Leveraging the Disagreement on Climate Change

Theory and Evidence

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Big picture

- How do climate risks affect financial system?
    - Topic of a rapidly growing climate finance literature.
    - Relevant for financial regulators.
- Particularly relevant: How do climate risks affect housing & mortgage market?
    - What do we know so far? Mostly on housing prices.
    - Much less is known about how climate risks affect mortgage market.

This paper: 1. New stylized facts

- Purchases of homes more exposed to sea level rise (SLR) are
  - More likely to be leveraged ← extensive margin
  - More likely to use mortgage contracts with longer maturity (more exposure to long-run climate risk) ← intensive margin
  - Despite exposed properties having lower prices.
- Results are driven by (likely) more pessimistic homebuyers.
  - Buyers from counties with stronger concern about climate change, according to survey.
  - Buyers with stronger climate concern, as inferred by transaction's pricing of SLR risk.

This paper: 2. Theory

- To understand these facts, need a new model of credit market with belief disagreement.
  - Standard models predict optimists (not pessimists) leverage more; silent on maturity.
- We propose one. Key additions: endogenous maturity choice & competitive search.
  - Intuition: Pessimists can hedge against long-run climate risk with defaultable long-term mortgage.
- Implications: Monetary & securitization policies have (unintended) effects on debt market's climate exposure.
  - Test these implications in our data.

Related literature

- Empirical climate finance
  - Pricing of climate risk: Bernstein Gustafson Lewis JFE 2019, Baldauf Garlappi Yannelis RFS 2020, Murfin Spiegel RFS 2020, Bakkensen Barrage RFS 2021, Hino Burke PNAS 2021, Giglio Maggiori Rao Stroebel Weber RFS 2021...
  - Climate risk in mortgage market: Keys Mulder 2020, Issler et al 2020, Ouazad Kahn RFS 2021, Liao Mulder 2021, Sastry 2022
  - Surveys: Hong Karolyi Scheinkman RFS 2020, Giglio Kelly Stroebel 2021, Furukawa Ichiue Shiraki 2021, 5th National Climate Assessment
  - First to study how climate risk $\times$ belief disagreement affects debt market
- Theory
  - Credit markets with heterogeneous beliefs: Geanakoplos NBERma 2010, Fostel Geanakoplos AER 2008, ECT 2015, Simsek ECTA 2013, Bailey Dávila Kuchler Stroebel Restud 2019...
  - First to apply and evaluate theory in climate context

Stylized model

One-page summary

Mortgage search

Homebuyer chooses optimal mortgage contract; maturity is an endogenous choice.

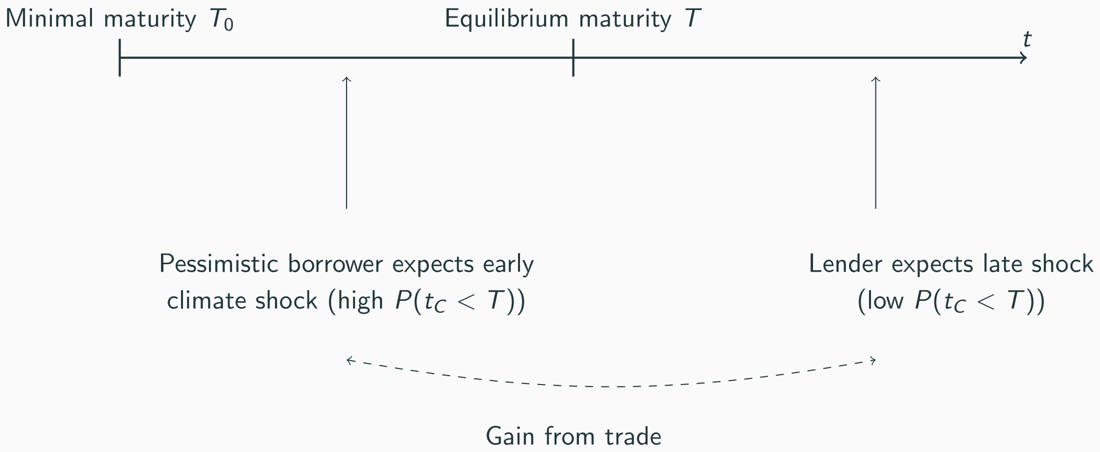
Competitive search determines approval rate.

Borrower can default at any $t_{def} \leq T$:
- Lose house + face default cost.

Climate shock
- Can trigger default
- Disagreement over arrival rate

t_C t

Intuition


Minimal maturity T_0
Equilibrium maturity T
t
Pessimistic borrower expects early climate shock (high $P(t_C < T)$)
Lender expects late shock (low $P(t_C < T)$)
Gain from trade

Testable implications

	Pessimistic buyer ($\lambda > \lambda_b$) & exposed property ($D > \bar{\lambda} F_{def}$)	Otherwise
Leverage probability	high	low
Maturity	long	short

Data

Data

- Extensive housing & mortgage transaction data from Corelogic (2001-2016).
    - Single-family homes within 1km from East Coast (>1m transactions).
- Property-level geophysical measures.
    - Whether inundated under various sea level rise scenarios (from ▸ NOAA SLR shapefiles).
    - Distance to coast (ArcGIS) & minimum bare-earth elevation (First Street).
- County-level climate belief proxy: % of adults saying whether global warming is happening (Yale climate opinion survey 2014).
    - Assumption: a buyer from a county with more pessimistic belief is more likely to be have a pessimistic belief herself.
    - Potential ▸ selection bias.
- ▸ Summary statistics

Identification: exploits high resolution variation in SLR risk exposure

Example: Miami inundation map under 3ft SLR scenario. Comparing properties using ZIP×Distance×Elevation×House Size×Time fixed effect (Bernstein et al 2019).

Results

Result 1: Climate-Leverage relationship

	Leveraged==1
SLR Risk	-0.093***
	(0.008)
Controls (property, sale price, buyer cty)	Y
Z x D x E x B x T fe	
Buyer county controls × SLR Risk	
N	1580756
R2	0.019

"Naiive" regression (no fixed effects)

Result 1: Climate-Leverage relationship

	Leveraged==1	
SLR Risk	-0.093***	0.021***
	(0.008)	(0.007)
Controls (property, sale price, buyer cty)	Y	Y
Z x D x E x B x T fe		Y
Buyer county controls × SLR Risk		
N	1580756	405893
R2	0.019	0.473

Result 1: Climate-Leverage relationship

	Leveraged==1	
SLR Risk	-0.093***	0.021***
	(0.008)	(0.007)

Purchases of exposed homes are 2% more likely to be leveraged (extensive margin)

Comparison: Share of leveraged transactions increase by ∼4% bt 2001-2007 in our sample

Controls (property, sale price, buyer cty)	Y	Y
Z x D x E x B x T fe		Y
Buyer county controls × SLR Risk		
N	1580756	405893
R2	0.019	0.473

Result 1: Climate-Leverage relationship

	Leveraged==1		
SLR Risk	-0.093***	0.021***	-0.004
	(0.008)	(0.007)	(0.007)
SLR Risk × Pessi. Buyer			0.047***
			(0.009)
Controls (property, sale price, buyer cty)	Y	Y	Y
Z x D x E x B x T fe		Y	Y
Buyer county controls × SLR Risk			
N	1580756	405893	405893
R2	0.019	0.473	0.473

Relationship is driven by transactions with (likely) pessimistic buyers

Result 1: Climate-Leverage relationship

	Leveraged==1			
SLR Risk	-0.093***	0.021***	-0.004	-0.003
	(0.008)	(0.007)	(0.007)	(0.014)
SLR Risk × Pessi. Buyer			0.047***	0.034***
			(0.009)	(0.011)
Controls (property, sale price, buyer cty)	Y	Y	Y	Y
Z x D x E x B x T fe		Y	Y	Y
Buyer county controls × SLR Risk				Y
N	1580756	405893	405893	405893
R2	0.019	0.473	0.473	0.473

Relationship is driven by transactions with (likely) pessimistic buyers

Result 1: Climate-Leverage relationship

	Leveraged==1				
SLR Risk	-0.093***	0.021***	-0.004	-0.003	
	(0.008)	(0.007)	(0.007)	(0.014)	
SLR Risk × Pessi. Buyer			0.047***	0.034***	
			(0.009)	(0.011)	
Moderate SLR Risk					0.003
					(0.014)
High SLR Risk					-0.035
					(0.031)
Moderate SLR Risk × Pessi. Buyer					0.026**
(inundated at $(3, 6]$ft SLR)			Note monotonicity		(0.011)
High SLR Risk × Pessi. Buyer					0.083***
(inundated at $\leq$ 3ft SLR)					(0.023)
Controls (property, sale price, buyer cty)	Y	Y	Y	Y	Y
Z x D x E x B x T fe		Y	Y	Y	Y
Buyer county controls × SLR Risk				Y	Y
N	1580756	405893	405893	405893	405893
R2	0.019	0.473	0.473	0.473	0.473

Result 2: Climate-Maturity relationship

	Long Maturity==1				
SLR Risk	-0.019***	0.005	-0.004	0.002	
	(0.002)	(0.005)	(0.007)	(0.014)	
SLR Risk × Pessi. Buyer			0.018***	0.024***	
			(0.007)	(0.007)	
Moderate SLR Risk					0.006
					(0.014)
High SLR Risk					-0.028
					(0.024)
Moderate SLR Risk × Pessi. Buyer					0.023***
					(0.008)
High SLR Risk × Pessi. Buyer					0.031*
					(0.019)
Controls (property, sale price, buyer cty)	Y	Y	Y	Y	Y
Z × D × E × B × T fe		Y	Y	Y	Y
Lender fe		Y	Y	Y	Y
Buyer county controls × SLR Risk				Y	Y
N	822890	150746	150746	150746	150746
R2	0.002	0.441	0.441	0.441	0.441

Result 2: Climate-Maturity relationship

	Long Maturity==1				
SLR Risk	-0.019***	0.005	-0.004	0.002	
	(0.002)	(0.005)	(0.007)	(0.014)	
SLR Risk × Pessi. Buyer			0.018***	0.024***	
			(0.007)	(0.007)	
					0.006
					(0.014)
					-0.028
					(0.024)
					0.023***
					(0.008)
					0.031*
					(0.019)
Controls (property, sale price, buyer cty)	Y	Y	Y	Y	Y
Z × D × E × B × T fe		Y	Y	Y	Y
Lender fe		Y	Y	Y	Y
Buyer county controls × SLR Risk				Y	Y
N	822890	150746	150746	150746	150746
R2	0.002	0.441	0.441	0.441	0.441

Purchases of exposed home by more pessimistic buyers tend to have longer maturity (intensive margin)

Robustness checks

- Other belief specifications:
    - Finer bins of climate beliefs + Other survey questions. ▸ Details
    - Alternative survey data: Gallup. ▸ Details
- Other fixed effect specifications. ▸ Details
    - Including investment-property (i.e., non-owner-occupied) fixed effect.
- Finer bins of SLR exposure. ▸ Details
- Potential confounders: More buyer county controls (income, pop, edu, age, race, unemp rate, housing starts, crime). ▸ Details
- FEMA flood map, past flood events ▸ Details

Diving Deeper

Selection bias

- Concern: our sample of coastal homebuyers is biased. Reason: optimists more likely to select/sort towards coastal properties. Thus, county-level belief is a biased proxy for individual-level buyer belief.
- One approach: Infer buyer belief from each transaction. ▸ Details
  - Idea: a transaction's capitalization of SLR risk in housing price is informative of the homebuyer's climate belief. ▸ Microfoundation
  - E.g.: All else equal, if housing transaction A prices SLR risk at -10% & transaction B at 0%, then homebuyer in A is likely more pessimistic.

Results hold with property-level belief inferred from home prices

	Leveraged	Long maturity
SLR	-0.030	0.131**
	(0.044)	(0.059)
SLR x $\widehat{PessiBuyer}$	0.039***	0.012
	(0.009)	(0.008)
Z x D x E x B x T fe	Y	Y
Property & buyer county controls	Y	Y
Buyer county controls x SLR	Y	Y
Lender fe		Y
N	210774	62928
R2	0.440	0.443

$\widehat{PessiBuyer}$ is transaction-specific and imputed from housing price regression.

Unintended effect of securitization policy?

- Securitization could reduce banks' incentive to screen climate risk: banks could shift climate risks to Government Sponsored Enterprises, by securitizing and selling off exposed mortgages that are below conforming loan limits (Ouazad Kahn 2021).
- Suppose this is true, then we should expect effects of SLR exposure on leverage and maturity to strengthen for conforming loan segment & weaken for nonconforming segment.
- This turns out to be the case in our data. Details

Unintended effect of monetary policy?

- Model predicts that policy rate i affects leveraged probability, but not maturity.
- These also turn out to be the case in our data. ▸ Details

Conclusion

- What makes climate risks special?
  - Possibility of large damage in the future.
  - Pronounced belief disagreement (esp. in U.S.).
- We found: risk of future damage $\times$ belief disagreement is an important determinant of how climate risks affect debt market.
- How financial markets adapt to climate change under belief disagreement: nontrivial patterns and policy implications. **Exciting research agenda!**

Thank you!

"Speaking of rising sea levels—I'll miss our little disagreement."

Appendix: Model

Primitives

- Continuous time. Risk neutral & deep-pocketed agents. Common discount rate r.
- A one-time climate shock arriving at a random time t_C.
- Indivisible housing asset yields utility stream $H_t = 1$ before t_C and $H_t = 1 - D$ after.
  - House price P exogenous (for now).
- Belief disagreement:
  - Homebuyers believe arrival rate of climate shock is $r\lambda$
  - Lenders: $r\bar{\lambda}$.
- Mortgage contract (B, m, μ) specifies:
  - Lender loans B to borrower
  - Borrower promises to pay m until maturity T
  - T arrives at endogenous rate $r\mu$, $\mu \in [0, \mu_0]$.

Borrower

- Expected payoff from a mortgage contract (B, m, μ):

$$\underbrace{\alpha\left[-\underbrace{(P-B)}_{\text{down payment}}+V(m,\mu)\right]}_{\text{mortgage approved}}+\underbrace{(1-\alpha)\left[-P+V(0,\infty)\right]}_{\text{not approved}}$$

- where continuation value $V(m, \mu)$ is defined as:

$$V := \mathbb{E}_{\lambda}\left\{\underbrace{\int_0^{t_{def}} re^{-rt}(H_t - m_t)}_{\text{repaying debt}} + e^{-rt_{def}}\big(-\underbrace{F_{def}}_{\text{default cost}} + \max\{\underbrace{p_{t_{def}}}_{\text{liquidation value}} - \underbrace{b_{t_{def}}}_{\text{remaining balance}}, 0\}\big)\right\}$$

$$p_{t_{def}} = \mathbb{E}_{\lambda}\int_{t_{def}}^{\infty} re^{-r(t-t_{def})}H_t dt, \quad b_{t_{def}} = \int_{t_{def}}^{T} re^{-r(t-t_{def})}mdt$$

Competitive lenders

- Expected payoff from a contract:

$$\Pi(B, m, \mu) := -B + PV(m, \mu) - \underbrace{K(\mu)}_{\text{operation cost (to pin down optimal } \mu)}$$

$$PV(m, \mu) := \mathbb{E}_{\bar{\lambda}}\{\int_0^{\min(T, t_{def})} re^{-rt} m dt + 1_{t_{def} < T} e^{-rt_{def}} \min(p_{t_{def}}, b_{t_{def}})\}.$$

- Free-entry condition pins down loan approval rate α:

$$0 = \underbrace{\eta(\alpha)}_{\text{prob. of finding a matching buyer}} \Pi(B, m, \mu) - \underbrace{\kappa}_{\text{fixed cost}} .$$

Competitive search

For each borrower type λ and each contract (B, m, μ):

Borrowers: endogenous mass n_b

$\updownarrow$

Number of matches produced: $\mathcal{M}(n_b, n_l) := M_0 n_b^{\gamma} n_l^{1-\gamma}$

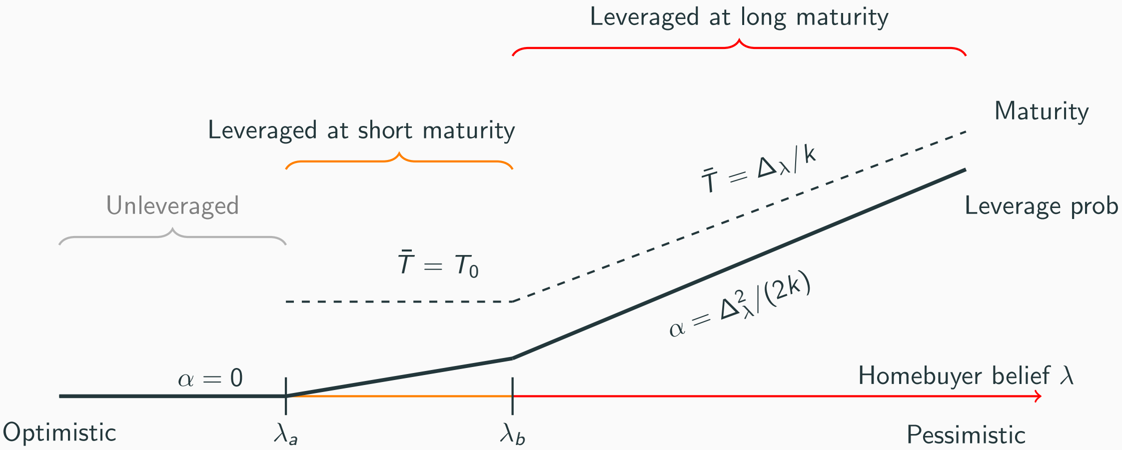
$\Rightarrow$ Prob a borrower finds a match: $\alpha := \frac{\mathcal{M}}{n_b}$

$\Rightarrow$ Prob a lender finds a match: $\eta := \frac{\mathcal{M}}{n_l}$

Lenders: endogenous mass n_l

▸ Equilibrium definition

Proposition: Equilibrium mortgage choice (assuming $D > \bar{\lambda} F_{def}$)



▸ Detailed closed-form solutions

Competitive search equilibrium

- Competitive search equilibrium consists of a menu Ω of available contracts, with quantities (n_b, n_l) associated with each borrower type λ and contract $a \in \Omega$, s.t.:
  1. Matching probabilities for a borrower is $\alpha = M/n_b$ and for a lender is $\eta = M/n_l$;
  2. n_b is the measure of borrowers for which a solves their optimization problem;
  3. n_l, the measure of lenders who enter the associated submarket, is so that free-entry condition is satisfied;
  4. the market clears: for each borrower type λ, the sum total of all the measures of borrowers in each submarket must satisfy
  $$\int_{a\in\Omega} n_b(a)da = f(\lambda)$$
  where f is the density function of the borrower type distribution.

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Closed-form solutions

- Leverage probability:

$$\alpha^{(1+\xi)/\xi} = \frac{1+\xi}{(1-\theta)\kappa}\left[P - \frac{1+\theta\rho}{1+\rho} v(\lambda) + \theta\xi\right]. \tag{1}$$

- Maturity:

$$\bar{T} = \begin{cases} \dfrac{\overbrace{(1+\bar{\lambda})[v(\bar{\lambda}) - v(\lambda)] - \bar{\lambda}}^{\text{“disagreement value”}}}{k} & \text{if } \lambda > \lambda_b, \\ T_0 & \text{otw.} \end{cases} \tag{2}$$

- Mortgage payment:

$$m = \underbrace{\Delta(\lambda, \bar{\lambda})}_{\text{disagreement}} - \underbrace{\bar{\lambda}(1-D)}_{\text{foreclosing the damaged house}} + \underbrace{\frac{1}{\bar{T}}[v(\lambda) + F]}_{\text{amortizing the subjective value}} \tag{3}$$

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Extension: Monetary policy

- Assume borrowers face funding cost ρ:

$$\underbrace{\alpha\left[-(1+\underbrace{\rho}_{\text{funding cost}})\underbrace{(P-B)}_{\text{down payment}}+V(m,\mu)\right]}_{\text{mortgage approved}}+\underbrace{(1-\alpha)\left[-(1+\rho)P+V(0,\infty)\right]}_{\text{not approved}}$$

- And banks face funding cost $i \leq \rho$, where i depends on monetary policy. Free-entry condition:

$$0=\underbrace{\eta(\alpha)}_{\text{prob. of finding a matching buyer}}[\underbrace{-(1+i)B}_{\text{funding cost}}+\underbrace{\Pi(m,\mu)}_{\text{expected payoff from mortgage}}-\underbrace{K(\mu)}_{\text{operation cost}}]-\underbrace{\kappa}_{\text{fixed cost}}$$

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Extension: Nash bargaining

- Assume for simplicity, seller has same belief as buyer (e.g., both buyer and seller are from the same county and inherit the same county-level belief).
- Borrower's bargaining power θ.
- To motivate trade, assume seller faces a higher house maintenance cost ξ relative to buyer.
- House price P determines by

$$\max_{P} U^{\theta}[P - v(\lambda) + \xi]^{1-\theta}.$$

- Solution:

$$P = \underbrace{\frac{1+\theta\rho}{1+\rho} v(\lambda) - \theta\xi}_{\text{standard ``hedonic'' term}} + \underbrace{(1-\theta)\,\alpha \left[\frac{\overbrace{S(m,\mu)}^{\text{joint surplus}}}{1+\rho} - \frac{\overbrace{\kappa}^{\text{mortgage cost}}}{\eta(\alpha)}\right]}_{\text{mortgage term}}, \tag{4}$$

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Extension: Insurance (and why few buy it)

Assume an insurance that charges rq continuously and pays δ when climate shock hits.

- Homebuyers can choose any coverage $\delta \in [0, \bar{\delta}]$, where $D - \bar{\delta} > \bar{\lambda} F$.
- If insurance is mandatory, then isomorphic to lowering D by $\delta \rightarrow$ same qualitative results.
- If insurance is not mandatory:
  - Assume premium is priced at the bank's belief: $q = \bar{\lambda}\delta$.
  - If $\bar{\lambda} \geq \lambda_a$, then no homebuyer will buy any insurance.
    - Intuition: Optimists find the premium too high as priced at a higher belief. Pessimists will surrender the house when the climate shock hits so insurance is no use.
  - If $\bar{\lambda} < \lambda_a$, then
    - Homebuyers with $\lambda \in [\bar{\lambda}, \lambda_a]$ will buy max insurance ($\delta = \bar{\delta}$). Continue to choose risk-free mortgage.
    - Homebuyers with $\lambda \notin [\bar{\lambda}, \lambda_a]$ will not buy insurance and behave as before.
  - Hence, similar qualitative results again.
  - Intuition: default is implicit insurance against climate shock, hence crowds out insurance uptake (related empirical evidence for this mechanism: Liao Mulder 2021)

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Appendix: Data

NOAA Sea Level Rise Data

- Maps sea level rise inundation.
  - Bathtub-style model.
  - Relative to Mean Higher High Water levels.
  - 0 to 10ft SLR scenarios mapped.
  - Variation in local SLR driven by small differences in elevation, topography, bathymetry, etc.
  - Publicly free at `https://coast.noaa.gov/slr/`
- Does not include potentially endogenous local factors, e.g.:
  - Erosion, subsidence/accretion, human mitigation.

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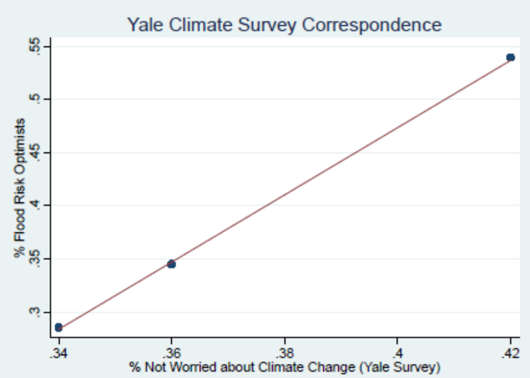
Summary statistics

	Mean	Std
Sale price ($)	370,819.40	523,768.00
Leveraged (mortgage dummy)	0.63	0.48
Mortgage amount ($)	178,732.50	262,627.20
Mortgage maturity (y)	17.20	14.44
Distance to coast (m)	402.74	296.83
Elevation (m)	6.84	11.69
Climate belief (county level,%)	64.97	4.06
Inundated with 1ft SLR	0.00	0.06
Inundated with 2ft SLR	0.01	0.10
Inundated with 3ft SLR	0.03	0.17
Inundated with 4ft SLR	0.07	0.26
Inundated with 5ft SLR	0.14	0.34
Inundated with 6ft SLR	0.21	0.41
N	876,729	

Yale data vs. Bakkensen-Barrage 2021 data



◂ Back to data ◂ Back to selection

Appendix: Robustness checks

Other belief specifications

	Leveraged			Long Maturity		
	Happening	Worried	Timing	Happening	Worried	Timing
SLR × Pess. Buyer (above median)	0.034***	0.049***	0.031**	0.024***	0.026***	0.023***
	(0.011)	(0.012)	(0.013)	(0.007)	(0.007)	(0.007)
SLR × 2nd Quartile Belief	0.023**	0.006	0.001	0.030***	0.008	0.025**
	(0.011)	(0.012)	(0.011)	(0.008)	(0.010)	(0.010)
SLR × 3rd Quartile Belief	0.011	0.058***	0.022	0.034***	0.033***	0.017
	(0.017)	(0.013)	(0.015)	(0.011)	(0.009)	(0.010)
SLR × 4th Quartile (highest) Belief	0.045**	0.047*	0.051***	0.034***	0.023	0.038***
	(0.018)	(0.027)	(0.015)	(0.010)	(0.017)	(0.010)
SLR × Belief (continuous)	0.002	0.003***	0.002*	0.002*	0.002**	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Z × D × E × B × M fe	Y	Y	Y	Y	Y	Y
Property & buyer county controls	Y	Y	Y	Y	Y	Y
Buyer county controls × SLR Risk	Y	Y	Y	Y	Y	Y
Lender fe				Y	Y	Y

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Imputed county-level belief from individual-level Gallup survey

	Leveraged	Long Maturity
SLR Risk	-0.031	0.006
	(0.021)	(0.021)
SLR Risk x Pess. Buyer	0.032**	0.028*
	(0.015)	(0.015)
Property & buyer county controls	Y	Y
Z x D x E x B x T fe	Y	Y
Buyer county controls x SLR	Y	Y
Lender f.e.		Y
N	210774	62928
R2	0.439	0.442

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Other fixed-effect specifications: Leveraged result

	Leveraged			
SLR Risk	0.007	-0.005	0.010	0.012
	(0.016)	(0.012)	(0.010)	(0.013)
SLR Risk $\times$ Pess. Buyer	0.032***	0.031***	0.019**	0.021**
	(0.010)	(0.011)	(0.008)	(0.010)
F.e.	Z$\times$D$\times$E$\times$B	Z$\times$D$\times$E$\times$B$\times$Q	Z$\times$D$\times$E$\times$B$\times$Q$\times$O	Z$\times$D$\times$E$\times$B$\times$M$\times$O
Property & buyer county controls	Y	Y	Y	Y
Buyer county controls $\times$ SLR Risk	Y	Y	Y	Y
N	852817	568636	490546	322484
R2	0.188	0.404	0.461	0.526

Z – zip code, D – distance to coast bin, E – elevation bin, B – number of bedrooms, Q – quarter and year of transaction, M – month and year of transaction, O – owner-occupied status.

Other fixed-effect specifications: Long maturity result

	Long Maturity			
SLR Risk	-0.011*	-0.003	-0.005	-0.010
	(0.006)	(0.011)	(0.012)	(0.019)
SLR Risk × Pess. Buyer	0.007	0.017***	0.012*	0.022**
	(0.005)	(0.006)	(0.007)	(0.009)
F.e.	Z×D×E×B	Z×D×E×B×Q	Z×D×E×B×Q×O	Z×D×E×B×M×O
Property & buyer county controls	Y	Y	Y	Y
Buyer county controls × SLR Risk	Y	Y	Y	Y
Lender fe	Y	Y	Y	Y
N	852817	568636	490546	322484
R2	0.188	0.404	0.461	0.526

Z – zip code, D – distance to coast bin, E – elevation bin, B – number of bedrooms, Q – quarter and year of transaction, M – month and year of transaction, O – owner-occupied status

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Finer SLR exposure bins

	Leveraged	Long Maturity
1.SLR (6ft)	0.0180	0.0169
	(0.014)	(0.017)
2.SLR (5ft)	0.0140	-0.0042
	(0.020)	(0.026)
3.SLR (4ft)	-0.0343	-0.0038
	(0.027)	(0.020)
4.SLR ($\leq$3ft)	-0.0362	-0.0305
	(0.031)	(0.024)
1.SLR x Pess. Buyer	0.0154	0.0140
	(0.012)	(0.009)
2.SLR x Pess. Buyer	0.0246*	0.0321**
	(0.015)	(0.014)
3.SLR x Pess. Buyer	0.0455**	0.0323**
	(0.018)	(0.014)
4.SLR x Pess. Buyer	0.0856***	0.0322*
	(0.023)	(0.018)
Property & buyer county controls	Y	Y
Buyer county controls x SLR	Y	Y
Z $\times$ D $\times$ E $\times$ B $\times$ M fe	Y	Y
Lender fe		Y
N	405893	150746
R2	0.473	0.441

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Including more buyer county controls (2010-2016 sample)

	Leveraged	Long Maturity
SLR Risk	-0.019	0.070*
	(0.031)	(0.040)
SLR Risk x Pess. Buyer	0.038**	0.039***
	(0.014)	(0.015)
Property & buyer county controls	Y	Y
Z x D x E x B x T fe	Y	Y
Buyer county controls x SLR	Y	Y
Lender f.e.		Y
N	210774	62928
R2	0.440	0.443

Buyer county controls: income, population, education (share of bachelors), age (18-29 share), race (black share).

Controlling for FEMA flood map

	Leveraged	Long Maturity
SLR	0.007	0.001
	(0.014)	(0.014)
SLR x Pess. Buyer	0.027**	0.023***
	(0.011)	(0.008)
FEMA Zone	-0.024***	-0.002
	(0.008)	(0.004)
FEMA Zone x Pess. Buyer	0.015	0.001
	(0.011)	(0.007)
Z x D x E x B x T FE	Y	Y
Buyer County x SLR Controls	Y	Y
Lender FE		Y
N	405908	150746
R2	0.473	0.441

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Appendix: Further results

Results driven by conforming loan segment

	Leveraged &		Long Maturity &	
	Conforming	Nonconform	Conforming	Nonconform
SLR Risk	-0.016	0.013*	-0.009	0.007
	(0.015)	(0.007)	(0.021)	(0.013)
SLR Risk × Pessi. Buyer	0.033***	-0.001	0.033***	-0.015**
	(0.012)	(0.004)	(0.012)	(0.007)
Property & buyer county controls	Y	Y	Y	Y
Buyer county controls × SLR Risk	Y	Y	Y	Y
Z × D × E × B × M fe	Y	Y	Y	Y
Lender fe			Y	Y
N	406601	406601	182771	182771
R2	0.478	0.566	0.569	0.669

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Effects of monetary policy

	Leveraged	Long Maturity
SLR Risk	-0.022	0.001
	(0.017)	(0.016)
SLR Risk x High Belief	0.051***	0.035***
	(0.015)	(0.012)
SLR Risk x High Belief x i	-0.010**	-0.005
	(0.005)	(0.004)
Z x D x E x B x M fe	Y	Y
Property & buyer county controls	Y	Y
Buyer county controls x SLR	Y	Y
Lender fe		Y
N	405,908	150,746
R^2	0.473	0.441

i: Market Yield on Treasury Securities at 2-Year Maturity

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Insignificant effects on borrowing amount (as model predicts)

	log(Mortgage amount)	
SLR Risk	-0.003	
	(0.011)	
SLR Risk x Pess. Buyer	0.004	
	(0.010)	
Moderate SLR Risk		-0.001
		(0.012)
High SLR Risk		-0.018
		(0.030)
Moderate SLR Risk x Pess. Buyer		0.005
		(0.010)
High SLR Risk x Pess. Buyer		-0.006
		(0.020)
Property & buyer county controls	Y	Y
Z x D x E x B x M fe	Y	Y
Lender fe	Y	Y
Buyer county controls x SLR	Y	Y
N	167402	167402
R2	0.919	0.919

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Insignificant effects on interest rates

	Interest rate	
SLR Risk	-0.095	
	(0.160)	
SLR Risk x Pess. Buyer	0.037	
	(0.088)	
Moderate SLR Risk		-0.074
		(0.162)
High SLR Risk		-0.348
		(0.365)
Moderate SLR Risk x Pess. Buyer		0.035
		(0.098)
High SLR Risk x Pess. Buyer		0.102
		(0.206)
Property & buyer county controls	Y	Y
Z x D x E x B x M fe	Y	Y
Lender fe	Y	Y
Buyer county controls x SLR	Y	Y
30 year f.e.	Y	Y
N	28873	28873
R2	0.725	0.725

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Appendix: Selection

Inferring transaction-specific belief from house prices

- Idea: higher capitalization of SLR in housing price implies likely more pessimistic buyer.
- Assume housing price follows true data generating process:

$$\log P^i = (\beta + \gamma\lambda^i)SLR^i + \text{controls} + \text{constant} + \epsilon^i \tag{5}$$

- Regress and predict error term $\hat{\zeta}^i$ in

$$\log P^i = \beta_1 SLR^i + \text{controls} + \text{constant} + \zeta^i \tag{6}$$

  - (5) and (6) implies $\zeta^i = \gamma SLR^i \lambda^i + \epsilon^i$ and therefore the predicted $\hat{\zeta}^i := E[\zeta^i] = \gamma SLR^i \lambda^i$
- Define our proxy for property-level climate belief as (the negative sign is because we expect γ to be negative)

$$\hat{\lambda}^i := -\hat{\zeta}^i. \tag{7}$$

  $\hat{\lambda}^i$ should be positively correlated with the true unobserved λ^i.
- For the subsample where $SLR^i = 1$, define $\widehat{PessiBuyer}^i$ as 1 if $\hat{\lambda}^i$ is above median.

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