Tsunami Risk and Information Shocks

Evidence from the Oregon Housing Market

Oregon State University

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Advisor: Steven Dundas

Masters Final Oral Examination : February 19, 2020

The Really Big One

7-15%

Odds of a magnitude 8.7-9.2 Cascadia earthquake in the next 50 years

~37%

Odds of a magnitude 8.0-8.6 Cascadia earthquake in the next 50 years

>10,000

Potential fatalities due to a combined 9.0 Cascadia earthquake and tsunami

The Really Big One

$30 billion

Estimated economic losses – almost 1/5th of Oregon's gross state product

22,000

Number of permanent residents living in the tsunami inundation zone (2012)

1-3 years

Estimated time to restore drinking water

Risk salience and resilience

- Improving resilience at the state, county, individual level
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- If the risk is not salient, individuals will likely underprepare themselves
- Gap between subjective risk perceptions and objective risk?

Research question

- Did two recent information shocks – the March 2011 Tohoku earthquake and tsunami and the July 2015 New Yorker article "The Really Big One" - change Oregonians' risk perceptions about the Cascadia earthquake and tsunami?

- Does the tsunami risk discount in property values increase following an exogenous information shock about tsunami risks?

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THE REALLY BIG ONE

An earthquake will destroy a sizable portion of the coastal Northwest. The question is when.

By Kathryn Schulz
July 13, 2015

OREGONLIVE
The Oregonian

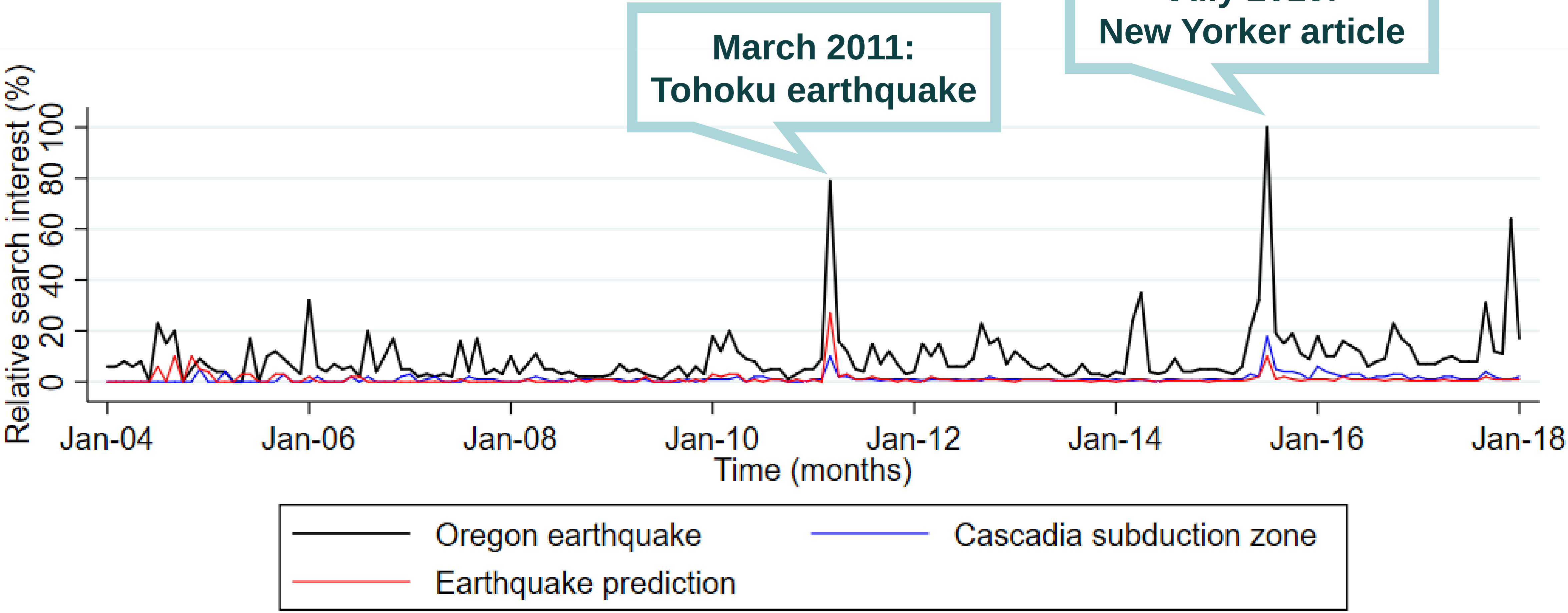
Pacific Northwest

Oregon coast will be ‘toast’ when Big One hits; politicians will make devastation even worse: The New Yorker

Updated Jul 03, 2019; Posted Jul 03, 2019

Information shocks

Google searches in Oregon as measured by search interest relative to the maximum



Outline

1 Motivation

2 Hazards and housing markets: previous research

3 Study area and data

4 Methodology

5 Results

6 Discussion & conclusion

Previous research

- Rosen’s (1974) hedonic model of market equilibrium and MWTP of amenities
- House prices can capitalize property risk factors:
  - Natural hazards: Atreya et al. (2013), Bin and Landry (2013), Brookshire et al. (1985)
  - Manmade hazards: Hansen et al. (2006), McCluskey and Rausser (2001)

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- Using Difference-in-Differences hedonic models to show that disaster events increase house price differentials across hazard zones:
  - Floods and hurricanes: Atreya et al. (2013, 2015), Bin and Landry (2013), Hallstrom and Smith (2005). Earthquakes: Naoi et al. (2009).

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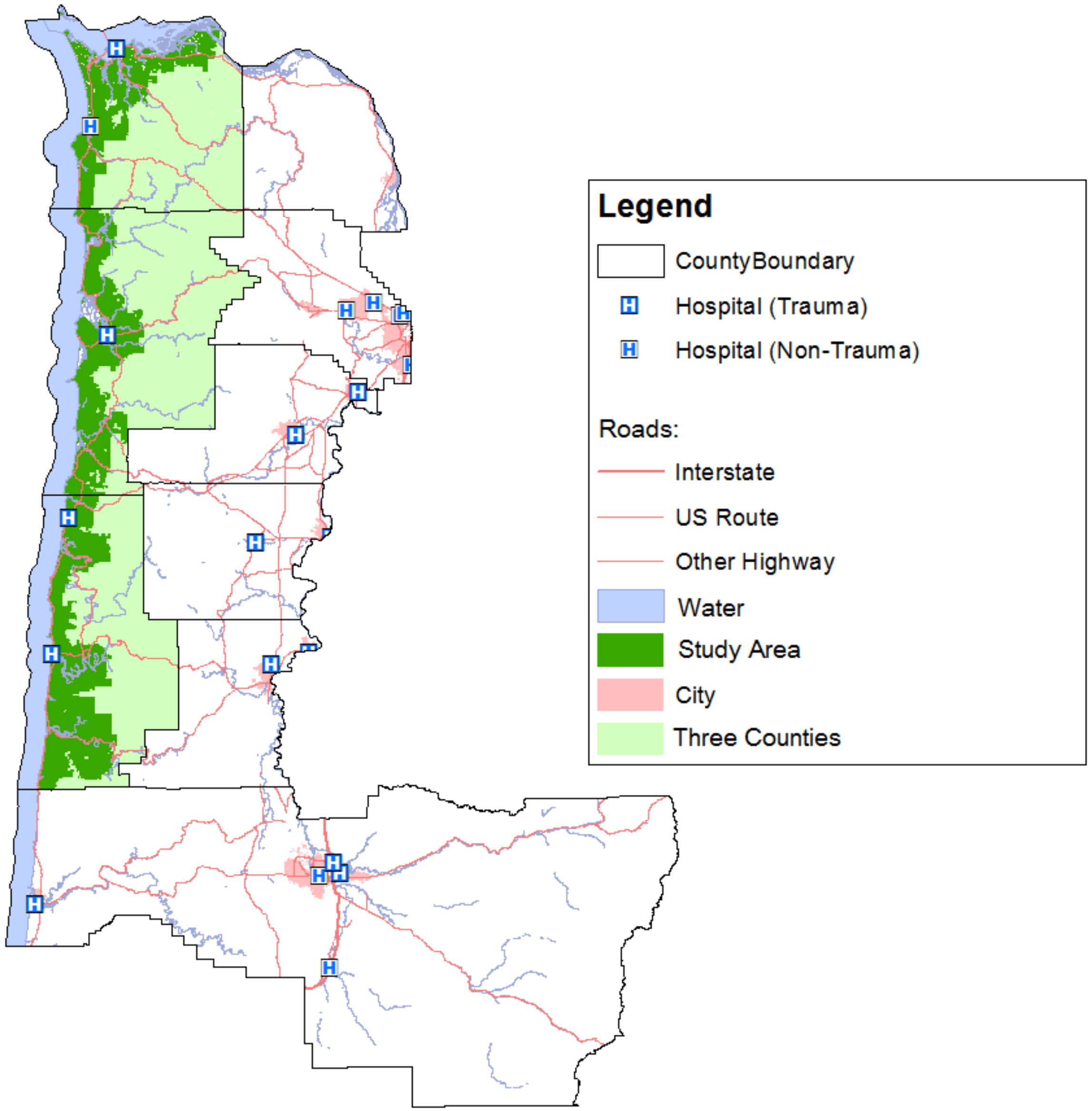
- Using "distant" or "pure" information shocks:
  - Atreya and Ferreira (2015), Gu et al. (2018), Hallstrom and Smith (2005), Nakanishi (2017)
- Exploring the combined earthquake/tsunami risk or earthquake risk alone:
  - Beron et al. (1997), Brookshire et al. (1985), Gu et al. (2018), Hidano et al. (2015), Nakanishi (2017), Naoi et al. (2009)

Study area

- Three northern coastal counties: Clatsop, Tillamook, and Lincoln

- Spatial range: within 2 miles of the original tsunami inundation line



Tsunami hazard lines

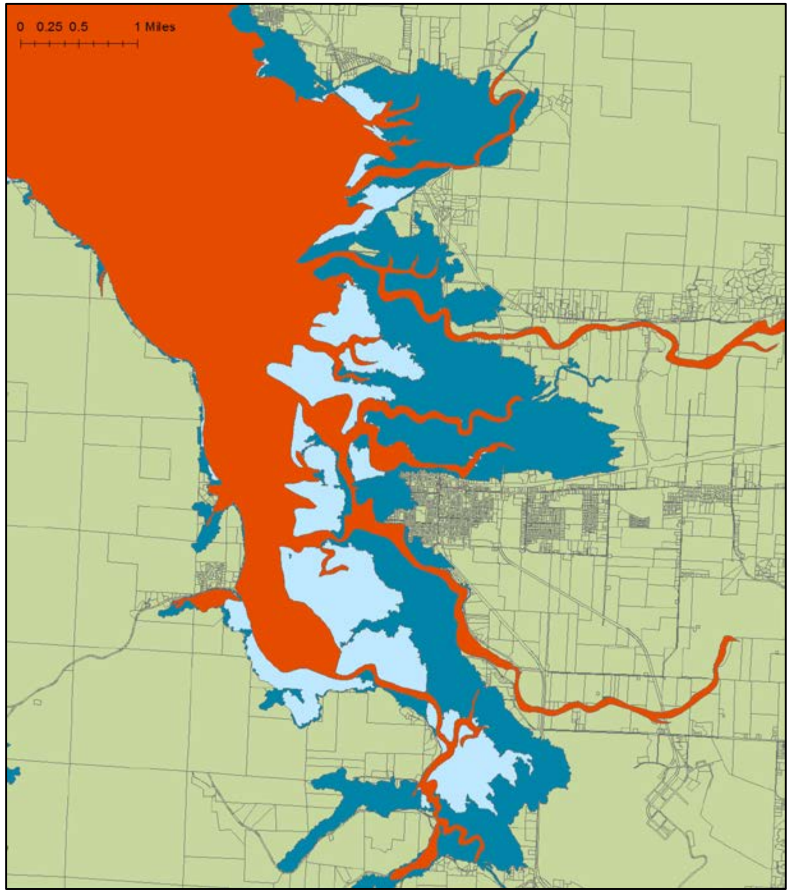
Tillamook Bay, OR

- Treatment:
  - 1995 SB 379 line
  - 2013 TIM series

- Time range: 2009 – 2017

Red: 1995 SB 379 line

Blue: SM and XXL 2013 scenarios



2013 TIM series: SM, M, L, XL, XXL scenarios

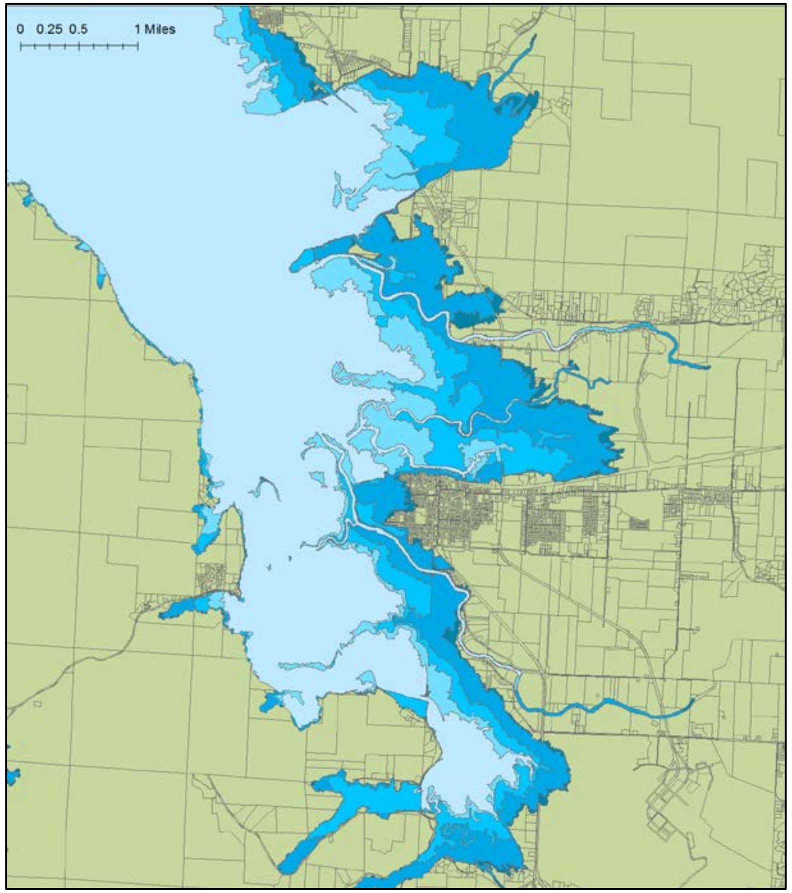


Table 1. Variable Definitions and Descriptive Statistics, Full Sample, 2009-2017

Variables	Labels	Mean	SD	Min	Max
Structural					
bedrooms	Number of bedrooms	2.8	.93	1	8
baths	Number of bathrooms	2	.8	.5	6
sqfootage	Indoor square footage	1,684	733	208	16,500
g18_eligible	1 if Goal 18 eligible, else 0	.04	.2	0	1
armored	1 if has shoreline armoring, else 0	.013	.11	0	1
Location					
sfha	1 if in Special Flood Hazard Area (SFHA), else 0	.17	.38	0	1
elevation	Elevation (ft)	79	70	2.8	746
beachaccess	Distance to nearest beach access point (ft)	3,108	5,327	0	50,974
ocean	Distance to ocean shoreline (ft)	10,991	16,995	0	126,398
oceanfront	1 if on oceanfront, else 0	.052	.22	0	1
stateland	Distance to nearest state park or public land (ft)	5,277	6,374	0	39,241
fedland	Distance to nearest national park or public land (ft)	4,423	4,094	0	29,406

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Model I: 2011 Tohoku earthquake only

$$ln(price_{ict}) = \boldsymbol{X}'_{\boldsymbol{ict}}\beta_1 + \beta_2 sb379_i + \beta_3 tohoku_t + \delta_1 sb379_i * tohoku_t + quarter_t$$

$$+ blckgrp_c * year_t + \epsilon_{ict}$$

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Average Treatment Effect on the Treated

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$$+ blckgrp_c * year_t + \epsilon_{ict}$$

Model II: 2015 New Yorker article only

$$\ln(price_{ict}) = \boldsymbol{X}'_{\boldsymbol{ict}}\beta_1 + \beta_2 xxl2013_i + \beta_3 article_t + \overbrace{\delta_1}^{\text{ATET}} xxl2013_i * article_t$$

$$+ quarter_t + blckgrp_c * year_t + \epsilon_{ict}$$

Model III: Combined events

ATET

$$ln(price_{ict}) = \boldsymbol{X'_{ict}}\beta_1 + \beta_2 sb379_i + \beta_3 tohoku_t + \beta_4 article_t + \underbrace{\delta_1}_{} sb379_i * tohoku_t$$

$$+ \underbrace{\delta_2}_{} sb379_i * article_t + quarter_t + blckgrp_c * year_t + \epsilon_{ict}$$

ATET

Table 2. Variable Definitions and Descriptive Statistics, by SB 379, 2009-2017

Variables	Labels	Outside SB 379 inundation zone Mean	Outside SB 379 inundation zone SD	Inside SB 379 inundation zone Mean	Inside SB 379 inundation zone SD	Standardized diff. in means
Structural						
bedrooms	Number of bedrooms	2.9	.92	2.7	.94	0.23
baths	Number of bathrooms	2.1	.8	1.9	.77	0.20
sqfootage	Indoor square footage	1,744	745	1,514	670	0.32
g18_eligible	1 if Goal 18 eligible, else 0	.019	.14	.1	.3	-0.35
armored	1 if has shoreline armoring, else 0	.0024	.049	.043	.2	-0.27
Location						
sfha	1 if in Special Flood Hazard Area (SFHA), else 0	.067	.25	.46	.5	-0.99
elevation	Elevation (ft)	99	71	22	10	1.52
beachaccess	Dist. to nearest beach access point (ft)	3,711	5,769	1,403	3,248	0.49
ocean	Distance to ocean shoreline (ft)	13,427	18,337	4,099	9,511	0.64
oceanfront	1 if on oceanfront, else 0	.027	.16	.12	.33	-0.37
stateland	Distance to nearest state park or public land (ft)	6,235	6,720	2,566	4,225	0.65
fedland	Distance to nearest national park or public land (ft)	4,598	4,177	3,928	3,804	0.17
Observations		12,608		4,456		

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  - Spatial and temporal fixed effects
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- Matching to improve covariate balance:
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  - Nearest neighbor Mahalanobis matching (NNM)

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  - Nearest neighbor propensity score matching (PSM)
  - Nearest neighbor Mahalanobis matching (NNM)
  - Variables influencing treatment assignment: elevation, distance to the ocean

Matching results

- Propensity score matching did not appreciably improve covariate balance
  - Balance for $elevation$ and $lnocean$ improved in most but not all models
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- Run models using both methods' matched data and compare to full data results

Table 3. Difference-in-differences selected results, full data

Variables	Labels	Model I	Model II	Model III
Diff-in-Diff				
sb379xtohoku	SB 379 tsunami in. zone (=1) x sold after 2011 earthquake and before 2015 article	-0.0847**		-0.0792**
		(0.0389)		(0.0347)
xxl2013xarticle	2013 XXL tsunami in. zone (=1) x sold after 2015 article		-0.00881	
			(0.0239)	
sb379xarticle	SB 379 tsunami in. zone (=1) x sold after 2015 article			-0.0638*
				(0.0347)
Observations		7,568	9,496	17,064
R-squared		0.426	0.508	0.463

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

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Variables	Labels	Model I	Model II	Model III
Event/Treatment				
tohoku	1 if sold after 2011 earthquake and before 2015 article, else 0	0.0853**		0.0838**
		(0.0399)		(0.0387)
article	1 if sold after 2015 article, else 0		0.0434**	0.119***
			(0.0211)	(0.0437)
sb379	1 if in tsunami in. zone given by 1995 SB 379, else 0	0.0516		0.0777**
		(0.0329)		(0.0313)
xxl2013	1 if in tsunami in. zone given by 2013 XXL, else 0		0.0276	
			(0.0228)	
Observations		7,568	9,496	17,064
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sb379	1 if in tsunami in. zone given by 1995 SB 379, else 0	0.0516		0.0777**
		(0.0329)		(0.0313)
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Table 6. Difference-in-differences selected results, matched data

		Nearest neighbor Mahalanobis			Nearest neighbor propensity score		
Variables	Labels	Model I	Model II	Model III	Model I	Model II	Model III
Diff-in-Diff							
sb379xtohoku	SB 379 (=1) x sold after 2011 EQ and before 2015 article	-0.106		-0.0910	-0.127		-0.0519
		(0.0726)		(0.0654)	(0.0794)		(0.0691)
xxl2013xarticle	2013 XXL tsunami in. zone (=1) x sold after 2015 article		-0.0712			-0.0790	
			(0.0504)			(0.0485)	
sb379xarticle	SB 379 tsunami in. zone (=1) x sold after 2015 article			-0.0869			-0.0592
				(0.0649)			(0.0674)
Observations		2,334	5,018	5,247	2,317	5,026	5,252
R-squared		0.513	0.532	0.531	0.494	0.532	0.518

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tohoku	1 if sold after 2011 EQ and before 2015 article, else 0	0.0456		0.0414	0.0461		-0.00517
		(0.0962)		(0.0937)	(0.110)		(0.101)
article	1 if sold after 2015 article, else 0		0.117**	0.0918		0.130***	0.0540
			(0.0514)	(0.103)		(0.0498)	(0.109)
sb379	1 if in tsunami in. zone given by 1995 SB 379, else 0	0.119**		0.112*	0.113*		0.111*
		(0.0599)		(0.0576)	(0.0666)		(0.0612)
xxl2013	1 if in tsunami in. zone given by 2013 XXL, else 0		0.0735			0.0902*	
			(0.0458)			(0.0460)	
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- Inconclusive but suggestive of a null result: that there is no evidence that either the Tohoku earthquake or New Yorker article were capitalized into house prices

Contributions

- Measured effects of a “pure” or “distant” information shock in a region with no recent event

Tsunami information trail sign at the top of Safe Haven Hill in Newport, OR. ©FEMA

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    - Even if the risk of a Cascadia event is salient, it may not be salient enough to translate into housing market behavior
- Investigated tsunami risk disentangled from earthquake risk

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Next steps…

- Verify that a null result reflects the true behavioral impact of the information shocks

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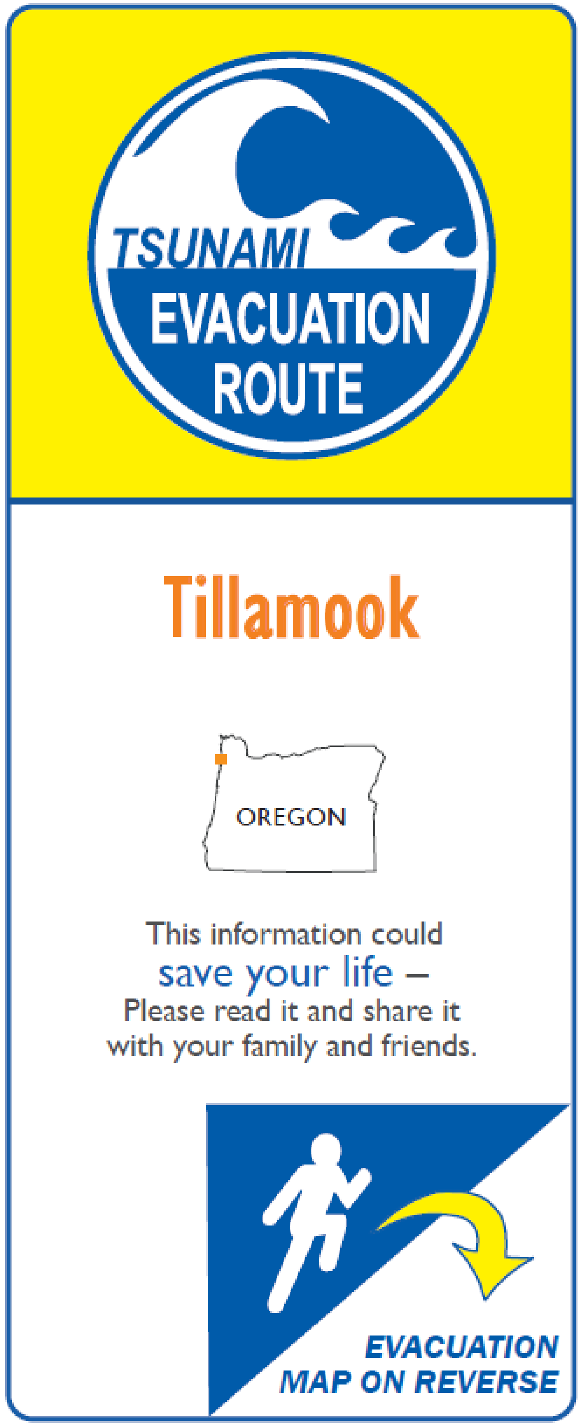
    - Four-group propensity score weighting
    - Entropy balancing



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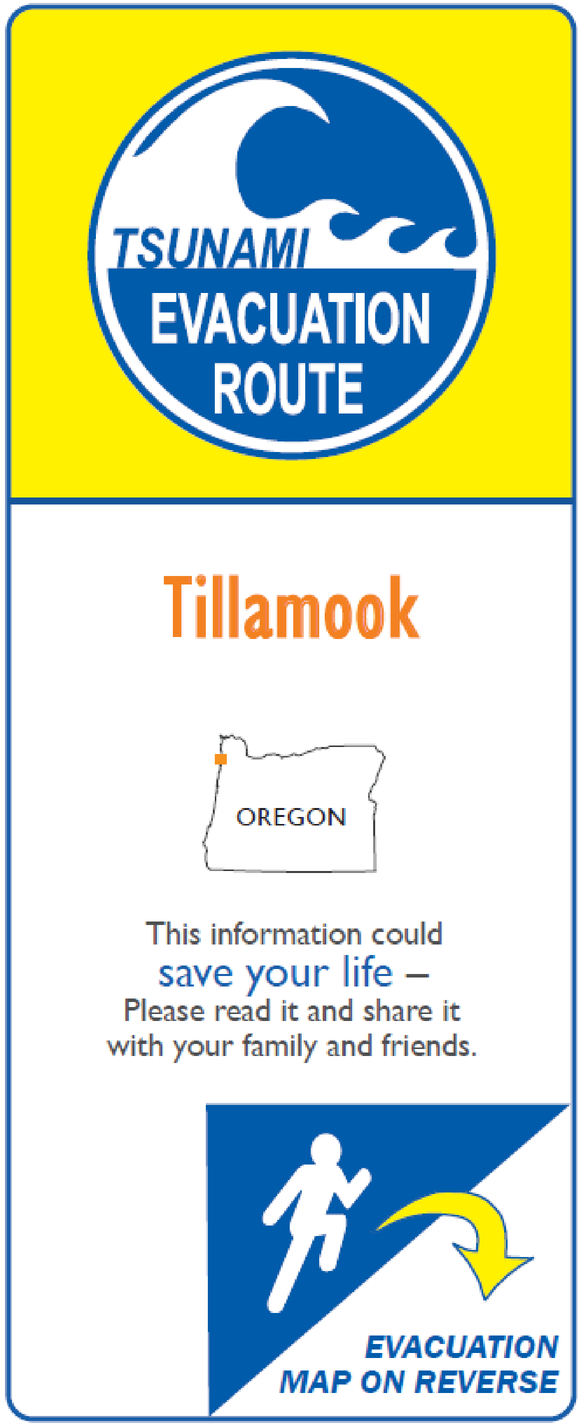
2. Disentangle coastal amenities from tsunami risk: GIS viewshed analysis



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  - Market failure to internalize risk
- Policy challenges
  - Existing efforts to communicate risk have not done enough
  - Some policies have even rolled back efforts, e.g., *HB 3309*
- It may fall on policymakers to more effectively communicate the risk of a Cascadia event

THANK YOU

Oregon State University