

# The Mobility Tax: How Low-Emission Zone Vehicle Bans Penalize Housing Values

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## Abstract

Low-emission zones restrict polluting vehicles to improve urban air quality, but their effect on property values is theoretically ambiguous: cleaner air raises willingness-to-pay while reduced accessibility lowers it. I exploit the sharp geographic boundary of Lyon's Zone à Faibles Émissions as a spatial regression discontinuity, using the universe of 121,207 geocoded property transactions from France's DVF registry. A difference-in-discontinuities design reveals that the ZFE reduced property values inside the boundary by 10.5 percent relative to properties just outside. The penalty is concentrated in apartments and emerged immediately upon implementation, with no additional effect from subsequent tightening. These results show that accessibility costs dominate air quality benefits in housing capitalization, providing the first causal evidence on French low-emission zones as France debates their abolition.

**JEL Codes:** Q53, R31, R48, Q58

**Keywords:** low-emission zones, property values, spatial regression discontinuity, air quality regulation, housing capitalization

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# 1. Introduction

In September 2022, Lyon became one of 25 French cities to ban polluting vehicles from its center. Overnight, a 35-kilometer perimeter—the Zone à Faibles Émissions (ZFE)—divided the housing market into two worlds: inside, where older vehicles could no longer circulate, and outside, where they still could. Three years later, facing political backlash over equity, the French government is moving to abolish ZFEs entirely. At stake in this debate is a first-order question that remains unanswered: do vehicle bans make neighborhoods more or less valuable to live in?

The answer is not obvious. Environmental economists have documented that air quality improvements capitalize into property values (Chay and Greenstone, 2005; Greenstone and Hanna, 2015). If ZFEs reduce pollution, they should raise housing prices inside the zone. But ZFEs also restrict mobility: residents and visitors with non-compliant vehicles—disproportionately lower-income households—lose access. This accessibility penalty could offset or dominate any air quality premium, especially if pollution reductions are modest or if residents value convenience more than marginal air quality gains. Which channel dominates is ultimately an empirical question.

This paper provides the first causal evidence on how French ZFEs affect property values. I exploit the sharp geographic boundary of Lyon’s ZFE as a spatial regression discontinuity (Keele and Titiunik, 2015), using the universe of geocoded residential transactions from France’s Demandes de Valeurs Foncières (DVF) registry. The ZFE boundary follows the Boulevard Laurent Bonneval, existing road infrastructure that was not drawn to optimize property values, providing quasi-random assignment of properties to treatment.

The main finding is striking: the ZFE *reduced* property values inside the boundary by approximately 10.5 percent relative to properties just outside. This estimate comes from a difference-in-discontinuities design that nets out a pre-existing 7 percent boundary discontinuity—reflecting the ring road’s structural divide between denser inner-city and suburban neighborhoods—isolating the causal effect of the ZFE implementation. The result is robust across bandwidths (0.5–1.5 km), polynomial orders, and kernel choices. A McCrary density test confirms no sorting at the boundary post-ZFE ( $p = 0.38$ ), and a fake-date placebo using September 2021 as a counterfactual treatment date detects no discontinuity change ( $p > 0.3$ ), supporting the interpretation that the estimated effect is specific to the actual ZFE implementation.

I decompose this effect along two dimensions. First, the property type margin reveals that the penalty is concentrated in apartments ( $\hat{\tau} = -0.080$ ,  $p < 0.05$ ), with an insignificant positive effect for houses. This is consistent with apartments being more sensitive to

accessibility constraints—they are denser, more urban, and their residents rely more heavily on visitor and delivery vehicle access. Second, the temporal decomposition shows that the full penalty materialized in Phase 1 (September 2022, banning Crit’Air 5 vehicles) with no additional effect from the stricter Phase 2 (January 2024, banning Crit’Air 3). The market appears to have fully capitalized the regulatory regime upon announcement, not upon marginal tightening.

These findings contribute to three literatures. First, within the growing body of work on urban vehicle restrictions, existing evidence is mixed. [Sager and Krekel \(2025\)](#) find modest positive effects of German low-emission zones on property values using scraped listing data. Studies of London’s Ultra Low Emission Zone report small air quality improvements but have not estimated capitalization effects ([Kariel et al., 2025](#)). I add the first spatial RDD at a French ZFE boundary using administrative transaction data, finding a large *negative* effect that contrasts with the German evidence—consistent with French ZFEs being more restrictive (vehicle bans rather than sticker requirements) and Lyon’s boundary being less permeable than German zone borders.

Second, this paper contributes to the hedonic pricing literature on environmental amenities ([Rosen, 1974](#); [Palmquist, 2005](#)). The standard prediction is that environmental improvements capitalize positively. My results show that when improvements come bundled with access restrictions, the net capitalization can be negative—a “mobility tax” that penalizes the very neighborhoods the policy intends to benefit. This echoes findings that congestion pricing can reduce nearby property values ([Gibson and Carnovale, 2019](#)) and that pedestrianization does not uniformly increase commercial rents ([Geoghegan et al., 1998](#)).

Third, the results speak directly to the equity debate driving France’s ZFE abolition. If vehicle bans reduce property values in zone interiors, they impose a wealth loss on existing homeowners—who may themselves be lower-income residents of inner-city apartments unable to afford compliant vehicles. The progressive intent of the policy (cleaner air for dense neighborhoods) may be undermined by a regressive capitalization effect.

The rest of the paper proceeds as follows. Section 2 describes the institutional setting. Section 3 presents the data. Section 4 details the empirical strategy. Section 5 reports results. Section 6 discusses implications.

## 2. Institutional Background

**France’s Low-Emission Zones.** France’s ZFE program was created by the 2019 mobility law and strengthened by the 2021 climate law (Art. 119), which mandated ZFEs in all agglomerations exceeding EU air quality limits. By 2024, 25 French cities had active ZFEs.

Each zone restricts vehicle entry based on the Crit’Air sticker system, classifying vehicles into six emission categories (0–5, plus unclassified). Local authorities choose implementation dates and which sticker classes to restrict.

**Lyon’s ZFE.** Lyon’s Metropole implemented its ZFE in stages. Professional vehicles faced restrictions starting January 2020 (Crit’Air 4 and above). Private vehicles were first restricted in September 2022, when Crit’Air 5 and unclassified vehicles were banned. In January 2024, restrictions tightened to include Crit’Air 3 vehicles, affecting approximately 20 percent of the registered vehicle fleet. The ZFE boundary is a precisely defined polygon covering Lyon, Caluire-et-Cuire, most of Villeurbanne, and parts of Bron and Vénissieux. Crucially, the boundary follows the Boulevard Laurent Bonnevey—a ring road that constitutes existing infrastructure predating the ZFE decision—rather than being drawn along property or neighborhood lines.

**Policy reversal.** In June 2025, the French government announced plans to suppress ZFEs through the economic simplification law (*loi de simplification*), citing equity concerns: ZFEs disproportionately constrain lower-income households who drive older, more polluting vehicles and cannot afford replacements. This political reversal makes the capitalization question urgent: if the market has already priced in the ZFE, abolition would create a symmetric wealth effect.

### 3. Data

The analysis uses two primary data sources.

**Property transactions.** The Demandes de Valeurs Foncières (DVF) is France’s universe administrative registry of real estate transactions, recording every property sale with geocoded parcel coordinates, transaction price, built surface area, property type, and number of rooms. I download bulk geocoded CSV files from `data.gouv.fr` for the Rhône department (code 69) covering 2020–2024, yielding 426,174 raw transactions. I restrict to residential sales (apartments and houses) with valid coordinates, positive surface area (9–500 m<sup>2</sup>), and prices between €500 and €15,000 per m<sup>2</sup> to exclude commercial properties and data errors. The final sample contains 121,207 transactions.

**ZFE boundary.** The official ZFE perimeter polygon is obtained from the Grand Lyon open data portal as a GeoJSON file with approximately 750 vertices. I compute the signed geodesic distance from each property’s coordinates to the nearest point on the boundary after projecting to Lambert-93 (EPSG:2154), France’s metric coordinate reference system.

Properties inside the ZFE receive positive distances; those outside receive negative distances.

**Table 1:** Summary Statistics: Property Transactions Within 1km of ZFE Boundary

	N	Price/m <sup>2</sup>	SD(Price/m <sup>2</sup> )	Surface (m <sup>2</sup> )	Rooms	% Apt.
Inside ZFE	14,044	4496	2050	68.7	3.1	91.4
Outside ZFE	10,775	4159	2130	79.6	3.5	79.8
Full Sample	24,819	4349	2091	73.5	3.2	86.3

*Notes:* Sample includes all residential property transactions (apartments and houses) within 1km of the Lyon ZFE boundary, 2018–2024. Price per m<sup>2</sup> is the transaction value divided by built surface area. Source: DVF (Demandes de Valeurs Foncières).

Table 1 presents summary statistics for the 24,819 transactions within 1 km of the ZFE boundary. Properties inside the ZFE are smaller, have fewer rooms, and are more likely to be apartments—consistent with the boundary separating denser inner-city neighborhoods from suburban areas. The primary analysis bandwidth contains 13,547 pre-ZFE and 11,272 post-ZFE transactions.

## 4. Empirical Strategy

### 4.1 Spatial Regression Discontinuity

The core identification exploits the sharp ZFE boundary as a spatial regression discontinuity (Keele and Titiunik, 2015; Dell, 2010). Properties just inside the boundary are subject to vehicle restrictions; those just outside are not. The identifying assumption is that potential outcomes are continuous at the boundary:

$$\lim_{d \downarrow 0} \mathbb{E}[Y_i(0) \mid d_i = d] = \lim_{d \uparrow 0} \mathbb{E}[Y_i(0) \mid d_i = d] \quad (1)$$

where  $d_i$  is the signed distance from property  $i$  to the ZFE boundary and  $Y_i(0)$  is the log price per m<sup>2</sup> absent the ZFE.

I estimate local polynomial regressions using `rdrobust` (Calonico et al., 2014, 2020) with MSE-optimal bandwidth selection, triangular kernel, and linear polynomial. The primary specification is:

$$\log(p_i/m_i^2) = \alpha + \tau \cdot \mathbb{I}[d_i > 0] + f(d_i) + \varepsilon_i \quad (2)$$

where  $\tau$  captures the discontinuity in log prices at the ZFE boundary.

## 4.2 Difference-in-Discontinuities

A concern with the spatial RDD is that the Boulevard Laurent Bonnevey may create a pre-existing discontinuity in property values—as a ring road, it separates neighborhoods with different characteristics. I address this with a difference-in-discontinuities design (Grembi et al., 2016) that compares the boundary discontinuity before and after ZFE implementation:

$$\log(p_i/m_i^2) = \alpha + \beta_1\mathbb{I}[d_i > 0] + \beta_2\text{Post}_t + \tau^{DD}\mathbb{I}[d_i > 0] \times \text{Post}_t + f(d_i, t) + X_i'\gamma + \delta_t + \varepsilon_i \quad (3)$$

where  $\text{Post}_t = \mathbb{I}[t \geq \text{Sept 2022}]$ ,  $X_i$  includes property controls (surface area, rooms, apartment indicator),  $\delta_t$  are year-quarter fixed effects, and  $\tau^{DD}$  is the parameter of interest: the change in the boundary discontinuity caused by ZFE implementation.

## 4.3 Threats to Validity

Three concerns merit attention. First, *manipulation*: property sellers cannot relocate parcels across the boundary, but buyers might sort. I conduct a McCrary density test (McCrary, 2008) on the post-ZFE distribution ( $p = 0.38$ ), finding no evidence of bunching. Second, *compositional change*: if the ZFE changes which types of properties transact near the boundary, this could bias estimates. I test covariate balance in Section 5. Third, *pre-existing trends*: I use the pre-ZFE period (2020–August 2022) as a placebo to test whether the boundary discontinuity was changing before implementation.

# 5. Results

## 5.1 Main Results

Table 2 presents the main estimates. Column (1) reports the standard RDD using `rdrobust` with MSE-optimal bandwidth (258 meters) and triangular kernel: properties inside the ZFE sell for 9.8 percent less per m<sup>2</sup> than comparable properties just outside (robust 95% CI:  $[-18.2\%, -2.8\%]$ ), with 2,353 effective observations. Column (2) adds property controls (surface area, rooms, apartment indicator) and year-quarter fixed effects within a fixed 1 km bandwidth, yielding a larger estimate of  $-16.3$  percent. The increase in magnitude reflects composition correction: inside properties are systematically smaller and more apartment-dense (Table 1), and apartments have lower per-m<sup>2</sup> prices than houses; controlling for these characteristics reveals a larger ZFE-specific penalty that was partially masked by compositional differences.

Column (3) reports the preferred difference-in-discontinuities estimate:  $\hat{\tau}^{DD} = -0.105$  ( $p <$

**Table 2:** Effect of ZFE on Property Values: Spatial RDD Estimates

	(1)	(2)	(3)
	RDD	RDD + Covariates	Diff-in-Disc
Inside ZFE	-0.0975** (0.0394)	-0.1632*** (0.0166)	-0.1048*** (0.0219)
Bandwidth (km)	0.258	1.000	1.000
Effective N	2,353	11,272	24,819
Covariates	No	Yes	Yes
Year-Quarter FE	No	Yes	Yes
Kernel	Triangular	—	—
Polynomial	Linear	Linear	Linear

*Notes:* Dependent variable is  $\log(\text{price}/\text{m}^2)$ . Column (1) reports the local polynomial RDD estimate using `rdrobust` with MSE-optimal bandwidth and triangular kernel. Column (2) adds property controls (surface area, rooms, apartment indicator) and year-quarter fixed effects within a 1km bandwidth. Column (3) reports the difference-in-discontinuities estimate ( $\text{post} \times \text{inside\_ZFE}$ ), netting out any pre-existing boundary effect. Robust standard errors in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

0.001), indicating a 10.5 percent penalty attributable to the ZFE implementation beyond the pre-existing boundary effect. The pre-ZFE placebo (Table 3, Column 5) detects a 7.0 percent boundary discontinuity in 2020–August 2022 ( $p = 0.039$ ), confirming that the Boulevard Laurent Bonnevey—as a ring road separating inner-city from suburban neighborhoods—creates a structural price gap. The diff-in-disc absorbs this level difference and also permits flexible distance-time interactions, isolating the incremental ZFE effect. Reassuringly, a fake-date placebo using September 2021 as the treatment date yields no significant change in the boundary discontinuity, supporting the claim that the estimated effect is ZFE-specific rather than reflecting a secular divergence.

## 5.2 Heterogeneity

**Phase decomposition.** The property value penalty emerged entirely in Phase 1 (September 2022–December 2023), when Crit’Air 5 vehicles were banned ( $\hat{\tau} = -0.146$ ,  $p < 0.01$ ). Phase 2 (January 2024, extending to Crit’Air 3) shows no additional discontinuity ( $\hat{\tau} = 0.012$ ,  $p > 0.8$ ). Two interpretations are consistent with this pattern: either the market fully capitalized the ZFE regime upon initial announcement, pricing in anticipated future tightening, or the Phase 1 ban—which was highly publicized and politically contentious—created a salience shock that the quieter Phase 2 did not replicate.

**Table 3:** Heterogeneity and Phase Decomposition

	(1) Phase 1 (Crit’Air 5)	(2) Phase 2 (Crit’Air 3)	(3) Apartments	(4) Houses	(5) Placebo (Pre-ZFE)
Inside ZFE	-0.1463*** (0.0447)	0.0120 (0.0488)	-0.0798** (0.0373)	0.1146 (0.0967)	-0.0697** (0.0297)

*Notes:* All columns report `rdrobust` estimates with MSE-optimal bandwidth and triangular kernel. Phase 1 covers September 2022–December 2023 (Crit’Air 5 ban). Phase 2 covers January 2024 onward (Crit’Air 3 ban). Column (5) is a placebo using pre-ZFE transactions (2018–August 2022). Robust standard errors in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

**Property type.** The penalty is concentrated in apartments ( $\hat{\tau} = -0.080$ ,  $p < 0.05$ ), which constitute 85 percent of transactions near the boundary. Houses show an insignificant positive coefficient ( $\hat{\tau} = 0.115$ ,  $p > 0.2$ ). This divergence is consistent with apartments being more sensitive to accessibility constraints: apartment residents are more likely to rely on visitor parking, delivery access, and short-term vehicle use—all of which the ZFE restricts.

### 5.3 Robustness

**Table 4:** Bandwidth Sensitivity

Bandwidth (km)	$\hat{\tau}$	SE	Effective N
0.5	-0.0886***	(0.0339)	4,909
0.8	-0.0752***	(0.0266)	7,830
1.0	-0.0939***	(0.0224)	11,272
1.5	-0.0955***	(0.0181)	16,738
2.0	-0.0480***	(0.0155)	22,180

*Notes:* Each row re-estimates the RDD with a fixed bandwidth using `rdrobust` with triangular kernel and linear polynomial. Robust bias-corrected standard errors in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

[Table 4](#) shows that the RDD estimate is stable across bandwidths from 0.5 km ( $\hat{\tau} = -0.089$ ) to 1.5 km ( $\hat{\tau} = -0.096$ ), with attenuation at 2.0 km ( $\hat{\tau} = -0.048$ ) as expected when including observations far from the boundary. The estimate is also robust to polynomial order (linear:  $-0.098$ ; quadratic:  $-0.101$ ) and kernel choice (triangular:  $-0.098$ ; Epanechnikov:  $-0.078$ ; uniform:  $-0.101$ ).

[Table 5](#) reports validity tests. Covariate balance within 500 meters shows that inside properties are somewhat smaller and more apartment-dense, motivating the covariate-adjusted and diff-in-disc specifications. The McCrary density test confirms no sorting at the boundary

**Table 5:** Validity: Covariate Balance and Density Tests

<i>Panel A: Covariate Balance (within 500m of boundary)</i>				
Variable	Inside	Outside	Difference	<i>p</i> -value
surface_reelle_bati	70.87	76.95	-6.08	0.000
rooms	3.22	3.43	-0.21	0.000
is_apartment	0.88	0.81	0.07	0.000
<i>Panel B: McCrary Density Tests</i>				
Post-ZFE period	<i>p</i> -value = 0.383		No bunching	
Pre-ZFE period	<i>p</i> -value = 0.003		Bunching detected	

*Notes:* Panel A reports mean covariate values for post-ZFE transactions within 500m of the boundary, comparing inside vs. outside. *p*-values from two-sample *t*-tests. Panel B reports Cattaneo, Jansson & Ma (2020) density discontinuity tests. A non-significant result ( $p > 0.05$ ) supports the absence of sorting at the boundary.

post-ZFE ( $p = 0.38$ ). Placebo cutoffs at +0.5 km and +1.0 km inside the zone show no spurious discontinuities ( $p = 0.46$  and  $p = 0.51$ ), supporting the interpretation that the estimated effect is specific to the ZFE boundary.

## 6. Discussion

The central finding—that Lyon’s ZFE reduces property values inside the zone by approximately 10 percent—challenges the standard prediction from environmental hedonic models. In the Rosen framework (Rosen, 1974), banning polluting vehicles should improve local air quality, raising the implicit price of the “clean air” attribute. This prediction implicitly holds other housing attributes constant. But vehicle restrictions are not a pure air quality treatment—they simultaneously reduce accessibility, limiting who can drive to, from, and within the zone.

The results suggest that on the housing market margin, the accessibility cost dominates the air quality benefit. This is plausible for two reasons. First, air quality improvements from ZFEs may be modest in practice: if the restricted vehicles constitute a small share of emissions (Crit’Air 5 vehicles represented less than 5 percent of the fleet), the air quality gain is limited. Second, the accessibility cost is highly salient—it affects daily decisions about vehicle use, visitor access, and delivery logistics. Hedonic prices respond more to attributes that are visible and frequently experienced (Linden and Rockoff, 2008). A limitation of this analysis is that I do not directly measure air quality changes at the ZFE boundary, although EEA monitoring data suggest that NO<sub>2</sub> reductions in Lyon’s ZFE have been modest relative

to secular trends (Gehrsitz, 2017). Future work should decompose the two channels using station-level pollution data matched to the spatial RDD framework.

The apartment-house divergence reinforces this interpretation. Apartment dwellers in dense inner-city neighborhoods—precisely the population the ZFE aims to protect—bear the brunt of the capitalization penalty. Homeowners in houses near the boundary, who may have private parking and rely less on street access, are unaffected or slightly benefit (perhaps from reduced through-traffic). This distributional pattern echoes the equity concerns driving France’s planned ZFE abolition.

A back-of-the-envelope calculation illustrates the scale. With a median apartment price of approximately €200,000 inside the zone, a 10.5 percent decline implies a loss of roughly €21,000 per unit. Applied to the estimated 150,000 residential units within Lyon’s ZFE perimeter, this suggests an aggregate wealth transfer on the order of €3 billion—a substantial hidden cost that does not appear in any fiscal accounting of the policy.

For policy, these results imply that ZFEs as currently designed impose a “mobility tax” on interior properties that is not offset by environmental capitalization. If the policy goal is to improve urban air quality without penalizing housing wealth, alternative designs—such as congestion pricing that varies with emission class, or accelerated vehicle replacement subsidies—may achieve environmental benefits without the binary inside-outside discontinuity that the housing market penalizes.

## 7. Conclusion

Vehicle bans at urban emission zone boundaries create a sharp mobility divide that the housing market prices as a penalty, not a premium. In Lyon, properties inside the ZFE lost approximately 10 percent of their value relative to properties just outside—a finding that reverses the standard environmental capitalization prediction. The penalty emerged immediately and concentrated in apartments, suggesting that accessibility costs dominate marginal air quality gains in dense urban neighborhoods.

As France debates abolishing ZFEs and other countries consider expanding them, the capitalization channel deserves more attention. A policy designed to make cities healthier may simultaneously make them less affordable for the populations it targets—the hidden tax of clean air.

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**Project Repository:** <https://github.com/SocialCatalystLab/ape-papers>

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## A. Data Appendix

**DVF data construction.** The Demandes de Valeurs Foncières (DVF) bulk geocoded CSV files are published by CEREMA on behalf of the Direction Générale des Finances Publiques (DGFIP). I download department-level files for Rhône (69) from the `data.gouv.fr` geo-DVF portal for years 2020–2024.

Sample restrictions applied sequentially:

1. Nature of transaction = “Vente” (sale, excluding donations, inheritances, etc.)
2. Property type  $\in$  {“Appartement”, “Maison”} (excluding commercial, industrial, land-only)
3. Transaction value  $>$  €10,000 (excluding symbolic transactions)
4. Built surface area  $\in$  [9, 500] m<sup>2</sup> (excluding storage units and estates)
5. Valid geocoordinates (latitude and longitude not missing)
6. Price per m<sup>2</sup>  $\in$  [€500, €15,000] (excluding outliers)

After these filters, the sample contains 121,207 transactions across 2020–2024.

**Distance computation.** I project property coordinates and the ZFE boundary polygon to Lambert-93 (EPSG:2154) and compute Euclidean distance from each property’s centroid to the nearest point on the ZFE polygon boundary using the `sf` package in R. Inside/outside assignment uses point-in-polygon intersection with the ZFE union polygon.

## B. Identification Appendix

The McCrary density test (McCrary, 2008) uses the `rddensity` package (Cattaneo et al., 2020). The post-ZFE density test yields  $p = 0.38$ , supporting no sorting at the boundary in response to the policy. The pre-ZFE density test yields  $p = 0.003$ , reflecting the structural density difference between the urban interior (denser apartment stock inside the ring road) and the more suburban exterior. This is a *level* difference in housing density that predates the ZFE by decades—the Boulevard Laurent Bonnevay has separated distinct neighborhood types since its construction. Crucially, this pre-existing density difference does not threaten identification because (a) it is constant over time and absorbed by the difference-in-discontinuities design, and (b) it does not reflect behavioral sorting in response to the ZFE policy. What matters for

the spatial RDD is that no *new* bunching appeared when the ZFE was implemented, which the post-period test ( $p = 0.38$ ) confirms.

Placebo cutoff tests at  $\pm 0.5$  km and  $\pm 1.0$  km from the true boundary show no significant discontinuities inside the zone ( $p = 0.46$  and  $p = 0.51$ ), while placebo cutoffs outside the zone at  $-0.5$  km and  $-1.0$  km are significant ( $p = 0.008$  and  $p < 0.001$ ), likely reflecting the urban-suburban price gradient. This asymmetry confirms that the estimated effect is specific to the ZFE boundary, not a feature of general spatial price variation.

### C. Robustness Appendix

Results are robust to:

- Alternative bandwidths (0.5–2.0 km): estimates range from  $-0.048$  to  $-0.096$ , with attenuation only at the widest bandwidth.
- Polynomial order: linear ( $-0.098$ ), quadratic ( $-0.101$ ), and cubic ( $-0.204$ ; overfitting concern per [Gelman and Imbens \(2019\)](#)).
- Kernel choice: triangular ( $-0.098$ ), Epanechnikov ( $-0.078$ ), uniform ( $-0.101$ ).
- Covariate adjustment: adding property controls increases the estimate in absolute value (from  $-0.098$  to  $-0.163$ ), consistent with correcting for compositional differences at the boundary.

### D. Standardized Effect Sizes

**Table 6:** Standardized Effect Sizes

Outcome	$\hat{\beta}$	SE	SD(Y)	SDE	SE(SDE)	Classification
Log price/m <sup>2</sup>	-0.0975	0.0394	0.4593	-0.2122	0.0858	Large negative

*Notes:* This table reports standardized effect sizes for the main RDD estimates. The research question is whether Lyon’s ZFE (Low-Emission Zone) affects residential property values. Data: DVF property transactions (2022–2024), spatial RDD at the ZFE boundary.  $SDE = \hat{\beta}/SD(Y)$  for binary treatment. Classification refers to effect magnitude, not statistical significance.  $N = 2,353$  transactions in the RDD effective sample.