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

Camp Resources XXXI

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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

- **No causal evidence:** No rigorous facility-level analyses of how federally mandated insurance affects pollution outcomes
- **Limited empirical evidence:** Few studies test theoretical predictions about liability insurance as an environmental policy tool (Shavell, 2007)

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

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 and their implications:

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

Data & Empirical Strategy

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

- Panel dataset of 309,640 facilities across 19 states (Texas (treated): 64,090 facilities, Control states: 245,550 facilities)
- Primary analysis dataset: 143,647 single-walled facilities (pre-1999) $\rightarrow$ Highest risk facilities types

Empirical Strategy: Difference-in-Differences

Identification Strategy: Difference-in-differences comparing Texas facilities (treated) to facilities in EPA UST Trust Fund states (control) following Texas's 1999 policy change

$$\mathrm{Y}_{i,t} = \beta \cdot (\mathrm{Texas}_i \times \mathrm{Post}_t) + \gamma \cdot \mathrm{Controls}_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t}$$

- Outcomes: Facility closure, tank replacement, market exit, leaks
- Fixed effects: Facility (α_i) and year (α_t)

Headline Results: Risk Predictability & Firm Response

1. **UST Leak Risk is Predictable** Risk Graph
   - Single-walled tanks have higher risk than double-walled tanks
   - Risk increases substantially with tank age
   - Oldest single-walled tanks show 7-8% annual leak probability
2. **Firm Response to Risk-Based Pricing** Event Study
   - **Tank Closures** $\uparrow$ 1.8 percentage points ($p < 0.01$) By Age
   - **Conditional on Closure:**
     - **Replacement:** $\uparrow$ 10.3 percentage points ($p < 0.05$)
     - **Exit:** $\downarrow$ 11.0 percentage points ($p < 0.01$) Exit vs Replace

Headline Results: Environmental Outcomes

Impact on Reported Leaks:

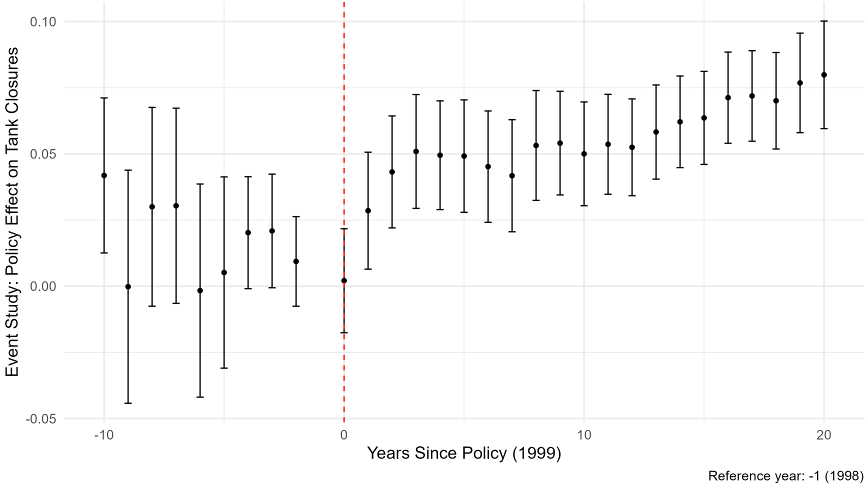
- Overall leak probability $\downarrow$ 1.24 percentage points ($p < 0.01$) Event Study
- Represents $\sim$30% reduction relative to mean leak probability

HTE By Age

Next Steps and Ongoing Work

1. **Rust Style Structural Model of Retrofit/Closure Behavior**
   - Quantifying welfare loss of uniform insurance and decompose the effects into discrete behavioral responses
   - Welfare impacts of fully internalizing externality through insurance pricing
   - Comparing non-price interventions (e.g., mandates and subsidies) to risk-based insurance
2. **Econometric Extensions**
   - Replicate the OLS results using hazard models
3. **Heterogeneity Analysis**
   - Effects by facility size, ownership structure, and geography
   - Selection effects of financial responsibility mechanisms
   - Distributional impacts across different facility types

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



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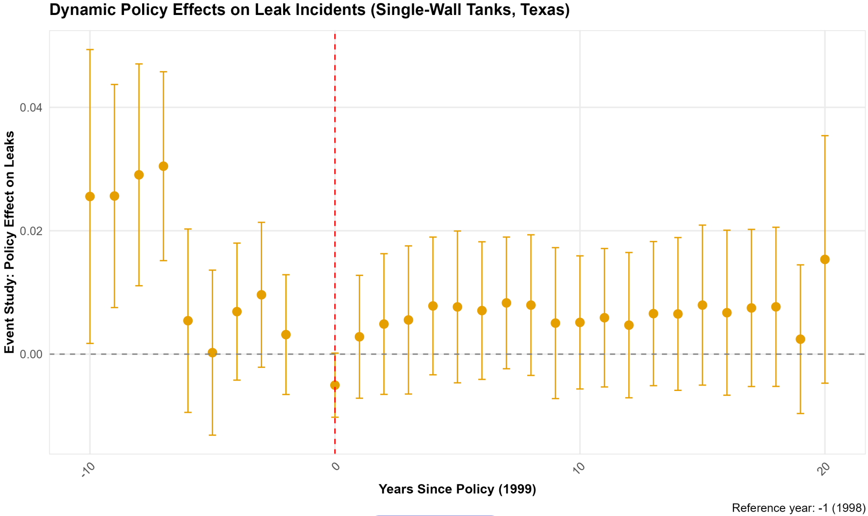

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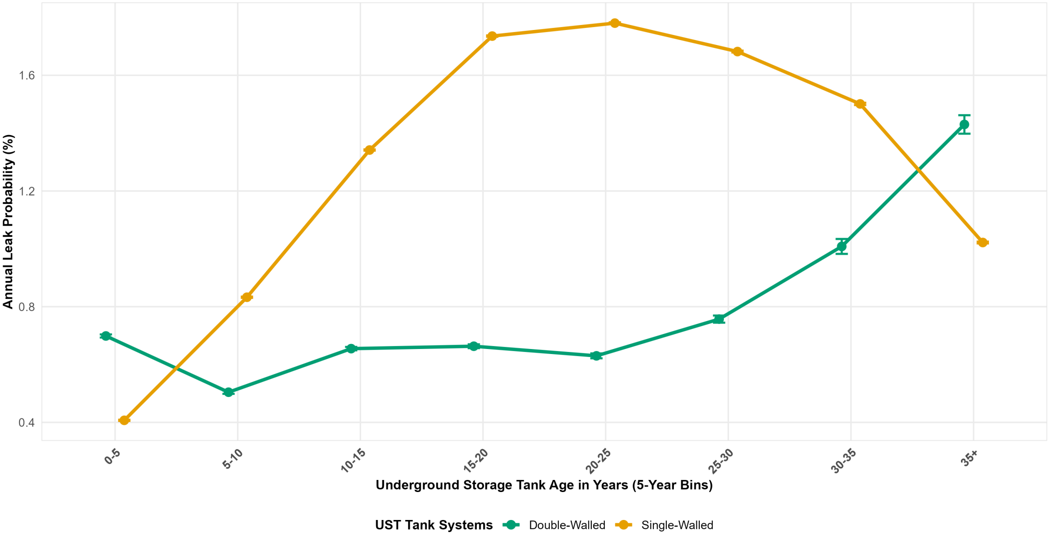
Predicted Annual Leak Probability by Underground Storage Tank Age and Wall Type

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



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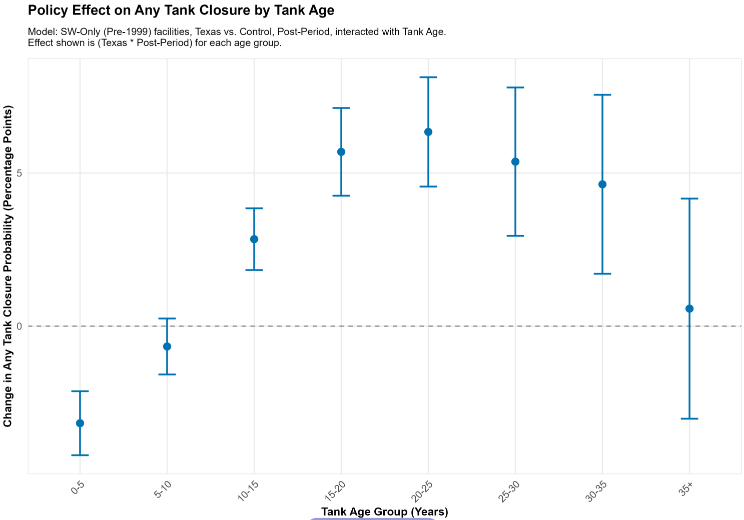

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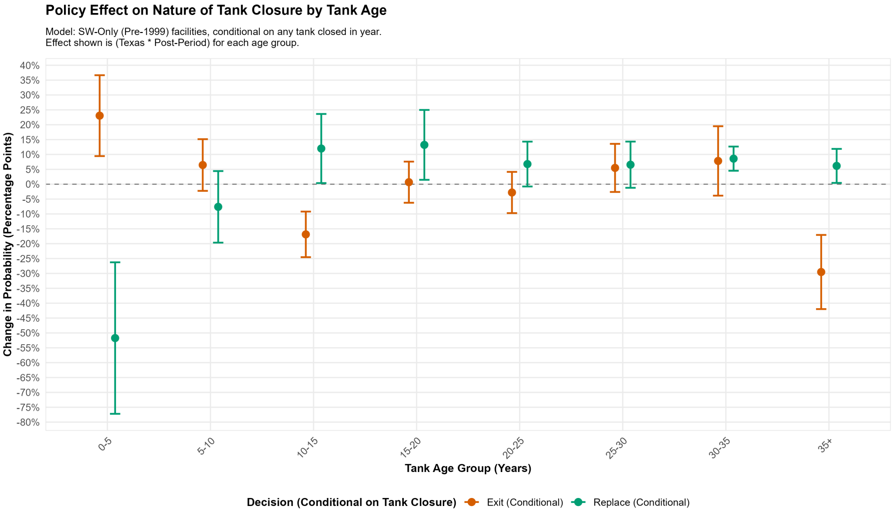

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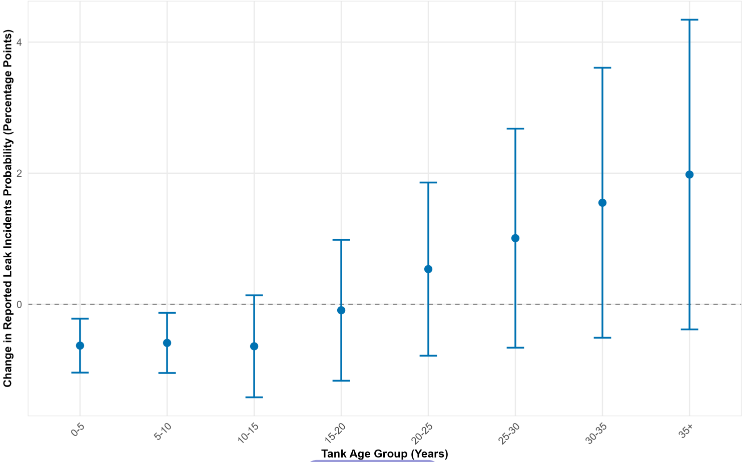
Policy Effect on Reported Leak Incidents by Tank Age

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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