On optimal extraction under asymmetric information over reclamation costs

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Background and research questions

Background:

- Funds for reclamation are often insufficient
- Reclamation payment is the present reclamation cost
- Reclamation cost is private information
- Future reclamation cost is estimated by the firm

Research questions:

- How to design regulation including the contract between the regulator and the firm that gives the highest possible (expected) net benefits to the society?
- Properties of the regulation. In particular, how is pollution tax affected by firm's private information?

Literature

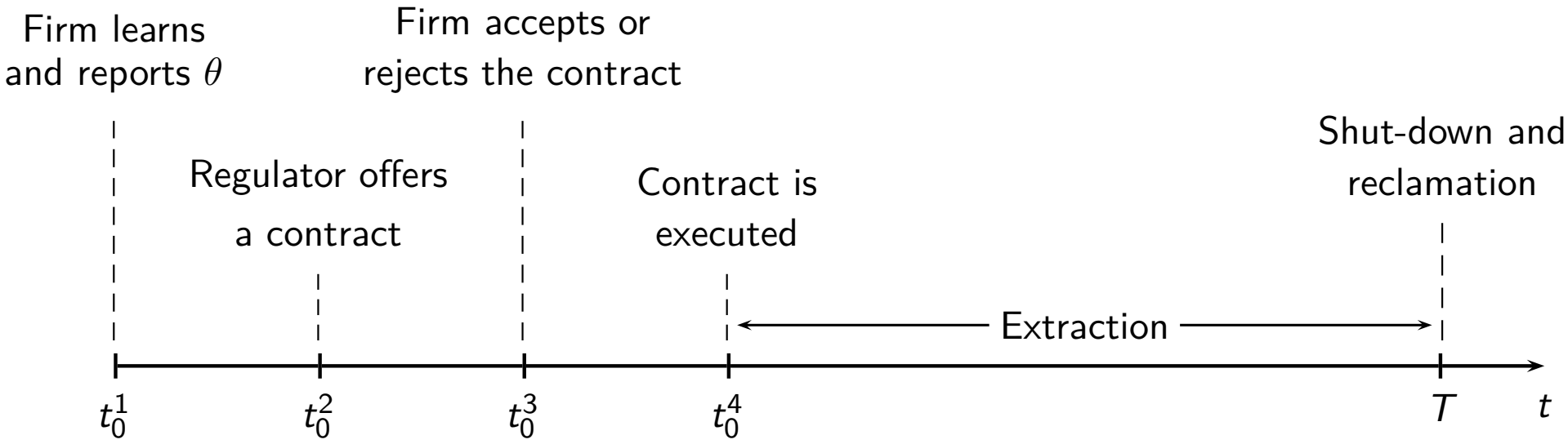
Exhaustible resources and asymmetric information:

- Extraction cost is private information: Gaudet et al. (1995) and Osmundsen (1995)
- Initial resource stock is private information: Osmundsen (1998) and Martimort et al. (2018)

Reclamation:

- Yang and Davis (2018)

Time-line



- Extraction stage regulation: pollution tax Γ and production horizon T; reclamation payment
- Reclamation contract: reclamation effort R and monetary transfer M

Reclamation contract

Regulator's problem is to

$$\max_{\{R(\theta),M(\theta)\}} \int_{\underline{\theta}}^{\overline{\theta}} \big(- D(n_T - R(\theta)) - C(R(\theta),\theta) - \lambda M(\theta)\big) f(\theta)\, \mathrm{d}\theta$$

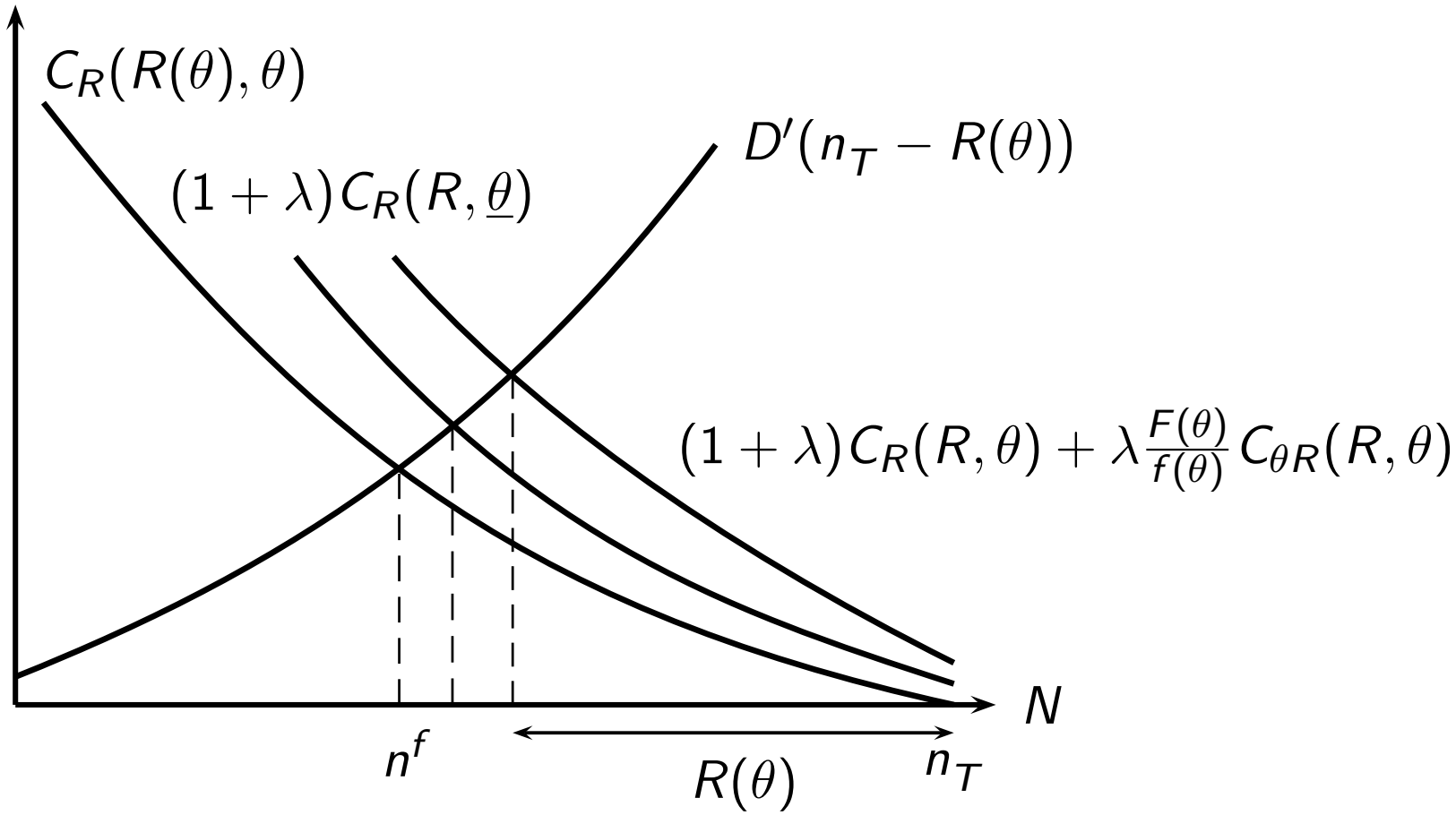
subject to the incentive compatibility constraint

$$-C(R(\theta),\theta) + M(\theta) \geq -C(R(\hat{\theta}),\theta) + M(\hat{\theta}) \tag{1}$$

for all $(\theta, \hat{\theta}) \in \Theta^2$, and the participation constraint

$$W(\Gamma, T) + [-C(R(\theta),\theta) + M(\theta)]e^{-rT} \geq 0 \quad \text{for all} \quad \theta \in \Theta \tag{2}$$

Optimal reclamation effort: illustration



Higher the firm's cost type is, the smaller is the required reclamation effort

Optimal transfer

The optimal transfer of the contract satisfies the following conditions:

$$M'(\theta) < 0 \quad \text{and} \quad M(\overline{\theta}) = C(R(\overline{\theta}), \overline{\theta}) - W(\Gamma, T)e^{rT}.$$

- High cost type receives a smaller transfer; low cost type receives the largest
- Net benefit of reclamation is negative and the total payoff zero for the highest cost type
- Total payoff is highest for the lowest cost type

Extraction stage: optimal regulation

Regulator's optimization problem at the extraction stage is to

$$\max_{\{q(t),T\}} \int_0^T (U(q(t)) - G(q(t), X(t)) - D(N(t)))e^{-rt}\,\mathrm{d}t + S(N(T), T)$$

$$\text{s.t} \quad \dot{X}(t) = -q(t), \quad X(0) = x_0, \quad X(T) \geq 0, \tag{3}$$

$$\dot{N}(t) = \alpha q(t) - h(N(t)), \quad N(0) = 0, \quad N(T) \geq 0, \tag{4}$$

$$q(t) \geq 0. \tag{5}$$

Optimal shut-down date and the tax:

- Shut-down date: benefit of waiting with the shut-down equals the cost
- Pollution tax is the negative of the shadow value of the pollution stock (current value)

First-best vs. second-best pollution tax

The pollution tax under asymmetric information over reclamation costs can be higher or lower than the pollution tax under complete information

Intuition: suppose low reclamation cost is the true type

- First-best: low cost firm can be allowed to pollute more.
  Low tax
- Second-best: true type is not known; decision is based on expected value.
  Higher tax should be used to protect against possibly high reclamation cost

Why not exclude some types?

The cut-off type:

- The type for which the society's total present value of extraction payoff equals the present value of the reclamation contract
- If the cut-off type exists, then extraction is not allowed for higher cost types

Conclusion

Benefits of the optimal contract and regulation:

1. Saves public funds
2. Improves the state of environment
3. Too expensive sites are not permitted

Thank you!

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