Strategic Interactions Among Private and Public Efforts when Preventing and Stamping Out a Highly Infectious Animal Disease

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Introduction

FOR CERTAIN LISTED DISEASES, the Sanitary and Phytosanitary Agreement of the World Trade Organization (WTO) allows countries to implement precautionary trade bans on livestock and produce imports from a country in the event of a disease outbreak in the country of origin. Many listed diseases have been the subject of significant trade bans in recent years. The most disruptive of these listed diseases has been Foot and Mouth Disease (FMD), see Table 1. During a FMD outbreak, losses to a country are difficult to assess because market disruptions lead to shifting and volatile prices. Long-term investment in sector development has been impeded due to uncertainty about prospects for access to international markets.

The epidemiology modeling literature refers to diseases where recurrence can occur as susceptible-infected-susceptible (SIS) diseases. Here both prevention and stamp-out actions involve externalities in that the behavior of one's neighbors matters. A pecuniary loss from this class of diseases is reduced market returns due to impeded access to international markets, a loss shared by all growers regardless of farm disease status. Effort costs are private but the benefits from restored access are shared by all.

The literature emphasizing strategic issues in animal health is small. Insights do not generally transfer from human health economics because such policies as slaughter and absolute movement control have no parallel among current human health policy options. We shed some light on the problem by developing a multi-agent dynamic model of a SIS disease that accounts for Nash privately optimal behavior.

Table 1. FMD status among Organization for Economic Cooperation and Development (OECD) countries.

Country	FMD Status
France	Outbreaks in 1981 and 2001
Greece	Outbreaks in 1996 and 2000
Ireland	Outbreaks in 2001
Japan	Outbreaks in 2000 and 2010
Netherlands	Outbreaks in 1984 and 2001
South Korea	Outbreaks in 2000, 2002 and 2010
Turkey	Endemic
United Kingdom	Outbreaks in 1981, 2001 and 2007

Model

THERE ARE TWO POSSIBLE states, namely the susceptible (S) and infected (I) states. These states refer to the country's disease status. In the susceptible state, each agent earns profit w. There are N agents, referred to as growers, labeled $n \in \{1,2, \dots, N\} \equiv \Omega_N$. Grower n will take a disease prevention effort of magnitude $a_n \geq 0$ and the continuous flow cost of taking this effort level is $c^a(a_n)$, an increasing and convex function. Grower n receives payoff $\pi^{S,n} \equiv w - c^a(a_n)$ as a continuous flow in the susceptible state.

Ceteris paribus an increase in prevention effort by any one grower lowers the hazard rate, $\phi(h_0, a_1 \dots, a_N)$, for disease presence in a country where the government's level of prevention efficiency or effort is represented by $h_0 > 0$ and $\phi(\cdot)$ is decreasing in each action.

In the infected state each grower earns amount $w - L$ where L is the loss from being locked out from international markets. Denote the stamp-out effort taken by grower n as magnitude $b_n \geq 0$ where the continuous flow cost of taking effort level b_n is $c^b(b_n)$, again increasing and convex in the choice argument. Therefore, in the infected state grower n receives payoff $\pi^{I,n} \equiv w - L - c^b(b_n)$ as a continuous flow. The probability rate for recovery is $\eta(g_0, b_1, \dots, b_N)$ where public sector effort is given as $g_0 > 0$. Let μ be the the intensity parameter for a Poisson process, independent of other variables in the model. The continuous time discount rate is r. Farm valuations in the Susceptible and Infected states are, respectively,

$$\text{Susceptible}: \quad V^{S,n} = \frac{(r+\mu+\eta)\pi^{S,n} + \phi\pi^{I,n}}{(r+\mu)\psi(\cdot)};$$

$$\text{Infected}: \quad V^{I,n} = \frac{\eta\pi^{S,n} + (r+\mu+\phi)\pi^{I,n}}{(r+\mu)\psi(\cdot)};$$

$$\psi(\cdot) \equiv r + \mu + \eta(\cdot) + \phi(\cdot).$$

Grower n is assumed to make prevention choice a_n when susceptible, and stamp-out choice b_n when infected, at each time ignoring costs and benefits to others (Figure 1).

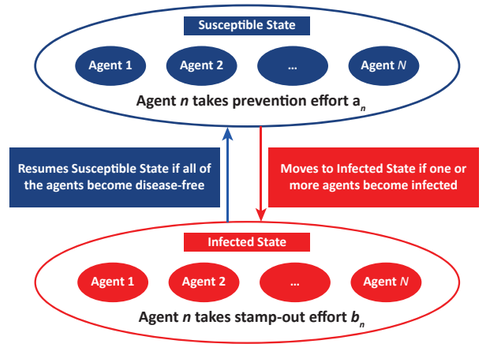

Figure 1. An illustration of multi-agent dynamic model of a SIS disease in presence of private control efforts

Results and Policy Implications

Point 1: *A decision environment conducive to forward-planning matters when seeking to remain free of an infectious animal disease.*
The model indicates that a professional, non-political public animal health management workforce and strong property rights will encourage preventive and stamp out efforts because prospects for garnering returns on present investments are greater.

Point 2: *Public stamp-out efforts countenance moral hazard concerns that public prevention efforts do not.*
We argue that, from an incentive point of view, public efforts to prevent are better than public efforts to stamp-out. Growers are likely to complement public prevention efforts with private prevention and stamp-out efforts, but may seek to free-ride on public stamp-out efforts.

Point 3: *An increase in the loss due to a disease outbreak will increase private incentives to prevent and to stamp-out while insurance indemnities will reduce these incentives.*
We suggest that the threat of a trade ban is likely to improve biosecurity incentives all round. It follows that moral hazard issues arise for private prevention and stamp-out efforts whenever insurance indemnities reduce the extent of loss.

Point 4: *Although caution is warranted when devising biosecurity action subsidy schemes, it is generally better to subsidize prevention efforts than subsidize stamp-out efforts.*
This policy suggestion is based on complementary interactions between many preventive actions that are less likely to exist between stamp-out efforts. This suggestion should be viewed within reason; some private stamp-out efforts may be so effective absent implications for incentives that implications of subsidies for incentives should be ignored.