Optimal Border Policies for Invasive Species under Asymmetric Information

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Invasive Species Problem

- Unintentional inclusion of a harmful pest in shipment of a valuable good.
- The crop itself or a byproduct such as soil born insect on plants for planting or on wood packaging material
- Exporters can undertake effort to abate risk
- Risk varies by exporter

Model Components

- Extends McAusland and Costello (2005)
- Shipments
  - ‘Clean’ or ‘Infected’
  - Standard downward-sloping demand curve in importing country.
  - ‘Infected’ shipments cause (constant) marginal damage d.

Model Components

- Importer (e.g., NAPPO)
  - Risk neutral.
  - Chooses inspection intensity I. Increasing convex cost function $k(I)$.
  - I is the probability of discovering infection conditional on shipment being infected.
  - I causes good value to depreciate.
  - Fumigates detected infected shipments at cost f.
  - Makes transfer t and imposes fumigation fee ϕ.

Model Components

- Regulator's Objective: Maximize expected domestic social welfare
  - cost of inspection
  - value of good to domestic consumers
  - expected damage from invasive
  - net payments to exporters.

Model Components

- Exporters:
  - Unit supply of good.
  - Risk neutral.
  - Baseline risk B of infection.
  - Can undertake abatement effort $a = a^{\ell}$, a^{h}.
  - Abatement reduces risk to B-a.
  - Heterogeneous abatement cost (private info).
    - Type 1 exporter $\theta c = \theta c^{\ell}$, θc^{h} : $0<\theta<1$.
    - Type 2 exporter cost is $c = c^{\ell}$, c^{h}.
    - Probability of type 1: g.

Model

- Stackelberg game
  - Regulator chooses I, offers contracts to exporters $\langle t_i, \phi_i \rangle$ i=1,2, to maximize

$$\int_0^{\delta(I)} p(z)\mathrm{d}z - \delta(I)p(\delta(I)) - k(I) - g\left\{[B - a_1]\left[[1 - I]d + I[f - \phi]\right] + t_1\right\}$$
$$-[1 - g]\left\{[B - a_2]\left[[1 - I]d + I[f - \phi]\right] + t_2\right\}$$

  - Exporters choose contract and abatement that maximize profit, e.g., for type 1:

$$\pi_1 = t_1 - \theta c_1 - I\phi_1(B - a_1) + \delta(I)p(\delta(I))$$

Model

- Symmetric Information Baseline
  - Regulator can dictate a, only subject to participation constraints that exporter profit be non-negative.
  - Never optimal to have $a_1 < a_2$.
  - Focus on (interesting) case $a_1 > a_2$.

Model

- Symmetric information contracts:

$$
\begin{aligned}
t_1 &= \theta c^h - \delta(I)p(\delta(I)); \\
t_2 &= c^\ell - \delta(I)p(\delta(I)); \\
\phi_1 &= 0; \\
\phi_2 &= 0.
\end{aligned}
$$

Model

- Asymmetric Information
  - Regulator cannot dictate abatement
  - Contracts must satisfy incentive compatibility constraints in addition to participation.

$$
\begin{aligned}
t_1 - \theta c_1 - I\phi_1(B - a_1) + \delta(I)p(\delta(I)) &\geq t_1 - \theta \tilde{c}_1 - I\phi_1(B - \tilde{a}_1) + \delta(I)p(\delta(I)) \\
t_1 - \theta c_1 - I\phi_1(B - a_1) + \delta(I)p(\delta(I)) &\geq t_2 - \theta c_1 - I\phi_2(B - a_1) + \delta(I)p(\delta(I)) \\
t_1 - \theta c_1 - I\phi_1(B - a_1) + \delta(I)p(\delta(I)) &\geq t_2 - \theta \tilde{c}_1 - I\phi_2(B - \tilde{a}_1) + \delta(I)p(\delta(I))
\end{aligned}
$$

Model

- Asymmetric Information Contracts:
  - abatement non-increasing in type
  - low type gets information rent

$$
\begin{aligned}
t_1 &= [1-\theta]c^\ell + \theta c^h + I\phi_1(B - a^h) - \delta(I)p(\delta(I)); \\
t_2 &= c^\ell - \delta(I)p(\delta(I)); \\
\phi_1 &= \frac{\theta[c^h - c^\ell]}{I[a^h - a^\ell]}; \\
\phi_2 &= 0.
\end{aligned}
$$

Policy Scenarios

- Extensions
  - Limited liability
  - Use information to offer different inspection regimes
  - Technical assistance
  - Cooperative/non-cooperative strategies among multiple importers (e.g., NAPPO)

Case Studies

- Wood packaging: wood-boring insects
- Horticulture informal clean stock program
- Netherlands bulb industry-soil born pests