Levees and levies: Local financing of climate infrastructure maintenance and housing market dynamics
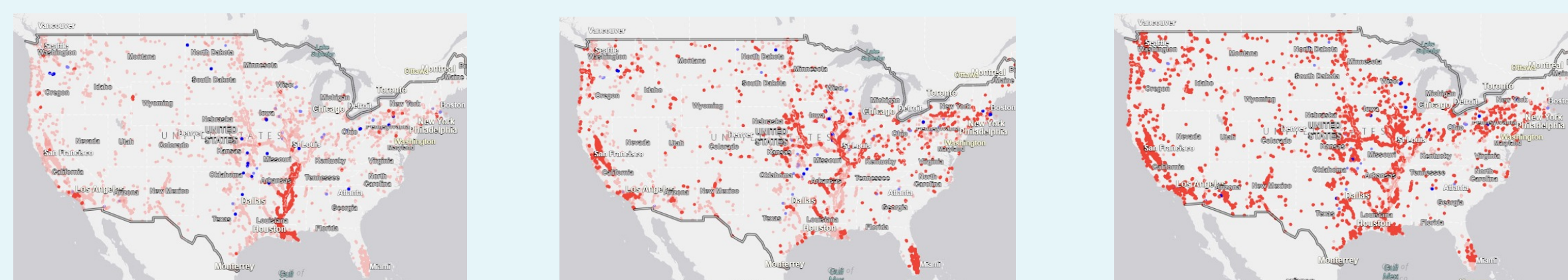
Yichun Fan, Massachusetts Institute of Technology

Motivation

- Flood protection infrastructure important for climate adaptation.
  (levees: 22% county, 21.3M population, $2.85T property value.)
- Lifespan 100 years: Costly **maintenance**.

Fact 1: Levee maintenance mainly local responsibility.

(79.5% by municipalities and special districts. Property tax.)

USACE constructed and O&M   USACE constructed and locally O&M   Locally constructed and O&M

Fact 2: Levees in poor conditions due to maintenance deficiency.

(40% US levees rated as "unacceptable" maintenance quality.)

Hurricane Katrina 2005   Spring 2019 Midwest   2023 Town of Pajaro

Conceptual Framework

Does local financing of levee maintenance create a feedback loop?

Local Financing (Property Tax Revenue)

Housing Value → Levee Maintenance

Risk Capitalization

Levee Failure Risk
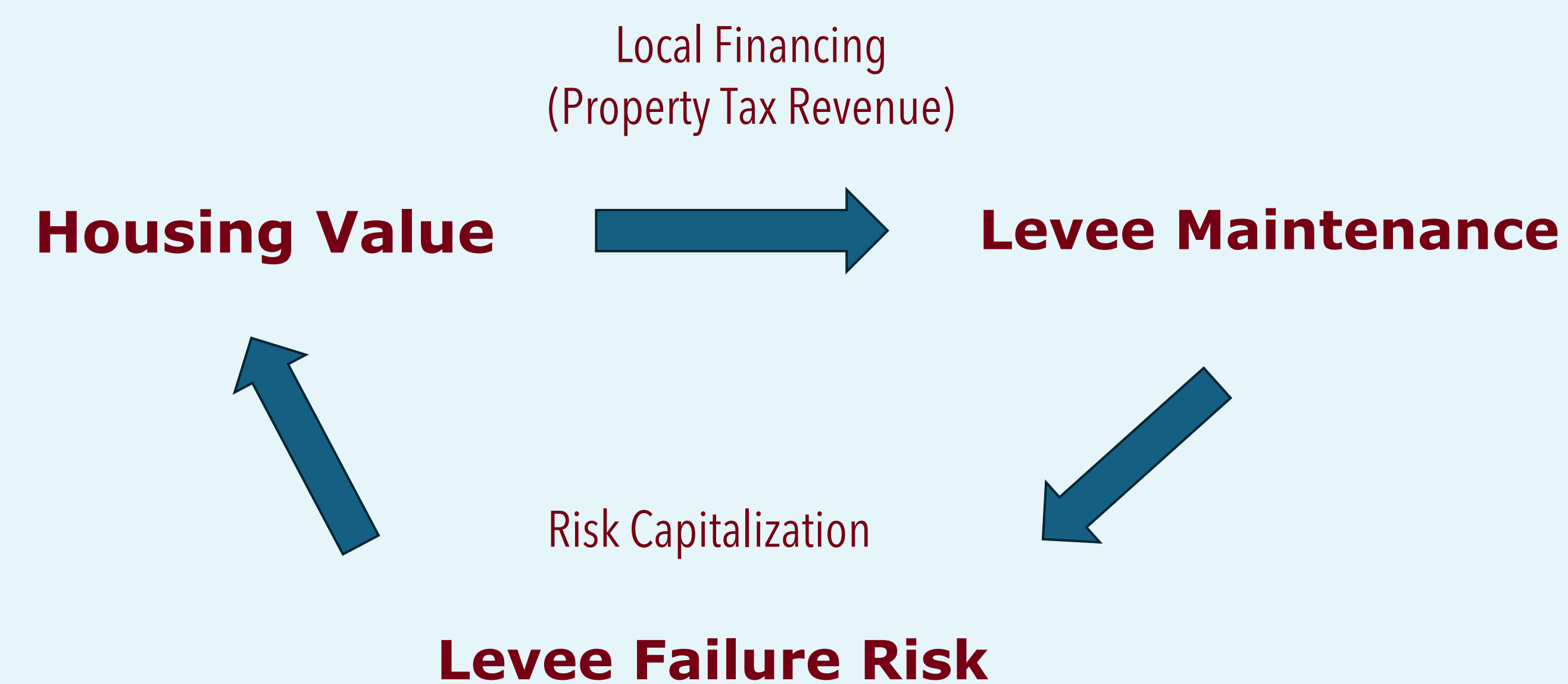
Measurement: Levee Maintenance Quality & Performance

Maintenance quality
Inspection records from US army Corps of Engineers (USACE)
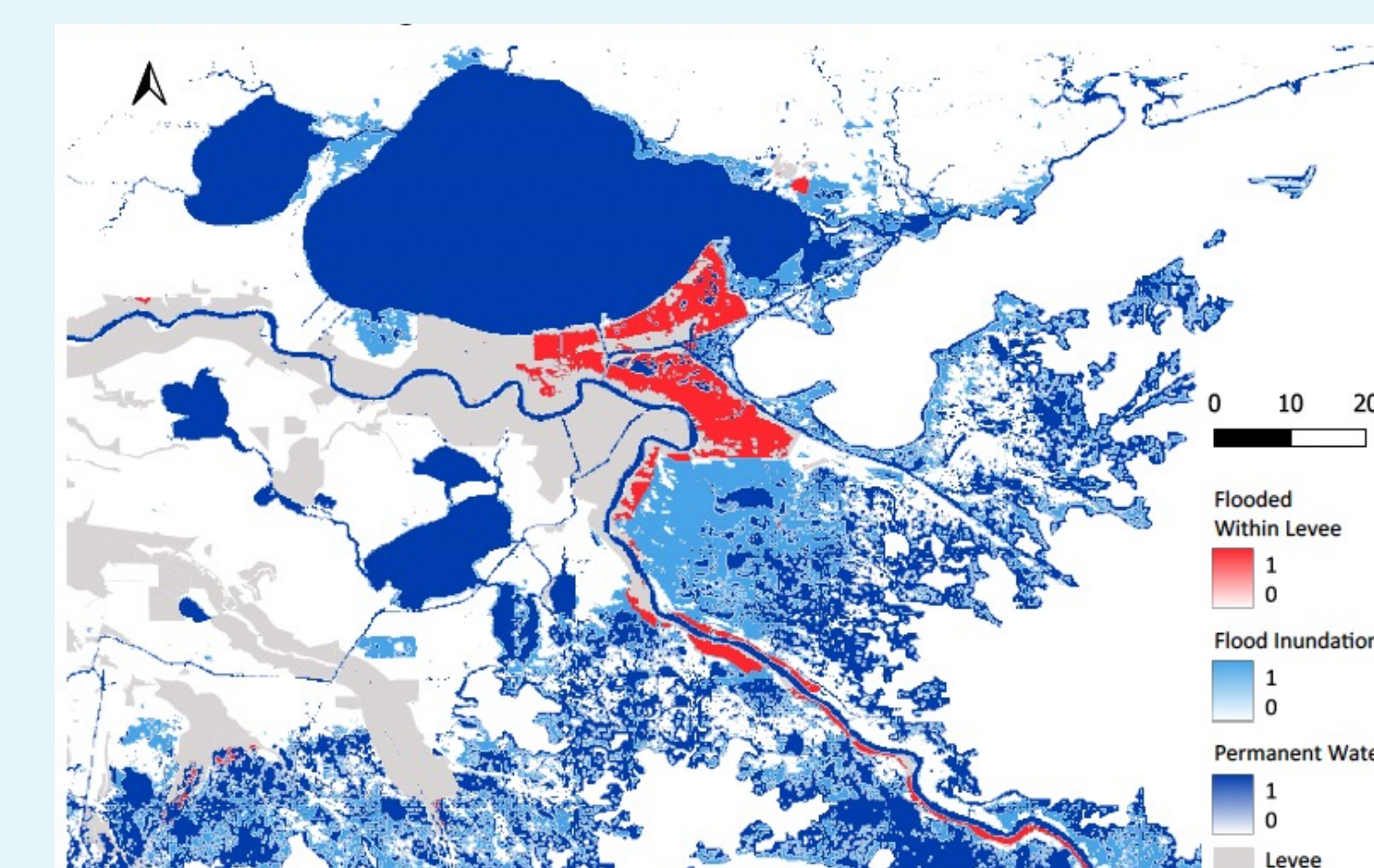Under PL 84-99: Eligibility of Rehabilitation and Inspection Program (RIP)

- 2.9% Acceptable, 57.1% Minimally Acceptable, 40% Unacceptable.
- Designed protection level.
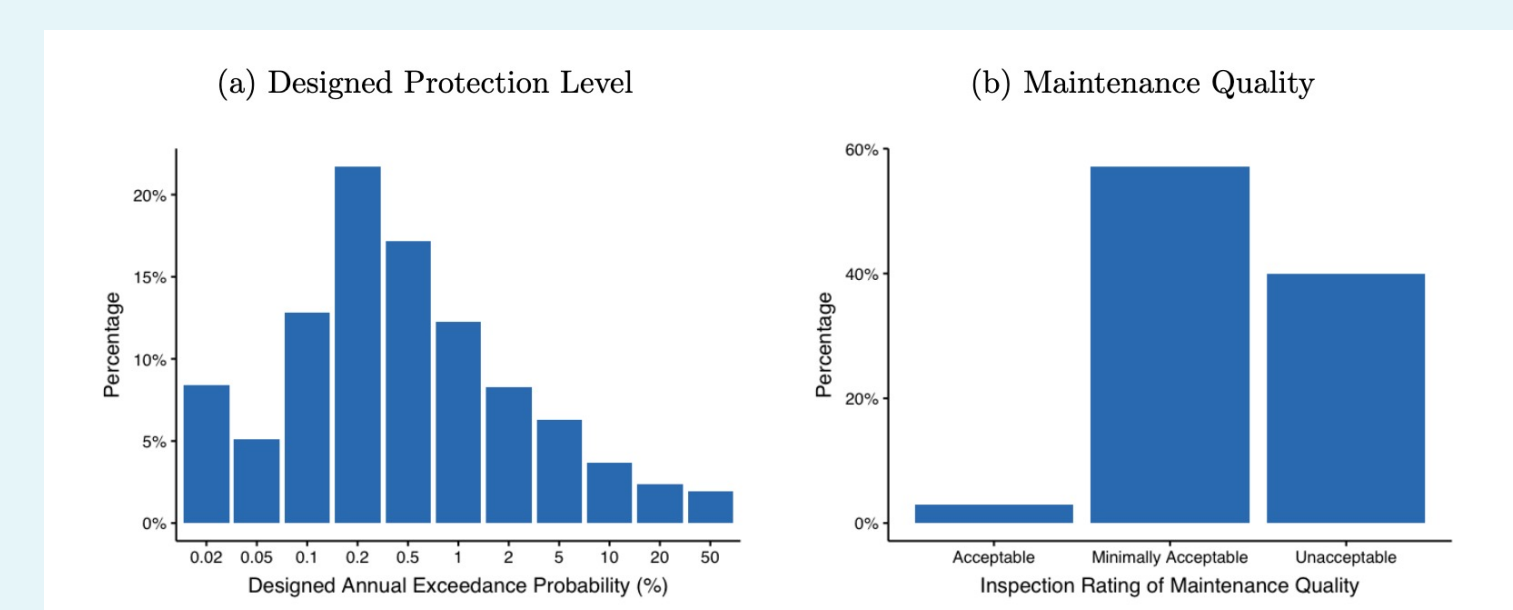
Levee performance
Moderate Resolution Imaging Spectroradiometer (MODIS).
Daily, 250 meter resolution.

- Flood inundation mapping (Tellman et al., 2021) for 103 flood events since 2000.
  - Flood events from Dartmouth Flood Observatory (DFO).
 - Water detection algorithms on imageries using Google Earth Engine.

3-day standard algorithms + empirically derived thresholds to the short-wave-infrared, near-infrared, and red bands (bands 7, 2, and 1) from MODIS

Example: Hurricane Katrina

Inequality in Levee Quality

- 1 SD increase in tract income:
  - 8.3 percent increase in protection.
  - 9.6 percent increase in (minimally) acceptable quality.
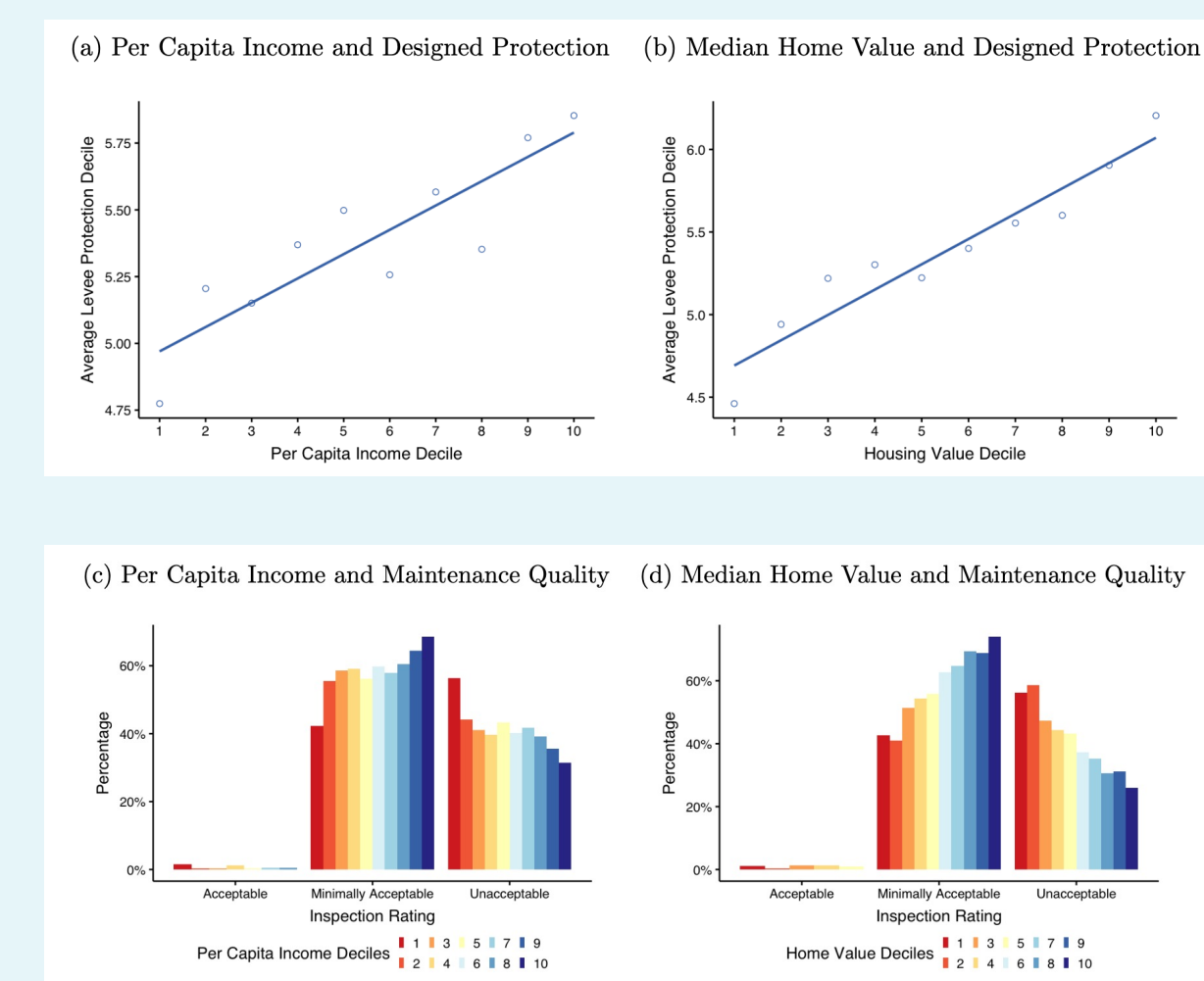
Local Fiscal Capacity

- Local fiscal capacity matters:
  Income disparity in maintenance larger when municipal governments or special districts are local sponsors.

Table 3: Income inequality in levee maintenance quality by local sponsorship

Local Sponsor	All (1)	(Minimally) Acceptable Quality State/County (2)	Municipality (3)	Special District (4)
Log(Per Capita Income)	0.084*** (0.016)	0.053 (0.033)	0.113*** (0.027)	0.094*** (0.020)
Log(Levee Population)	0.038*** (0.004)	0.050*** (0.011)	0.077*** (0.013)	0.042*** (0.005)
State FE	Yes	Yes	Yes	Yes
Protection level FE	Yes	Yes	Yes	Yes
Floodzone ratio control	Yes	Yes	Yes	Yes
Observations	2,340	463	731	1,091
Adjusted R²	0.535	0.651	0.434	0.712

Causality:

Quasi-random economic variations (e.g., Trade shock/ Technology shock)

↓

Housing value & Property tax revenue

↓

Levee maintenance quality

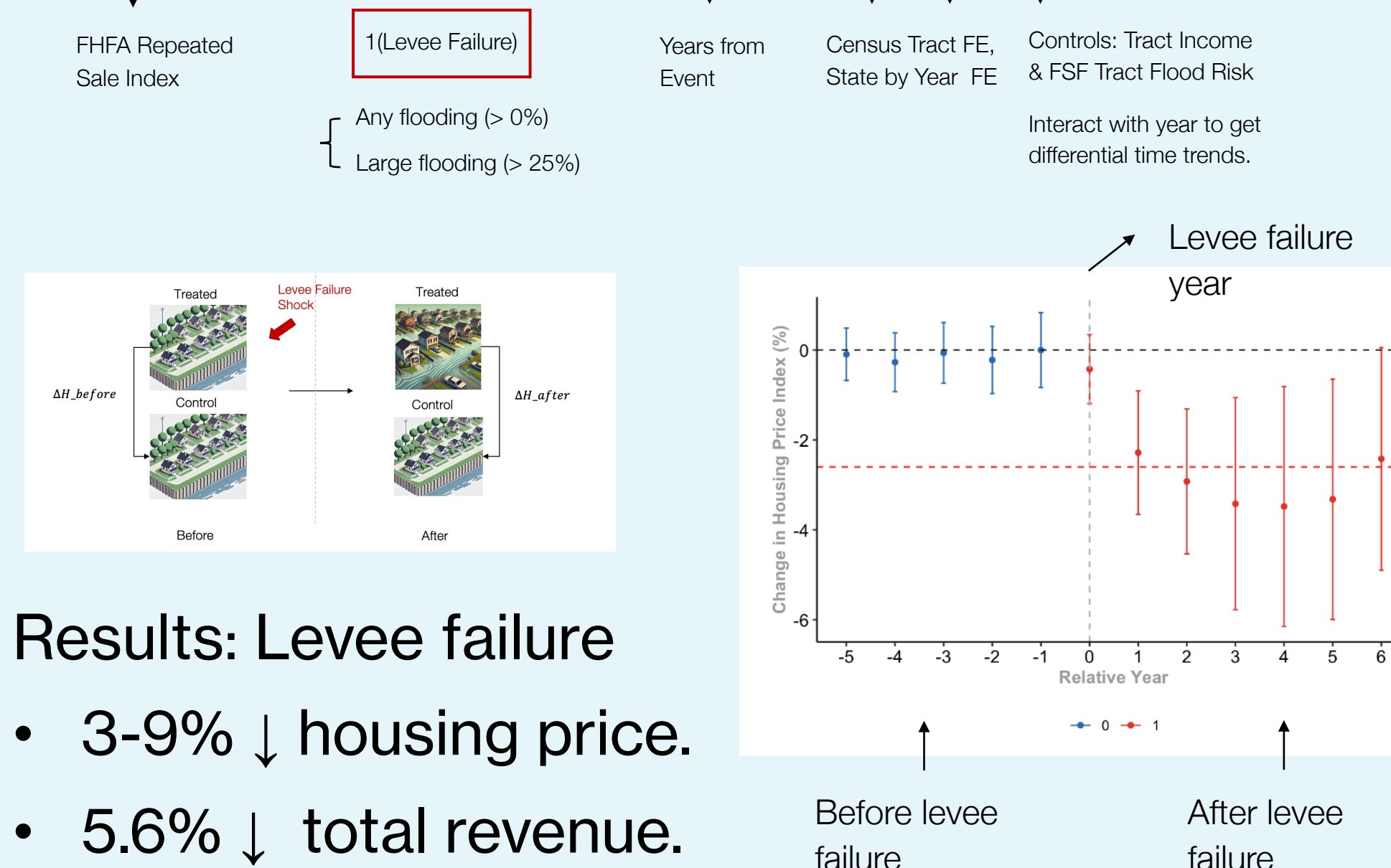## Levee Failure and Economic Feedback Loop

Maintenance and levee failure

- Maintenance impacts failure risk.
- Maintenance moderates income disparity in failure risk.

	Times flooded within levees since 2000		
	(1)	(2)	(3)
Log(Per Capita Income)	−0.287** (0.128)	−0.246* (0.130)	−0.166 (0.139)
Floodzone Ratio	0.655*** (0.178)	0.686*** (0.179)	0.545*** (0.191)
Log(Protection Level)		−0.325*** (0.057)	−0.231*** (0.075)
Acceptable Quality			−1.185*** (0.167)
State FE	Yes	Yes	Yes
Ownership FE	Yes	Yes	Yes
Observations	2,089	2,062	1,700
Adjusted R²	0.273	0.284	0.289

Levee failure on housing value

$$HPI_{ift} = \sum_{\tau=-5}^{6} \beta_t (LeveeFail_{if} \times EventTime_{ft}^\tau) + \delta_i + \theta_{st} + (X_i \times Year_y)\eta + \epsilon_{ift}$$

FHFA Repeated Sale Index
1(Levee Failure)
Any flooding (> 0%)
Large flooding (> 25%)
Years from Event
Census Tract FE, State by Year FE
Controls: Tract Income & FSF Tract Flood Risk
Interact with year to get differential time trends.

Before levee failure   After levee failure

Levee failure year

Results: Levee failure
- 3-9% ↓ housing price.
- 5.6% ↓ total revenue.

Economic inefficiency

- Levee maintenance: average benefit cost ratio 8.81.
- 36.37% positive NPV levees poorly maintained. ~ $456 million flood loss.