Nitrates and People Perception: a Hedonic Application

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Abstract

This paper examines the effect of living in vulnerable zone in term of nitrates on property prices using a change in the geographical delimitation of the zone in France. Using an identification strategy based on a spatial difference-in-differences specification, we show that the 2012 revision policy decreases significantly property prices not only in areas that becomes vulnerable at the time of the policy but also in areas that were already considered as vulnerable before the policy change.

Keywords: Hedonic Price Analysis, difference in difference, water pollution

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Introduction

In Europe, Council Directive 91/676/EEC has been implemented to protect waters against pollution caused by nitrates from agricultural sources through a number of measures incumbent on Member States. These measures concern monitoring surface waters and groundwater, designating vulnerable zones, introducing codes of good agricultural practice, adopting action programs, and evaluating the actions implemented. In this project, we are concerned with vulnerable zones which are all known areas of land which drain into surface waters and groundwater which are affected by pollution or at risk of being so. In fact, nitrates in drinking water, which may come from nitrogen fertilizers applied to crops, are a potential health risk (Crutchfield et al., 1997). Vulnerable zones have been revised in 2012 in France due to pollution concentration from surface waters and groundwater observed in 2010-2011. Today, nearby 55 % of France is classified as vulnerable zones, which corresponds to regions where agricultural land is the most important. This project aims to examine the impact of a potential change in the environment linked with the change of vulnerable zones in 2012 on property prices. In fact, water quality can have a significant effect on property values (Leggett and Bockstael, 2000).

The literature underlines the need to develop novel methods to improve our ability to estimate the marginal willingness to pay for environmental improvements (Bento, 2013), (Lavaine, 2014). A wide range of studies on this topic use quasi-experimental technique. Davis (2004) measures the effect of health risk on housing values by exploiting a severe increase in pediatric leukemia in an isolated county in Nevada as a natural experiment. In addition, Currie et al. (2015) measure recently the housing market and health impacts of 1,600 openings and closings of industrial plants that emit toxic pollutants. Chay and

Greenstone (2005) exploit the quasi-random assignment of air pollution changes across counties induced by federally mandated air pollution regulations to identify the impact of particulate matter on property values. Greenstone and Gallagher (2008) use the Superfund cleanups to analyze its local welfare impacts. In the same vein, to mitigate selection and endogeneity problems and to infer the impact of a new directive on property prices, we use the 2012 boundary revision as a quasi-experimental approach. While this is not the first difference in difference study to use the effect of an environmental policy on hedonic prices as a natural experiment, this study aims to analyze the consequences of a shift in risk perception on housing markets not only in areas directly concerned by a policy change, but also in neighborhood areas indirectly concerned by this policy change. It aims to shed light on people's willingness to pay for perceived differences in nitrates risk. The analysis of this paper focuses on municipalities in the Centre and Poitou Charentes region, where residents recently were considered to be living in a sensitive geographical area in terms of nitrates, though this is not the only place in France. The geographic region for the control group is then represented by all towns not classified as vulnerable zones. House prices in new sensitive areas are compared before and after the 2012 designation of vulnerable zones with the nearby municipalities. The conditions of supply and demand for housing are relatively similar in both groups, so that we can expect a similar set of implicit prices in vulnerable zones and in its surroundings.

Data and empirical strategy

Data sources

Property prices are drawn from a unique and detailed dataset -PERVAL- compiled by the Chambre of Notaires (who records property transactions) from 2011 to 2014. Table 1 presents a summary statistics about property transaction over 4 years in the Centre and Poitou Charentes Region. We have precisely obtained information about property transactions for 4 departments [1] namely Vienne (86) and Charente Maritime (17) for the Poitou Charente region; Loiret (45) and Indre et Loire (37) for the Centre region. We have classified municipalities with respect to the date they have been considered as vulnerable. Out of 676 municipalities, 135 have never been classified as nitrates sensitive, 456 have been classified as nitrates sensitive before 2012 and 85 have been classified as nitrates sensitive in 2012. Figure 1 provides a geographical representation of this delimitation. The key variables of the PERVAL dataset are the property prices, the number of floors, the number of rooms, the type of flat or house, the property surface, the presence of a terrace, an attic, a parking space, a balcony, a pool or a terrace and a variable which indicates if the property is less than 5 years old. Panel A of table 1 shows the average price by property and year. We observe that property prices are higher before the 2012 boundary than after 2012 for all municipalities of the study, hinting at potential effects from the regulation. Also shown is the number of transactions per municipalities by year. One concern with our analysis is that a change of a sensitive area can affect the number of property transactions, potentially leading to sample selection bias. As shown in Table 1, the number of transactions is higher

[1] Department is a French geographical level below the regional level.

across the nitrates areas than in non-nitrates areas. Further, when we run regressions using the number of transactions as the dependent variable, we do not find a statistically significant relationship between the number of transactions and the geographical boundary, suggesting a change in the number of transactions, if it arises, is unlikely to bias our estimates.

Empirical Methodology

Our goal is to assess the impact of vulnerable zone boundary on property prices. We estimate difference in difference models to exploit the change in the boundary in 2012. Housing prices are compared before and after the geographical boundary change with nearby municipalities acting as a control group. We implement this by estimating the following equation:

$$Y_{imy} = \beta nitrates_{im} * policy_y + \delta X_{imy} + \sigma_y + \alpha_m + \epsilon_{imy} \quad (1)$$

where Y is the log of property prices of the transaction i in municipality m at year y [2]. Turning to the independent variables, 'policy' is an indicator variable for the year of the new boundary of vulnerable area that corresponds to 2012, and 'nitrate' is an indicator variable for whether the municipality is classified as vulnerable. β is the difference-in-difference parameter. X_{imy} is a vector of properties controls that includes year of construction, the surface of the property, the surface of the parking, the surface of the main room, the number of rooms, the presence of an attic and the presence of a balcony. It also differentiates specific attributes for house and flat such as the type of house and the presence of a pool

[2] The unit of observation is the transaction-year. We have 14348, 13376, 16159 and 13624 transactions in 2011, 2012, 2013 and 2014 respectively.

and a terrace or the type of flat and the number of level. We control for temporal patterns by including year dummies in σ_y. Because many properties were sold repeatedly during the sample period it is possible to control for unobserved municipalities-characteristics. Thus, we include municipalities fixed effects (α_m) to control for time-invariant characteristics of the municipality. ϵ_{imy} represents the error term, which consists of an idiosynchratic component and a term clustered on the municipality and year [3]. Kuminoff et al. (2010) suggest that large gains in accuracy can be realized by moving from the standard linear specifications for the price function to a more flexible framework that would use a combination of spatial fixed effects, quasi-experimental identifications, and temporal controls for housing market adjustment.

As with any difference in difference design, the key underlying assumption for identification is that the control group serves as a valid counterfactual for the treatment group with parallel trends. Although we cannot explicitly verify this assumption, we feel this threat is limited in this setting for several reasons. First, figure 2 shows a similar evolution of prices in both group before the 2012 revision of boundary areas. Furthermore, we vary the definition of treatment to test the robustness of our results in the next section. Because the boundary of a sensitive zone could be anticipated, we also could expect sorting of households according to preferences prior to the boundary. Using a really rich and exhaustive dataset for property transactions, we are able to distinguish municipalities that were already considered as vulnerable in 2012 to municipalities that will become vulnerable in 2012. The issue of sorting, following the 2012 policy, is limited in municipalities considered

[3]We cluster on the municipality because this is the unit of boundary for vulnerable zones, and on the year since this is the unit of measurement for the price. This yields a total of 2704 clusters (676 municipalities*4 years). By clustering on the municipality we are also accounting for potential serial correlation within a municipality.

vulnerable before 2012 as households may have already sort themselves at the time of the old geographical boundary.

Results

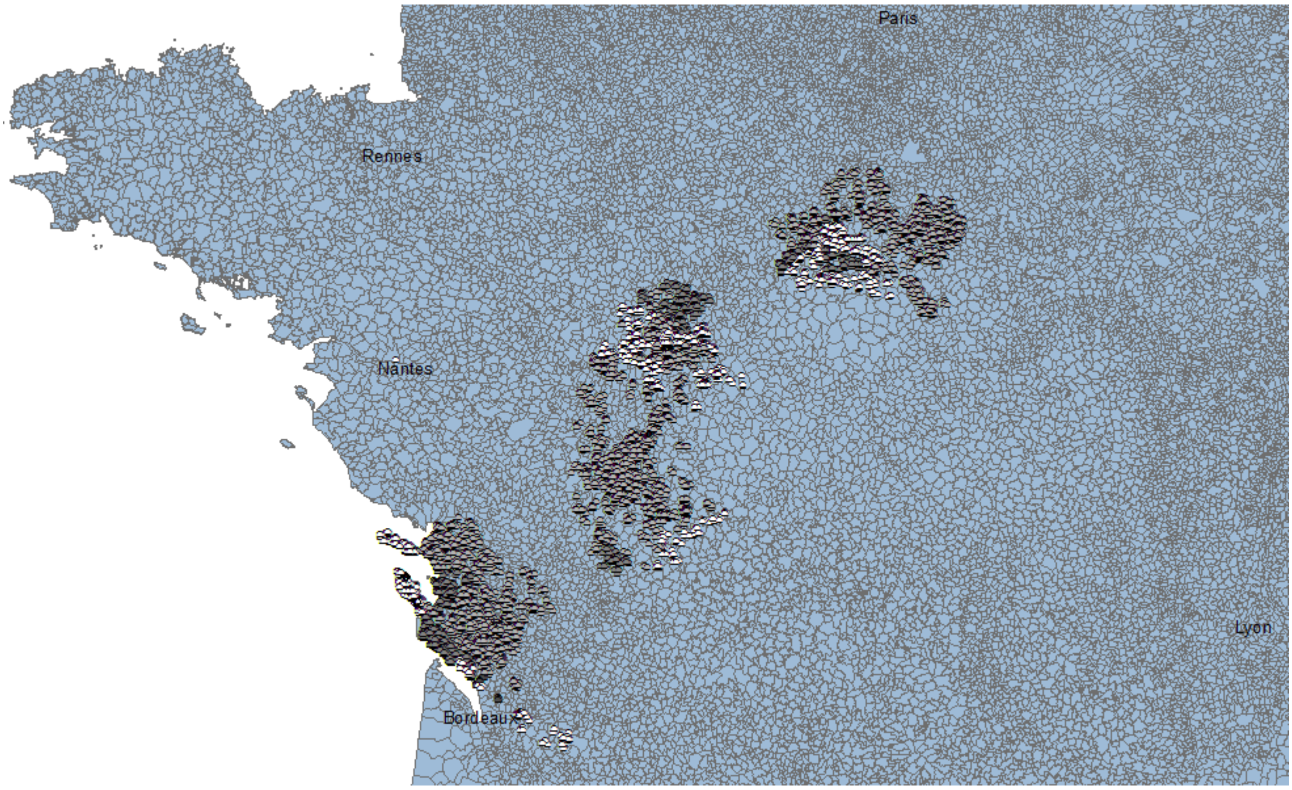
Figure 2 provides a yearly graph of adjusted prices levels from 2011 to 2014 for the treatment and control groups, with prices levels adjusted by δX_{imy}, σ_y and α_m. Prior to the 2012 regulation, prices levels are higher in municipalities with classification. Immediately after the regulation, prices levels in vulnerable areas decrease whereas prices levels in non-vulnerable areas increase. After the 2012 revision, prices level in municipalities that are not classified as nitrates sensitive exceed those of nitrates sensitive areas. This visual display clearly demonstrates a strong, temporal effect of the 2012 regulation on prices levels. The following tables provide regression estimates of equation (1), which are largely analogous to this figure. First, table 2 presents the effect of the regulation on the overall property market. Fixed effects are included in all of the columns. While the first block of table 2 looks at the entire dataset, the last two blocks restrict the sample with respect to the treatment group. In fact, each block corresponds to a different treatment. Hence, We test for the heterogeneity of the treatment results by interacting the 'policy' variable with different definition of treatment. In fact, it is interesting to wonder what could be the impact of the 2012 revision on municipalities that were already considered as vulnerable. To do so, we choose to vary the treatment group ('nitrates') to distinguish the impact of the 2012 revision on municipalities that were already classified as vulnerable in 2012 and municipalities that will only become vulnerable in 2012. Column 1 uses a difference-in-differences model without property characteristics. Column 2 takes full advantage of control variables. Property characteristics are added to control for any differences in the evolution of property characteristics between the treatment and control group. The estimates are negative but not significant in the three different treatment as shown in every columns of table 2. This absence of significant results for the overall sample leads us to wonder about the existence of potential heterogeneity among houses and flats in this market.

Thus, the following tables, table 3, table 4 and table 5 divide the dataset between flats and houses due to potential differences in the evolution of their markets and prices. The first two columns of each table present the results for flat whereas the last two columns of each table focus on house results. Treatments in table 2 are the same ones as used in tables 3, 4 and 5. While the treatment group in table 3 corresponds to municipalities that were considered as vulnerable before 2012 or in 2012, the control group corresponds to municipalities that are not vulnerable. The difference-in-differences estimator from table 3 is negative and significant for both house and flat. Adding control variables in column 2 and 4, decrease the size of the coefficient. Results show property prices decrease by 4% for house and 5% for flat after the 2012 revision in municipalities that were considered as vulnerable before 2012 or in 2012. We repeat the same exercise in table 4 restricting the treatment group to municipalities that are only considered as vulnerable in 2012. The difference-in-differences estimator from table 4 is negative and significant for flat in both specifications. The coefficient, representing the impact of the revision on house prices located in a vulnerable zone since 2012, is not significant when adding control variables in column 4. Results show property prices decrease nearby 6% for flat after the 2012 revision in municipalities that were considered as vulnerable in 2012. We finally repeat once again the exercise restricting now the treatment group in table 5 to municipalities that were considered as vulnerable before 2012 only. The difference-in-differences estimator from table 5 is negative and significant for house in both specifications. However, the coefficient representing the impact of the revision on flat prices, located in a vulnerable zone before 2012, is not significant without considering control variables in column 1. Results show property prices decrease nearby 4% for house and flat after the 2012 revision in municipalities that were considered as vulnerable before 2012. First, using alternatively the same definition of treatment, it is interesting to note the difference of results between table 2 and table 3, 4 and 5. Feitelson et al. (1996) noted that in theory, hedonic price studies do not require the segmentation of housing markets if all attributes are adequately taken into account. However, in practice, several types of market segmentation are likely to exist in most markets. This is because housing markets are not uniform (Adair et al., 1994),(Fletcher et al., 2000). Hence, literature highlights it is unrealistic to treat the housing market in any geographical location as a single entity. Unfortunately, the definition, composition, and structure of submarkets have not been given much attention in hedonic price literature, although this is an important empirical issue (Fletcher et al., 2000). Thus, the market segmentation has been done in this study dividing the market with respect to house and flat. The lack of significant results in table 2 compared to the following tables is in line with this literature highlighting the importance of market segmentation in empirical work. In the same vein, the literature highlights that examining the full housing value distribution can have important policy implications for the results of a hedonic analysis (Gamper-Rabindran and Timmins, 2013). Gamper-Rabindran and Timmins (2013)'s valuation of the Superfund cleanup shows that a focus on the median housing value would have understated the larger effects at the lower tails of the housing value distribution. In this paper, the distinction between house and flat acts as a proxy of the property value distribution. In general, results highlight a decrease in property prices in municipalities classified as vulnerable (the treatment group) compared to municipalities classified as not vulnerable (the control group). Even if we consider people are informed about the change of vulnerable zone boundary, the demand for property may not decrease in municipalities that were already considered as sensitive in term of nitrates due to an absence of newer risk. Unless it is assumed that owners of properties, located in municipalities classified as sensitive before 2012, are informed about a larger nitrate risk in 2012, then the perception of a risk derived the hedonic pricing analysis does not explain a decrease in property prices in municipalities that were already at risk. The perception of the increase in health risks seem to be stronger than the real increase in health risks in municipalities that were at risk before 2012. The 2012 boundary revision seems to act as a reminder about the potential nitrate danger faced by municipalities.

Conclusion

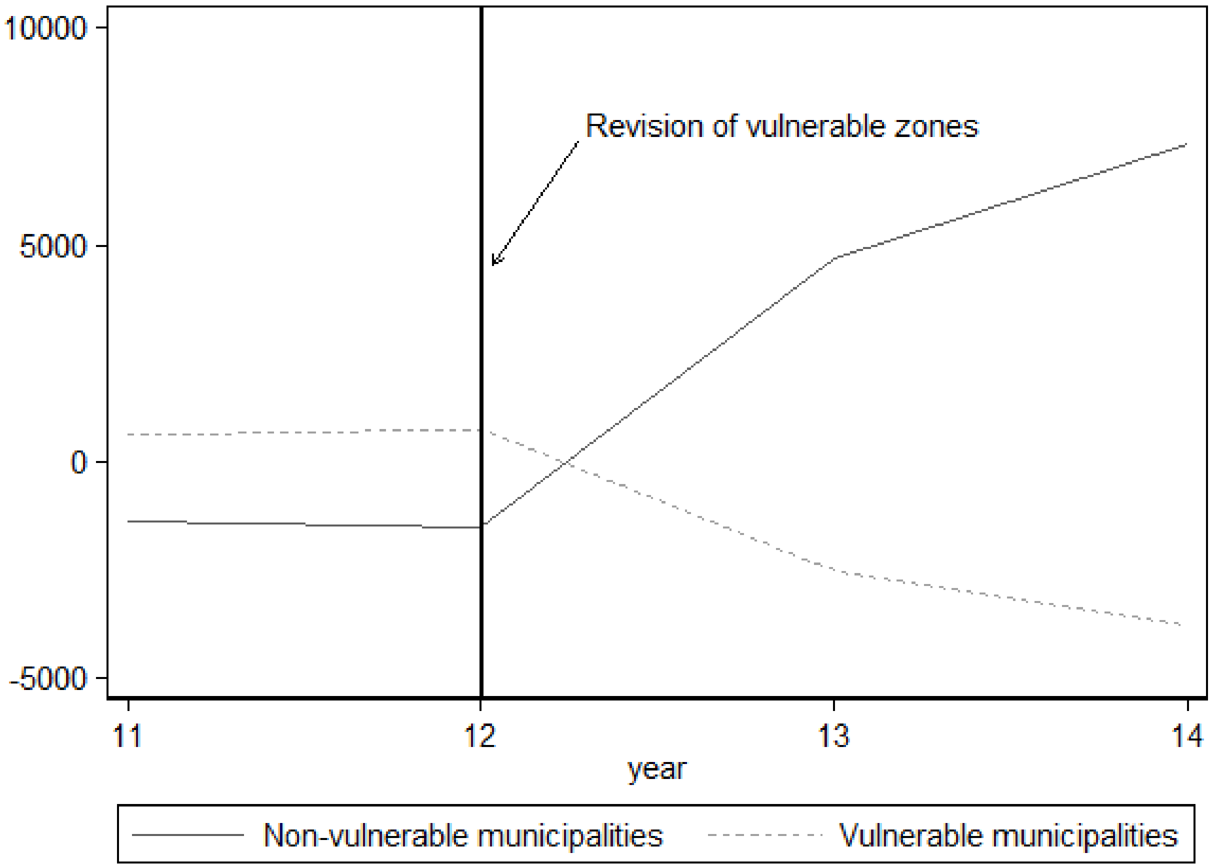
The goal of this paper was to examine the population perception surrounding nitrates risk. To account for the endogeneity of nitrate exposure, we exploit the change in boundary areas in term of nitrates that occurred in 2012 in France. To do so, the empirical model compares property prices in municipalities considered as vulnerable (the treatment group) to municipalities considered as not vulnerable (the control group). Results are not significant for the overall market and highlight the importance of considering different market segment such as house and flat. In line with literature, results highlight that examining the full property distribution leads to an absence of significativity. Considering house and flat as a sub-market, results show a significant and negative impact of the 2012 boundary definition on property values. Regression coefficients underlines that property prices decrease for house and flat after the new geographical boundary of 2012 in municipalities classified as vulnerable compared to counterparts. These results provide an answer of the impact of geographical boundary due to environmental risks on property prices. Implementing boundaries could increase property prices via additional measures. In fact, setting up additional measures of risk reduction in these geographical boundaries by the state could reduce households' exposure and so increase the price of their dwellings. Thus, the net impact of risk prevention boundaries on housing prices could theoretically be an increase or a decrease of prices in the vicinity of the hazardous plants. Nevertheless, these new boundaries, above all, can reveal risk, and results from this paper suggest that the net impact on housing prices would be negative.

Figure 1: Geographical boundary of nitrates sensitive areas.



Note: This figure corresponds to the geographical boundary of nitrates sensitive areas. Property transactions are plotted thanks to their GPS coordinates. It corresponds to 4 regions: Loiret, Indre et Loire, Vienne and Charentes Maritime. White corresponds to a property which is not in a vulnerable zone. Grey and black correspond to a property which belongs to a vulnerable zone. The different colors mean they were considered as vulnerable at a different period (Grey before 2012 and Black in 2012).

Figure 2: Adjusted yearly price level by nitrate sensitive municipalities



Note: Prices levels are adjusted by property characteristics, year dummy variables and municipalities characteristics (FE). The solid vertical lines indicate the date of the regulation. 'Vulnerable municipalities' (dashed line) are municipalities classified as nitrates sensitive in 2012 or before 2012, and 'Non vulnerable municipalities' (darker line) are municipalities without any classification.

Table 1: Summary Statistics Mean(SE)

Variables	All time period N= 13840	Before 2012 N=7477	After 2012 N=6363
		A. Dependent variables	
Average Prices (Euros)	159774.8 (124793.6)	166764.7 (130183.4)	151561.3 (117626.8)
		B Property characteristics	
		B.1 House characteristics	
typ_house	.30 (.45)	.32 (.46)	.28 (.44)
pool	.02 (.16)	.03 (.17)	.02 (.15)
terrace	.10 (.31)	.09 (.29)	.11 (.32)
attic	.15 (.36)	.15 (.36)	.15 (.36)
balcony	.12 (.33)	.10 (.30)	.15 (.35)
parking_surface	.55 (3.82)	.20 (2.03)	.97 (5.17)
main_room_surface	89.01 (55.30)	94.39 (57.42)	82.67 (52.01)
less5years	.11 (.31)	.08 (.28)	.13 (.34)
room_nb	3.90 (1.92)	4.10 (1.83)	3.67 (2.01)
		B.1 Flat characteristics	
typ_flat	.76 (.42)	.80 (.39)	.71 (.44)
level_nb	2.39 (1.81)	2.51 (1.94)	2.30 (1.70)
attic	.15 (.36)	.15 (.36)	.15 (.36)
balcony	.12 (.33)	.10 (.30)	.15 (.35)
parking_surface	.55 (3.82)	.20 (2.03)	.97 (5.17)
main_room_surface	89.01 (55.30)	94.39 57.42)	82.67 (52.01)
less5years	.11 (.31)	.08 (.28)	.13 (.34)
room_nb	3.91 (1.92)	4.1 (1.83)	3.67 (2.01)

Note: Reported values are means with standard deviations in brackets. The number of observations is 13840. The time period covered in the analysis is 2011-2014, and the unit of analysis is the transaction -year. 'Treated' is defined as municipalities in a sensitive area, and 'control' are municipalities in non-sensitive area in term of nitrates.

Table 2: The impact of vulnerable zones revision on property prices with respect to treatment

VARIABLES	(1) treatment 1	(2)	(3) treatment 2	(4)	(5) treatment 3	(6)
nitrates*policy	-0.0250	-0.0168	-0.00851	-0.0163	-0.0318	-0.0151
	(0.0211)	(0.0153)	(0.0227)	(0.0217)	(0.0235)	(0.0163)
attic		-0.0540***		-0.0142		-0.0461***
		(0.0155)		(0.0266)		(0.0145)
balcony		0.119***		0.126***		0.126***
		(0.0153)		(0.0196)		(0.0156)
parking_surface		0.00625***		0.00657***		0.00579***
		(0.00103)		(0.00115)		(0.00109)
main_room_surface		0.00348***		0.00274**		0.00332***
		(0.00111)		(0.00136)		(0.00118)
less5years		0.323***		0.325***		0.335***
		(0.0217)		(0.0237)		(0.0248)
room_nb		0.124***		0.140***		0.128***
		(0.0227)		(0.0277)		(0.0239)
house		0.263***		0.258***		0.285***
		(0.0231)		(0.0328)		(0.0239)
Municipalities FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes		
Observations	13,787	13,787	6,803	6,803	11,387	11,387
R-squared	0.266	0.655	0.229	0.622	0.279	0.677

Note: This table presents the coefficient estimates of the reduced form estimate of the effect of vulnerable zone boundary on the log of property prices. The treatment group represents both properties that were vulnerable before 2012 and properties that will become vulnerable in 2012. All regressions are estimated using municipalities fixed effect, with standard errors clustered at the year and municipality level. Robust standard errors in parentheses. Statistical significance is denoted by: *** p<0.01, ** p<0.05, * p<0.1

Table 3: The impact of vulnerable zones revision on property prices for property classified as vulnerable in 2012 and before 2012 (treatment 1)

	(1)	(2)	(3)	(4)
VARIABLES	Flat		House	
nitrates*policy	-0.0758**	-0.0513**	-0.0704***	-0.0424***
	(0.0367)	(0.0209)	(0.0221)	(0.0162)
Property characteristics	No	Yes	No	Yes
Municipalities FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	4,777	4,777	9,010	9,010
R-squared	0.375	0.669	0.392	0.671

Note: This table presents the coefficient estimates of the reduced form estimate of the effect of vulnerable zone revision on the log of property prices. The treatment group represents both properties that were vulnerable before 2012 and properties that will become vulnerable in 2012. All regressions are estimated using municipalities fixed effect, with standard errors clustered at the year and municipality level. Robust standard errors in parentheses. Statistical significance is denoted by: *** p<0.01, ** p<0.05, * p<0.1

Table 4: The impact of vulnerable zones revision on property prices for property classified as vulnerable in 2012 (treatment 2)

	(1)	(2)	(3)	(4)
VARIABLES	Flat		House	
nitrates*policy	-0.115**	-0.0612*	-0.0533*	-0.0333
	(0.0445)	(0.0352)	(0.0288)	(0.0215)
Property characteristics	No	Yes	No	Yes
Municipalities FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	3,122	3,122	3,681	3,681
R-squared	0.229	0.548	0.386	0.671

Note: This table presents the coefficient estimates of the reduced form estimate of the effect of the revision on the log of property prices. The treatment group represents only properties that will become vulnerable in 2012. All regressions are estimated using municipalities fixed effect, with standard errors clustered at the year and municipality level. Robust standard errors in parentheses. Statistical significance is denoted by: *** p<0.01, ** p<0.05, * p<0.1

Table 5: The impact of vulnerable zones revision on property prices for property classified as vulnerable before 2012 (treatment 3)

VARIABLES	(1) Flat	(2)	(3) House	(4)
nitrates*policy	-0.0532	-0.0403**	-0.0755***	-0.0431**
	(0.0402)	(0.0182)	(0.0236)	(0.0170)
Property characteristics	No	Yes	No	Yes
Municipalities FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	3,907	3,907	7,480	7,480
R-squared	0.407	0.721	0.404	0.675

Note: This table presents the coefficient estimates of the reduced form estimate of the effect of the revision on the log of property prices. The treatment group represents only properties that were vulnerable before 2012. All regressions are estimated using municipalities fixed effect, with standard errors clustered at the year and municipality level. Robust standard errors in parentheses. Statistical significance is denoted by: *** p<0.01, ** p<0.05, * p<0.1

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