matching, the Cartorisque GIS did not contain all the regulatory PPRi maps, which led to some “false zero” results (properties actually within a PPRi zone but appearing outside the PPRi in the dataset) during matching if the map wasn’t available. To overcome biases in the estimates, the database was restricted to municipalities in which at least one recorded transaction within a PPRi zone in 2006, which made sure that the PPRi map for the municipality was available at the time of matching.

Municipal data from Insee and the Corine Land Cover geographic database have also been exploited to control the extrinsic attributes of the housing units and characterise the attractiveness of their immediate surroundings (municipal population, relative share of natural spaces in the municipality, etc.). The “as the crow flies” distance of the properties from the centre of the municipality is also included as a proxy of distance and accessibility of the town centre.

These data are completed by the list of official natural disaster classifications in the Gaspar register, and by indicators from the National

15. The Perval databases are produced by a company named Min.Not ADSN. The data used in this study were produced following work to ensure consistency between the fields and variable dictionaries used by BIEN and Perval, conducted by the SOeS (statistics department of the French ministry of Environment).

16. These criteria are recommended by the company Min.Not ADSN (the producer of Perval databases) for real estate statistics. A full description of these filters and their impact on the notarial data is provided by Vermont (2015).

17. Cartorisque is a geographic information system (SIG) that groups maps of major natural and technological risks (<http://www.cartorisque.prim.net>). In 2006, no PPRt has been approved; hence, only the PPRn maps in force for 2006 were used. The published information comes from the State’s decentralised services, under the authority of the prefects concerned.

18. GASPAR – Gestion Assistée des Procédures Administratives relatives aux Risques naturels et technologiques/Assisted management of administrative procedures concerning natural and technological risks. Gaspar contains information on preventive or regulatory documents down to municipal level.

Natural Risk Observatory (ONRN) on the per municipality average cost of flood damage claims paid out under the natural disaster (“Cat Nat”) insurance scheme between 1995 and 2010¹⁹. These indicators are a proxy of the expected compensation for damage cost by households in the event of a flood. The ONRN publishes these indicators in amount brackets, which provides a scale of relative severity of damages from one municipality to another.

The estimation sample includes 18,350 transactions (of which 9,040 apartments and 9,310 houses); 19% are situated within a PPRi zone and 62.2% occurred after enforcement of the

IAL requirement on 1st June 2006 (Table 1). The properties are located in 484 municipalities spread across 39 *départements* (Figure I). On average, these municipalities are relatively densely populated, more urban and have more public amenities and shops than all the municipalities subject to a PPRn and concerned by the IAL requirement.

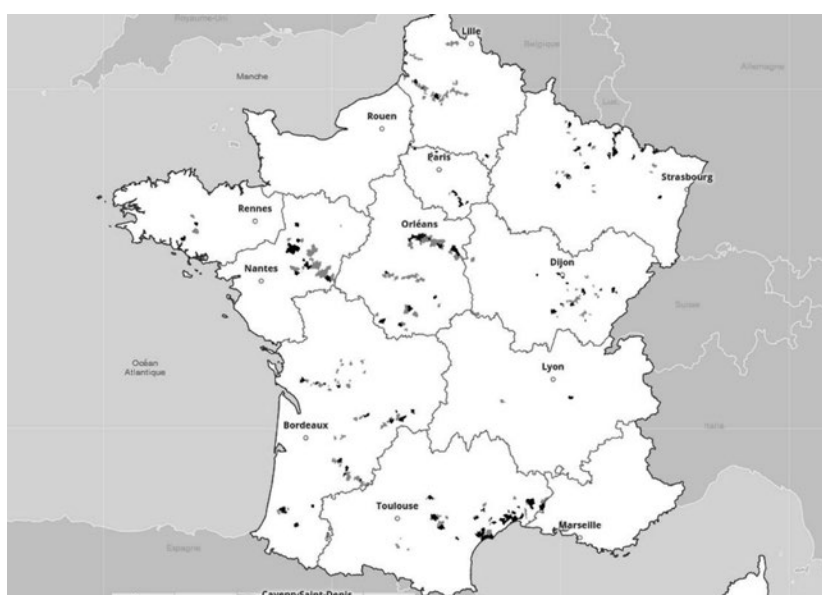
19. The average cost of claims paid out by insurers under the natural disaster scheme for the flood risk in the broadest sense (flood and mudslides, flood due to rising groundwater and coastal flooding) in mainland France between 1995-2010. These average costs only concern insured properties other than motorised land vehicles and are net of any excess. Insured damages account for 60-90% of the total economic cost according to Letremy (2009) and Sigma Re (2014).

Table 1
Base used for the estimations

	Outside PPRi zones			In PPRi zones			Total		
	Before 1st June	After	Total	Before 1st June	After	Total	Before 1st June	After	Total
Apartments	2,809 (38.0)	4,578 (62.0)	7,387 (100)	659 (39.9)	994 (60.1)	1,653 (100)	3,468 (38.4)	5,572 (61.6)	9,040 (100)
Houses	2,771 (37.1)	4,699 (62.9)	7,470 (100)	694 (37.7)	1,146 (62.3)	1,840 (100)	3,465 (37.2)	5,845 (62.8)	9,310 (100)
Total	5,580 (37.6)	9,277 (62.4)	14,857 (100)	1,353 (38.7)	2,140 (61.3)	3,493 (100)	6,933 (37.8)	11,417 (62.2)	18,350 (100)

Note: The properties in the base used for the estimations are described in the Online complement C1.
Coverage: Municipalities in mainland France in which at least one real estate transaction was recorded in 2006 and which was covered by a PPRi in 2006, and outside seismic zoning and outside the scope of an official classification as “natural disaster” in 2006.
Sources: Perval and BIEN 2006 notarial databases, Cartorisque and Gaspar; author’s calculations.

Figure I
Municipalities subject to a PPRi included in the study



Sources: Perval and BIEN 2006 databases, Cartorisque, GéoREF; author’s calculations.

Impact of the IAL requirement on residential property prices

Before and after 1st June 2006, the average prices of apartments in PPRi zones are relatively similar to those outside the zones and are not significantly different at the 1% level (Table 2). These average prices are not corrected for the quality of the properties sold but nonetheless seem to follow the same general

trend as that for apartments outside the PPRi zones (Figure II-A, lower curves, and II-B upper curves). After 2006, the per-square-metre price is systematically lower in PPRi zones (except in July), and appears to increase at a slower rate than for apartments outside the PPRi zones. For individual houses, the price (in euros, excluding agency and notary fees) is almost always lower within than outside the PPRi zones (Figure II-A, upper curves,

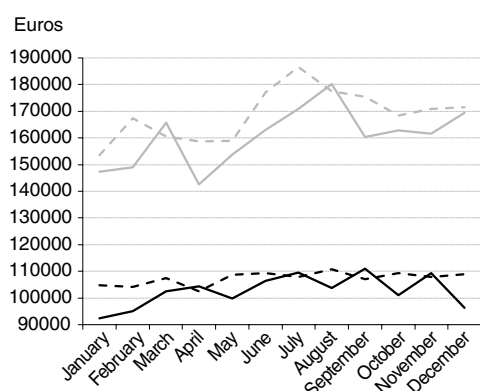
Table 2
Selling price (in euros, excluding agency and notary fees) of properties according to the zoning and date of sale

			Outside PPRi zones		In PPRi zones		Difference-in-differences (standard error)
	Outside a PPRi zone	In a PPRi zone	Before 1 st June	After 1 st June	Before 1 st June	After 1 st June	
Apartments							
Average selling price	107,574	102,760	105,603	108,784	99,050	105,220	2,989 (2,864)
Price per m ²	1,987	1,904	1,898	2,041	1,831	1,953	-21 (40)
Number of transactions	7,387	1,653	2,809	4,578	659	994	-1,434
Houses							
Average selling price	170,104	161,476	159,903	176,119	152,317	167,023	-1,509 (4,248)
Price per m ²	1,634	1,585	1,557	1,679	1,505	1,633	7 (36)
Number of transactions	7,470	1,840	2,771	4,699	694	1,146	-1,476

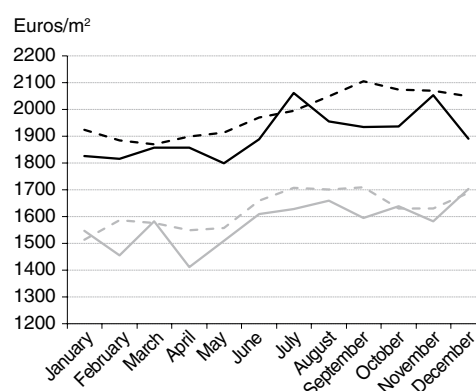
Coverage: Municipalities in mainland France in which at least one real estate transaction was recorded in 2006 and which was covered by a PPRi in 2006, and outside seismic zoning and outside the scope of an official "natural disaster classification" in 2006.
Sources: *Perval* and *BIEN* 2006 notarial databases, *Cartorisque* and *Gaspar*, author's calculations.

Figure II
Price (in euros, excluding agency and notary fees) of monthly transactions according to location and date of sale

A – Average prices



B – Price per m²



--- Apartments - outside a PPR zone
— Apartments - in a PPR ZONE
... Houses - outside a PPR zone
-.- Houses - in a PPR zone

Coverage: Municipalities in mainland France in which at least one real estate transaction was recorded in 2006 and which was covered by a PPRi in 2006, and outside seismic zoning and outside the scope of an official "natural disaster classification" in 2006.
Sources: *Perval* and *BIEN* 2006 notarial databases, *Cartorisque* and *Gaspar*, author's calculations.

and II-B, lower curves). Analysis of the graph does not point to a change in the marked trend in house prices after the IAL came into force. The number of housing transactions in PPRi zones is relatively low (cf. Table 1), however, so average prices may be more volatile than outside these zones.

The estimation results obtained using the difference-in-differences hedonic price model by ordinary least squares (OLS) are reported in Table 3 (OLS and Box-Cox columns). The variables included in the estimation were selected after analysis of the multicollinearity²⁰. For ease

of reference, only the coefficients of interest are presented (the coefficients corresponding to the characteristics of the housing unit and their municipality have the expected sign and are globally highly significant, see the detailed results in Online complement C3). Before 1st June 2006, the housing location within a PPRi zone rather than in the white (no-risk) zone of a flood-risk municipality had no significant effect on its price, once controlled for the

20. Multicollinearity was analysed using two methods: analysis of correlations between the explanatory variables, and analysis of the Variance Inflation Factor (VIF).

Table 3
Impact of the IAL on the average transaction prices (excluding agency and notary fees) within and outside PPRi zones, as a % of the price

Model	Apartments			Houses		
	OLS	Box-Cox	OLS T1-T4	OLS	Box-Cox	OLS T1-T4
<i>Month of sale</i>						
January	<i>Réf.</i>	<i>Réf.</i>	<i>Réf.</i>	<i>Réf.</i>	<i>Réf.</i>	<i>Réf.</i>
February	-2.7*** (1.8)	-	-2.4 (1.8)	5.6** (2.2)	+***	5.5** (2.2)
March	0.7 (2.1)	+	0.9 (2.1)	3.9* (2.1)	+*	3.9* (2.1)
April	1.2 (1.8)	+		3.1 (2.1)	+*	
May	0.9 (2.2)	+		4.6** (2)	+**	
June	2.9* (1.6)	+*		10.5*** (2.2)	+***	
July	5.3** (2.2)	+***		11.7*** (1.9)	+***	
August	7.7*** (1.5)	+***		11.7*** (2)	+***	
September	4.2** (1.8)	+**		8.9*** (2.1)	+***	
October	6.0*** (2.1)	+***	6.8*** (2.2)	11.1*** (2)	+***	11.2*** (2.1)
November	4.7** (1.8)	+**	5.4** (2.1)	7.1*** (2.4)	+***	7*** (2.6)
December	7.8*** (2.3)	+***	8.5*** (2.5)	9.9*** (2.2)	+***	9.8*** (2.2)
PPRi Zone	-0.6 (2.7)	-	-0.8 (3.0)	1.2 (2.3)	+	2.2 (2.7)
After 1 st June x PPRi Zone (obligation of IAL)	-0.2 (2.4)	-	-0.3 (3.3)	0 (0.02)	-	0 (0.03)
Lambda	0	0.2	0	0	0.42	0
R2	0.59	0.59	0.57	0.51	0.51	0.5
Number of observations	9,040	9,040	4,279	9,310	9,310	4,258

Note: Significant at the 1% ***, 5% **, 10% * level. Standard errors (in parenthesis) are computed by cluster so as to account for the possible spatial correlation of the residuals on local housing markets (unobserved variables, or local characteristics such as criminality, shocks (e.g. factory closing, etc.). The clusters retained are the municipalities.

Coverage: Municipalities in mainland France in which at least one real estate transaction was recorded in 2006 and which was covered by a PPRi in 2006, and outside seismic zoning and outside the scope of an official "natural disaster classification" in 2006.

Sources: *Perval* and *BIEN* 2006 notarial databases, *Cartorisque* and *Gaspar*; author's calculations.

quality of the property and the municipality's characteristics. On the whole, enforcement of the IAL has not had an effect on the difference in price between properties in zones regulated by a PPRi and those outside the PPRi zones: the estimates of the effect of treatment on the treated are very low for apartments and individual houses and never differ significantly from zero. An alternative difference-in-differences model estimating the effect of the IAL month-by-month in PPRi zones²¹ was also implemented (see Online complement C3, figures C3-I and C3-II). The estimated coefficients are not significant for the months after June. Nor are they significant for the months preceding the coming into force of the IAL, which supports the assumption of the absence of a pre-trend in the treatment group.

There are several possible interpretations of these results. The first is that the disclosure requirement does not provide additional information for potential buyers. If buyers were already informed, market prices already included the "risk" factor before June 2006 and the IAL requirement have not changed anything in that respect. The assumption of complete and perfect information cannot therefore be rejected. The second possibility is that the information provided by the IAL is new for buyers and the proportion of informed buyers has increased, but the information contained in the IAL does not efficiently reduce perception biases (e.g. information not clear enough, too complex, etc.). The final interpretation possible is that the information is provided at too late a stage in the sales process, once price negotiations have been completed, so that it does not have a direct impact on price in the short term. We cannot rule out the fact that certain buyers decide against buying exposed properties; in this case, the short-term impact would be on sales, then in the medium term on prices through the supply and demand equilibrium.

A robustness check on the estimation period was conducted. According to expert opinion, the average time lapse between the initial sales agreement and signature of the final deed of sale is three months. If the sale takes place in June, the initial sales agreement may have been signed in March or April. In this case, the buyer only received a risk statement at the time of signature of the final deed of sale and it is unlikely that they would withdraw at that stage. To remove the possible bias due to the time lapse between signature of the initial sales agreement and of the deed of sale, the preceding

model is estimated on the subsample of housing transactions from January to March (first quarter) and those from October to December (fourth quarter). The impact of introduction of the IAL on residential property prices (excluding fees) remains zero and non-significant (Table 3, "OLS T1-T4" column).

Sensitivity of the results to the factors of perception and memory of the risk

To refine the analysis, we now consider two factors likely to affect potential buyers' perception of the risk: firstly, the housing unit's floor (or number of storeys for a house) because its strong link with to the perception of flood risk vulnerability, and secondly the date of the last official classification as natural disaster in the municipality, because recent damage events can affect experience and local "memory" of the risk.

Housing unit floor

First, we test whether the IAL has had more impact on ground-floor apartments than on those on the upper floors or, for houses, on single-storey houses than on those with several storeys. Equation 1 is completed using the following terms

$$\beta_Z^{RDC} 1_{Zrisque} 1_{RDC} + \sum_{t=2}^{11} \beta_t^{RDC} 1_{t,RDC} + \delta^{RDC} 1_{Zrisque} 1_{ApJun} 1_{RDC}.$$

The coefficient δ^{RDC} is interpreted as an additional effect of the IAL on ground-floor or single-storey housing prices, with regard to the effect of the IAL on the price of housing units taken as reference, i.e. apartments on the upper floors or houses with several storeys. The assumption is that the perception of a property's vulnerability correlates strongly with its height position and that the ground floor of a building is perceived as the most exposed to flood risk. If this is the case, apartment buyers will not normally alter their decision for floors above the ground floor. For houses, the lower floor will suffer damage in the event of a flood, regardless of whether the building has a single storey or several storeys. However, a house with more than one storey provides a safe haven if water levels rise and may therefore appear safer than a single-storey house. We can therefore expect a greater price adjustment for single-storey houses.

21. $\delta_{1_{ApJun}}^{RDC} 1_{Zrisque}$ is replaced by $\sum_{t=2}^{12} \delta_{t,1_{Zrisque}}^{RDC}$.

All other things being equal, enforcement of the IAL requirement led to a 9% fall in the price of ground-floor apartments in PPRi zones when compared to ground-floor apartments not subject to the IAL (Table 4). The difference-in-differences estimator for single-storey houses is also negative (cf. Table 4), but not significant.

Recent damage events in the municipality

In behavioural economics and psychology, it is well documented that risk perception is very strongly influenced by experience and one's own history (Tallon & Vergnaud, 2007). The sign for this correlation is nonetheless ambiguous. According to the "availability heuristic" assumption (Tversky & Kahneman, 1973), an individual is all the more likely to overestimate (or respectively underestimate) the probability of a random event if they have recent experience (respectively, "distant") of a similar event and can easily (respectively, with difficulty) recall it. On the contrary, according to "gamblers' fallacy", agents consider that it is rather unlikely that an event that has just occurred will reoccur any time soon and, reciprocally, that after a long period with no occurrences, an event is more likely to occur to "correct" the low probability factor, even if the events are independent. If the municipality has not experienced a natural disaster for several years, the IAL may

recall otherwise forgotten information. In the opposite case, it may reactive memories of recent events.

In our estimation sample, 33 municipalities suffered a natural disaster (excluding shrinkage and swelling of clay soils) in 2005, the year preceding the sale, and 230 at least once in the five years preceding the sale. Immediate memory of the risk is therefore potentially very heterogeneous within our estimation sample. The date of the last official classification as natural disaster is used as a proxy of the last major flood in the municipality. To the reference equation, we add the variables from the difference-in-differences model crossed with a dummy variable equal to 1 if the municipality was subject to at least one natural disaster classification in the year preceding the sale (in 2005), then at least one such classification in the five years preceding the sale. The crossed effect is interpreted as the additional effect of the IAL requirement compared to the reference situation, i.e. with no natural disaster classification in 2005 and, respectively, none in the five years preceding the sale.

In the municipalities that experienced a natural disaster in the year preceding the sale, enforcement of the IAL requirement had a significant depreciative effect of -7% on the price of apartments subject to the IAL requirement

Table 4
Impact of the IAL on the average transaction prices (excluding agency and notary fees) within and outside the PPRi zones depending on the housing unit's storey, as a % of the price

Model	Apartments			Houses		
	OLS	Box-Cox	OLS T1-T4	OLS	Box-Cox	OLS T1-T4
PPRi Zone	-2.2 (2.6)	-	-2.4 (2.9)	0.7 (2.6)	+	1.4 (3)
Ground floor apartments or single-storey houses x PPRi Zone	1.4 (2.8)	+	-1.3 (3.1)	1 (2.6)	+	1,6 (3,6)
After 1 st June x PPRi Zone (<i>obligation of IAL</i>)	10.1** (4.2)	***	10.3 (7.4)	2.7 (4.7)	+	4.7 (5.9)
Ground floor/single-storey x After 1 st June x PPRi Zone	-9.1* (4.9)	-°	-11.1° (7.6)	-7.3 (5.5)	-	-10.3 (8.9)
Lambda	0	0.2	0	0	0.42	0
R2	0.59	0.59	0,57	0.51	0.52	0.51
Number of observations	9,040	9,040	4,279	9,310	9,310	4,258

Note: Significant at the 1% ***, 5% **, 10% * level. Standard errors (in parenthesis) are computed by cluster (cf. Table 3). The estimation controls for the month of sale; the coefficients are presented in Table C4-1 of the Online complement C4.

Coverage: Municipalities in mainland France in which at least one real estate transaction was recorded in 2006 and which was covered by a PPRi in 2006, and outside seismic zoning and outside the scope of an official "natural disaster classification" in 2006.

Sources: *Perval* and *BIEN* 2006 notarial databases, *Cartorisque* and *Gaspar*; author's calculations.

when compared to similar properties that were not subject to it (Table 5). The same result is obtained if we take the two years prior to the sale into consideration (not reported here). Nonetheless, the OLS estimator is not significant at the 10% level (p-value of 12%), so this result remains fragile. For individual houses, the effect is not significant.

Over a time frame of five years prior to the sale, enforcement of the IAL requirement has no impact on residential property prices, regardless of whether or not the municipality was affected by a natural disaster. The IAL therefore only appears to have an impact on the price of apartments when the last events are very recent, which is consistent with the availability heuristic assumption and undermines the assumption of complete and perfect information.

Sensitivity of the results to the characteristics of local real estate markets

The impact of disclosure to new buyers is estimated depending on tension on the local real estate market. Tension corresponds to the adequacy of supply of available houses with demand for housing within a territory. A zone is described as “tense” (respectively “slack”) if the supply of available housing is not (resp. is) enough to cover demand. When supply is lower than demand, buyers’ bargaining power is expected to be weaker because they have less choice and are probably less able to ask for a price drop after learning about the property’s exposure to risk. Conversely, if supply is abundant when compared to demand, potential buyers find it easier to negotiate the price downwards or pull out of the sale.

Table 5
Impact of the IAL on the average transaction prices (excluding agency and notary fees) within and outside PPRi zones, by date of the last official classification as natural disaster, as a % of the price

Model	Apartments			Houses		
	OLS	Box-Cox	OLS T1-T4	OLS	Box-Cox	OLS T1-T4
<i>At least one classification as “natural disaster” in 2005</i>						
PPRi Zone	0.5 (3.1)	-	0.2 (3.8)	1.4 (2.5)		1.3 (3)
At least one “Cat Nat” in 2005 x PPRi Zone	-3.4 (5.3)	-	-2.8 (5.5)	-1.5 (7.1)	-	6.2 (6.2)
After 1 st June x PPRi Zone	2.7 (2.5)	+	-3.0 (4.2)	0 (2.6)	-	0.9 (3.7)
At least one “Cat Nat” in 2005 x PPRi Zone x After 1 st June	-7.1* (4.6)	-*	-0.7 (6.2)	-1.4 (6.7)	-	-9.8 (7.2)
Lambda	0	0.2	0	0	0.42	0
R2	0.59	0.59	0.57	0.51	0.52	0.51
Number of observations	9,040	9,040	4,279	9,310	9,310	4,258
<i>At least one classification as “natural disaster” in the 5 previous years</i>						
PPRi Zone	1.9 (5.6)	+	-1.4 (7.6)	5.9 (4)	+**	4.7 (4.8)
At least one “Cat Nat” in the 5 previous years x PPRi Zone	-3.1 (5.9)	-	0.9 (7.7)	-7.8 (5.1)	-**	-4.4 (4.8)
After 1 st June x PPRi Zone	-2.0 (4.8)	-	-15.7** (7.7)	-1.4 (4.4)	-	-1.6 (5.8)
At least one “Cat Nat” in the 5 previous years x PPRi Zone x After 1 st June	2.3 (5.8)	+	15.9* (0.1)	1.4 (5.2)	+	1.7 (5.9)
Lambda	0	0.2	0	0	0.42	0
R2	0.59	0.59	0.57	0.51	0.52	0.51
Number of observations	9,040	9,040	4,279	9,310	9,310	4,258

Note: Significant at the 1% ***, 5% **, 10% * level. Standard errors (in parenthesis) are computed by cluster (cf. Table 3). The estimation controls for the month of sale; the coefficients are presented in Table C4-2 of the Online complement C4.

Coverage: Municipalities in mainland France in which at least one real estate transaction was recorded in 2006 and which was covered by a PPRi in 2006, and outside seismic zoning and outside the scope of an official “natural disaster classification” in 2006.

Sources: *Perval* and *BIEN* 2006 notarial databases, *Cartorisque* and *Gaspar*; author’s calculations.

We use a French policy scheme known as the “Robien law ‘recentred’ zones” as proxies of tension on real estate markets in 2006; these zones were defined in August 2006 and split the territory into four areas according to market tension. Zone A is the most tense and most notably includes Paris and its conurbation, the Côte d’Azur and municipalities in the French Genevois territory; as the number of sales in a PPRi zone after 1st June 2006 was very low for this “zone A” (4 out of 632 apartment sales, 7 out of 375 house sales), it is excluded from the estimation sample. Zone B1 covers conglomerations of over 250,000 inhabitants, the periphery of the Côte d’Azur, the overseas *départements* and Corsica; zone B2 includes other conglomerations of over 50,000 inhabitants and other expensive conglomerations near the borders, coasts and close to the Parisian conurbation; zone C, which is the least tense, covers the rest of France.

To the reference equation, we add the terms of the difference-in-differences model crossed with an indicator equal to 1 if the municipality is located in zone B1, and those crossed with

an indicator equal to 1 if the municipality is located in zone C (zone B2 is taken as the reference). The crossed effect for a given zone is interpreted as an additional effect of the IAL in that zone, compared to the effect on the price of properties in the zone taken as reference.

For apartments, enforcement of the IAL requirement did not have a significant effect on prices regardless of the zone considered. For houses, the IAL had an additional effect of -9% (significant at the 10% level) on sales prices in zone C and -8% (significant at a 13% level) in zone B1 (Table 6). The impact of the IAL in the reference zone (B2) is positive and significant but lower (+6%)²², so the overall impact of the IAL on house prices in zones C and B1 is negative. Hence, in municipalities where the real estate market is the least tense, enforcement of the IAL requirement went hand-in-hand with a 3% decline in housing

22. This “Robien B2” zone corresponds to specific real estate markets, including expensive coastal zones and border zones. The positive amenity effect of the proximity of the coast shore or of a river can outweigh the negative effect of flood risk exposure.

Table 6
Impact of the IAL on the average transaction prices (excluding agency and notary fees) within and outside the PPRi zones according to real estate market tension, as a % of the price

Model	Apartments			Houses		
	OLS	Box-Cox	OLS T1-T4	OLS	Box-Cox	OLS T1-T4
Zone Robien B1	12.0* (6.9)	+***	7.5 (7.2)	0.05 (0.05)	+	7.5 (5.7)
Zone Robien B2	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Zone Robien C	-20.1** (10.2)	-***	-18.3* (9.9)	-0.33*** (0.06)	-***	-29.7*** (6.1)
PPRi Zone	3.7 (4.2)	+	4.4 (4.5)	-0.05 (0.03)	-**	-3.6 (4.0)
Zone Robien B1 x PPRi Zone	-9.4* (5.5)	-***	-10.1* (5.9)	0 (0.05)	+	-1.9 (6.6)
Zone Robien C x PPRi Zone	-5.6 (0)	-	-6.6 (0)	0.11** (0)	+***	10.7* (0)
After 1 st June x PPRi Zone (IAL, obligatoire)	-1.5 (4.8)	-	-4.7 (5.6)	0.06* (0.03)	+°	2.1 (4.7)
Zone Robien B1 x After 1 st June x PPRi Zone (IAL, obligatoire)	1.4 (5.3)	+	3.4 (6.7)	-0.08° (0.06)	-°	-2.9 (7.8)
Zone Robien C x After 1 st June x PPRi Zone (IAL, obligatoire)	8.7 (8)	+	4.2 (10.7)	-0.09* (0.05)	-*	-3.7 (7.3)
Lambda	0	0.2	0	0	0.42	0
R2	0.58	0.59	0.57	0.51	0.52	0.51
Number of observations	8,408	8,408	3,989	8,935	8,935	4,098

Note: Significant at the 1% ***, 5% **, 10% * 15% level. Standard errors (in parenthesis) are computed by cluster (cf. Table 3). Coverage: Municipalities in mainland France in which at least one real estate transaction was recorded in 2006 and which was covered by a PPRi in 2006, and outside seismic zoning and outside the scope of an official “natural disaster classification” in 2006. Sources: Perval and BIEN 2006 notarial databases, Cartorisque, ONRN ; Insee ; Corine Land Cover, IGN ; author’s calculations.

transaction prices. In municipalities in the more tense zone B1, the impact was negative but to a lesser degree and was less significant.

Placebo test

We now test the effect of the fictitious implementation of the IAL at various dates prior to the enforcement of the IAL (1st February, 1st March, 1st April and 1st May). The expected effect of applying this placebo is zero. If it were significant, it would indicate that the sellers of properties exposed to risks had anticipated the introduction of the IAL requirement. From a methodological viewpoint, a significant effect of a “placebo” measure would raise concerns over a significant difference between housing transactions outside and within the PPR zones and that the selected control group is not therefore appropriate.

The difference between apartment prices in regulated PPRi zones and in the rest of the municipality is not affected by the fictitious introduction of the IAL on 1st February, 1st March or 1st April (Table 7-A). However, the effect of a fictitious introduction on 1st May has a significant effect of -5%. This suggests that after 1st May 2006, the price

of apartments in regulated PPRi zones were perhaps already lower than those of apartments in the rest of the municipality, which could be the sign of some slight anticipation. Conversely, the enforcement of the IAL requirement on fictitious dates did not affect house prices, regardless of the date. This test means we do not have to reject the assumptions used in identification of the difference-in-differences model for houses.

Finally, we run placebo tests for the sensitivity specifications for which significant effects were obtained (real estate market tension for individual houses, storey and past damage events in the municipality for apartments). For houses, the effect of a placebo IAL requirement crossed with Robien zones is not significant. For apartments, the effect of a fictitious IAL requirement crossed with the housing unit’s storey is significant for an introduction date of 1st March; this suggests that the price of ground-floor apartments was perhaps already lower in regulated PPRi zones than in the rest of the municipality. This result raises concerns over a bias in the estimate of the effect of the introduction of the IAL requirement on ground-floor apartment prices in PPRi municipalities and prompts us to interpret the difference-in-differences model result with

Tableau 7
Impact of the IAL on the average transaction prices (excluding agency and notary fees) within and outside the PPRi zones, by placebo month, as a % of the price

A – Main specification

	February	March	April	May
<i>Apartments</i>				
PPRi Zone x After the 1 st of ...	0.1 (3.4)	-0.0 (2.4)	-1.3 (2.6)	-4.5* (2.5)
R2	0.58	0.58	0.58	0.58
Number of observations	3,468	3,468	3,468	3,468
<i>Houses</i>				
PPRi Zone x After the 1 st of ...	-4.2 (4.4)	-1.8 (3.6)	-2.7 (3.8)	1.0 (4.7)
R2	0.5	0.5	0.57	0.57
Number of observations	3,465	3,465	3,465	3,465

B – Sensitivity

	February	March	April	May
<i>Apartments</i>				
PPRi Zone x After the 1 st of ...	0.5 (3.7)	2 (2.7)	-1.5 (3.5)	-3.9 (2.7)
Ground floor/One-storey x PPRi Zone x After the 1 st of ...	-2.4 (8.0)	-17.6* (9.8)	0.3 (13.5)	-4.5 (14.1)
R2	0.58	0.58	0.58	0.58
Number of observations	3,468	3,468	3,468	3,468
<i>Houses</i>				
PPRi Zone x After the 1 st of ...	-5.1 (4.9)	-0.5 (3.8)	-2.8 (3.7)	-1.5 (3.6)
At least one 'CatNat' in 2005 x PPRi Zone x After the 1 st of ...	11.6* (6.0)	0.7 (4.8)	3.6 (5.1)	-7.1 (5.1)
R2	-	0.58	0.58	0.58
Number of observations	3,468	3,468	3,468	3,468

Note: Significant at the 1% ***, 5% **, 10% * level. Standard errors (in parenthesis) are computed by cluster (cf. Table 3).
Coverage: Municipalities in mainland France in which at least one real estate transaction was recorded in 2006 and which was covered by a PPRi in 2006, and outside seismic zoning and outside the scope of an official “natural disaster classification” in 2006.
Sources: *Perval* and *BIEN* 2006 notarial databases, *Cartorisque*, ONRN ; Insee ; *Corine Land Cover*, IGN ; author’s calculations.

caution. Likewise, a fictitious IAL requirement on 1st February has a positive effect on the price of apartments located within municipalities affected by a natural disaster in 2005, compared to those located in an unaffected municipality (non-significant effect) and those located in municipalities affected at least once in the five years preceding the sale.

* *
*

The aim of this paper was to test the assumption of complete and perfect information in the hedonic price model on the French property markets. The enforcement of the IAL requirement for properties located within the boundaries of a PPRi was used as a quasi-natural experiment of an information shock in the context of residential property transactions.

The results of the estimations suggest that the IAL had no significant impact on the average price (exclusive of fees) of properties sold in the 484 PPRi municipalities included in our estimation sample. One reason may be that the majority of buyers were already sufficiently informed about exposure to risks before the IAL came into force and thus the assumption of complete and perfect information is verified. However, it is also possible that buyers are poorly informed by the IAL (difficulties understanding the risk statement, technical information, etc.), and that this policy does not improve their risk perception, or that householders are informed at too late a stage in the transaction, meaning that the new information is not taken on-board when negotiating the price. In this case, the impact of preventive information on risk perception is

underestimated because householders cannot exploit it during negotiations.

Nonetheless, from its year of introduction, for certain categories of properties and in certain municipalities, we can observe a depreciative effect of the IAL on the sales price of existing housing units. The introduction of the IAL led to an average fall of 9% of the price of ground-floor apartments in PPRi zones of municipalities subject to floods. The results also point to a negative impact on the price of houses on the least tense real estate markets (the so-called “recentred Robien zone C”). This policy could thus have modified some buyers’ perception of natural risks, which somewhat undermines the assumption of complete and perfect information in real estate markets. The final results urge caution when interpreting the results of the hedonic price model for characteristics that cannot be observed directly or which are difficult to appreciate, such as exposure to natural risks.

The short estimation period after the IAL coming into force is the main limit of this study. Some potential buyers may well have decided not to buy after receiving the risk statement. The short-term effect of the IAL would thus be to lengthen the time it takes to sell a property in exposed, regulated zones. The price drop expected after a fall in demand for those properties would then be observed several months later, after adjustment of supply and demand. In the absence data for the years before and after 2006, this possibility could not be tested.

It would therefore be useful to extend our study over several years, before and after the IAL coming into force, to obtain a more robust evaluation of the reform and be able to control better for seasonal effects on real estate markets. □

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Natural and technological risk statement form in 2006



Etat des risques naturels et technologiques

en application des articles L 125 - 5 et R 125 - 26 du code de l'environnement

1. Cet état des risques est établi sur la base des informations mises à disposition par arrêté préfectoral
 n° _____ du _____ mis à jour le _____

Situation du bien immobilier (bâti ou non bâti)

2. Adresse commune _____ code postal _____

3. Situation de l'immeuble au regard d'un ou plusieurs plans de prévention de risques naturels prévisibles [PPRn]

L'immeuble est situé dans le périmètre d'un PPRn **prescrit** oui non
 L'immeuble est situé dans le périmètre d'un PPRn **appliqué par anticipation** oui non
 L'immeuble est situé dans le périmètre d'un PPRn **approuvé** oui non

Les risques naturels pris en compte sont :

Inondation <input type="checkbox"/>	Crue torrentielle <input type="checkbox"/>	Remontée de nappe <input type="checkbox"/>
Avalanche <input type="checkbox"/>	Mouvement de terrain <input type="checkbox"/>	Sécheresse <input type="checkbox"/>
Séisme <input type="checkbox"/>	Cyclone <input type="checkbox"/>	Volcan <input type="checkbox"/>
Feux de forêt <input type="checkbox"/>	autre <input type="text"/>	

4. Situation de l'immeuble au regard d'un plan de prévention de risques technologiques [PPRT]

L'immeuble est situé dans le périmètre d'un PPRT **approuvé** oui non
 L'immeuble est situé dans le périmètre d'un PPRT **prescrit *** oui non

* Les risques technologiques pris en compte sont :

Effet thermique <input type="checkbox"/>	Effet de surpression <input type="checkbox"/>	Effet toxique <input type="checkbox"/>
--	---	--

5. Situation de l'immeuble au regard du zonage réglementaire pour la prise en compte de la sismicité
 en application du décret 91-461 du 14 mai 1991 relatif à la prévention du risque sismique, modifié par le décret n°2000-892 du 13 septembre 2000

L'immeuble est situé dans une commune de sismicité zone Ia zone Ib zone II zone III Zone 0

pièces jointes

6. Localisation
 extraits de documents ou de dossiers de référence permettant la localisation de l'immeuble au regard des risques pris en compte

vendeur/bailleur – acquéreur/locataire

7. Vendeur - Bailleur Nom prénom _____ rayer la mention inutile _____

8. Acquéreur – Locataire Nom prénom _____ rayer la mention inutile _____

9. Date _____ à _____ le _____

Le présent état des risques naturels et technologiques est fondé sur les informations mises à disposition par le préfet de département. En cas de non respect, l'acquéreur ou le locataire peut poursuivre la résolution du contrat ou demander au juge une diminution du prix. [V de l'article 125-5 du code de l'environnement]