Incentivizing Risk Reduction: The Role of Risk-Based Liability Insurance in Managing Underground Storage Tank Pollution

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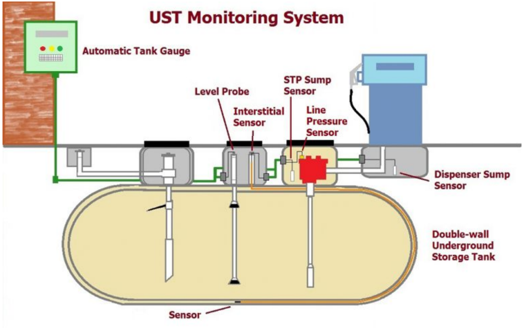
What is a UST?

Underground Storage Tanks (USTs) are containers storing hazardous substances underground, primarily at gas stations.



Motivation & Environmental Context

Environmental Risk

Leaking Underground Storage Tanks (USTs) are the leading source of groundwater contamination in the US (EPA, UST facts 2024).

- Approximately 500,000 facilities nationwide storing hazardous motor fuels
- Significant threat to drinking water supplies and public health (Marcus, 2021)

Research Gaps

Critical knowledge gaps persist in UST regulation:

- No rigorous evaluation of regulatory effectiveness
- Unknown how financial responsibility mechanisms affect pollution outcomes

I leverage Texas's 1999 transition from flat-fee to risk-based insurance as a natural experiment to identify how insurance pricing structure affects environmental outcomes through facility owners' investment decisions.

Research Questions for Today

Research Questions & Theoretical Predictions

Core Mechanism: Risk-based pricing directly connects premiums to expected damage costs, internalizing pollution externalities that flat-fee systems allow firms to ignore

Theory predicts transition to risk-based insurance pricing can improve welfare. This work tests the necessary conditions:

1. **Can observable characteristics create effective risk-differentiated contracts?**
   - Efficient risk-based pricing requires observable tank characteristics to be strong predictors of leak risk
2. **Do firms respond strategically to risk-based price signals?**
   - For welfare improvements, it is *necessary* for firms' behavior to be responsive to the prices/contracts they face
3. **Do these behavioral responses translate into environmental benefits?**
   - If firms respond to incentives by removing or upgrading risky tanks, pollution

Empirical Setting: Texas as Natural Experiment

Texas' 1999 transition from public to private insurance creates ideal identification:

Before (pre-1999)

- Uniform flat-fee premiums
- State-run insurance program
- No risk differentiation

After (post-1999)

- Risk-adjusted premiums in Texas, but not control
- Private market insurance
- Pricing based on facility risk

Identification Strategy: Difference-in-differences comparing Texas facilities (treated) to facilities in other EPA UST Trust fund states (control)

Data: Universe of Underground Storage Tanks (1970-2020)

- **Total unique facilities:** 309,640
  - Texas facilities: 64,090
  - Control state facilities: 245,550 (across 18 states)
- **Control states:** AL, AR, ID, IL, KS, LA, MA, ME, MN, MT, NC, NM, OH, OK, PA, SD, TN, VA

Estimation Sample

- **Full dataset:** 309,640 unique facilities across 19 states
- **Primary analysis sample:** Single-walled facilities existing before 1999
  - 143,647 facilities (46.4% of full sample)
  - Texas: 7,884 facilities
  - Control states: 135,763 facilities
- **Sample restriction rationale:**
  - Single-walled tanks represent the highest observable risk category
  - Pre-1999 restriction ensures clean identification
  - Focuses analysis on incumbent behavior under policy change

Can we predict UST reported leaks?

10-fold cross-validation:

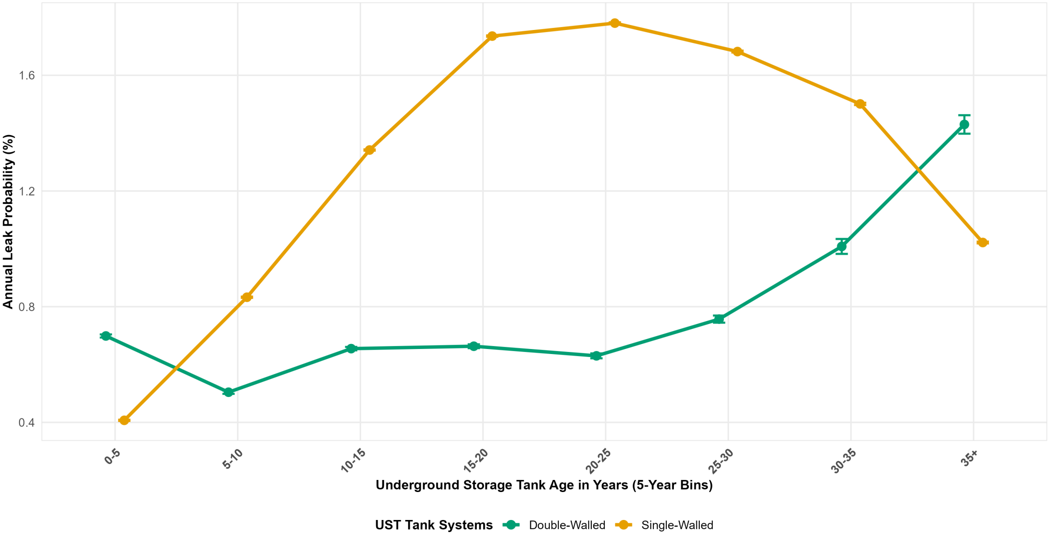
$$\begin{aligned}\text{Reported Leak}_{i,s,t} =& \alpha_t + \delta_s + \sum_k \beta_k \text{Wall}_{k,i} + \sum_m \gamma_m \text{Age Bins}_{m,i} + \\ & \sum_{k,m} \zeta_{km} (\text{Wall}_{k,i} \times \text{Age}_{m,i}) + \theta \mathbf{X}_{i,s,t} + \epsilon_{i,s,t}\end{aligned}$$

- Reported $\text{Leak}_{i,s,t}$: Dependent variable for individual i in location s at time t
- α_t, δ_s: Year fixed effects & State effects
- $\text{Wall}_{k,i}$: Indicator for Single-Walled UST Systems
- $\text{AgeBin}_{m,i}$: 5 year facility Age bins
- $\mathbf{X}_{i,s,t}$: Additional Control variables (e.g., tank size, material, release detection method)

I plot predicted leak probability by tank age and wall type.

Predicted Annual Leak Probability by Underground Storage Tank Age and Wall Type

Cross-validation estimates from 10-fold facility-level sampling. Overall sample leak rate: 1.13 % (N = 4,191,898)
RMSE: Overall = 0.0963 , Single-Walled = 0.1063 , Double-Walled = 0.081



How do incumbent UST owners alter UST closure decisions under new policy?

$$\text{Tank Closure}_{i,t} = \beta \cdot \text{Treatment}_{i,t} + \sum_{a=1}^{N} \gamma_a \cdot \mathbf{1}[\text{AgeBin}_a]_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t}$$

- $\text{Treatment}_{i,t}$ is an indicator for Texas facilities post-1999
- $\mathbf{1}[\text{AgeBin}_a]_{i,t}$ is an indicator for tank age bins (e.g., 0-5, 6-10, etc.)
- α_i and α_t facility and year fixed effects

Has the nature of tank closures changed?

$$\text{Y}_{i,t} = \beta \cdot \text{Treatment}_{i,t} + \sum_{a=1}^{N} \gamma_a \cdot \mathbf{1}[\text{AgeBin}_a]_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t} \mid \text{Tank Closure}_{i,t} = 1$$

- $Y_{i,t}$ is an indicator for $\text{Exit}_{i,t}$ or $\text{Replace}_{i,t}$
- run separately for exit and replacement indicators

Dependent Variables:	Tank Closure		Exit | Closure		Replace | Closure	
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Texas × Post-Policy	0.0303***	0.0183***	-0.0953**	-0.1107***	0.0733	0.1032**
	(0.0058)	(0.0054)	(0.0348)	(0.0345)	(0.0420)	(0.0361)
Age Bin Controls	No	Yes	No	Yes	No	Yes
Fixed-effects						
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Facility FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Clustered (state) standard errors in parentheses. Significance: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Sample restricted to Single-Walled facilities (pre-1999). Observations: 3,816,313 (Closure models), 136,078 (Exit and Replace models).

Age-specific HTE: Replacement rates stable at ~10% across ages; exit rates vary - higher in younger facilities, lower in older ones.

HTE Closure HTE Change in Nature Event Study

Effect of Risk-Based Pricing on Reported Leaks

To assess how the policy change affected environmental outcomes, I estimate:

$$\text{Reported Leak}_{i,t} = \beta \cdot \text{Texas}_i \times \text{Post1999}_t + \sum_{a=1}^{N} \gamma_a \cdot \mathbf{1}[\text{AgeBin}_a]_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t}$$

Where:

- $\text{Reported Leak}_{i,t}$ indicates whether facility i reported a leak in year t
- $\text{Texas}_i \times \text{Post1999}_t$ captures the treatment effect
- Fixed effects control for time-invariant facility characteristics and temporal trends
- Model estimated on single-walled tanks only, the highest risk category

Risk-based pricing should reduce leak incidents through:

1. Improved technology choices (replacement effect)
2. Exit of highest-risk facilities

Dependent Variable:	Reported Leak (0/1)	
Model:	(1)	(2)
Texas × Post-1999	-0.0097***	-0.0124***
	(0.0030)	(0.0032)
Age Bin Controls	No	Yes
Fixed-effects		
Year FE	Yes	Yes
Facility FE	Yes	Yes

Notes: Clustered (state) standard errors in parentheses. Significance: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Sample restricted to Single-Walled facilities (pre-1999).

HTE Leaks

Event Study

Summary of Findings

- **Policy (TX, 1999):** Flat-fee $\rightarrow$ risk-based pricing
- **Owner Responses:**
  - Closure $\uparrow$ 1.8 ppt ($p < 0.01$)
  - Replacement $\uparrow$ 10.3 ppt ($p < 0.05$)
  - Exit $\downarrow$ 11 ppt ($p < 0.01$)
- **Leak Outcomes:**
  - Overall $\downarrow$ 1.24 ppt ($p < 0.01$)

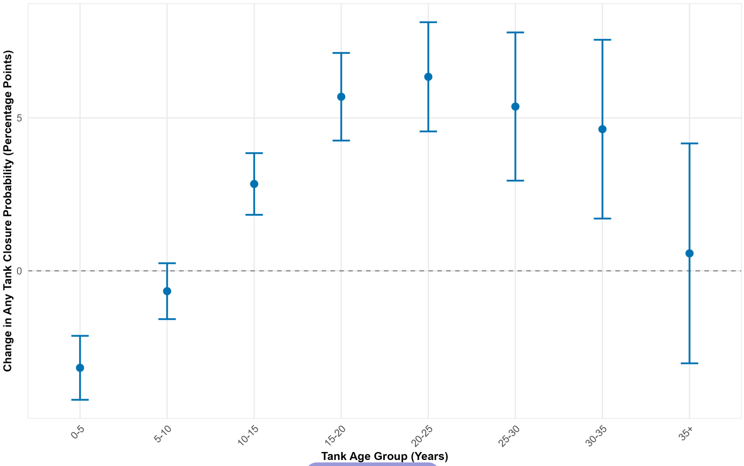
Overall findings suggest that risk-based insurance pricing effectively incentivizes UST owners to reduce pollution risk through increased closures and replacements, while decreasing the likelihood of exiting the market relative to control states.

Ongoing and Future Work

1. **Heterogeneity Analysis**
   - Effects by facility size, ownership structure
   - Geographic variation in policy response
   - Study selection effects of FR Mechanisms and Pollution
2. **Policy Counterfactuals with Structural Model**
   - Alternative insurance designs
   - Targeted subsidy programs
   - Incorporating unpriced health externalities

Policy Effect on Any Tank Closure by Tank Age

Model: SW-Only (Pre-1999) facilities, Texas vs. Control, Post-Period, interacted with Tank Age.
Effect shown is (Texas * Post-Period) for each age group.



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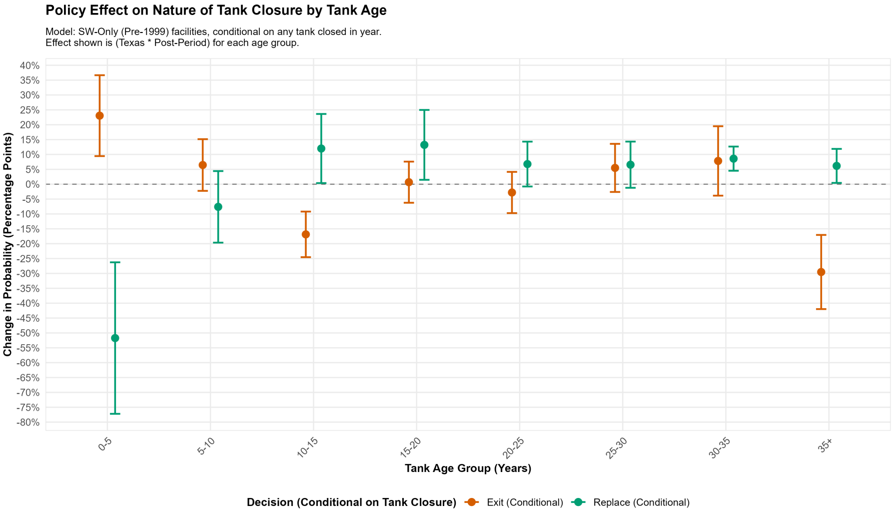

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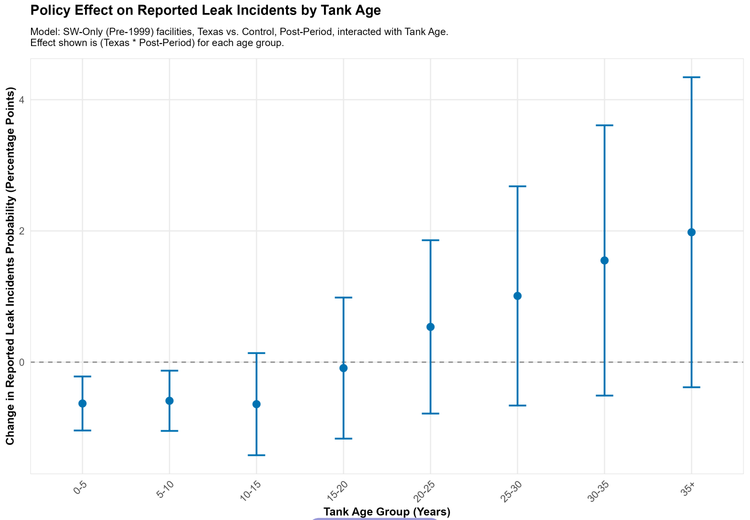

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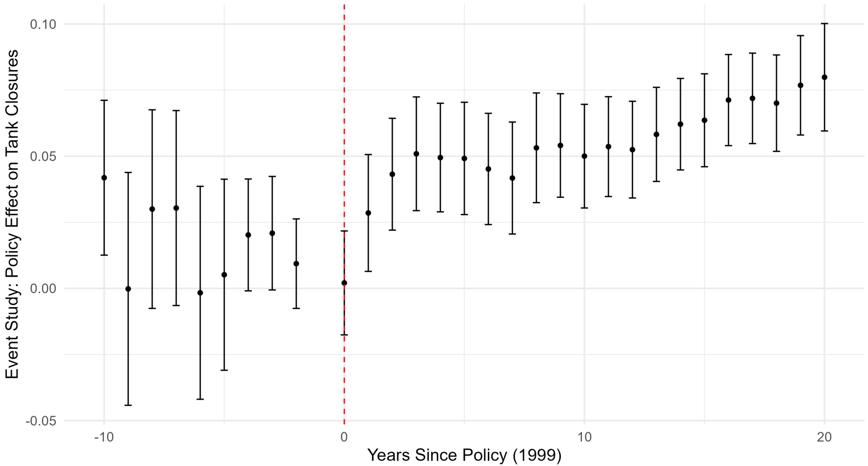
Dynamic Policy Effects on Tank Closures (Single-Wall Tanks, Texas)



Reference year: -1 (1998)

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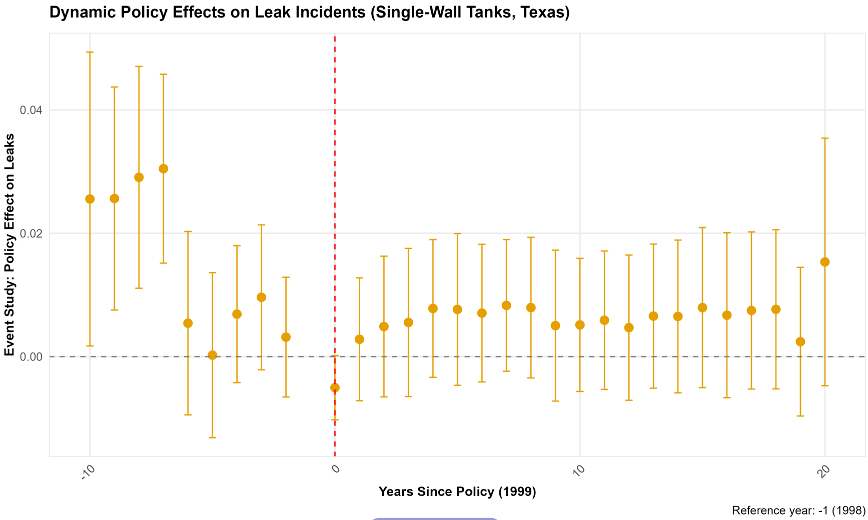

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