Housing Investment, Sea Level Rise, and Climate Change Beliefs

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Abstract

We empirically investigate the association of new U.S. housing investment with local sea level rise risks and the role of climate change beliefs in shaping this relationship. The analysis combines U.S. Census data on housing construction permits with NOAA sea level rise projections and county-level estimates of climate change beliefs (Howe et al., 2015), along with standard controls for housing construction. We find that (i) higher sea level rise vulnerability is associated with significantly lower new housing construction in areas with high climate change beliefs or concern, but that (ii) this relationship is significantly attenuated in more skeptical areas. These results suggest a significant role for climate change skepticism in market adaptation to sea level rise.

1 Introduction

Global sea levels are commonly projected to rise between 1 and 4 feet by the year 2100, posing an existential threat to many coastal areas. In the United States, 3 feet of global sea level rise (SLR) could inundate 13,000 square miles - an area larger than the state of Maryland - and increase flood zone areas by almost 40% (Neumann et al., 2000). Rational adaptation and relocation of economic activity have been shown to be critical for minimizing

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the potential costs of these changes (Desmet et al., 2018). While developers should theoretically adjust housing investment in anticipation of future SLR if agents have homogeneous rational beliefs (Bunten and Kahn, 2017), one salient threat to such anticipatory adaptation is disagreement over climate risks (as also noted by Bunten and Kahn, 2017). Despite its critical importance, the response of new housing construction to SLR risks and the role of climate change beliefs in shaping this response remains an open empirical question. McCoy and Zhang (2018) document that increased flood risk salience in New York after Hurricane Sandy significantly decreased the probability of homeowner investments in *existing* flood zone homes (e.g., kitchen remodeling, roof replacements) that had not been damaged by the storm. They also find that this effect attenuates with distance to storm damages, consistent with a key role of flood salience in shaping the response.[1] We seek to build on these insights by presenting an analysis that focuses both on new housing construction and considers a broader geographical area that includes regions with significant climate change skepticism. A nascent literature has already linked climate skepticism to limited price capitalization of climate risks in existing coastal homes (Bernstein, Gustafson, Lewis, 2018) and agricultural land (Severen, Costello, Deschenes, 2018). Bakkensen and Barrage (2018) also find evidence of household sorting into high flood risk areas in part based on lower flood risk beliefs.[2] Motivated by these findings, this paper thus presents what is to the best of our knowledge a first broad empirical test of the association between new U.S. housing construction, sea level rise risk, and climate change beliefs.

Our analysis combines data on new housing construction permits form the U.S. Census Bureau with sea level rise inundation layers from the National Oceanic and Atmospheric Administration (NOAA) and county-level climate change belief estimates from the Yale Project on Climate Change Communication (Howe, Mildenberger, Maron, and Leiserowitz,

[1] In a national analysis, Bernstein, Gustafson, and Lewis (2018) also initially find a weakly significant negative association between housing upgrades and SLR exposure, but fail to detect a significant effect once recently flooded properties are dropped from the sample.

[2] Kahn and Zhao (2018) moreover present a theoretical framework to analyze the impacts of climate change skeptics in a spatial equilibrium between two cities, finding that skeptics would be expected to lower the price of land in the cooler city less impacted by climate change.

2015). We further include controls for key determinants of housing supply identified by prior studies, such as construction costs (using data from *R.S. Means* following Gyourko and Saiz, 2006) and local employment growth (using a shift-share instrumental predictor as in Quigley and Raphael, 2005), inter alia. The analysis focuses on the U.S. Eastern seaboard and Gulf Coast states during the post-crisis years of 2011-2016. The main results are twofold.

On the one hand, we find a significant *negative* association of sea level rise exposure and new housing development, estimating that construction permits are -0.26% lower for every 1% increase in land at inundation risk. Of course this estimate cannot be interpreted as a ceteris paribus effect and is likely a lower bound (in absolute value, that is, biased towards zero) as SLR risk is positively correlated with both waterfront amenity values and flatter topography, which would be expected to increase new housing development (Saiz, 2010), all else equal. On the other hand, and perhaps more interestingly, we find that this relationship is significantly attenuated by climate change skepticism. The estimated impact of SLR exposure remains negative only in counties in the top quartile of belief that global warming *is happening*, or, alternatively, in the bottom quartile of *lack of concern* about climate change. These results are robust to controlling for potential confounders such as initial land use regulations (Wharton Residential Land Use Index from from Gyourko, Saiz, and Summers, 2008), FEMA flood zones, political preferences (Kahn, 2011), key demographics such as incomes and education, and both state and state-by-year fixed effects that absorb regional variation and shocks to housing construction over the relevant time period.

These results are important both for providing novel broad-scale empirical evidence supporting theoretical predictions and assumptions on housing investment adaptation to sea level rise, but also for adding to nascent empirical evidence that climate change skepticism poses a genuine threat to such adaptation in many markets across the United States.

As a cross-sectional comparison, our analysis is inevitably subject to numerous caveats, and ultimately provides only suggestive evidence of causal relationships. We are also unable to delineate the relative importance of several potential underlying mechanisms, including private builder beliefs, sorting, and local regulations. For example, North Carolina (in)famously passed a law in 2012 restricting state agencies from considering sea level rise projections in coastal planning decisions.[3] While we incorporate a proxy for initial regulatory stringency, we cannot distinguish the additional impact of new building codes and regulations versus the role of builder beliefs. To the extent that such rules reflect local climate change beliefs, however, our reduced-form estimates capture the combination of these impact channels (similar in spirit to, e.g., Kahn's (2011) estimates of the impacts of liberal political ideology on housing supply). While many important questions remain, this paper thus presents among the first empirical evidence on the association of new housing construction with sea level rise risks and climate change beliefs.

The remainder of the paper proceeds as follows. Section 2 describes the data, Section 3 presents the empirical analysis and results, and Section 4 concludes.

2 Data

Following prior studies on housing supply (e.g., Glaeser, Gyourko, and Saiz, 2008), we collect new construction permit data from the U.S. Census to measure (gross) housing investment. Our analysis focuses on the county-year level for coastal states along the U.S. Eastern seaboard and the Gulf of Mexico. Both Pennsylvania and the District of Colombia are also considered as they feature areas that are vulnerable to sea level rise. Our main analysis focuses on cumulative construction of single family homes in each county between 2011 and 2016. We also consider annual and total (i.e., including multi-unit) permit issuance for comparison. Next, we collect standard explanatory variables for housing supply. First, we derive construction cost estimates using *R.S. Means'* square foot cost model, following Gyourko and Saiz (2006). We use the model to compute the construction cost of a representative Ameri-

3 H.B. 819, see, e.g., Schwartz and Fausset, New York Times, September 12, 2018 ("North Carolina, Warned of Rising Seas, Chose to Favor Development").

can home - with characteristics[4] chosen to match median values in the 2011-2015 American Housing Survey - in the second quarter of 2018 for all available cities in our sample states. In order to compute changes in construction costs over time, we match each city to the closest larger city for which *R.S. Means* provides a historical construction cost index. Finally, each county is matched to the nearest city within its state with *R.S. Means* data.[5]

Next, we collect socio-economic controls from the Bureau of Labor Statistics and the U.S. Census. These include employment by county and industry (3-digit NAICS, 2011-2016) data which we use to construct a shift-share instrument for predicted county-level employment growth, following Quigley and Raphael (2005), and also, e.g., Osei and Winters (2018). Specifically, we combine each county's initial (year 2011) employment shares by industry with national employment growth rates by industry from 2011-2016 to construct a shift-share instrumental predictor of each county's employment growth over this time period. Further demographic controls include county populations, age, and education information from the American Community Survey (2012-2016), and annual median household income from the Small Area Income and Poverty Estimates. As additional control variables, we collect maps of special flood hazard areas (as of June 2018) from FEMA, President Trump's 2016 county-level vote shares from Dave Leip's Atlas of U.S. Presidential Elections, and ease-of-building information from the Wharton Residential Land Use Regulation Index (WRLURI), available for the year 2008 at the municipality level from Gyourko, Saiz, and Summers (2008).[6]

We combine these data with geo-spatial sea level rise inundation layers from the National Oceanic and Atmospheric Administration (NOAA). As sea level rise vulnerability measure, we compute the percentage of each county's land area projected to be inundated at two or six feet of SLR, respectively. Finally, we obtain county-level estimates of climate change beliefs

[4] Our representative house features two stories, 1500 square feet area, two full bathrooms, a one-car attached garage, "average" building quality, and default model values for the other variables.

[5] We exclude four island and peninsular counties for which nearest city construction costs are only available from inland locations that are likely to be poor proxies for on-island costs, namely Dukes County, MA; Nantucket County, MA; Accomack County, VA, and Northampton County, VA.

[6] We assign each county in our data containing a municipality with WRLURI data that municipality's index. If a county contains more than one municipality with WRLURI data, a simple average was used.

(for 2013) from Howe, Mildenberger, Maron, and Leiserowitz (2015) from the Yale Project on Climate Change Communication. In order to maintain comparability across studied counties, our preferred sample focuses only on coastal and adjacent counties with SLR vulnerability (defined by positive inundation at six feet). However, we also conduct estimates for all counties in coastal and adjacent vulnerable (Pennsylvania, DC) areas. Table 1 presents key summary statistics.

3 Analysis

Our first specification analyzes cumulative housting stock additions in each vulnerable county j between 2011-2016, $\ln Q_j$, echoing literature specifications such as GGS (2008):

$$\ln Q_j = \beta_0 + \Delta \ln \mathbf{X}_j' \boldsymbol{\gamma} + \mathbf{X}_{j,2011}' \boldsymbol{\lambda} + \beta_1 (SLR_j) + \beta_2 (Beliefs_j) + \beta_3 (SLR_j \cdot Beliefs_j) + \varepsilon_j \quad (1)$$

Here, $\Delta \ln \mathbf{X_j}$ is a vector of the growth rates (changes in the natural logarithm of control variables between 2011 and 2016), and $\mathbf{X}_{j,2011}'$ represents initial or general levels of relevant controls, including state fixed effects for some specifications. In order to avoid overcontrolling the regression, our preferred specification does not include population growth from 2011-2016 in $\Delta \ln \mathbf{X_j}$ due to the endogeneity of migration to vulnerable areas as a potential response margin. However, we confirm that the results are robust to including population growth controls, as shown in Appendix Table A1. Similarly, we control directly for demand shifters such as the employment growth instrument in (1) instead of including prices and estimating a more structural supply model (as in, e.g., Mayer and Somerville, 2000). Our approach is thus more in line with, e.g., Kahn (2011) in adopting a reduced form approach to analyzing the key association of interest, namely how cumulative housing investment varies with sea level rise exposure SLR_j, climate beliefs $Beliefs_j$, and their interaction.

Table 1: Summary Statistics

	Mean	Std.Dev.	Median	Min	Max	N
Coastal and Vulnerable Adj. Counties						
#Permits, 2011-16, Single-Family	3,024	6,524	1,189	0	93,408	298
#Permits, 2011-16, All	3,160	6,704	1,262	0	95,961	298
Annual #Permits, Single-Family	504	1,114	187	0	18,533	1,788
% Inundated at 6ft SLR (SLR^{6ft})	17.8	21.5	10.6	0.0002	98.2	298
% Inundated at 2ft SLR (SLR^{2ft})	13.3	17.2	7.4	0	92.2	298
Population, 2011 ('1000s)	267.1	454.1	97.2	4.3	4,180	298
gPopulation, 2011-2016	2.6	4.8	1.8	-7.2	18.2	298
Construction Costs ($/sqft), 2011	98.3	16.0	92.9	79.1	153.1	294
gConstr.Costs (%), 2011-16	13.0	3.9	11.8	5.2	22.8	294
Med. HH. Income ($1000), 2011	50.5	15.6	46.2	26.3	105.4	298
gMed.HH.Inc (%), 2011-16	11.4	5.3	11.4	-4.7	27.0	298
Shift-Share $g\widehat{Employment}$ (%), 2011-16	9.4	1.7	9.6	-2.9	14.6	298
Land Area (sq.miles)	563	412	491	7.5	3,397	298
FEMA Flood Zone (% of area), 2018	24.4	21.3	17.2	0.0001	99.5	298
WRLURI, 2008	0.22	0.96	.17	-2.15	4.10	162
Trump Vote Share, 2016 (%)	51.8	16.5	54.0	4.1	88.4	298
% Bachelor's	16.0	6.1	15.7	4.3	34.5	298
Median Age	40.6	5.3	40.1	24.4	57.7	298
% Over 62 Years	20.6	5.7	19.2	9.4	42.8	298
Unemployment (%), Annual	7.2	2.3	6.8	2.6	18.8	1,788
Climate Beliefs:						
% "Not Worried"	43.8	7.0	44.6	24.9	59.2	298
% "No Harm to US"	33.0	5.7	33.3	16.9	45.2	298
% "Not Happening"	12.7	3.9	12.5	4.2	23.8	298
% "Happening"	68.5	5.9	68.7	54.7	83.6	298
All Counties in Coastal States & PA, DC						
#Permits, 2011-16, Single-Family	1,793	4,954	306	0	93,408	1,067
% "Not Worried"	46.8	6.6	47.3	24.9	59.3	1,067
Population, 2011 ('1000s)	129.0	291.3	37.67	1.5	4,180	1,067
Med. HH. Income ($1000), 2011	43.5	13.4	40.3	21.0	119.5	1,067
Land Area (sq.miles)	647	514	567	2	6,671	1,067

We first estimate (1) without the SLR_j and $Beliefs_j$ variables, with results presented in Table 2 Column 1. Figure 1 depicts the resulting residuals (z-axis) against each county's sea level rise exposure (x-axis) and the estimated fraction of households "not worried" about climate change (y-axis). The analogous figure using disbelief that climate change is *happening* instead looks very similar and is shown in the Appendix (Figure A1). Several points stand out. First, the strong negative residual at 40% exposure and high worry is New York County, New York. We ensure that this observation is not solely driving our findings by also showing results excluding New York State (Column 4). Second, at various slices of SLR risk, it appears that the residuals are higher, the higher the estimated percentage of unconcerned households. Figure 2 below showcases this pattern by plotting residuals against beliefs separately for "Low" (below-median) and "High" (above-median) SLR exposed counties. While housing investment residuals appear unrelated to climate beliefs in areas with low SLR exposure, in high risk areas, we find a *positive* relationship between new construction residuals and lack of concern about climate change. Third, it is interesting to note that the counties with the highest SLR exposure paradoxically feature only high percentages of lack of climate change concern. This correlation was previously noted by Bernstein, Gustafson, and Lewis (2018), and aligns with the finding of Bakkensen and Barrage (2018) that households sort into high-risk areas based on lower flood risk beliefs.

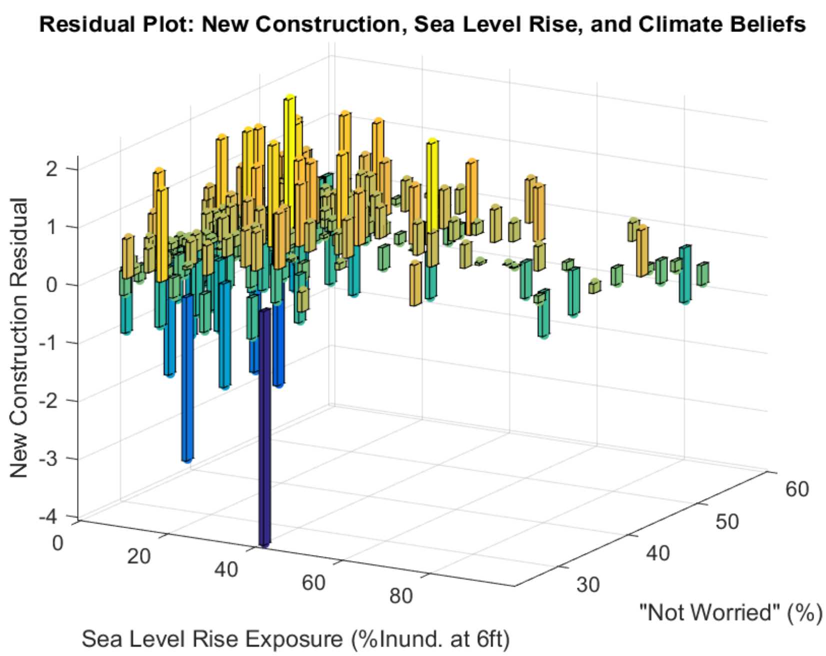

Figure 1

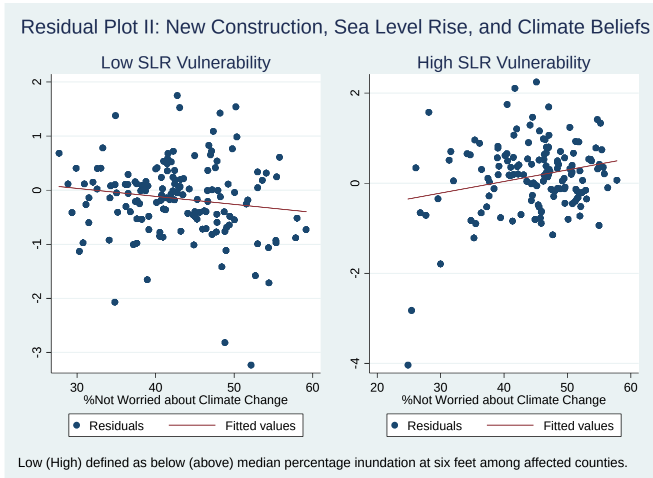

Figure 2

Table 2 presents results for (1) with the estimated percentage "Not worried" as $Beliefs_j$ indicator. Column 2 presents benchmark estimates, Column 3 adds state fixed effects, Column 4 excludes New York, and Column 5 weights observations by initial population.

All specifications show a significant *negative* association between SLR exposure and new housing construction, but a significant *positive* interaction between SLR exposure and a lack of climate change concerns. That is, high risk counties appear to invest relatively more in new housing stock, the less concerned their populations are about climate change. While a hypothetical county with 100% concern about climate change is estimated to have -0.26% less new housing construction for every 1% increase in sea level rise exposure, this response is significantly attenuated by the presence of unconcerned households, ceasing to be negative in estimate once their population share reaches 35%. Given the correlation of SLR exposure with known positive drivers of housing development (e.g., topography, amenity value), it is important to note that a positive *level* estimate of the association between SLR and housing development in our setup could theoretically still be consistent with a true negative ceteris paribus effect. However, the fact that we find systematic *changes* in this association due to variation in climate change beliefs is strongly suggestive of the mechanism that climate skepticism is attenuating the housing investment response to SLR (as beliefs should be orthogonal to topography, and any association of beliefs with amenity valuations via income or state-level unobservables are controlled for in the regression, with further controls for basic demographics added below).

To provide a different perspective on the data, Table 3 presents the same results as Table 2 but using quartile dummies for belief that climate change "is happening" $q_n^{\text{"Is Happening"}}$, $n \in \{1, 2, 3, 4\}$ as $Beliefs_j$ measures. We set $q_1^{\text{"Is Happening"}}$ as omitted category so that the basic coefficient on SLR now measures the estimated impact for counties in the bottom quartile of belief in climate change (i.e., the most skeptical quartile). Once again, the data reveal that the association between SLR exposure and new housing is positive in the most climate skeptical areas (+0.146%), but decreases progressively to (+0.0782) in the second quartile, (+0.038) in the third quartile, and finally becoming negative (-0.004) in the top quartile of belief that climate change is happening.

We now examine the robustness of these results. First, Table 4 considers alternative sample cuts. In order to allow non-linear effects whilst including counties with zero sea level rise exposure, this table presents a quadratic (rather than a logarithmic) specification in SLR. Column (1) shows results for the benchmark sample in this specification, which again yield a negative and significant coefficient on SLR in a hypothetical county with 100% concern about climate change, but a positive and significant interaction between lack of concern and SLR exposure. Column (2) restricts the analysis to coastal counties only. The sample size drops by almost half, and the main coefficients of interest cease to be precisely estimated. We note, however, that using disbelief that climate change is *happening* as $Beliefs_j$ measure again yields a marginally significant positive interaction even in this smaller sample (see Table A4). Columns (3) and (4) expand the sample to include all counties in coastal states, plus Pennsylvania and Washington DC, with and without state fixed effects. The results again show the same pattern as in the benchmark, suggesting a negative baseline association of sea level rise exposure and new housing investment, but that this relationship is attenuated by lack of concern about climate change.

The Appendix presents the following additional robustness checks. First, Table A1 adds controls for population growth 2011-2016, the 2016 Trump vote share, the Wharton Residential Land Use Regulation Index, the share of each county currently in a FEMA special flood hazard area, and select demographics (median age and percentages over 62 years old and with a bachelor's degree, respectively). All specifications continue to show a positive and significant interaction between SLR and %NotWorried. Next, Table A2 presents results for *all* new housing unit permits, including those from multi-family homes. Given the findings of Bernstein, Gustafson, and Lewis (2018) that SLR risk appears to be capitalized (only) in the non-owner occupied housing segment regardless of local climate change beliefs, one might expect the results to be attenuated when including multi-unit buildings in the sample. Indeed, we find that the estimated coefficients are smaller, but still positive and precisely estimated. Table A3 uses an alternative SLR vulnerability measure based on inundation exposure at two feet. Given that SLR^{6ft} and SLR^{2ft} are highly correlated, the results are qualitatively similar. Finally, Table A4 showcases additional results for alternative climate belief measures, including the estimated percentage who believe that "global warming will harm people in the US not at all/only a little" and who "do not think that global warming is happening." Both measures yield the same core results as the benchmark.

Our second specification (2) uses the panel nature of the data to accounts for annual co-variation between new construction with other explanatory variables $\mathbf{X}'_{j,t}$, including year fixed effects δ_t or year-by-state fixed effects $(\delta_t \cdot \gamma_s)$ that flexibly control for aggregate and regional shocks and trends (such as differential recession recovery patterns across state-years).

$$\ln Q_{j,t} = \beta_0 + \gamma_s + \delta_t(\cdot\gamma_s) + \ln \mathbf{X}'_{j,t}\boldsymbol{\lambda} + \beta_1(\ln SLR_j) + \beta_2(Skeptical_j) + \beta_3(SLR_j \cdot Skeptical_j) + \varepsilon_{j,t} \tag{2}$$

Standard errors $\varepsilon_{j,t}$ are now clustered at the county level to allow for correlated shocks within counties. Table 5 presents the results, which again suggest a significant negative elasticity of new housing construction with respect to SLR vulnerability around -0.25 in a hypothetical county with 100% climate change concern, but that this relationship is significantly dampened by lower levels of climate change worry observed in many counties.

Table 2: Benchmark Results: Climate Worry

Dependent Variable: New Single Family Housing Units $\ln Q_{2011-16}$

	(1)	(2)	(3)	(4)	(5)
$\ln Pop_{2011}$	0.872***	0.906***	0.928***	0.973***	0.900***
	(0.0458)	(0.0473)	(0.0480)	(0.0391)	(0.0502)
$\widehat{gEmpl}._{`11-16}$	8.991***	8.956***	8.401***	10.83***	8.701***
	(2.703)	(2.596)	(2.806)	(2.433)	(2.787)
gConstr.Costs$_{`11-16}$	-5.949***	-4.203***	-3.267	-1.993	-4.217***
	(1.368)	(1.408)	(3.136)	(1.304)	(1.435)
lnConstr.Costs$_{2011}$	-5.180***	-4.220***	-4.435***	-2.823***	-4.270***
	(0.613)	(0.652)	(1.706)	(0.514)	(0.662)
gMed.Inc.$_{`11-16}$	0.801	0.577	0.295	1.143	0.463
	(1.008)	(0.913)	(0.832)	(0.883)	(0.907)
lnMed.Inc.$_{2011}$	2.116***	1.769***	1.770***	1.406***	1.762***
	(0.269)	(0.274)	(0.274)	(0.196)	(0.292)
lnArea	0.377***	0.353***	0.361***	0.246***	0.370***
	(0.0711)	(0.0784)	(0.0848)	(0.0655)	(0.0825)
lnSLR^{6ft}		-0.290**	-0.261**	-0.154*	-0.304**
		(0.122)	(0.102)	(0.0860)	(0.130)
%NotWorried		0.00968	0.0163	0.0178*	0.0111
		(0.0103)	(0.0104)	(0.00916)	(0.0106)
%NotWorried·lnSLR^{6ft}		0.00827***	0.00742***	0.00544***	0.00854***
		(0.00268)	(0.00219)	(0.00192)	(0.00285)
Observations	293	293	293	276	293
Adj. R-squared	0.775	0.804	0.830	0.851	0.795
Specification:			State F.E.	Exclude NY	Pop. Weights

Table presents OLS regression results of natural log of sum of single family housing unit permits issued in county j from 2011-16 on indicated control variables plus a constant. The sample is coastal and adjacent counties along the U.S. Eastern seaboard and Gulf Coast with non-zero land inundation risk from 6 feet of sea level rise. Col. (3) adds state fixed effects, Col. (4) excludes all New York state counties, and Col. (5) weights observations by year 2011 county populations. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Benchmark Results: Climate Change Belief

Dependent Variable: New Single Family Housing Units $\ln Q_{2011-16}$

	(1)	(2)	(3)	(4)	(5)
lnPop_{2011}	0.872***	0.880***	0.888***	0.959***	0.865***
	(0.0458)	(0.0498)	(0.0502)	(0.0373)	(0.0535)
$\widehat{gEmpl}._{11-16}$	8.991***	9.364***	9.148***	11.15***	9.077***
	(2.703)	(2.649)	(2.880)	(2.337)	(2.837)
$g\text{Constr.Costs}._{11-16}$	-5.949***	-4.988***	-2.617	-2.579**	-5.048***
	(1.368)	(1.429)	(3.079)	(1.251)	(1.472)
$\text{lnConstr.Costs}_{2011}$	-5.180***	-4.599***	-5.019***	-3.084***	-4.674***
	(0.613)	(0.674)	(1.703)	(0.491)	(0.680)
$g\text{Med.Inc.}_{11-16}$	0.801	0.483	0.314	1.084	0.416
	(1.008)	(0.889)	(0.830)	(0.864)	(0.886)
lnMed.Inc._{2011}	2.116***	1.893***	2.039***	1.487***	1.902***
	(0.269)	(0.286)	(0.270)	(0.198)	(0.303)
lnArea	0.377***	0.378***	0.368***	0.246***	0.403***
	(0.0711)	(0.0816)	(0.0863)	(0.0621)	(0.0874)
Coastal County (=1)		0.0804	0.0649	0.197**	0.0567
		(0.108)	(0.117)	(0.0966)	(0.111)
lnSLR^{6ft}		0.146***	0.124***	0.130***	0.149***
		(0.0336)	(0.0250)	(0.0335)	(0.0343)
$q_2^{\text{"Is Happening"}} \cdot \text{lnSLR}^{6ft}$		-0.0678*	-0.0426	-0.0607	-0.0671
		(0.0401)	(0.0369)	(0.0404)	(0.0409)
$q_3^{\text{"Is Happening"}} \cdot \text{lnSLR}^{6ft}$		-0.108***	-0.0897***	-0.108***	-0.110***
		(0.0381)	(0.0324)	(0.0384)	(0.0395)
$q_4^{\text{"Is Happening"}} \cdot \text{lnSLR}^{6ft}$		-0.150***	-0.120***	-0.109***	-0.153***
		(0.0509)	(0.0418)	(0.0409)	(0.0520)
$q_2^{\text{"Is Happening"}}$		0.243*	0.197	0.130	0.252*
		(0.144)	(0.152)	(0.135)	(0.146)
$q_3^{\text{"Is Happening"}}$		0.411***	0.363**	0.227	0.433***
		(0.158)	(0.156)	(0.141)	(0.164)
$q_4^{\text{"Is Happening"}}$		0.0291	-0.0164	-0.249	0.0545
		(0.206)	(0.194)	(0.169)	(0.214)
Observations	293	293	293	276	293
Adj. R-squared	0.775	0.807	0.830	0.858	0.797
Specification:			State F.E.	Exclude NY	Pop. Weights

Table presents OLS regression results of natural log of sum of single family housing unit permits issued in county j from 2011-16 on indicated control variables plus a constant. The sample is coastal and adjacent counties along the U.S. Eastern seaboard and Gulf Coast with non-zero land inundation risk from 6 feet of sea level rise. Col. (3) adds state fixed effects, Col. (4) excludes all New York state counties, and Col. (5) weights observations by year 2011 county populations. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4: Alternative Sample Cuts

Dependent Variable: New Single Family Housing Units $\ln Q_{2011-16}$				
	(1)	(2)	(3)	(4)
$\ln\text{Pop}_{2011}$	0.914***	0.853***	1.188***	1.135***
	(0.0475)	(0.0633)	(0.0321)	(0.0317)
$\widehat{gEmpl.}_{`11-16}$	9.212***	8.618***	6.913***	3.870***
	(2.640)	(3.295)	(1.474)	(1.316)
$g\text{Costs}_{`11-16}$	-4.514***	-2.658	1.247	-1.050
	(1.447)	(1.856)	(0.966)	(2.015)
$\ln\text{Costs}_{2011}$	-4.164***	-3.869***	-3.512***	-5.615***
	(0.626)	(0.804)	(0.446)	(1.007)
$g\text{Med.Inc.}_{`11-16}$	0.393	-0.555	1.331**	1.764***
	(0.925)	(1.104)	(0.590)	(0.526)
$\ln\text{Med.Inc.}_{2011}$	1.768***	1.768***	2.197***	2.481***
	(0.260)	(0.363)	(0.157)	(0.171)
lnArea	0.333***	0.459***	0.0235	0.214***
	(0.0733)	(0.106)	(0.0369)	(0.0377)
SLR^{6ft}	-0.158***	-0.0920	-0.343***	-0.257***
	(0.0559)	(0.0813)	(0.0577)	(0.0495)
$(\text{SLR}^{6ft})^2$	0.00187***	0.00117	0.00435***	0.00322***
	(0.000626)	(0.000823)	(0.000736)	(0.000635)
%NotWorried	-0.0148	0.0108	-0.0193***	-0.0239***
	(0.0157)	(0.0289)	(0.00641)	(0.00637)
$\%\text{NotWorried}\cdot\text{SLR}^{6ft}$	0.00405***	0.00224	0.00809***	0.00605***
	(0.00121)	(0.00181)	(0.00123)	(0.00105)
$\%\text{NotWorried}\cdot(\text{SLR}^{6ft})^2$	-4.72e-05***	-2.87e-05	-9.99e-05***	-7.48e-05***
	(1.33e-05)	(1.80e-05)	(1.56e-05)	(1.34e-05)
Observations	293	174	1,036	1,036
Adj. R-squared	0.802	0.778	0.764	0.815
Sample	Coastal & Adj. Counties	Only Coastal Counties	All in Coastal States & PA,DC	All in Coastal States & PA,DC
State Fixed Effects:				✓

Table presents OLS regression results of natural log of sum of single family housing unit permits issued in county j from 2011-16 on indicated control variables plus a constant. The samples are coastal and adjacent vulnerable (to 6 feet of SLR) counties along the Eastern U.S. seaboard and Gulf Coast in Col. (1), only coastal counties on Col. (2), and all counties in coastal states plus PA and DC which have SLR vulnerable areas in Cols. (3)-(4). Column (4) adds state fixed effects. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: Panel Analysis

Dep. Var.: New Single Family Housing Units $\ln Q_{j,t}$			
	(1)	(2)	(3)
$\text{lnPopulation}_{j,t}$	0.892***	0.960***	0.963***
	(0.0406)	(0.0453)	(0.0463)
$\text{lnConstr.Cost}_{j,t}$	-4.884***	-3.785***	-4.167***
	(1.365)	(1.310)	(1.544)
$\text{lnMed.HH.Income}_{j,t}$	2.243***	1.679***	1.767***
	(0.253)	(0.271)	(0.295)
$\%\text{Unemployed}_{j,t}$	0.00174	-0.00443	0.0131
	(0.0327)	(0.0293)	(0.0364)
lnArea_j	0.373***	0.355***	0.351***
	(0.0824)	(0.0861)	(0.0880)
lnSLR_j^{6ft}		-0.253**	-0.248**
		(0.104)	(0.106)
$\%\text{NotWorried}_j$		0.0225**	0.0223**
		(0.0105)	(0.0108)
$\%\text{NotWorried}_j \cdot \text{lnSLR}_j^{6ft}$		0.00715***	0.00704***
		(0.00223)	(0.00228)
Observations	1,745	1,745	1,745
Adj. R-squared	0.783	0.807	0.800
#Clusters (County)	293	293	293
State F.E.	✓	✓	
Year F.E.	✓	✓	
State*Year F.E.			✓

Table presents OLS regression results of natural log of number of single family housing unit permits issued in county j in year t on the indicated control variables, a constant, plus state and year fixed effects (Cols. 1-2) or state-by-year fixed effects (Col. 3). The sample is coastal and adjacent counties along the U.S. Eastern seaboard and Gulf Coast with non-zero land inundation risk from 6 feet sea level rise. Standard errors are heteroskedasticity robust and clustered at the county level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

4 Conclusion

Verbal expressions of climate change skepticism abound in the United States public sphere, ranging from households' survey responses to snowball demonstrations in Congress[7] and reported bans of the term "climate change" among, e.g., Florida Department of Environmental

[7] In 2015, Senator Jim Inhofe brought a snowball on to the Senate floor in an effort to argue against climate science (see, e.g., February 26th 2015 Washington Post article "Jim Inhofe's snowball has disproven climate change once and for all" by Philip Bump).

Protection employees.[8] Whether these stated preferences serve as predictors of agent *behavior* remains an open question. For example, President Donald Trump has been widely noted for denouncing climate change as a "hoax" while working to build a sea wall to protect one of his golf resorts from its effects.[9] This question of stated versus revealed preferences is critically important for our understanding and modeling of the economic impacts of climate change. With rational foresight, adaptive investment and relocation of economic activity can decrease the costs of sea level rise by orders of magnitude (Desmet et al., 2018). With heterogeneity in beliefs, however, prices may not reflect future risks (Bernstein, Gustafson, and Lewis, 2018; Bakkensen and Barrage, 2018), thus potentially hampering market incentives for efficient adaptation. This paper presents what is to the best of our knowledge a first broad empirical test of whether new U.S. housing investment appears to respond to sea level rise vulnerability, and how this response is shaped by local climate change beliefs. We combine U.S. Census data on construction permits with NOAA sea level rise inundation layers and climate belief estimates from Howe et al. (2015) in order to analyze this issue empirically. Focusing on the Eastern U.S. seaboard and Gulf Coast areas during the post-crisis years of 2011-2016, we find a significant *negative* association of sea level rise vulnerability and new housing construction, but only for areas with the highest levels of climate change beliefs or concern. For areas with more skepticism, we find a robustly significant positive interaction between lack of belief and sea level rise vulnerability. These results highlight the real potential of climate change skepticism to undermine efficient housing market adaptation to sea level rise in many markets across the United States.

[8] See, e.g., Miami Herald's March 8th 2015 article "In Florida, officials ban term 'climate change'" by Tristam Korten.

[9] See, e.g., Politico's May 23rd 2016 article "Trump acknowledges climate change — at his golf course" by Ben Schreckinger.

References

[1] Bakkensen, Laura, and Lint Barrage (2018) "Flood Risk Belief Heterogeneity and Coastal Home Price Dynamics: Going Under Water?" *National Bureau of Economic Research WP No. 23854.*

[2] Bernstein, Asaf, Matthew Gustafson, and Ryan Lewis (2018) "Disaster on the horizon: The price effect of sea level rise." Forthcoming, *Journal of Financial Economics.*

[3] Bunten, Devin, and Matthew E. Kahn (2017) "Optimal real estate capital durability and localized climate change disaster risk." *Journal of Housing Economics* 36 (2017): 1-7.

[4] Desmet, Klaus, Robert E. Kopp, Scott A. Kulp, Dávid Krisztián Nagy, Michael Oppenheimer, Esteban Rossi-Hansberg, and Benjamin H. Strauss (2018) "Evaluating the Economic Cost of Coastal Flooding." *National Bureau of Economic Research WP No. 24918.*

[5] Glaeser, Edward L., Joseph Gyourko, and Albert Saiz (2008) "Housing supply and housing bubbles." *Journal of Urban Economics,* 64: 198-217.

[6] Gyourko, Joseph, and Albert Saiz (2006) "Construction costs and the supply of housing structure." *Journal of Regional Science*, 46(4): 661-680.

[7] Gyourko, Joseph, Albert Saiz, and Anita Summers (2008) "A new measure of the local regulatory environment for housing markets: The Wharton Residential Land Use Regulatory Index." *Urban Studies* 45(3): 693-729.

[8] Howe, Peter D., Matto Mildenberger, Jennifer R. Marlon, and Anthony Leiserowitz (2015) "Geographic variation in opinions on climate change at state and local scales in the USA." *Nature Climate Change*, doi:10.1038/nclimate2583.

[9] Kahn, Matthew E. (2011) "Do liberal cities limit new housing development? Evidence from California." *Journal of Urban Economics*, 69(2): 223-228.

[10] Kahn, Matthew E., and Daxuan Zhao. "The impact of climate change skepticism on adaptation in a market economy." Research in Economics 72, no. 2 (2018): 251-262.

[11] Mayer, Christopher J., and C. Tsuriel Somerville. "Residential construction: Using the urban growth model to estimate housing supply." *Journal of Urban Economics* 48, no. 1 (2000): 85-109.

[12] McCoy, Shawn J., and Xiaoxi Zhao (2018) "A City under Water: A Geospatial Analysis of Storm Damage, Changing Risk Perceptions, and Investment in Residential Housing." *Journal of the Association of Environmental and Resource Economists*, 5(2): 301-330.

[13] Neumann, J. E. (2000). "Sea-level rise & Global climate change: A review of Impacts to US Coasts (Vol. 4)." *Pew Center on Global Climate Change.*

[14] Osei, Michael J., and John V. Winters (2018) "Labor Demand Shocks and Housing Prices across the US: Does One Size Fit All?" *IZA DP No. 11636*.

[15] Quigley, John M., and Steven Raphael (2005) "Regulation and the high cost of housing in California." *American Economic Review*, 95(2): 323-328.

[16] Saiz, Albert (2010) "The geographic determinants of housing supply." *The Quarterly Journal of Economics* 125(3): 1253-1296.

[17] Severen, Christopher, Christopher Costello, and Olivier Deschenes (2018) "A Forward-Looking Ricardian Approach: Do land markets capitalize climate change forecasts?" J*ournal of Environmental Economics and Management,* 89: 235-254.

5 Appendix

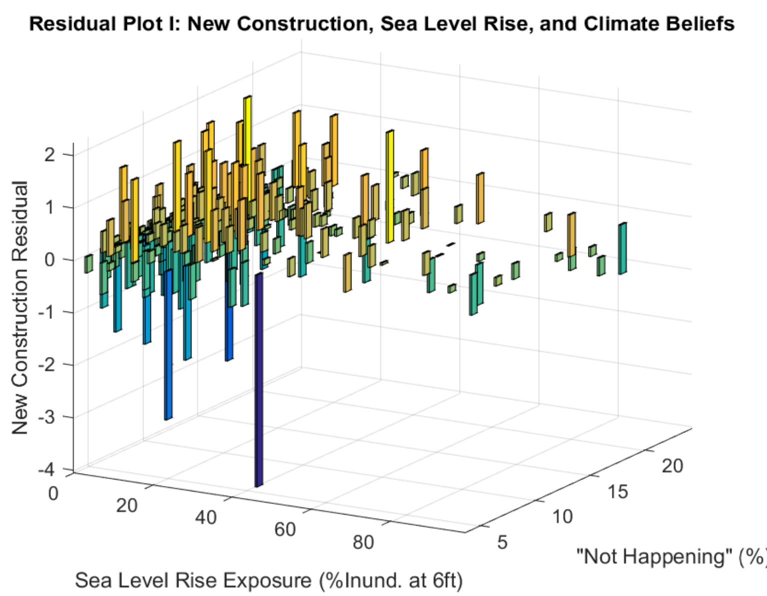

Figure A1

Table A1: Additional Controls

Dependent Variable: New Single Family Housing Units $\ln Q_{2011-16}$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\ln SLR^{6ft}$	-0.290**	-0.255**	-0.292**	-0.297**	-0.907***	-0.289**	-0.268**	-0.794***
	(0.122)	(0.117)	(0.122)	(0.124)	(0.249)	(0.122)	(0.124)	(0.246)
%NotWorried	0.00968	-0.00302	0.0107	-0.00786	-0.00911	0.0106	0.0139	-0.0195
	(0.0103)	(0.00924)	(0.0103)	(0.0186)	(0.0171)	(0.0103)	(0.0107)	(0.0261)
%NotWorried$\cdot \ln SLR^{6ft}$	0.00827***	0.00719***	0.00838***	0.00838***	0.0236***	0.00835***	0.00760***	0.0204***
	(0.00268)	(0.00262)	(0.00270)	(0.00271)	(0.00579)	(0.00269)	(0.00272)	(0.00575)
$g\text{Pop}_{'11-16}$		8.742***						8.003***
		(1.281)						(1.862)
%FEMA Floodzone_{2018}			-0.00160					
			(0.00213)					
$\text{Trump\%}_{2016}$				0.819				-0.0814
				(0.668)				(1.081)
WRLURI_{2008}					0.162**			0.156**
					(0.0642)			(0.0657)
$\text{Med.Age}_{'12-16}$							-0.0552**	-0.0188
							(0.0240)	(0.0417)
Over $62(\%)_{'12-16}$							0.0664***	0.0317
							(0.0222)	(0.0386)
$\text{Bachelor}(\%)_{'12-16}$							0.0301*	0.00147
							(0.0161)	(0.0265)
Observations	293	293	293	293	159	293	293	159
Adj.R-squared	0.804	0.837	0.803	0.804	0.778	0.803	0.814	0.808

Table presents OLS regression results of natural log of sum of single family housing permits issued in county j from 2011-2016 on indicated control variables plus a constant. The sample is coastal and adjacent counties along the U.S. Eastern seaboard and Gulf Coast with non-zero land inundation risk from 6 feet of sea level rise. WRLURI_{2008} denotes Wharton Residential Land Use Regulation Index. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A2: All New Housing Units

Dependent Variable: All New Housing Units $\ln \widetilde{Q}_{2011-16}$					
	(1)	(2)	(3)	(4)	(5)
$\ln\text{Pop}_{2011}$	0.930***	0.969***	0.975***	0.928***	0.987***
	(0.0384)	(0.0380)	(0.0425)	(0.0474)	(0.0383)
$\widehat{gEmp}_{`11-16}$	9.993***	9.784***	8.994***	8.893***	10.55***
	(2.508)	(2.328)	(2.460)	(2.577)	(2.399)
$g\text{Costs}_{`11-16}$	-4.538***	-2.752**	-1.354	-0.588	-1.655
	(1.275)	(1.248)	(2.834)	(1.560)	(1.285)
$\ln\text{Costs}_{2011}$	-4.100***	-3.158***	-1.716	-2.616***	-2.560***
	(0.406)	(0.457)	(1.246)	(0.592)	(0.493)
$g\text{Med.Inc.}_{`11-16}$	1.464*	1.216	0.844	1.027	1.399
	(0.788)	(0.849)	(0.803)	(0.913)	(0.865)
$\ln\text{Med.Inc.}_{2011}$	1.665***	1.345***	1.351***	1.210***	1.326***
	(0.178)	(0.178)	(0.200)	(0.208)	(0.194)
lnArea	0.274***	0.249***	0.257***	0.288***	0.226***
	(0.0454)	(0.0615)	(0.0714)	(0.0721)	(0.0646)
$\ln\text{SLR}^{6ft}$		-0.203**	-0.197**	0.307	-0.136*
		(0.0899)	(0.0800)	(0.405)	(0.0814)
%NotWorried		0.0138	0.0194**	0.0580*	0.0163*
		(0.00908)	(0.00945)	(0.0320)	(0.00901)
$\%\text{NotWorried}\cdot\ln\text{SLR}^{6ft}$		0.00644***	0.00608***	-0.00705	0.00504***
		(0.00203)	(0.00172)	(0.00959)	(0.00183)
Observations	293	293	293	174	276
Adj. R-squared	0.815	0.845	0.862	0.833	0.857
Sample:	Coastal & Adj. Counties	Coastal & Adj. Counties	Coastal & Adj. Counties	Only Coastal Counties	Exclude New York
State F.E.:			✓		

Table presents OLS regression results of natural log of sum of all housing unit permits issued in county j from 2011-2016 on indicated control variables plus a constant. The sample in Cols. (1)-(3) is coastal and adjacent counties along the U.S. Eastern seaboard and Gulf Coast with non-zero land inundation risk from 6 feet of sea level rise. Col. (3) adds state fixed effects. Col. (4) restricts sample to coastal counties. Col. (5) excludes New York state. Robust S.E.s in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A3: 2-Feet Sea Level Rise

Dependent Variable: New Single Family Housing Units $\ln Q_{2011-16}$				
	(1)	(2)	(3)	(4)
$\ln\text{Pop}_{2011}$	0.867***	0.907***	0.927***	0.973***
	(0.0462)	(0.0475)	(0.0485)	(0.0397)
$\widehat{gEmp}_{`11-16}$ (shift-share)	8.923***	8.534***	8.049***	10.47***
	(2.748)	(2.666)	(2.869)	(2.492)
$g\text{Costs}_{`11-16}$	-6.100***	-4.195***	-3.588	-2.015
	(1.372)	(1.400)	(3.150)	(1.308)
$\ln\text{Costs}_{2011}$	-5.181***	-4.237***	-4.434***	-2.853***
	(0.615)	(0.647)	(1.702)	(0.515)
$g\text{Med.Inc.}_{`11-16}$	0.826	0.452	0.190	1.074
	(1.029)	(0.930)	(0.850)	(0.904)
$\ln\text{Med.Inc.}_{2011}$	2.083***	1.766***	1.773***	1.417***
	(0.271)	(0.271)	(0.274)	(0.197)
lnArea	0.379***	0.354***	0.364***	0.248***
	(0.0711)	(0.0787)	(0.0857)	(0.0666)
$\ln\text{SLR}^{2ft}$		-0.283**	-0.235**	-0.0983
		(0.137)	(0.109)	(0.0901)
%NotWorried		0.0127	0.0196*	0.0209**
		(0.0108)	(0.0108)	(0.00972)
$\%\text{NotWorried}\cdot\ln\text{SLR}^{2ft}$		0.00813***	0.00687***	0.00424**
		(0.00304)	(0.00236)	(0.00208)
Observations	289	289	289	272
Adj. R-squared	0.772	0.799	0.826	0.847
State Fixed Effects:			✓	
Exclude New York:				✓

Table presents OLS regression results of natural log of sum of single family housing permits issued in county j from 2011-2016 on indicated control variables plus a constant. The sample is coastal and adjacent counties along the U.S. Eastern seaboard and Gulf Coast with non-zero land inundation risk from 2 feet of sea level rise. Column (4) excludes New York state. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A4: Alternative Belief Measures

Dependent Variable: New Single Family Housing Units $\ln Q_{2011-16}$

	(1)	(2)	(3)	(4)	(5)	(6)
Beliefs Measure: (%)	"Not Worried"	"No US Harm"	"Not Happening"	"Not Happening"	"Not Happening"	"Not Happening"
$\ln SLR^{6ft}$	-0.290**	-0.125	-0.0505	-0.0219		
	(0.122)	(0.0795)	(0.0488)	(0.0548)		
Beliefs	0.00968	0.0266***	0.0203	0.0332	-0.0393***	-0.0335***
	(0.0103)	(0.00900)	(0.0148)	(0.0206)	(0.00968)	(0.00869)
Beliefs$\cdot \ln SLR^{6ft}$	0.00827***	0.00619***	0.0102***	0.00672*		
	(0.00268)	(0.00221)	(0.00355)	(0.00374)		
SLR^{6ft} (%)					-0.125***	-0.100***
					(0.0291)	(0.0237)
$(SLR^{6ft})^2$					0.00164***	0.00127***
					(0.000364)	(0.000298)
Beliefs$\cdot SLR^{6ft}$					0.0110***	0.00872***
					(0.00197)	(0.00163)
Beliefs$\cdot (SLR^{6ft})^2$					-0.000135***	-0.000107***
					(2.44e-05)	(2.01e-05)
Observations	293	293	293	119	1,036	1,036
Adj.R-squared		0.804	0.801	0.849	0.759	0.813
Sample:	Coastal & Adj. Counties	Coastal & Adj. Counties	Coastal & Adj. Counties	Only Coastal Counties	All Counties in Coastal States	All Counties in Coastal States
State F.E.						✓

Table presents OLS regression results of natural log of sum of single family housing permits issued in county j from 2011-2016 on indicated control variables plus a constant. Sample in Cols. (1)-(3) is coastal and adjacent counties along the U.S. Eastern seaboard and Gulf Coast with non-zero land inundation risk from 6 feet of sea level rise. Col. (4) considers coastal counties only. Cols. (5)-(6) consider all coastal state, PA, and DC counties. The Beliefs variables are estimated percentages "not very/not at all worried about global warming" in Col. (1), "who think global warming will harm people in the US not at all/only a little" in Col. (2), and "who do not think that global warming is happening" in Cols. (3)-(6). Robust S.E.s in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.