Natural Resources and Sovereign Expropriation

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Is leasing or selling natural resource credible?

- If resource rent goes up the temptation will be great to terminate the lease
- But it may not work any better to sell the resource
- Either way, time-inconsistency problem, eventual expropriation
    - Recent high-profile case: expropriation of Repsol's share in Argentinian YPF
- Literature:
    - Mahajan (1990), Clark (2003)
    - Volume edited by Hogan and Sturzenegger (2010)
        - Closest in analytical approach: Schwartz and Trolle (2010)
    - Closely related to the literature on default on sovereign debt, going back to Eaton and Gersovitz (1981)

Some questions

- Is there an optimal contract length? (Or, more generally, form.)
- How does contract length vary with costs of entry and termination?
- Under what conditions is it best to sell the resource (set contract length equal to infinity)?
- Shorter contracts:
  - lease rate adjusted frequently; contracts are less likely to be terminated
  - lower (cumulative) termination costs; higher costs of writing contracts
- Longer contracts:
  - lease rate less flexible; contracts likely to be terminated
  - higher termination costs; lower costs of writing contracts

Model

- Resource generates rent R_t, geometric Brownian motion, $dR_t = \mu R_t dt + \sigma R_t dW_t$
- Govmt signs leasing contract for resource. Lease payment rate L
- Govmt can terminate contract, expropriate resource and lease again.
- $0 = \tau_0 = T_0 \leq \tau_1 \leq T_1 \leq \tau_2 \leq T_2 \leq \dots$
  - T_i is end of contract i, determined as the contract is signed
  - τ_i is time of termination of contract i; stopping time (in the probabilistic sense)
- Expected surplus, discount rate $\delta > \mu$,

$$G\left(r_0, \tilde{T}_1, \tilde{\tau}_1, \tilde{L}_1\right) = E_{r_0}\left[\sum_{j=1}^{\infty}\left(\int_{\tau_{j-1}}^{\tau_j} e^{-\delta t} L_j dt - e^{-\delta \tau_j} 1_{\{\tau_j < T_j\}} K_{\tau_j}\right)\right]$$

- L_i determined at beginning of period i. K_t is the cost of expropriation at time t

Equilibrium

- Many identical potential lessees $\Rightarrow$ perfect competition for leases
- Cost of entry at time t: C_t
- Expected profit of lessee

$$\pi(r, \tau_{i-1}, \tau_i, L_i) = E\left[\int_{\tau_{i-1}}^{\tau_i} e^{-\delta[t-\tau_{i-1}]}[R_t - L_i]\,dt - C_{\tau_{i-1}} \middle| R_{\tau_{i-1}} = r\right]$$

- Find contracting strategy (sequences of contract expiration times and termination times) and lease rates such that expected surplus is maximized given the lease rates and expected profit in each contract period, given the contracting strategy, is zero

$$\pi(r, \tau_{i-1}, \tau_i, L_i) \equiv 0$$

Net surplus

Insert zero-profit condition in surplus

$$G = E\left[\sum_{i=1}^{\infty}\left(\int_{\tau_{i-1}}^{\tau_i} e^{-\delta t} R_t dt - e^{-\delta \tau_{i-1}} C_{\tau_{i-1}} - e^{-\delta \tau_i} 1_{\{\tau_i < T_i\}} K_{\tau_i}\right)\right]$$

Get

$$G = E\left[\int_0^{\infty} e^{-\delta t} R_t dt\right] - E\left[\sum_{i=1}^{\infty}\left(e^{-\delta \tau_{i-1}} C_{\tau_{i-1}} + e^{-\delta \tau_i} 1_{\{\tau_i < T_i\}} K_{\tau_i}\right)\right]$$

- Surplus = gross value of resource - costs of writing and terminating contracts

Resource trap

- Surplus would be maximised if transactions costs (C's and K's) could be avoided
- If government can credibly commit to no expropriation ($K_i \equiv \infty$) then no contracts terminated
  - $\Rightarrow$ only costs of writing contracts remain $\Rightarrow$ Optimal to sell resource and incur contracting cost only once
- But with bounded costs of expropriation an infinitely long contract will be terminated with probability 1
- Resource trap: positive transactions costs and lower net surplus

- Assume $K_t = kR_t$, $C_t = cR_t$. Write $L_i = l_i R_{\tau_i}$. Get

$$G(r_0) = E\left[\int_0^{\tau_1} e^{-\delta t} l_0 r_0 dt - e^{-\delta \tau_1} 1_{\{\tau_1 < T_1\}} kR_{\tau_1}\right] + \\ + E\left[e^{-\delta \tau_1} G\left(R_{\tau_1}; \tilde{l}_2, \tilde{T}_2, \tilde{\tau}_2\right)\right]$$

- Have $G(r_0) = r_0 G(1)$ and

$$G\left(1; \tilde{p}_1, \tilde{T}_1, \tilde{\tau}_1\right) = E_1\left[\int_0^{\tau_1} e^{-\delta t} l_0 dt - e^{-\delta \tau_1} 1_{\{\tau_1 < T_1\}} kR_{\tau_1} + \\ + R_{\tau_1} e^{-\delta \tau_1} E_{\tau_1}\left[G\left(1; \tilde{l}_2, \tilde{T}_2, \tilde{\tau}_2\right)\right]\right]$$

Stationarity

- Problem "starts anew" at τ_1
- Resource rent process begins at 1 in each contract period
- Optimal contract length T the same for all contract periods
- Termination time in each contract period will have same distribution
  - will be same functional of sample path
- Fix contract length T, lease rate l

$$V(T,l) = \sup_{\tau} G(1; l, T, \tau)$$

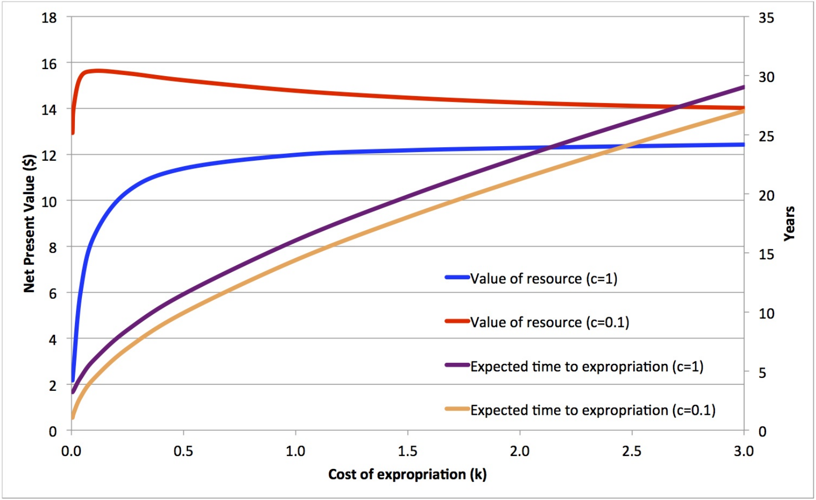
'Sequential' American option

- Have

$$V(T,l) = sup_{\tau \leq T} E\left[\int_0^{\tau} e^{-\delta t} l dt - e^{-\delta\tau} 1_{\{\tau<T\}} kR_\tau + \right.$$
$$\left. + R_\tau e^{-\delta\tau} V(T,l) \,|\, R_0 = 1\right]$$

- American call option on dividend paying asset, maturity T and strike price of k.
- If option exercised before maturity then payoff is $V[R_\tau - k]$, where $V = V(T,l)$ is the value of the option; not $[R_\tau - k]^+$ as in standard American call
- If option is held to maturity, payoff is $V(T,l)\,R_T$
  - So payoff is endogenous
- The dividend (lease rate) is also endogenous, determined by zero-profit condition

Solution for $T = \infty$; $\delta = 0.1$, $\mu = 0.05$, $\sigma = 0.2$



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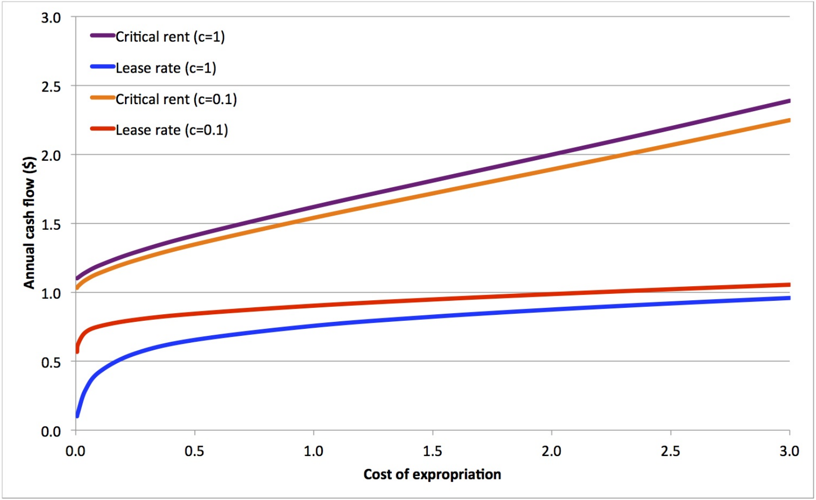

First general results

- For a fixed lease payment I it holds that

$$V_T \geq \frac{E\left[1_{\{\tau=T\}} e^{-\delta T} \left(I - R_T \left(\delta - \mu\right) V\right)\right]}{1 - ER_\tau e^{-\delta\tau}}$$

  where τ is the optimal termination time for I and T.
- $R_t e^{-\delta t}$ is a supermartingale starting at 1 so $E\left[R_\tau e^{-\delta\tau}\right] < 1$ and denominator is positive
- Numerator is difference of two positive numbers, so sign can go either way
- For "long" contracts, however, the numerator is approximately zero ($\Pr\{\tau = T\} \approx 0$) so then we have $V_T \gtrsim 0$

Long contracts

The lease payment is endogenous

$$l(T) = \delta \frac{E\left[\int_0^\tau e^{-\delta t} R_t dt\right] - c}{1 - E\left[e^{-\delta\tau}\right]}$$

(τ optimal for T) and in general needs to be accounted for

$$dV(T, l(T)) = V_T dT + V_l dl.$$

- Easy: $V_l \geq 0$, so the longer the contract the better
- If contracts are to be "long" it is better to simply sell the resource

Short contracts

High probability of contract being allowed to expire without termination; $P\{\tau = T\} \approx 1$. Get

$$p = \frac{\delta}{\delta - \mu} \frac{1 - e^{-(\delta-\mu)T}}{1 - e^{-\delta T}} - \frac{\delta c}{1 - e^{-\delta T}}$$

$$\left(1 - e^{-(\delta-\mu)T}\right) V = \frac{1}{\delta}\left(1 - e^{-\delta T}\right) p$$

So

$$V = \frac{1}{\delta - \mu} - \frac{c}{1 - e^{-(\delta-\mu)T}} \Rightarrow V_T > 0$$

Is selling optimal?

- It is better to have an infinite contract than a long, but finite one, which will be terminated for sure
- Short contracts that are never terminated are not optimal
- There could be an intermediate, globally optimal, finite contract which would be
  - terminated with positive probability, but could also be
  - allowed to expire with positive probability
- And there could be better contract forms!