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Second-Best Prioritization of Environmental Cleanups

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Superfund Overview

- What are Superfund sites?
  - Hazardous waste sites
  - Usually caused by dumping or improper management
  - Does not include sites posing immediate risks
- How are they cleaned?
  - Cleaned by the EPA to allow for development
  - Funding comes from litigation against those who dirtied the site
    - Funding for all sites and all litigations is in one big pot
- Examples: Philadelphia Navy Yard, Havertown PCP Site, Roebling Steel (Florence, NJ)

Philadelphia Navy Yard – Girard Point

Before

After

Apache Powder Site – Benson, AZ

Covanta Coal Plant Site – Lawrence, MA

Superfund Overview

- Remediation process goes beyond just cleanup
  - Also includes completing a full economic development of the site
  - This helps local economies!
    - Hamilton & Viscusi (1999 JPAM)
- Process for prioritizing site cleanups is vague
  - Nine total criteria
  - Not based on any economic factors!

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- **Research Question(s):** Is the EPA leaving money on the table by not considering economic factors when prioritizing cleanup sites?
  - How can the EPA increase overall social welfare by prioritizing sites?

Preview of Methods

- Modify a standard theoretical macroeconomic model
  - Account for local economic benefits of cleanup
    - Both short-run and long-run benefits
- Run a Monte Carlo simulation using the modified model
  - Calibrated with actual data
  - Test various new prioritization policies against the current one

Preview of Results

- Theoretical model identifies which variables play a role

- Simulation results show benefits of various prioritization policies (relative to current system)

- Resulting ordered heuristics we suggest for the EPA, with each subsequent one as a tie-breaker for the previous:
    1. Smallest cleanup costs
    2. Most productivity loss due to site waste
    3. Currently recessed localities
    4. Largest local discount rates

- Note: These heuristics are virtually costless to implement
    - Not doing so means leaving money on the table

Before Superfund

- Frequent environmental disasters gained national attention in the 1950s, '60s, & '70s
  - Cuyahoga River Fires (1952, 1969, etc.) – Cleveland, OH area
  - The Valley of the Drums (1960s–1982) – Brooks, KY
  - The Love Canal (1977) – Niagara Falls, NY
- President Nixon created the EPA on December 12, 1970

Before Superfund

Cuyahoga River Fire

The Valley of the Drums

Establishment & Expansion of Superfund

- CERCLA (1980) – Comprehensive Environmental Response, Compensation, & Liability Act
  - Provides the EPA with the federal authority and resources to secure/clean waste sites
- SARA (1986) – Superfund Amendments & Reauthorization Act
  - Program expanded to include minimum cleanup requirements
  - Requires consent decrees, subject to public comment, to be made in federal courts
  - Mandates planning of post-cleanup commercial and public-use redevelopment prior to the start of remediation

Superfund Budget

- Funding largely comes from legal payments required by polluters
  - Originally from taxes on polluters
  - Now from ex-post legal battles
- Funding is NOT site-specific
  - All funds go into one big pot

Superfund Budget

- Yearly Superfund expenditures average ≈$2 billion since 2001
  - Relatively constant over time
  - Spread out over ≈300 ongoing sites per year
- Funding is not sufficient to clean all sites in a given year
  - Currently 1,338 sites on the NPL (National Priorities List)
- Funding scarcity ⇒ the EPA must choose how to prioritize sites

Remediation Timeline

1. A hazardous waste site is identified
2. Sites posing an immediate threat to human health skip this list
   - These are NOT Superfund sites – forget them
3. EPA assigns a hazard score, $\in [0, 100]$, to each site
4. Sites scoring high enough are placed on the NPL
5. EPA uses nine criteria to decide which sites from the NPL begin remediation
   - Local economic conditions, etc. are NOT included

- Note: No laws preventing the EPA from using additional criteria
  - We test this and find that they do not consider the criteria we identify as important

Existing Literature

- Superfund cleanups have lasting positive economic impacts
  - Hamilton & Viscusi (1999 JPAM)
- Median home values ↑ by 15.4% near cleanup site
  - Gamper-Rabindran et al. (2011 NBER)
- Case study found total benefits ↑ by roughly $72–112 million
  - Kiel & Zabel (2001 JREFE)
- Similar impact on industrial properties
  - An Atlanta-area waste site discovery caused $56 million in total land depreciation
    - Ihlanfeldt & Taylor (2004 JEEM)

Existing Literature

- Increase in value directly correlates with site proximity
  - Gamper-Rabindran et al. (2011 NBER); Mastromonaco (2014 ERE)
- The effect disappears after ≈3 km
  - Gamper-Rabindran & Timmins (2013 JEEM)

Standard Ramsey Model – Small (3 km) Open Economies

- Continuous-time framework
- Central planner balances consumption (c) and capital (k)
- Planner's Goal: Maximize the net present value of utility of all consumption, present and future
- Results in typical Brownian motion framework
  - Steady state (s.s.) levels of consumption (c^*) and capital (k^*)
  - One-time disruptions from s.s. end up converging back toward s.s.
  - Permanent changes in productivity alter the s.s. itself

Model Modification #1

- We model recessions as a shock to economic productivity that imperfectly persists over time

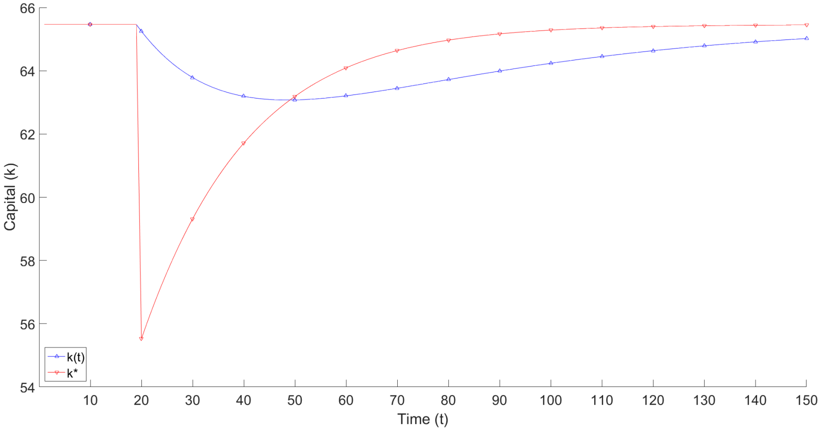

Figure: Stylized Representation of Capital (k) and Steady-State Capital (k^*). Recession at $t = 20$. Site is Never Cleaned.

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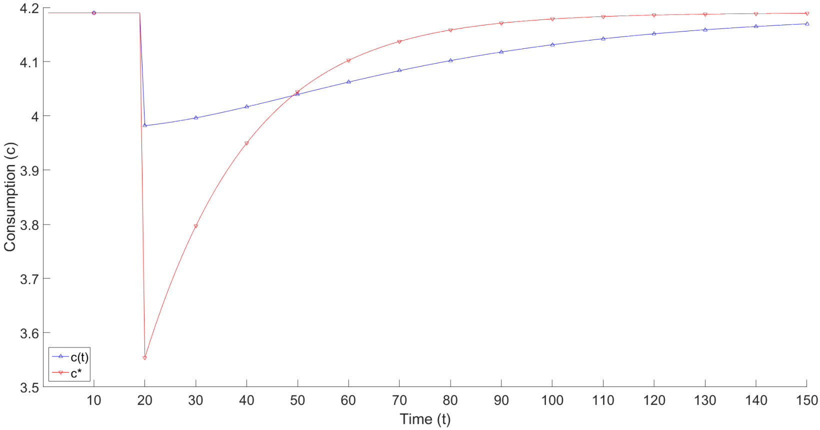

Figure: Stylized Representation of Consumption (c) and Steady-State Consumption (c^*). Recession at $t = 20$. Site is Never Cleaned.

Model Modification #2

- The short-run effect of cleanup is a direct injection of federal cash into the local economy
- We model this as a one-time boost in capital (k increases by $\overline{k}$)
  - This is literally the cost of cleaning up the site
- This short-run effect is transitory
  - It does not affect the steady state

Model Modification #3

- The long-run effect of cleanup is a permanent boost in economic productivity $(1 - A(w))$
  - This permanently alters the steady state

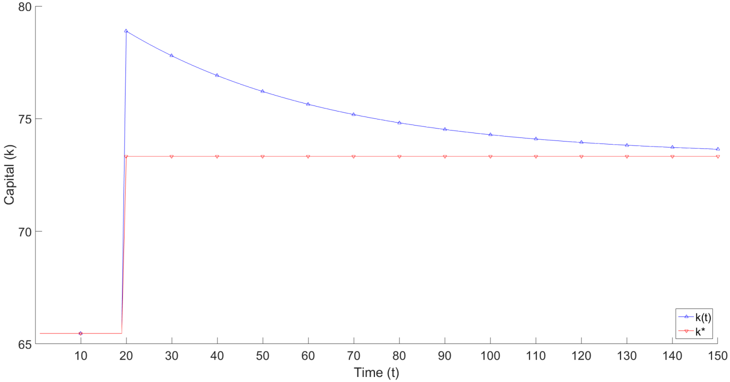

Figure: Stylized Representation of Capital (k) and Steady-State Capital (k^*). No Recession. Site is Cleaned at $t = 20$.

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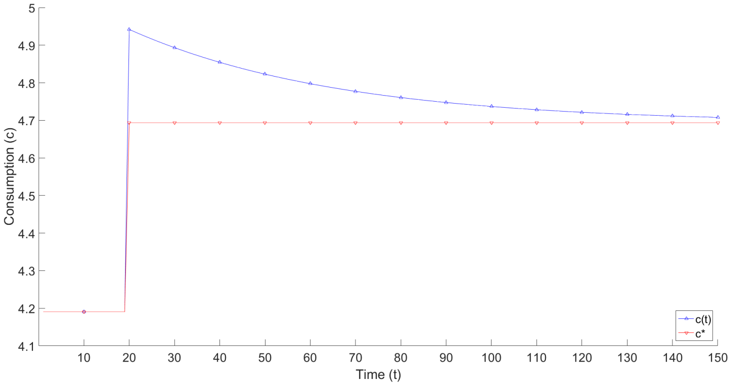

Figure: Stylized Representation of Consumption (c) and Steady-State Consumption (c^*). No Recession. Site is Cleaned at $t = 20$.

Theoretical Predictions

- We simultaneously add all 3 modifications to our theoretical model
- We systematically vary each aspect of the model to study the effects on social welfare, all else equal
- Theoretical Predictions:
  1. In the absence of funding constraints, it's always better to clean sooner
  2. Given a budget, smaller cleanup costs allow for more sites to be cleaned, increasing social welfare more
  3. Cleaning sites that dampen productivity more increase social welfare more
  4. Cleaning sites in recessed economies helps by ending the recessions faster
  5. Cleaning sites in economies with higher discount rates increases social welfare more

Simulation Setup

- Monte Carlo simulation with 1,000 draws
- Each draw has 500 cleanup sites spanning 60 quarters (15 years)
- The budget increases every 4 quarters (1 year)
  - Budget is based on actual EPA data
- Recessions occur stochastically
  - Can occur in any quarter

Monte Carlo draws

- Monte Carlo draws are made using variation in four dimensions:
  - Local economies' probability of entering a recession (ρ)
  - Local economies' discount rates (r)
  - Site cleanup costs ($\overline{k}$)
  - Sites' productivity dampening effects on the local economy ($1 - A(w)$)

- All four variable distributions are calibrated using actual data

Simulation Cleanup Policies

- We compare 8 different cleanup ordering policies for each MC draw:
  0. Baseline – random (with respect to economic variables)
  1. Recessed sites first, but otherwise random
  2. Sites ranked by highest ex ante probability of entering a recession (ρ)
  3. Sites ranked by highest local discount rate (r)
  4. Sites ranked by smallest cleanup cost ($\overline{k}$)
  5. Sites ranked by largest long-run damages from waste (long-run cleanup benefit, $1 - A(w)$)
  6. Sites ranked by largest expected net present value (ENPV) of utility per dollar spent
  7. Clean all sites immediately (no budget constraint)

Simulation Progression

- For a given MC draw, the 500 sites' four parameter values are drawn
  - This determines the sites' initial consumption and capital values for starting time $t = 1$
- For a given policy, all 500 sites are ranked
- Each site is considered for cleaning in rank order
  - If a site's cleanup cost is less than the remaining budget, it is cleaned and that cost is removed from the budget
  - Otherwise, that site is left uncleaned for now

Simulation Progression

- Quarters 2–4 follow according to the model
  - Recessions may or may not happen in any quarter, in accordance with ρ
- The budget increases in quarter 5
  - All remaining uncleaned sites are re-ranked for each given policy
  - Sites are again cleaned in rank order, when affordable
- This repeats through 60 quarters

Simulation Progression

- Calculate the total net present value of utility across all 60 quarters across all 500 sites
- We compare this across all 8 policies within each MC draw
  - Specifically, we calculate the percent increase for each of Policies 1–7 relative to baseline Policy 0
- Last, calculate the mean (etc.) percent increase across all 1,000 MC draws for each of those policy comparisons

Policy 7

- Policy 7: Cleaning all sites immediately – i.e., removing all budget constraints
  - Social welfare $\uparrow$ by a mean of 4.18% relative to the baseline (current) policy ($p < 0.001$)
- This is not realistically feasible
  - It serves as an upper-bound benchmark for other policies

Policy 6

- Policy 6: Prioritize sites by highest expected net present value (ENPV) of utility per dollar spent
  - Social welfare ↑ by a mean of 1.88% relative to the baseline (current) policy ($p < 0.001$)
- Rough estimation of ENPV of utility per dollar spent is feasible for the EPA
  - However, there may be large administrative costs ignored by our model

Policies 1–5

Table: Mean percent increase in social welfare relative to baseline (current) policy

Policy	Mean	p-value
1: Recessed first, then random	0.30%	< 0.001
2: Highest prob. of recession (ρ)	−0.03%	0.497
3: Largest discount rate (r)	0.21%	< 0.001
4: Smallest cleanup cost ($\bar{k}$)	1.85%	< 0.001
5: Largest long-run damages from waste ($1 - A(w)$)	0.37%	< 0.001

- Policies 1–5 utilize easily observable data (small administrative costs)
  - The EPA could implement any of them nearly costlessly
    - (Except maybe $A(w)$)

Policy Recommendation

- We recommend a "rule of thumb" approach
  - Rank policies, so each subsequent rule is a tie-breaker for the previous
- Ordered heuristics, starting with the most important:
  1. Smallest cleanup cost
  2. Largest amount of long-run damage caused by waste
  3. Recessed local economies
  4. Largest local discount rates

Summary

- EPA does not consider economic characteristics when prioritizing Superfund site cleanups
  - Large literature showing economic benefits $\Rightarrow$ Maybe they should?
- We model the local economic impact of site cleanup
  - Both short-run and long-run benefits
- Our Monte Carlo simulations show that prioritization improves welfare
  - We provide a set of guidelines for the EPA to follow
- These guidelines are nearly costless to implement
  - Ignoring these guidelines is leaving money on the table

Future Work

- Correlations among economic characteristics
- Other potential characteristics
  - Length of time to clean a site, geographical complementarities between sites, site contractors may respond to local economic conditions
- Allow the social planner to bank funds across time/borrow from their "future self"
  - Legally ambiguous
- Ex post analysis of our simulation if the EPA implements our guidelines
- Extensions to other types of federal spending
  - Transportation, education

Thank You