Rare Events and Risk Perception: Evidence from the Fukushima Accident

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Motivation

- ▶ Heterogeneity in the valuation of extreme events and in the perception of catastrophic risks, see e.g., Slovic (1987).

- ▶ Different reactions amongst agents after the realization of an extreme event?

- ▶ How has nuclear-risk perception changed in "at-risk" areas in the wake of Fukushima disaster?

- ▶ England and Wales: households' reaction? Political reaction?

Average transaction prices as a function of distance to nuclear plants and waste sites (Jan. 2007-Sep. 2014)
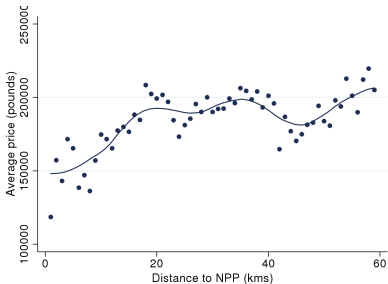
(a) Nuclear Plant.
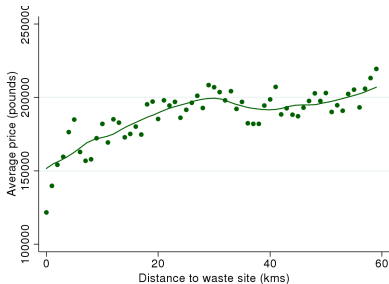
(b) Waste site.

Research question and strategy

- We study the heterogeneity in changes in nuclear-risk perception due to the Fukushima nuclear accident (FNA).

- Hedonic approach: we identify changes in nuclear-risk beliefs using housing transactions in England and Wales.

- Difference-in-difference strategy: we compare housing markets outcomes in areas close to nuclear plants and to areas further away before/after FNA.

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- ▶ Price malus of about 4% in areas close to NPPs due to Fukushima. Limited effect on the volume of transactions.

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- ▶ Stable opinion on nuclear energy despite FNA. "Not in my backyard story"?

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  - ▶ **a local-economy channel**: expectations about a substantial reduction of the nuclear program (deterioration of the local economy) → shift housing demand downward.

- ▶ Study of risk perception → neutralize local-economy impacts.

- ▶ We argue that our findings are explained by a strong revision of beliefs in nuclear risk.
  - ▶ Context: no threats on the continuation of UK nuclear program
  - ▶ Additional tests: the local-economy effect is negligible in UK.

Related literature

- Cost of disamenities:
  - No consensus on the overall effect of the proximity to an NPP on local housing market (Folland and Hough, 1991; Gamble and Downing, 1982; Clark et al., 1997).
  - Other disamenities, like coal-fired power plants (Blomquist, 1974; Davis, 2011), major infrastructure (Carruthers and Clark, 2010).
  - Clean-up of waste sites (Greenstone and Gallagher, 2008).

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  - Clean-up of waste sites (Greenstone and Gallagher, 2008).
- Industrial accidents and housing prices:
  - Bauer et al. (2013), FNA, Germany, ask prices, negative effect in NPPs areas due to NPPs phaseout.
  - Fink and Stratmann (2013), FNA, USA, postcode housing index, no effect; Boes et al. (2015), FNA, Switzerland, effect on online ask rents.
  - Zhu et al. (2015), FNA, Chinese land primary market (properties sold by local governments), short-term effect.
  - Bléhaut (2014), AZF industrial accident in France in 2001, no price effect in at-risk areas.

Fukushima nuclear accident

- ▶ A major tsunami triggered by the Great East Japan earthquake hit the Fukushima Daiichi nuclear plant on March 11, 2011;

- ▶ Failure of coolant systems and large radioactive leakages;

- ▶ Highest level in the classification of the International Nuclear Event Scale, (level of Chernobyl accident of 1986);

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- ▶ Interrogations regarding the actual safety around nuclear power stations across the World.

The UK context

- ▶ No change in nuclear program in UK, in contrast with most other countries (e.g. Germany or Switzerland).
  - ▶ Chris Huhne, SoS for Energy and Climate Change "I see no reason why the UK should not proceed with our current policy: that nuclear should be part of the future energy mix [...]". (Letter to Dr Mike W.Weightman, June 2011)

- ▶ Expectations about possible phase out of operational plants after FNA were nil or very short-lived.
  - ▶ No expectations about negative local economic effects – like a labor workforce outflow or a loss of local tax base.

- ▶ UK: suitable context to focus on risk perception following major industrial accident.
  - ▶ Additional tests: local-economy effect can be discarded.

Nuclear plants and waste sites in England and Wales

- ▶ 10 operational nuclear power plants (18 nuclear reactors)
  - ▶ 3 different technologies, Magnox, Advanced Gas-cooled Reactors, Pressurized Water Reactor;
  - ▶ For each site: location, site owners, capacity, connection-to-the-grid date, expected closure;

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  - ▶ For each site: location, site owners, capacity, connection-to-the-grid date, expected closure;
- ▶ 35 nuclear waste sites
  - ▶ Different types of waste: High Level Wastes (one site), Intermediate Level Wastes, Low Level Wastes.
  - ▶ Important difference in waste volumes stored. 23 major sites (more than 1000m3 of ILW).
  - ▶ For each site: location, site owners, waste classification, volume, radioactivity concentration, material composition, treatment and packaging.

Housing data: two datasets

- Land Registry

  - All sales (except commercial sales) over 2006-2014 in England and Wales.

  - Properties' characteristics available: price, postcode, the type of property (e.g., terrace house, separate house, recent/old house).

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- ▶ Nationwide

  - ▶ New mortgages issued by Nationwide between 2007 and 2013.

  - ▶ Wide range of controls for the property characteristics (e.g., the construction date, the number of bedrooms, bathrooms, garages, the square meters or heating facilities).

Treated and control groups around NPPs P_1, P_2, and P_3.

- ▶ Treated zone: 20 km "evacuation" zone around each NPP.
- ▶ Control zone: a 20-100 km band around any NPP or waste site but not in any evacuation zones.
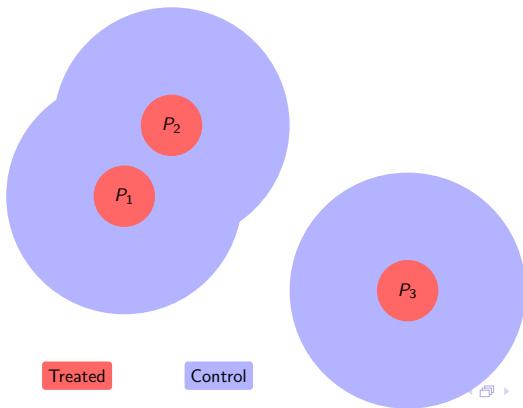
Identification

- ▶ Diff-in-Diff approach:

$$p_{ozt} = \beta_0 + \beta_1 T_{oz} \times \mathbb{1}_{t>\tau} + \beta_2 T_o + \beta_3 \mathbf{X}_o \times t + \gamma \mathbf{X}_o + \delta_{zt} + \varepsilon_{ozt}$$

output area (o): LSOA, 400-1,200 households, < 100 km of one NPP (z), month/year (t); observations ≈ 1.7 million (*LSOA* $*$ *months* $*$ *year*).

- ▶ p_{ozt}, either average price, volume or number of transactions (log);
- ▶ $T_{oz} = 1$ if LSOA close to site z (*distance* < 20km) and 0 if further away ($20 <$ *distance* < 100 km);
- ▶ X: transaction characteristics and output areas controls;
- ▶ LSOA fixed effects $+$ allow for differential trends in LSOA around each NPP;
- ▶ δ_{zt}, NPP-specific time fixed effects;
- ▶ error term clustered at the neighbourhood level;
- ✓ Parallel trends ante-Fukushima.

Effect of Fukushima on the housing market

PANEL A: Nuclear plants			
	(1)	(2)	(3)
Price	-.0379***	-.0241***	-.0325***
	(.0033)	(.0021)	(.0018)
Number of transactions	.00162	-.0098***	-.0136***
	(.0040)	(.0037)	(.0039)
Volume of transactions	-.0363***	-.0340***	-.0462***
	(.0054)	(.0044)	(.0044)
Observations	1,754,282	1,754,282	1,577,723
Controls (housing characteristics)			Yes
LSOA fixed effects		Yes	Yes

A strong effect?

- ▶ Effect twice larger than for nuclear waste sites in England and Wales (separate regression).

- ▶ Japan: Increase in radiation dose of $1\mu Sv/h$ decreases residential land value by 3.1% (Managi and Tanaka, 2014); only 8 out of 38 municipals in Fukushima prefecture have recorded a radiation level above $1\mu Sv/h$ after the accident (June and July 2011).

- ▶ Back-of-the-envelop calculation: decrease of the value of the stock of properties nearby NPPs by 7.6 billion Pounds in England and Wales.

Persistence of the Fukushima effect

Price	(1)	(2)
Treatment (03/11-11/12)	-.0318***	-.0218***
	(.0041)	(.0022)
Treatment (12/12-12/13)	-.0345***	-.0349***
	(.0053)	(.0027)
Observations	1,556,208	1,399,234
Controls (housing characteristics)		Yes
LSOA fixed effects		Yes

Interpreting changes in prices as changes in risk perception

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▶ We argue that our findings are explained by a strong revision of beliefs in nuclear risk.

Heterogeneity: Quantile regressions

Quantiles	.10	.25	.50	.75	.90
Price	-.00925	-.0405***	-.0332***	-.0565***	-.0710***
	(.0120)	(.0093)	(.0087)	(.0110)	(.0175)
Observations	158,319	158,319	158,319	158,319	158,319
Controls (housing)	Yes	Yes	Yes	Yes	Yes

Deprived areas: distributions of prices in treated (blue) and control zones (black)
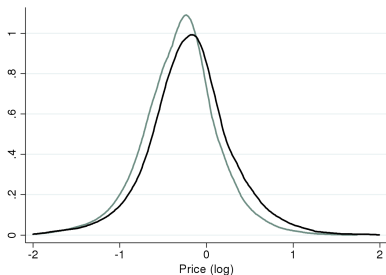
(c) Before Fukushima Accident.
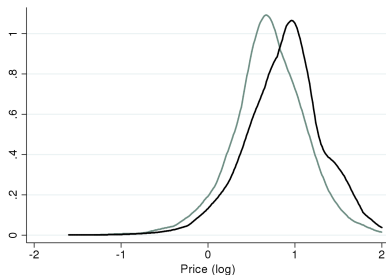
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Robustness checks

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Interpretation

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- ► Prices' compression within postcodes:
  - ► Different valuation of the underlying nuclear risk, richer agents may attribute a higher value to a safe environment.
  - ► Different access to information (precision of pre-disaster information on nuclear risk, capacity to process the FNA signal).

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- ▶ Deprived areas are more responsive:
  - ▶ Spillovers in information acquisition?
  - ▶ Asymmetric reaction across neighbourhoods? Compensation for wealthy at-risk areas that could mitigate the Fukushima effect?
  - ▶ Non-linearities in valuation: a decrease of the perceived quality of an low-quality good leads to a stronger decrease in its valuation?

Next step: Political reaction

▶ Political power: rich areas can be compensated by local politicians for nuclear risk (e.g. more schools, lower tax)?

▶ June 2013: announcement that communities living close to planned nuclear plants will be compensated. Indirect compensation for people living close to existing NPPs?

▶ Government grants received by local authorities

▶ Expenditures of local authorities and local taxes (tax cuts?).

▶ MPs vote on nuclear and energy issues.

▶ Other: information' campaign made by NPPs operators.

Take-home messages

- Strong effect of Fukushima on housing prices in England and Wales nearby NPPs.

- Smaller effect for nuclear waste sites.

- Downward shift in demand driven by changes in risk perception.

- Persistent effect, small effect on the number of transactions.

- Heterogeneous effect according to plants characteristics.

- Stronger effect for expensive properties and deprived areas.
  - Rich people have higher nuclear fear, positive spillovers in efforts to obtain information?
  - Heterogeneous priors?
  - Compensation for wealthy at-risk neighbourhood proximity to NPPs after FNA?
  - Relocation costs?

Thank you for your attention

Descriptive statistics in 2010

| Sample	All	$T_{np} = 1$	$T_{np} = 0$	$T_{ws} = 1$	$T_{ws} = 0$
Observations	308,326	12,064	207,493	32,440	133,247
			Housing market		
Volume of transactions[†]	514542.0	400105.8	541658.6	390673.9	533633.8
Average price[†]	226297.8	179361.5	238280.8	177173.9	233955.0
Number of transactions	2.169	2.157	2.167	2.146	2.173
fraction of new buildings	0.040	0.045	0.038	0.039	0.040
fraction of flats	0.158	0.089	0.187	0.096	0.167
			Deprivation scores		
Income rank	.533	.525	.520	.535	.534
Employment rank	.533	.470	.530	.492	.540
Barriers to housing rank	.503	.609	.472	.595	.493
			Distance to nuclear facilities		
Distance to plants	80.59	13.71	65.56	59.28	82.18
Distance to waste sites	52.82	13.62	53.70	12.30	56.35

Share of low-skilled workers as a function of distance to nuclear plants and waste sites in 1971 and 2011
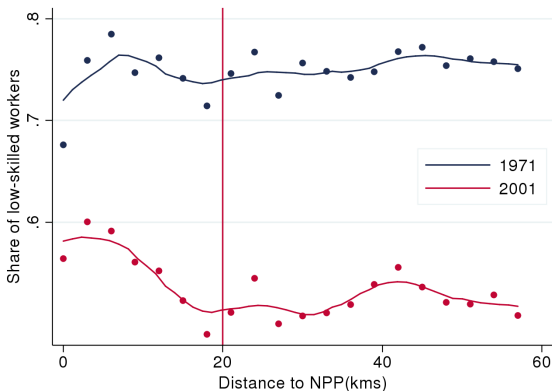
Heterogeneity: The role of NPP's characteristics

	(1)	(2)	(3)	(4)	
T $\times$ Connection	.00103***				
	(.00014)				
T $\times$ Expected closure		.00187***			
		(.00017)			
T $\times$ Number accidents			.00031		
			(.00143)		
T $\times$ Package ($1000m^3$)				-.000279***	
				(.000062)	
T $\times$ Share emplymt (%)					.00380***
					(.00059)
Observations	1,577,723	1,577,723	1,577,723	1,577,723	1,577,723
Controls (housing)	Yes	Yes	Yes	Yes	Yes
LSOA fixed effects	Yes	Yes	Yes	Yes	Yes

Non-deprived areas: distributions of prices in treated (blue) and control zones (black)
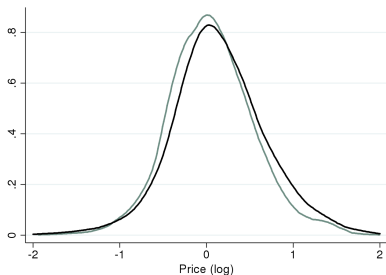
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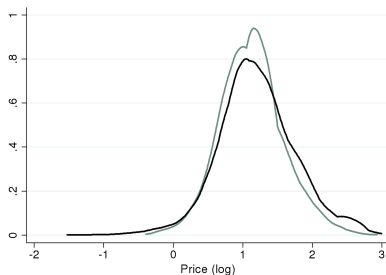
(f) After Fukushima Accident.

Effect of Fukushima on the housing market

PANEL B: Nuclear waste sites			
	(1)	(2)	(3)
Price	-.0180***	-.0146***	-.0193***
	(.0027)	(.0017)	(.0016)
Number of transactions	-.00122	-.0106***	-.0137***
	(.0033)	(.0030)	(.0034)
Volume of transactions	-.0.0192***	.0252***	.0331***
	(.0044)	(.0036)	(.0039)
Observations	1,600,981	1,600,981	1,429,256
Controls (housing characteristics)			Yes
LSOA fixed effects		Yes	Yes

The role of neighbourhood characteristics

	(1)	(2)	(3)
Treatment × Deprivation	-.0314***	-.0341***	-.0326***
	(.0046)	(.0047)	(.0047)
Treatment × Rural		-.0162***	-.0233***
		(.0046)	(.0045)
Treatment × Green support			-.2230
			(.1882)
Observations	729,689	729,689	729,689
Controls (housing)	Yes	Yes	Yes
LSOA fixed effects	Yes	Yes	Yes

Proxy for moving costs/ Possibility to move out of the at-risk area while keeping the same distance to workplace.
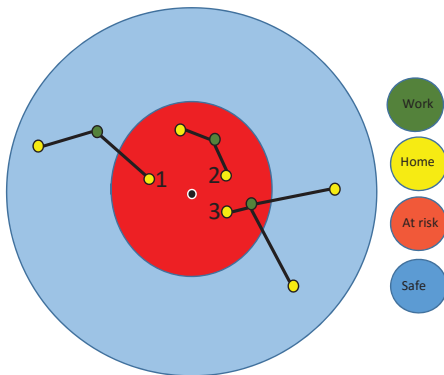
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