The Missing Premium: Earthquake Compensation and the Absence of Housing Market Capitalization in Groningen

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Abstract

The Dutch government disbursed over 970 million to homeowners in Groningen's earthquake zone through the Waardedalingsregeling, compensating 2–12% of property value decline. Standard capitalization theory predicts these transfers should inflate housing prices in eligible areas. Using neighborhood-level property assessments for 1,104 neighborhoods over 2016–2023 and a difference-in-differences design exploiting the sharp 2020 compensation announcement, I find no evidence of capitalization: the effect on property values is −0.49 thousand EUR (SE = 1.58), bounding any positive capitalization below 1.1% of mean property value. Pre-trends are flat, a 2018 placebo is null, and no dose-response gradient emerges. The compensation did not create a premium because it reimburses past losses rather than insuring future risk—markets correctly price it as a one-time transfer, not a permanent asset attribute.

JEL Codes: R31, Q54, H84

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1. Introduction

Nine hundred and seventy million euros. That is what the Dutch government has paid homeowners in Groningen province to compensate for property value declines caused by decades of natural gas extraction. The Groningen gas field—once Europe's largest—produced induced earthquakes that damaged tens of thousands of homes and depressed local housing markets (Koster and van Ommeren, 2015). In September 2020, the Instituut Mijnbouwschade Groningen (IMG) launched the Waardedalingsregeling, a compensation program that pays eligible homeowners 2–12% of their property's value upon sale. The question is whether this compensation capitalized into property values—whether the promise of a government transfer at the boundary of the eligible zone created a "missing premium" that should, in theory, exist but might not.

The theoretical prediction is clear. Since Oates (1969) and Rosen (1974), we know that location-specific amenities and disamenities capitalize into property values. Government transfers tied to location should be no different: if a neighborhood carries a 7% compensation guarantee, buyers should bid up prices to reflect that implicit insurance. This logic underlies flood insurance capitalization (Bin and Polasky, 2008; Gallagher, 2014), environmental remediation premiums (Muehlenbachs et al., 2015), and school spending bonds (Cellini et al., 2010). If capitalization holds, the Groningen compensation should produce a discrete jump in property values at the eligibility boundary—a "compensation cliff" separating winners from their ineligible neighbors just across the line.

But there are reasons to doubt full capitalization. The Waardedalingsregeling compensates for *past* value declines, not *future* risk. It is authorized under temporary legislation (the Tijdelijke wet Groningen), creating uncertainty about program continuation. And the compensation is triggered by sale—it is a transfer to sellers, not a permanent property attribute that transfers with the deed. These features distinguish it from permanent location amenities that standard capitalization theory envisions.

This paper tests whether the compensation capitalized into property values. I construct a panel of 1,104 neighborhoods in Groningen and adjacent provinces, tracking annual property tax assessments (WOZ values) from 2016 to 2023. I measure earthquake exposure for each neighborhood using the complete KNMI induced seismicity catalog (1,637 events, 1986–2020), calculating cumulative peak ground acceleration (PGA) at each neighborhood centroid. Neighborhoods with above-median earthquake exposure—those that closely correspond to the IMG compensation zone—constitute the treated group. The 2020 compensation announcement provides the time variation.

The difference-in-differences estimate is a precise zero. High-exposure neighborhoods experienced a WOZ change of −0.49 thousand EUR relative to low-exposure neighborhoods after the announcement (SE = 1.58, $p = 0.76$). At the mean property value of 242,000, the 95% confidence interval rules out effects larger than ±1.5% of property value. Since average compensation is approximately 7%, the data can reject capitalization rates above 21%. Pre-treatment trends are flat across all specifications: the event study shows no differential movement in 2016–2020. A placebo test assigning treatment at 2018 produces a coefficient of 0.58 (SE = 1.63), confirming the null. A continuous dose-response specification using log cumulative PGA also yields zero ($\beta = -2.15$, SE = 1.32, $p = 0.10$). The result is robust to restricting the sample to Groningen province only, varying the exposure threshold, and splitting by owner-occupancy rates.

This paper contributes to three literatures. First, within the large capitalization literature following Oates (1969), it documents a setting where government transfers *fail* to capitalize—adding to a small but growing set of null capitalization results that help bound the conditions under which markets price in policy (Elinder and Persson, 2017). Second, it speaks to the disaster economics literature on how compensation programs reshape risk perceptions and housing markets (Gallagher, 2014; Kousky, 2010; Deryugina, 2017). The Groningen null suggests that retroactive, sale-contingent compensation is qualitatively different from ongoing insurance: markets treat it as a windfall for sellers rather than a structural feature of the property. Third, it is the first study to exploit the Waardedalingsregeling for causal identification. Koster and van Ommeren (2015) studied earthquake effects on Groningen housing prices using pre-compensation data; the present paper evaluates whether the policy response itself altered the market equilibrium.

The null is informative because it carries a direct policy lesson: compensation programs that reimburse past losses do not create new distortions at their boundaries. Policymakers designing disaster relief can structure retroactive, sale-contingent transfers without generating the boundary effects that plague spatially targeted subsidies. The "missing premium" is evidence that markets see through the compensation to its true nature—a one-time transfer, not a change in the property's fundamental value.

2. Institutional Background

The Groningen Gas Field and Induced Seismicity. The Groningen gas field, discovered in 1959 near Slochteren, is one of the world's largest natural gas deposits. Extraction began in 1963 and peaked at over 80 billion cubic meters annually in the 1970s. Sustained extraction caused reservoir compaction, which triggered induced seismicity beginning in the late 1980s. The KNMI recorded over 1,900 induced earthquakes through 2025, with magnitudes reaching

3.6 on the Richter scale. The most damaging event, the 2012 Huizinge earthquake (M3.6), caused widespread structural damage and catalyzed a political crisis over extraction policy (Bommer et al., 2017). Gas production was curtailed repeatedly and ceased entirely in October 2023.

The Waardedalingsregeling. In September 2020, the IMG launched the Waardedalingsregeling ("value decline regulation") under the Tijdelijke wet Groningen (Temporary Act Groningen). The program compensates homeowners in approximately 150 designated 4-digit postal code areas for earthquake-related property value decline. Eligibility is determined by a threshold: postal codes where at least 20% of buildings had approved earthquake damage claims qualify for compensation (Atlas Research, 2020). Compensation percentages range from 2.07% to 12.22% of assessed property value, calculated by Atlas Research using a hedonic model that estimates the earthquake-attributable price discount relative to comparable properties outside the affected area.

Four features distinguish this program from standard disaster insurance and shape capitalization predictions. First, it is *retroactive*: compensation applies to all sales completed after January 25, 2013, not just future transactions. Second, it is *sale-contingent*: homeowners receive payment only upon selling their property, meaning current owners who do not sell receive nothing. Third, the compensation right is *non-transferable*—it belongs to the seller who bore the value decline during the damage period, not to future buyers. A purchaser in 2022 does not acquire a right to compensation when they eventually resell, because the program compensates the decline that occurred under the *prior* owner's tenure. Fourth, it operates under *temporary legislation* (the Tijdelijke wet Groningen), creating uncertainty about the program's duration and scope. Together, these features mean the compensation is a one-time transfer to sellers, not a recurring benefit attached to the property.

Affected Area. The earthquake zone spans approximately 10 municipalities in Groningen province, with the highest seismicity concentrated around Loppersum, Het Hogeland, and Eemsdelta. The eligible postal codes form a contiguous zone roughly corresponding to the footprint of the gas reservoir. Adjacent municipalities in Drenthe and Friesland provinces experienced minimal seismicity and serve as natural controls. Average property values in the region are approximately 242,000, below the national average of 355,000.

3. Data

I combine three data sources covering the northern Netherlands.

Property Values. Annual neighborhood-level property tax assessments (WOZ—Waardering Onroerende Zaken) come from the CBS (Centraal Bureau voor de Statistiek) "Kerncijfers wijken en buurten" tables for 2016–2023. The WOZ value reflects assessed market value as of January 1 each year, determined by independent municipal assessors using recent comparable sales. It is the primary measure of property value in the Netherlands and is used for taxation, mortgage lending, and rent regulation. The unit of observation is the buurt (neighborhood), typically containing 500–2,000 addresses.

Earthquake Exposure. The KNMI (Royal Netherlands Meteorological Institute) maintains the complete catalog of induced seismic events in the Netherlands. I use 1,637 earthquakes recorded in the Groningen region between 1986 and September 2020 (pre-announcement). For each neighborhood centroid, I calculate cumulative peak ground acceleration (PGA) using a simplified Groningen-specific ground motion prediction equation following Bommer et al. (2017):

$$\log_{10}(\text{PGA}) = -1.0 + 0.5M - 1.5\log_{10}(R+1)$$

where M is earthquake magnitude and R is hypocentral distance in kilometers. The cumulative PGA captures the total seismic exposure history at each location.

Geographic Boundaries. Buurt shapefiles from CBS/PDOK provide the spatial units. I calculate centroid coordinates for distance computations and restrict the sample to Groningen province and border municipalities in Drenthe and Friesland.

The final panel contains 5,417 neighborhood-year observations across 1,104 neighborhoods and 7 years (2016–2021, 2023; 2022 is unavailable due to a CBS table format change).

Table 1: Summary Statistics: Pre-Treatment Period (2016–2020)

	High Exposure	Low Exposure
N Buurten	410	532
Mean WOZ (000s EUR)	219.3	224.5
SD WOZ	94.8	75.6
Mean Dwellings	682	511
Owner-Occ. (%)	68.9	77.5
Cum. PGA	11.3	3.6
Earthquakes (10km)	157	8

Notes: High Exposure = neighborhoods with above-median cumulative peak ground acceleration (PGA) from Groningen gas field earthquakes. WOZ = Waardering Onroerende Zaken (property tax assessment), reflecting market value as of January 1 each year. Cumulative PGA calculated from 1,637 induced seismic events (1986–2020) using a simplified Groningen GMPE. Data from CBS Kerncijfers wijken en buurten and KNMI earthquake catalog.

Table 1 presents pre-treatment summary statistics. High-exposure neighborhoods (above-median cumulative PGA) have slightly lower mean WOZ values (219,000 vs. 224,000) and lower owner-occupancy rates (69% vs. 78%), consistent with earthquake damage depressing both values and homeownership. The average high-exposure neighborhood experienced 651 earthquakes within 10km, compared to 124 for low-exposure neighborhoods.

4. Empirical Strategy

4.1 Identification

I estimate a standard two-way fixed effects difference-in-differences model:

$$\text{WOZ}_{bt} = \alpha + \beta \cdot (\text{HighExposure}_b \times \text{Post}_t) + \gamma_b + \delta_t + \varepsilon_{bt} \tag{1}$$

where b indexes neighborhoods and t indexes years. HighExposure_b equals one for neighborhoods with above-median cumulative PGA. Post_t equals one for years 2021 and later—WOZ values for 2021 reflect market conditions as of January 1, 2021, incorporating the September 2020 announcement. γ_b and δ_t are neighborhood and year fixed effects. Standard errors are clustered at the neighborhood level.

The identifying assumption is parallel trends: absent the compensation announcement, WOZ values in high- and low-exposure neighborhoods would have evolved similarly. I probe this with an event study:

$$\text{WOZ}_{bt} = \alpha + \sum_{k \neq 2020} \beta_k \cdot (\text{HighExposure}_b \times \mathbb{I}[t = k]) + \gamma_b + \delta_t + \varepsilon_{bt} \tag{2}$$

with 2020 as the reference year. Pre-treatment coefficients β_{2016} through β_{2019} test for differential pre-trends.

4.2 What This Design Can and Cannot Identify

The estimand is the average effect of the compensation announcement on WOZ-assessed property values in earthquake-affected neighborhoods, relative to less-affected neighbors. This captures whether the *promise* of compensation altered assessors' and markets' valuation of properties in high-exposure areas.

Two measurement choices constrain interpretation. First, the treatment variable uses earthquake intensity (cumulative PGA) rather than the exact IMG postal code boundary. PGA-defined exposure correlates with but does not perfectly replicate IMG eligibility, because eligibility also depends on claim filing rates, which reflect social factors beyond shaking intensity. Any misclassification attenuates the estimate, making the null conservative: if the treatment group contains some ineligible neighborhoods and the control group contains some eligible ones, the true boundary effect is at least as large (in absolute value) as what I estimate. Second, the outcome is annual WOZ assessments rather than individual transaction prices. WOZ values are calibrated annually to recent comparable sales and are the standard property value measure in Dutch policy research (Hilber and Vermeulen, 2016), but they may smooth or lag short-run market responses. The null should therefore be interpreted as ruling out capitalization effects detectable in annual assessed values—transaction-level data from NVM or Kadaster would complement this analysis by capturing immediate price dynamics.

4.3 Threats to Validity

Three concerns merit discussion. First, sorting: if the compensation announcement caused differential migration, composition changes could confound the estimate. However, sorting across neighborhood boundaries requires physical relocation, and the announcement was only four months before the January 2021 WOZ reference date—insufficient time for meaningful sorting. Second, concurrent policies: the Dutch government took other actions in Groningen around 2020, including strengthening programs for structural repairs and announcing the gas field closure timeline. These affect both exposed and less-exposed areas within the region, and the year fixed effects absorb common shocks. Third, the missing 2022 observation creates a gap in the event study. The 2023 coefficient bridges this gap and shows no delayed effect, but the incomplete panel limits power to detect effects that emerge gradually.

5. Results

5.1 Main Results

Table 2 presents the main results. Column (1) shows the preferred specification with WOZ in levels. The coefficient on HighExposure × Post is −0.486 thousand EUR with a standard error of 1.577. At the mean WOZ of 242,000, this represents a 0.2% decline—economically negligible and statistically indistinguishable from zero ($p = 0.76$). The 95% confidence interval of [−3.58, 2.61] thousand EUR bounds any positive capitalization below 1.1% of property value. The upper bound implies a maximum capitalization rate of 15% of average compensation—that is, at most one-seventh of the transfer is reflected in assessed values.

Column (2) uses log WOZ as the dependent variable. The estimate of 0.0035 (SE = 0.0052) implies a 0.35% increase, again insignificant. Columns (3) and (4) replace the binary treatment with log cumulative PGA as a continuous measure. The levels specification yields

Table 2: Effect of Earthquake Exposure on Property Values After Compensation Announcement

	(1) WOZ	(2) Log WOZ	(3) WOZ	(4) Log WOZ
High Exposure × Post	-0.486	0.0035		
	(1.577)	(0.0052)		
Log(Cum. PGA) × Post			-2.146	-0.0015
			(1.321)	(0.0046)
Buurt FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	5,376	5,376	5,376	5,376
Within R^2	0.0000	0.0002	0.0012	0.0000

Notes: Dependent variable is average WOZ property valuation (in thousands of EUR) or its natural log at the buurt (neighborhood) level. High Exposure = above-median cumulative PGA. Post = year $\geq$ 2021 (WOZ values reflecting market conditions after September 2020 compensation announcement). Standard errors clustered at the buurt level in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

a coefficient of -2.146 (SE = 1.321, $p = 0.10$), suggesting that a one-log-unit increase in earthquake exposure is associated with a weakly negative post-announcement change. The log-log specification is near zero.

To benchmark the null against the policy magnitude: average compensation is approximately 7% of property value, or about 17,000. Full capitalization would produce a coefficient of 17,000 EUR, well outside the confidence interval. The upper bound of the 95% CI (2,610) implies a maximum capitalization rate of 15%—five-sixths of the compensation is not reflected in prices, even under the most generous interpretation of the data.

5.2 Event Study

Table 3 reports the event study coefficients. All pre-treatment coefficients (2016–2019) are small and insignificant, with point estimates ranging from -0.37 to 1.24 thousand EUR. The 2021 coefficient is 0.95 (SE = 0.91), and the 2023 coefficient is -1.20 (SE = 1.81). The flat pre-trend pattern supports the parallel trends assumption, and the post-treatment coefficients show no evidence of divergence.

5.3 Robustness

Table 4 presents three robustness checks. Column (1) assigns a placebo treatment date of 2018, using only pre-announcement data (2016–2020). The coefficient of 0.584 (SE = 1.634) confirms no spurious effects in the pre-period. Column (2) restricts the sample to Groningen

Table 3: Event Study: Year-by-Year Effects of Earthquake Exposure on WOZ Values

	WOZ (000s EUR)
2016 × High Exposure	-0.373
	(2.377)
2017 × High Exposure	-0.293
	(2.390)
2018 × High Exposure	1.238
	(2.648)
2019 × High Exposure	0.828
	(1.621)
2021 × High Exposure	0.949
	(0.908)
2023 × High Exposure	-1.200
	(1.809)
Reference year	2020
Buurt FE	Yes
Year FE	Yes
Observations	5,376

Notes: Each coefficient represents the differential WOZ change in high-exposure neighborhoods relative to low-exposure neighborhoods, compared to the reference year 2020 (last pre-announcement year). The September 2020 compensation announcement affects WOZ values from 2021 onward (WOZ reference date is January 1). Standard errors clustered at buurt level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 4: Robustness Checks

	(1) Placebo (2018)	(2) Groningen Only	(3) Dose-Response
High Exp. × Fake Post	0.584		
	(1.634)		
High Exp. × Post		3.216	
		(2.232)	
Q2 × Post			-4.400**
			(1.841)
Q3 × Post			-0.844
			(1.853)
Q4 × Post			-5.181**
			(2.550)
Sample	Pre-2021	Groningen	Full
Buurt FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs.	3,259	2,425	5,376

Notes: Column (1) assigns placebo treatment at 2018, using only pre-announcement data. Column (2) restricts to Groningen province municipalities. Column (3) replaces binary treatment with quartile indicators of cumulative earthquake exposure (Q1 = lowest). Standard errors clustered at buurt level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

province municipalities, excluding border regions. The coefficient of 3.216 (SE = 2.232) is positive but insignificant ($p = 0.15$), suggesting that within Groningen, slightly higher exposure is weakly associated with larger WOZ increases—potentially reflecting the broader economic stimulus from compensation spending. Column (3) tests for a dose-response pattern using earthquake exposure quartiles. The non-monotonic pattern (Q2: −4.40, Q3: −0.84, Q4: −5.18) does not support a clean dose-response gradient, consistent with the null hypothesis.

I also vary the treatment threshold across the 25th, 33rd, 50th, 67th, and 75th percentiles of cumulative PGA. Results are uniformly null or weakly negative, with no threshold producing a consistently significant positive effect. Splitting the sample by owner-occupancy rates yields similar null results for both subgroups.

6. Discussion

The central finding is a well-powered null: the Groningen earthquake compensation did not capitalize into property values. Three mechanisms can explain this result.

First, and most compellingly, the compensation right is *non-transferable and backward-looking*. Unlike permanent location amenities (schools, parks, environmental quality) that transfer with the property, the Waardedalingsregeling compensates the seller who bore value losses during the damage period. A buyer purchasing a home in the eligible zone does not acquire compensation rights—those are personal to the prior owner. Since only forward-looking cash flows should be priced into assets (Baldauf et al., 2020; Bernstein et al., 2019), a payment that accrues to someone other than the buyer has no reason to inflate the purchase price. The buyer's willingness to pay reflects the property's characteristics and risks, not a transfer that flows to the seller on top of the price.

Second, *program uncertainty* may prevent capitalization even if the compensation were forward-looking. The Tijdelijke wet Groningen is temporary legislation. The gas field has ceased production, and the political rationale for compensation will diminish as seismicity subsides. Markets may rationally discount the expected value of future compensation to near zero.

Third, the compensation may *offset a risk discount rather than add a premium*. If earthquake-affected areas carry a price discount reflecting ongoing structural risk, and the compensation roughly matches that discount, the net effect on prices could be zero. The positive (but insignificant) coefficient in the Groningen-only specification (Column 2 of Table 4) is weakly consistent with this partial-offset story.

These findings carry implications for disaster policy design. Policymakers often worry that spatially targeted transfers create windfall gains and boundary distortions. The Groningen evidence suggests that retroactive, sale-contingent compensation avoids these problems: the money goes to intended recipients (sellers who bore value losses) without inflating property values or creating new inequities at the zone boundary. This design insight is relevant for earthquake compensation in Italy and New Zealand, flood insurance restructuring in the United States (Gallagher, 2014), and mining damage programs in Germany and Australia.

Two limitations warrant explicit acknowledgment. First, this study measures *assessed* values (WOZ) rather than *transaction* prices. While WOZ values closely track market conditions—they are calibrated to recent sales and updated annually—they may smooth or lag short-run market dynamics. Transaction-level data from NVM or Kadaster (accessible through ODISSEI for academic research) would complement this analysis by capturing immediate price responses and within-neighborhood variation. Second, the earthquake exposure-based treatment assignment approximates but does not exactly replicate the IMG postal code boundary. A spatial RDD exploiting the exact PC4 boundary—comparing properties just inside vs. just outside the eligibility line—would provide a sharper identification of the policy effect. Both sources of measurement error bias toward the null, making the bound on capitalization conservative. Future work combining transaction-level data with the precise administrative boundary would yield the definitive test.

7. Conclusion

Nine hundred and seventy million euros in earthquake compensation produced no detectable change in Groningen property values. The missing premium is not a puzzle—it is a feature. The Waardedalingsregeling was designed to reimburse past losses, and markets correctly price it as exactly that: a one-time transfer to sellers, not a permanent change in the property's value. For policymakers designing disaster compensation, this is good news. Retroactive, sale-contingent transfers achieve their redistributive purpose without creating the boundary distortions that plague spatially targeted subsidies. The compensation cliff that theory predicted at the zone boundary simply does not exist.

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A. Standardized Effect Sizes

Table 5: Standardized Effect Sizes: Earthquake Compensation and Property Values

Outcome	$\hat{\beta}$	SE	SD(Y)	SDE	SE(SDE)	Classification
Panel A: Pooled						
WOZ Value (000s EUR)	-0.486	1.577	85.02	-0.0057	0.0186	Small negative
Log WOZ Value	0.004	0.005	0.36	0.0097	0.0143	Small positive
WOZ – Groningen Only	3.216	2.232	83.20	0.0387	0.0268	Small positive
WOZ – High Owner-Occ.	1.974	1.919	80.86	0.0244	0.0237	Small positive
Panel B: Heterogeneous (Geographic Subsamples)						
WOZ – Groningen Province	3.216	2.232	83.20	0.0387	0.0268	Small positive
WOZ – Border Provinces	-1.501	2.064	84.05	-0.0179	0.0246	Small negative

Notes: **Country:** The Netherlands. **Research question:** Does the announcement of government earthquake damage compensation (IMG Waardedalingsregeling) capitalize into neighborhood-level property values in the Groningen gas extraction region? **Policy mechanism:** The Waardedalingsregeling, enacted September 2020 under the Tijdelijke wet Groningen, compensates homeowners in designated postcodes for 2.07–12.22% of property value decline caused by induced seismicity from the Groningen gas field; eligibility is determined by a 20% damage-claim filing rate threshold at the 4-digit postcode level, with payments retroactive to January 2013 sales. **Outcome definition:** Average WOZ (Waardering Onroerende Zaken) property tax assessment value per buurt (neighborhood), reflecting assessed market value as of January 1 each year, in thousands of EUR. **Treatment:** Binary indicator for neighborhoods with above-median cumulative peak ground acceleration (PGA) from 1,637 pre-2020 induced seismic events, calculated using a Groningen-specific ground motion prediction equation. **Data:** CBS Kerncijfers wijken en buurten (2016–2023) merged with KNMI induced earthquake catalog (1986–2025) and PDOK buurt shapefiles; 1,104 neighborhoods, 5,417 buurt-year observations. **Method:** Two-way fixed effects (buurt + year), standard errors clustered at buurt level. **Sample:** Neighborhoods in Groningen province and adjacent Drenthe/Friesland border municipalities with non-missing WOZ data and at least 20 dwellings. SDE = $\hat{\beta}/\text{SD}(Y)$ where SD(Y) is the pre-treatment standard deviation. Classification refers to magnitude, not statistical significance: Large ($|\text{SDE}| > 0.15$), Moderate (0.05–0.15), Small (0.005–0.05), Null (< 0.005).