Climate Risk Perceptions and Demand for Flood Insurance

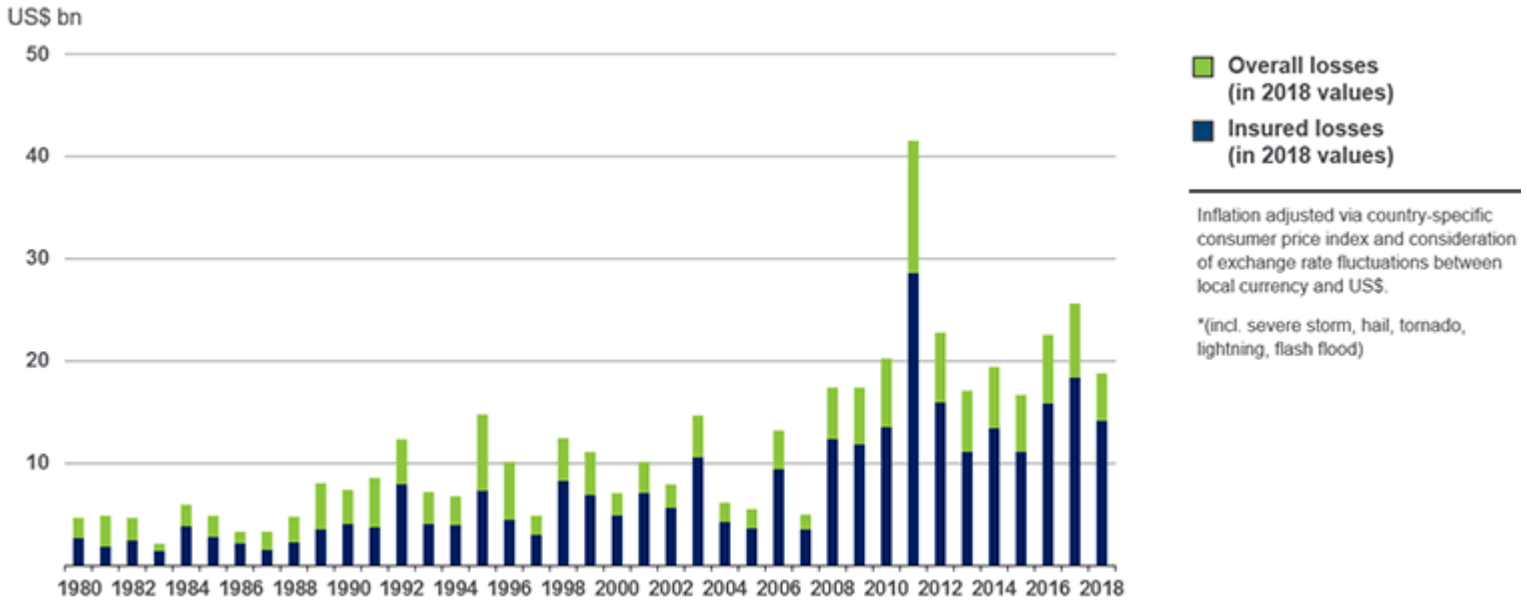
Dimuthu Ratnadiwakara
Louisiana State University

Buvaneshwaran Venugopal
University of Central Florida

May, 2021
ABFER 8^{th} Annual Conference: Real Estate & Urban Economics

Flood risks are increasing

Storm Events* in the U.S., 1980-2018

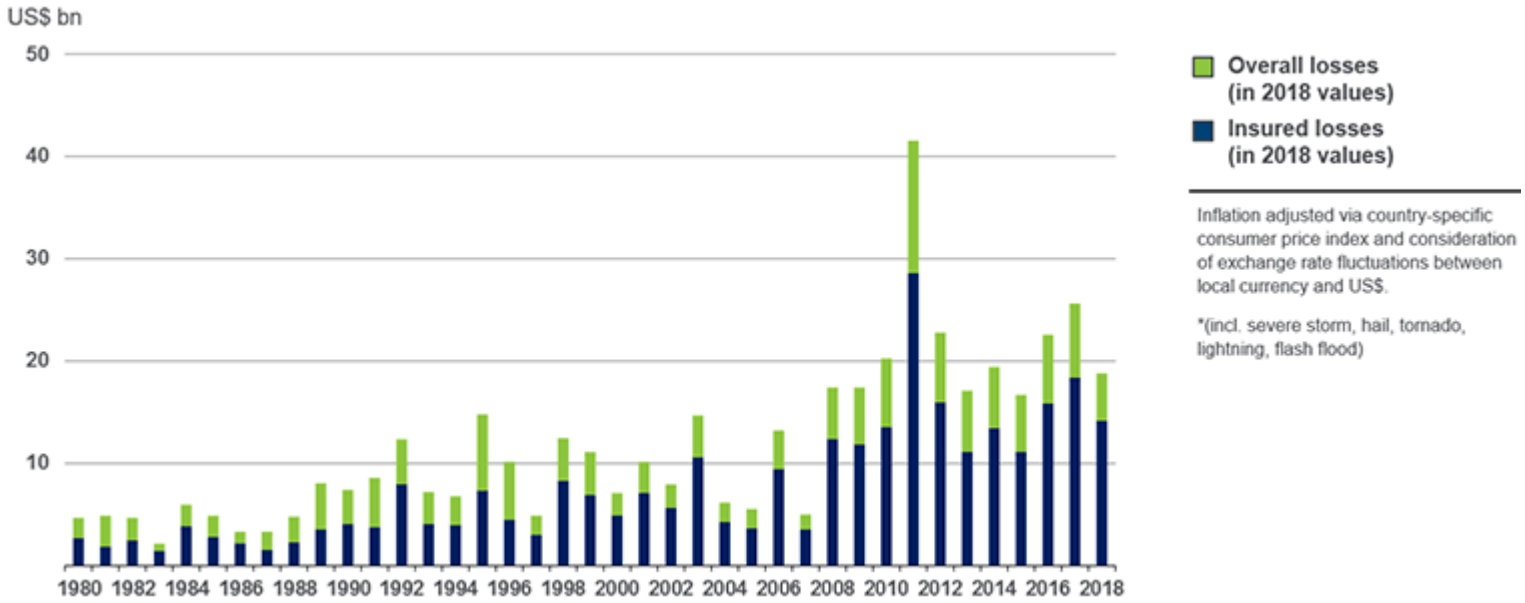


Source: c 2019 Munich Re, Geo Risks Research, NatCatSERVICE. As of March 2019.

- Flooding is the costliest natural disaster facing the U.S.
- 41 million Americans are exposed to 100 year flood events.

Flood risks are increasing

Storm Events* in the U.S., 1980-2018



Source: c 2019 Munich Re, Geo Risks Research, NatCatSERVICE. As of March 2019.

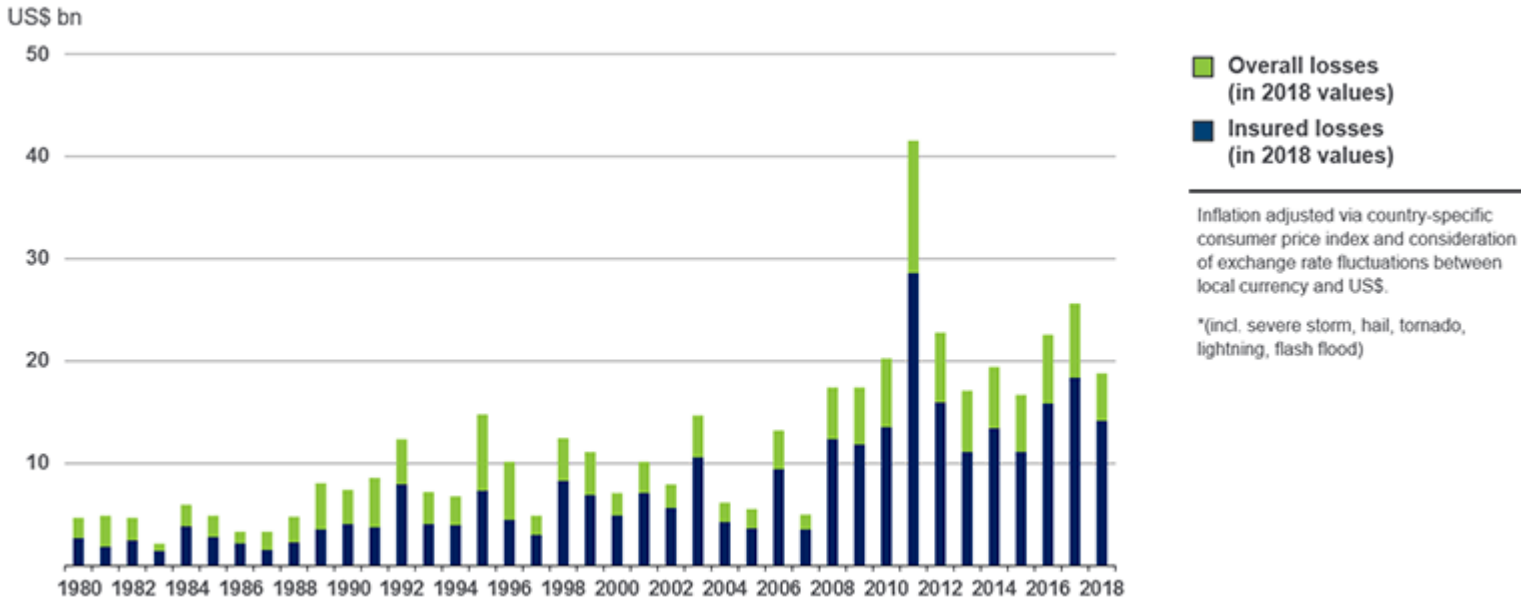
- Flooding is the costliest natural disaster facing the U.S.
- 41 million Americans are exposed to 100 year flood events.

Global warming is making floods more severe and frequent

- E.g.: Christensen and Christensen (2003), Seneviratne et al. (2017).

Flood risks are increasing

Storm Events* in the U.S., 1980-2018



Source: c 2019 Munich Re, Geo Risks Research, NatCatSERVICE. As of March 2019.

- Flooding is the costliest natural disaster facing the U.S.
- 41 million Americans are exposed to 100 year flood events.

Policy makers are drafting bills to fight climate risks

- Florida passed its Always Ready bills (SB 1954, SB 2514).
- Federal: Growing Climate Solutions Act, U.S. CLIMATE Act.

Flood insurance is a low-cost and an effective adaptation mechanism

Flood insurance helps property owners minimize losses and recover quickly

- Billings, Gallagher, & Ricketts (2019)

Flood insurance is a low-cost and an effective adaptation mechanism

Flood insurance helps property owners minimize losses and recover quickly

- Billings, Gallagher, & Ricketts (2019)

90% of policies are sold by the National Flood Insurance Program (NFIP)

- A Special Flood Hazard Area (SFHA) is an area that has 1% probability of a flood in a given year

	Max Coverage	SFHA	Outside SFHA
Building coverage	$ 250k	Required	Voluntary
Contents coverage	$ 100k	Voluntary	Voluntary

Flood insurance is a low-cost and an effective adaptation mechanism

Flood insurance helps property owners minimize losses and recover quickly

- Billings, Gallagher, & Ricketts (2019)

90% of policies are sold by the National Flood Insurance Program (NFIP)

- A Special Flood Hazard Area (SFHA) is an area that has 1% probability of a flood in a given year

	Max Coverage	SFHA	Outside SFHA
Building coverage	$ 250k	Required	Voluntary
Contents coverage	$ 100k	Voluntary	Voluntary

Flood insurance premiums are heavily subsidized

- Subsidized flood insurance costs $482 for $250,000 building and $100,000 contents
- Up to 45% in premium discounts are available **in SFHA**

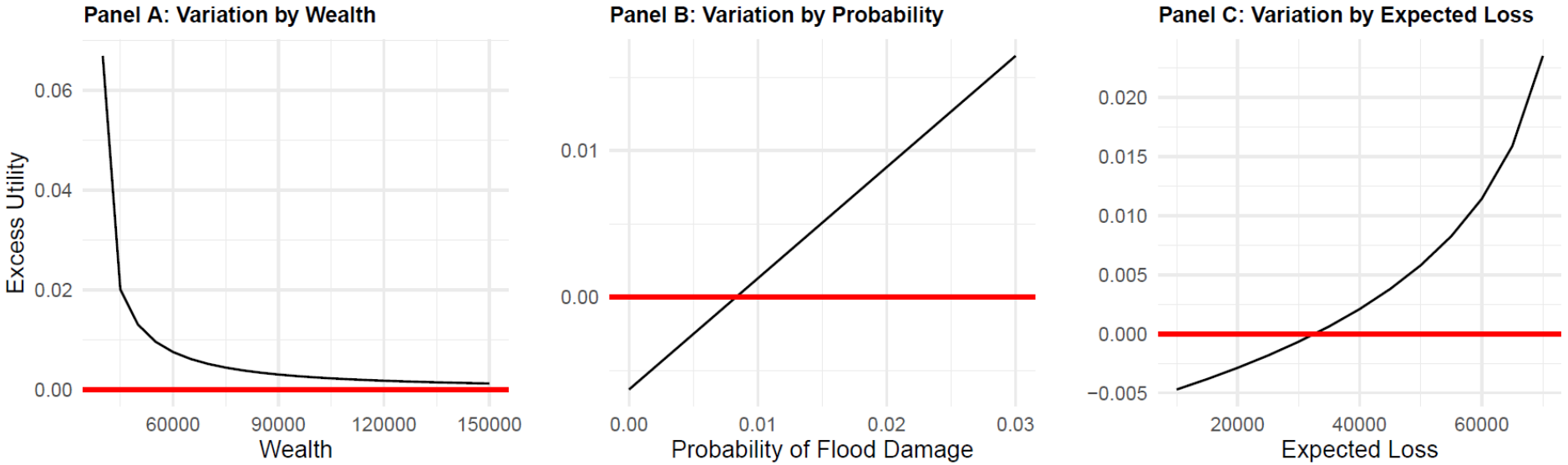
Flood insurance makes sense for most households

Consider a household who has an initial wealth of w with an expected flood loss of l with a probability p. Assuming an insurance premium of c and a utility function U the household will purchase flood insurance if:

$$U(w \quad c) \quad p \quad U(w \quad l) + (1 \quad p) \quad U(w) > 0$$

We assume:

1. $U(w) = log(w)$
2. w = \$75,000; The mean wealth of a U.S. household
3. l = \$39,850; The mean flood insurance claim outside SFHA from 2012 to 2018
4. p = 0.014; The fraction of policies with claims outside the SFHA from 2012 to 2018
5. c = \$470; The mean flood insurance premium



But... the flood insurance take-up is very low

Flooding Disasters Since 2000

Insurance Take-up outside SFHA

But... the flood insurance take-up is very low

Flooding Disasters Since 2000

Insurance Take-up outside SFHA

Why the flood insurance take-up is so low? What factors determine the flood insurance take-up?

- Insurance demand increases after a disaster (Gallagher (2014))
- Public disaster assistance discourages take-up (Davlasheride and Miao (2019))
- Income and cost (Browne and Hoyt (2000))

Do climate change beliefs impact flood insurance take-up?

Subjective probability weights that individuals assign to tail events can vary based on their beliefs and risk preferences

- Tversky and Kahneman (1992); Barberis (2013); Carman and Kooreman (2014)
- Not worried about global warming ⟩ low subjective probability of flood damage

Individuals' probability weights may affect the participation of risk-mitigation interventions

- Carman and Kooreman (2014)
- Low flood insurance take-up if individuals assign a lower probability weight to flood damages due to climate change denial

Our Paper

Using **flood insurance data from NFIP** and **data on beliefs about global warming from Yale Climate Opinion Maps** we show that beliefs about climate change are related:

- positively to the flood insurance demand in non-SFHA areas
- positively to the probability of carrying voluntary contents coverage in SFHA areas
- negatively to the choice of deductible in SFHA areas

Our Paper

Using **flood insurance data from NFIP** and **data on beliefs about global warming from Yale Climate Opinion Maps** we show that beliefs about climate change are related:

- positively to the flood insurance demand in non-SFHA areas
- positively to the probability of carrying voluntary contents coverage in SFHA areas
- negatively to the choice of deductible in SFHA areas

We use flood insurance renewal data to show that:

- Climate change deniers were less likely to renew voluntary flood insurance coverage after an **exogenous increase in flood insurance premium**

Data Sources

1. National Flood Insurance Program (NFIP)
   - 49 million policy observations effective 2009-2019, Variables include: Premium, effective date, coverage, ood zone, construction year, census tract

2. Yale Program on Climate Change
   - % of people who believe that global warming is happening and are worried at county level for years 2014, 2016, 2018, and 2019

3. Other Data Sources:

   American Community Survey (ACS)

   FEMA Disaster Declarations

   Zillow Home Value Index

   MIT Election Data Science Lab

De nitions and Key Variables

Census Tract	A neighborhood established by the Bureau of Census. 2,500 to 8,000 people
Flood Insurance Take-up	$\frac{\text{No of policies}}{\text{No of homes}}$ for each census tract-year
Non-SFHA Census Tract	Less than 5% of the policies in SFHA
Happening	Fraction of adults in a county who believe global warming is happening
Worried	Fraction of adults in a county who are worried about global warming
Personal	Fraction of adults in a county who think global warming can harm them personally

Three Samples

1. Non-SFHA Census Tract-Year Panel
   - 17,000 non-SFHA census tracts covering all the states, 2010-2019
   - Tract | Year | Take-up | Happening | Worried | Personal | Cost of flood insurance | ...

     4.5% 69.6% 57.4% 39.7% $231 per $100k

Three Samples

1. Non-SFHA Census Tract-Year Panel
   - 17,000 non-SFHA census tracts covering all the states, 2010-2019
   - Tract | Year | Take-up | Happening | Worried | Personal | Cost of flood insurance | ...

     4.5% 69.6% 57.4% 39.7% $231 per $100k

2. SFHA Census Tract-Year Panel
   - 19,000 SFHA census tracts, 2010-2019
   - Tract | Year | Contents Ins. % | Max. Deductible % | Happening | Cost of flood ins. | ...

     38.1% 33.7% 69.2% $742 per 100k

Three Samples

1. Non-SFHA Census Tract-Year Panel
   - 17,000 non-SFHA census tracts covering all the states, 2010-2019
   - Tract | Year | Take-up | Happening | Worried | Personal | Cost of flood insurance | ...

     4.5% 69.6% 57.4% 39.7% $231 per $100k

2. SFHA Census Tract-Year Panel
   - 19,000 SFHA census tracts, 2010-2019
   - Tract | Year | Contents Ins. % | Max. Deductible % | Happening | Cost of flood ins. | ...

     38.1% 33.7% 69.2% $742 per 100k

3. Non-SFHA Policy-Year Panel

Take-up rate increases with Worried in non-SFHA

$$\text{Take-up}_{tcy} = \sum_{b} \beta_b \, b + \gamma X_{tcy} + \underbrace{\mu_t}_{\text{Tract FE}} + \underbrace{\mu_{State,y}}_{\text{State-Year FE}} + \varepsilon_{tcy}$$

β_2 (Worried between 25 – 50, 50 – 75, 75 – 100)

Take-up rate increases with Worried in non-SFHA

$$\text{Take-up}_{tcy} = \sum_{b} \beta_b \, b + \gamma X_{tcy} + \underbrace{\mu_t}_{\text{Tract FE}} + \underbrace{\mu_{State,y}}_{\text{State-Year FE}} + \varepsilon_{tcy}$$

$b \in \{2\}$ (Worried between 25 – 50, 50 – 75, 75 – 100)

	Take-up Rate	
	(1)	(2)
Worried Q1-Q2	0.005	0.005
	(0.003)	(0.003)
Worried Q2-Q3	0.009**	0.013***
	(0.004)	(0.004)
Worried > Q3	0.039***	0.042***
	(0.005)	(0.005)
Controls	7	3
Census Tract FE	3	3
State Year FE	3	3
Observations	116,986	100,422
Adjusted R^2	0.976	0.976

Controls: income, age, race, education, population, cost of flood insurance, house price, disasters in previous 3 years

Content coverage take-up increases with Worried in SFHA

$$\%\ \text{SFHA with content coverage}_{tcy} = \sum_{b} \beta_b \, Worried_b + \beta X_{tcy} + \underbrace{\mu_t}_{\text{Tract FE}} + \underbrace{\mu_{State,y}}_{\text{State-Year FE}} + \varepsilon_{tcy}$$

	Content coverage	
	(1)	(2)
Worried Q1-Q2	0.014*	0.011
	(0.008)	(0.008)
Worried Q2-Q3	0.016*	0.016*
	(0.009)	(0.009)
Worried > Q3	0.023**	0.026**
	(0.011)	(0.012)
Controls	7	3
Census tract FE	3	3
State Year FE	3	3
Observations	128,153	107,139
Adjusted R^2	0.929	0.933

Controls: income, age, race, education, population, cost of ood insurance, house price, disasters in previous 3 years

Policies with maximum deductible decreases with Worried in SFHA

$$\%\ \text{SFHA with max deductible}_{tcy} = \sum_{b} \beta_b \mathbb{1}_b + \gamma X_{tcy} + \underbrace{\mu_t}_{\text{Tract FE}} + \underbrace{\mu_{State,y}}_{\text{State-Year FE}} + \varepsilon_{tcy}$$

	Maximum deductible	
	(1)	(2)
Worried Q1-Q2	-0.016*	-0.021**
	(0.008)	(0.009)
Worried Q2-Q3	-0.031***	-0.040***
	(0.009)	(0.010)
Worried > Q3	-0.038***	-0.054***
	(0.012)	(0.013)
Controls	7	3
Census tract FE	3	3
State Year FE	3	3
Observations	128,153	107,139
Adjusted R^2	0.887	0.892

Controls: income, age, race, education, population, cost of ood insurance, house price, disasters in previous 3 years

Identi cation Concerns

Perceptions may be correlated with unobservable factors.

Census tract and State Year xed effects help to rule out certain alternative explanations.

Unobservable local time-varying factors, such as changes to demographics and economic conditions, could bias our coef cient estimates.

- Upward: past experience, presence of children (Burningham et al. (2008)).
- Downward: structural enhancements, awareness (Mills et al. (2016)).

Two Identi cation Strategies

1 Exploit heterogeneous impact of widening partisan polarization on climate change beliefs after the 2016 general election

2 Study the response to exogenous increases in ood insurance premiums

Partisan polarization on climate change beliefs

Source: Ballew, Matthew T., et al. “Climate Change in the American Mind: Data, Tools, and Trends.” (2019)

Partisan polarization on climate change beliefs

Source: Ballew, Matthew T., et al. “Climate Change in the American Mind: Data, Tools, and Trends.” (2019)

2016 general elections acted as a catalyst in widening partisan divide (Brenan and Saad, 2018; Motta et al., 2019)

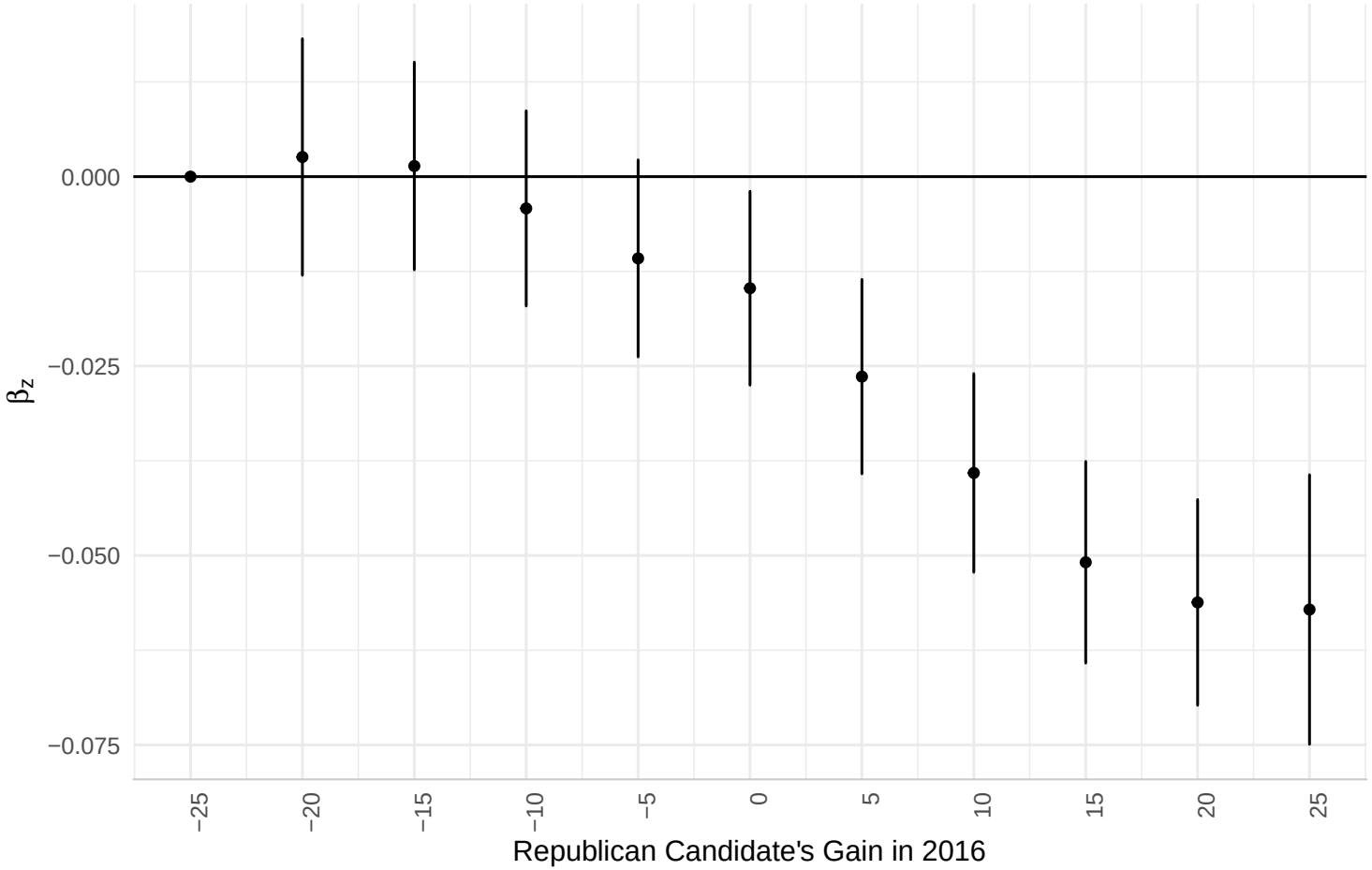
President Trump called global warming a “hoax” while concurrently reversing several government actions to address climate change

Republican vote gain share in 2016 as an instrument

IV: Republican Gain$_{2016\ 2012}$ After 2016

Instrument is relevant

$$log(Worried)_{cy} = \sum_z b_z \quad z \quad I(y = 2018) + m_c + m_y + e_{cy}$$



10% gain in a county by the 2016 Republican candidate) 2% drop Worried

Flood Insurance Take-up in Non-SFHA Census Tracts: IV Estimation

$$log(Worried)_{cy} = \delta \, Republican\ Gain_{2016\ \ 2012} \quad After\ 2016 + \beta X_{tcy} + \mu_t + \mu_{state,y} + \varepsilon_{tcy}$$

$$Take\text{-}up_{tcy} = \gamma log(\widehat{Worried})_{cy} + \beta X_{tcy} + \mu_t + \mu_{state,y} + \varepsilon_{tcy}$$

Flood Insurance Take-up in Non-SFHA Census Tracts: IV Estimation

$$log(Worried)_{cy} = d\, Republican\ Gain_{2016\ \ 2012} \quad After\ 2016 + bX_{tcy} + m_t + m_{state,y} + e_{tcy}$$

$$Take\text{-}up_{tcy} = g\, log(Worried)_{cy} + bX_{tcy} + m_t + m_{state,y} + e_{tcy}$$

	Take-up Rate			
	(1)	(2)	(3)	(4)
Worried	0.045***	0.033***		
	(0.002)	(0.002)		
Happening			0.034***	
			(0.002)	
Personal				0.036***
				(0.002)
Controls		X	X	X
Census tract FE	3	3	3	3
State Year FE	3	3	3	3
Cond. F. Stat	779.42	131.33	110.83	95.25
Observations	116,802	100,265	100,265	100,265
Adjusted R^2	0.975	0.975	0.975	0.976

Partial-R^2 of instrument is 23%

One-standard deviation increase in *Worried* is associated with 22.8% increase in take-up.

Content Coverage Take-up in SFHA: IV Estimation

$$log(Worried)_{cy} = d\ Republican\ Gain_{2016\ \ 2012} \quad After\ 2016 + bX_{tcy} + m_t + m_{state,y} + e_{tcy}$$

$$log(\%\ content)_{tcy} = g log(Worried)_{cy} + bX_{tcy} + m_t + m_{state,y} + e_{tcy}$$

	Content coverage			
	(1)	(2)	(3)	(4)
Worried	0.041***	0.046***		
	(0.005)	(0.005)		
Happening			0.046***	
			(0.005)	
Personal				0.056***
				(0.006)
Controls		X	X	X
Census tract FE	3	3	3	3
State Year FE	3	3	3	3
Cond. F. Stat	893.53	122.23	129.79	120.06
Observations	127,891	106,925	106,925	106,925
Adjusted R^2	0.865	0.872	0.872	0.874

Partial-R^2 of instrument is 31.5%

One-standard deviation increase in *Worried* associated with 32% increase in content coverage take-up

Maximum Deductible in SFHA: IV Estimation

$$log(Worried)_{cy} = d\ Republican\ Gain_{2016\ \ 2012} \quad After\ 2016 + bX_{tcy} + m_t + m_{state,y} + e_{tcy}$$

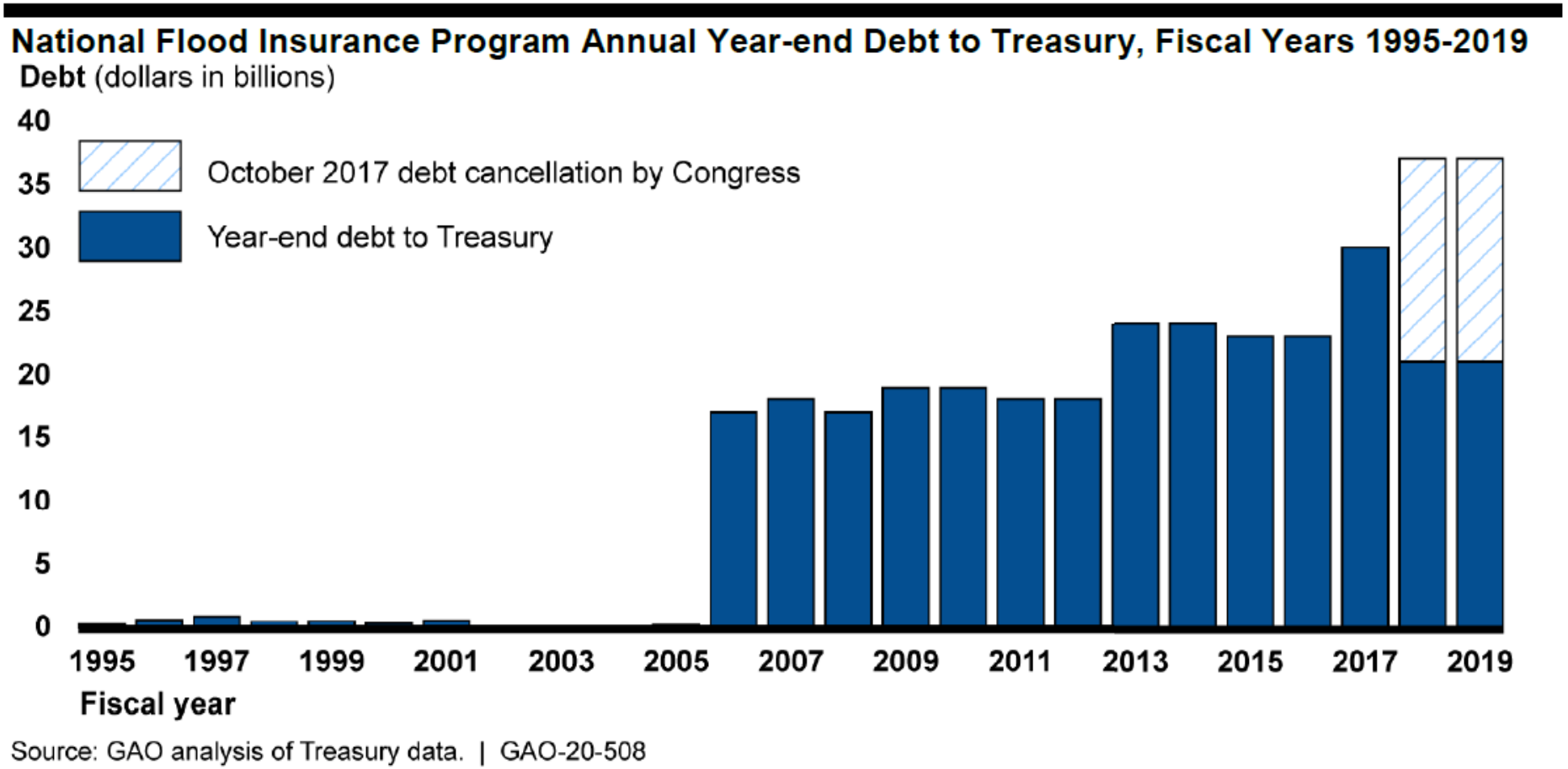
$$\%\ max\ deductible_{tcy} = g\widehat{log(Worried)}_{cy} + bX_{tcy} + m_t + m_{state,y} + e_{tcy}$$

	Maximum Deductible			
	(1)	(2)	(3)	(4)
Worried	-0.004	-0.021***		
	(0.004)	(0.004)		
Happening			-0.021***	
			(0.004)	
Personal				-0.026***
				(0.005)
Controls		X	X	X
Census tract FE	3	3	3	3
State * Year FE	3	3	3	3
Cond. F. Stat	893.53	122.23	129.79	120.06
Observations	127,891	106,925	106,925	106,925
Adjusted R^2	0.845	0.849	0.849	0.85

Partial-R^2 of instrument is 31.5%

One-standard deviation increase in *Worried* is associated with 14% drop in fraction of policies with maximum deductible.

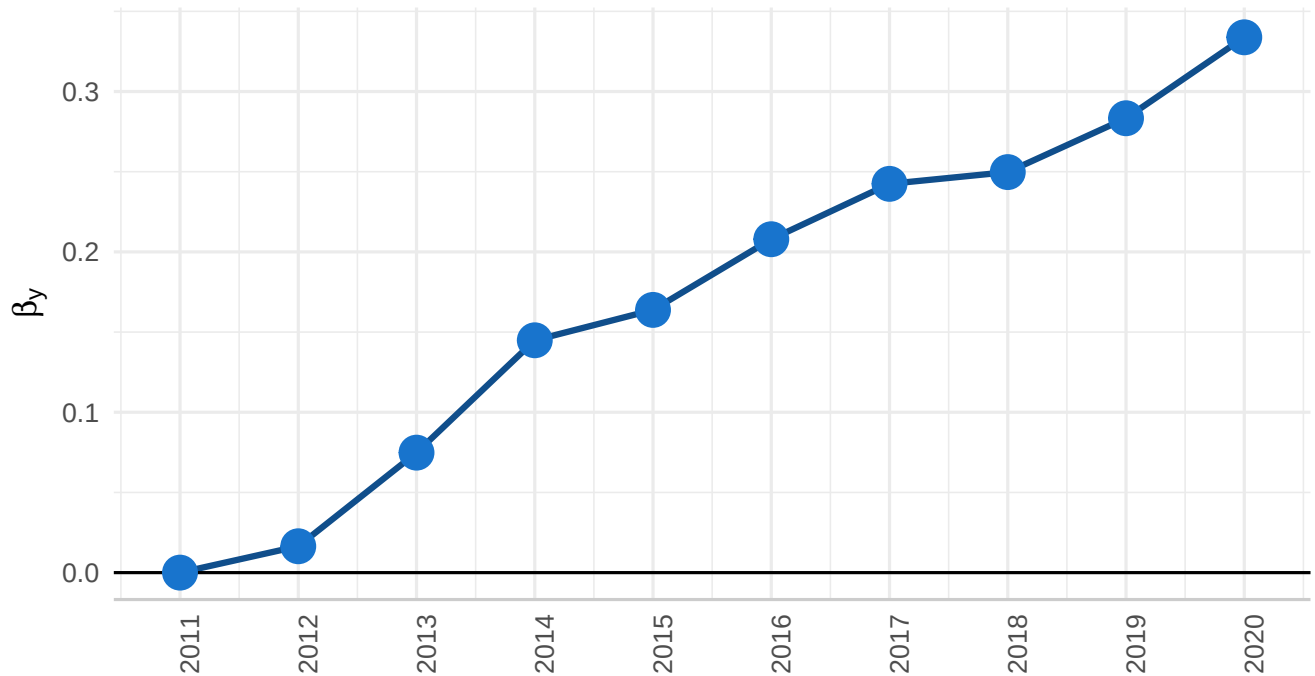
The Biggert-Waters Flood Insurance Reform Act of 2012



BW-12 raised the flood insurance premiums to reflect the actual overall flood risk to deal with the increasing debt of NFIP

Flood Insurance Premiums Increased by 18%

$$log(\text{premium})_{iy} = \sum_{y} b_y \quad y + m_i + e_{iy}$$



Propensity to terminate flood insurance in non-SFHA areas would vary depending on individuals' beliefs about global warming

- Recall that flood insurance is required in SFHA areas if there is a mortgage

Believers were less likely to terminate flood insurance coverage

$$Terminated_{iy} = \sum_{y} b_y \quad y \quad Worried + bX + m_i + e_{iy}$$

Believers were less likely to terminate flood insurance coverage

$$Terminated_{iy} = \sum_{y} b_y \quad y \quad Worried + bX + m_i + e_{iy}$$

Conclusion

Public perceptions regarding climate change can impact the choice of flood insurance coverage

For identification, we exploit the fact that perceptions about climate change has splintered sharply along party lines with widening polarization on the topic after the 2016 general election

After an exogenous increase in flood insurance premium, climate change deniers were more likely to terminate voluntary flood insurance coverage