Animal Health Economics: Plumbing

Prevention, Control and Scale of Analysis in Endemic Animal Diseases

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Work Packages

- WP1: From the individual to the population: Considering pathogen and host variability to model within-herd spread of pathogen
- WP2: From the population to the metapopulation: Modeling the between-herd spread of pathogens accounting for contact structure
- WP3: Predictive modeling to evaluate the epidemiological and economic efficiency of disease control strategies
- WP4: From predictive modeling to decision tools

What is the issue?

- Standard loss benefit analysis for disease asserts that if a farmer faces loss at level L with probability p and can take an action at cost c to eliminate the risk of direct entry onto a farm;
- then the action should be taken if and only if

$$pL \geq c$$

- This makes sense to a farmer because expected loss to be avoided is pL and cost is c so profit change is $pL - c$. Rule improves the bottom line
- But infectious diseases create externalities

What is the issue?

- Suppose now that there are two farms, A and B, in a region. Either farm can introduce a disease with probability p and pass it on to the other farm with (independent) probability q
- Now a given farm has two ways to get disease; directly with prob. p and indirectly with prob. q
- Expected loss is
  - $pL + pqL$ to each if neither act. Why?
  - c to each if both act? Why?
  - $pqL + c$ to a farm that acts when the other doesn't
  - pL to a farm that doesn't act when the other does

Games

For both farms, (Act,Act) is best box to be whenever $c < pL + pqL$

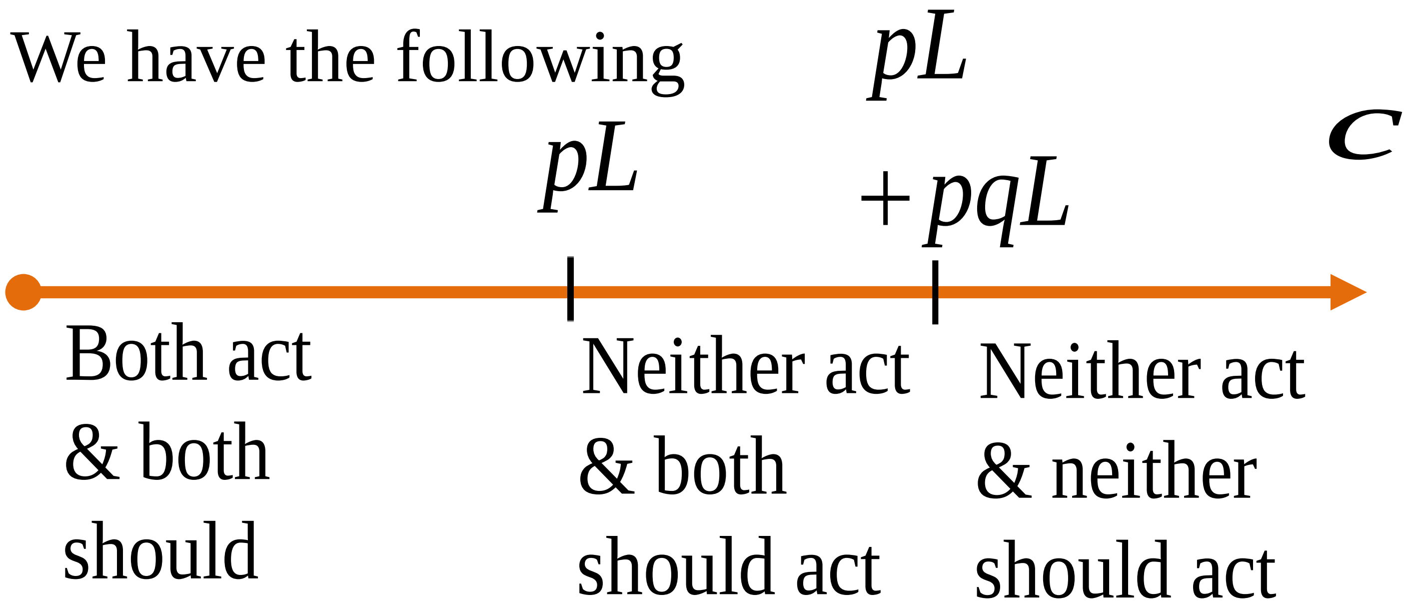
- This can be put in a game theory payoff matrix as follows. All entries are losses, so high is bad.

Farm	B acts	B doesn't act
A acts	(c, c)	$(pqL+c, pL)$
A doesn't act	$(pL, pqL+c)$	$(pL + pqL, pL+pqL)$

- Left entry is payoff to farm A, right to farm B
- When farm B does not act then farm A acts if and only if $pqL+c \leq pL + pqL$, i.e., $c \leq pL$
- When farm B acts then farm A acts if and only if $c \leq pL$
- So neither acts whenever $c > pL$

Outcome

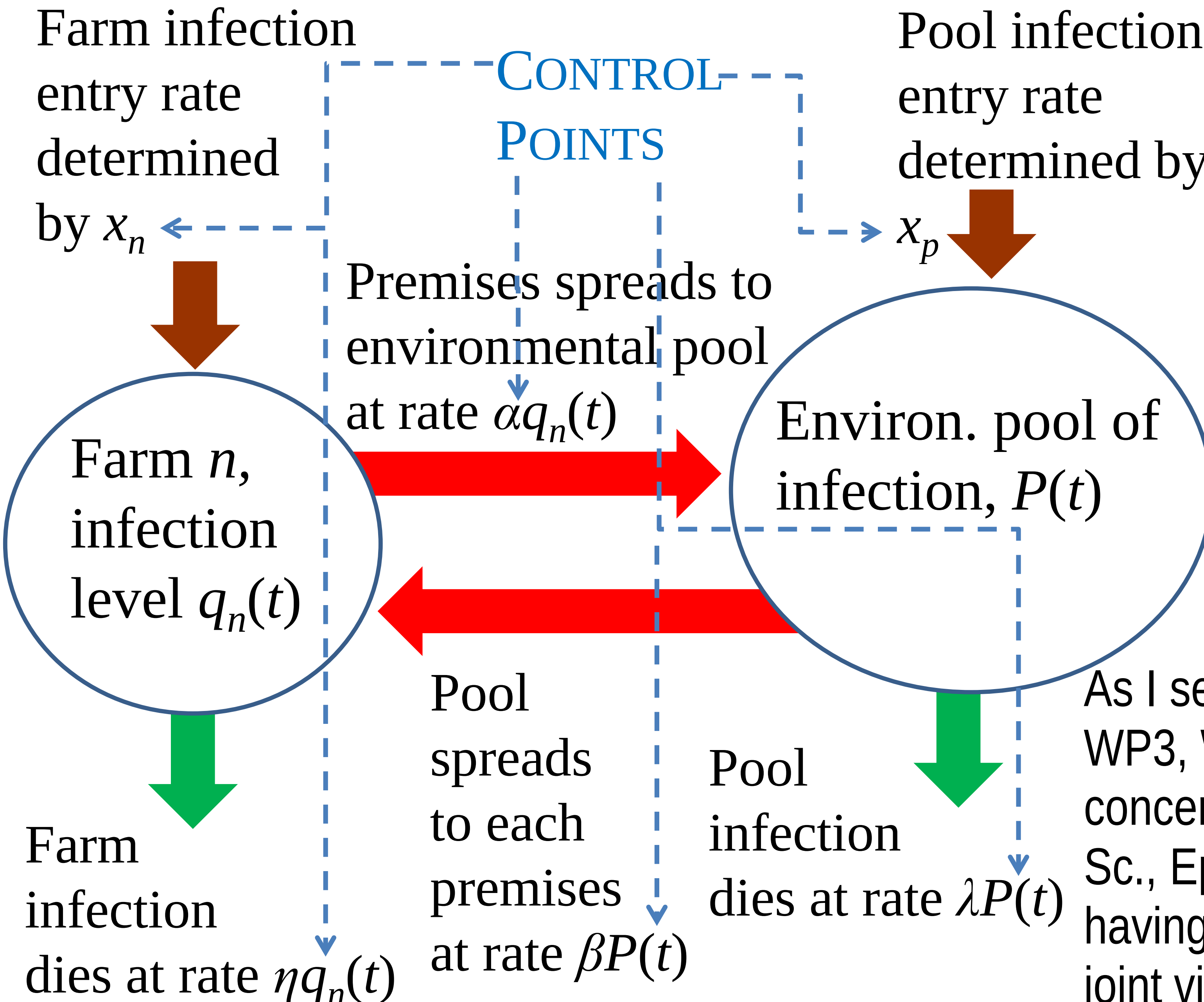
- If neither farm acts then loss to each is $pL + pqL$
- We have the following



- As infectiousness q increases, the problematic gap increases

Some Economics of Biosecurity Inputs

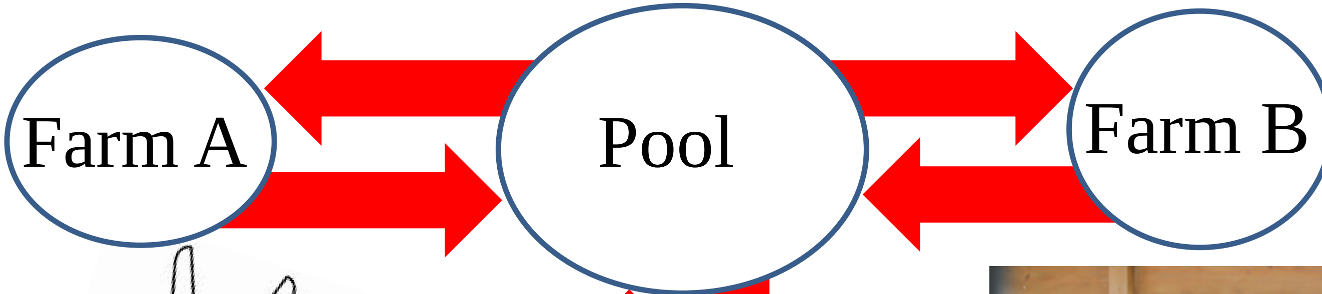
- What is the setting? For endemic infectious diseases, the notion of a 'common pool' is often invoked
- Quantitative epidemiologists often work with variants of differential equation system to study disease dynamics and equilibrium. With exception of vaccination, missing typically are biosecurity inputs
- Suppose that there is an environmental pool of infection that can be targeted with public effort x_p and N farms each of which can target disease on their farm with effort x_n
- Can readily show that when things settle down more public effort means less private effort

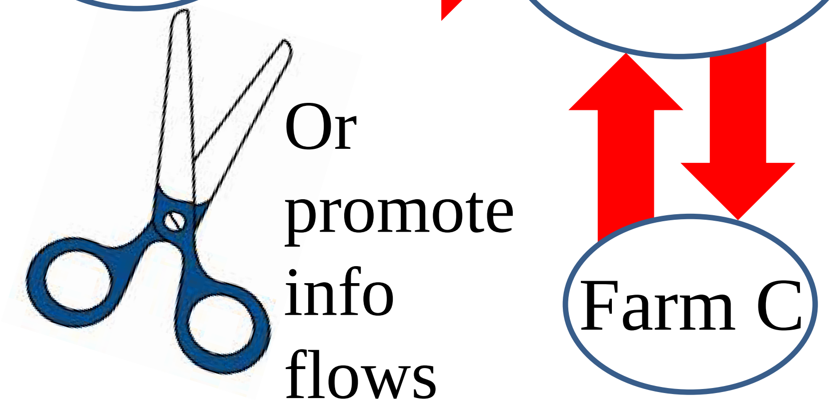


As I see it, WP3, WP4 concern Ani. Sc., Epi., Econ. having better joint view of plumbing

Equilibrium for 'common pool'

- Key point: efforts to control the x_n are substitutes as action of others reduces my need to act
- Each farm may
  - happily lean on good actions by other farms & gov't,
  - happily incur costs for own-farm to stay upright, but
  - be reluctant to incur cost of being leaned on
- Leaning on others leads to sub-optimal outcomes





*Much of gains from mkts can be had from contracts, with less risk. For ruminants, grass is a fly in ointment

*Larger enterprises are easier to engage in government, private programs and own provision of inputs?

*Do we want to go there? Organics, an. welfare, demand for pastoral env’t. Better understanding the plumbing may be the best solution. That involves integrated interdisciplinary work

Plumbing issue: Why test quality can matter for economic outcome

- In what follows, I ignore the technology of disease test quality, as in how it might affect disease transmission. Consider Johne's disease test (poor quality) and buying cows for production. Suppose there are two test outcomes; high H, or likely not diseased, and low L
  - Buyer would like to know that they are getting H, & would pay more
  - But seller may be ignorant too, have to pay test cost and may not want to report outcome
  - So there may be two cow types in the market; a) tested and known to be H, and b) the rest, i.e., a pool of *i*) untested and *ii*) tested but found by seller to be L
  - Incentive to test will be given by gap between price for known H cows and average price for the rest

Application

- Johne's Disease (paratuberculosis) is a bovine disease that U.S. government seeks to control through a voluntary reporting scheme
- Infectious and eventually causes decreased productivity in beef and dairy cattle. Some concern about zoonotic implications
- Scheme involves voluntary testing by herd owner and test-based herd classification. Owner selling, e.g., dairy replacement heifers can use this information to boost price or remain silent
- Silent herds: either *i*) don't test or *ii*) do & don't tell

Who’s who?

- So the question is how to go about getting the purchaser information that will cause them to pay more for the product?

All are
among silent

Some are declared H,
Some among silent

Model

- We extend Shavell, RAND J. Econ. (1994) to study dynamics
- Model to follow does not deal with on- or off-farm test benefits arising from technical management of disease transmission. We just look at role of markets in affecting incentives to test, and also stay in business
- Intent is to look closely at the how the voluntary scheme might play out over time to see if it fosters a more transparent production environment

Period t : Producers see premium I_{t-1}

& make a participation decision

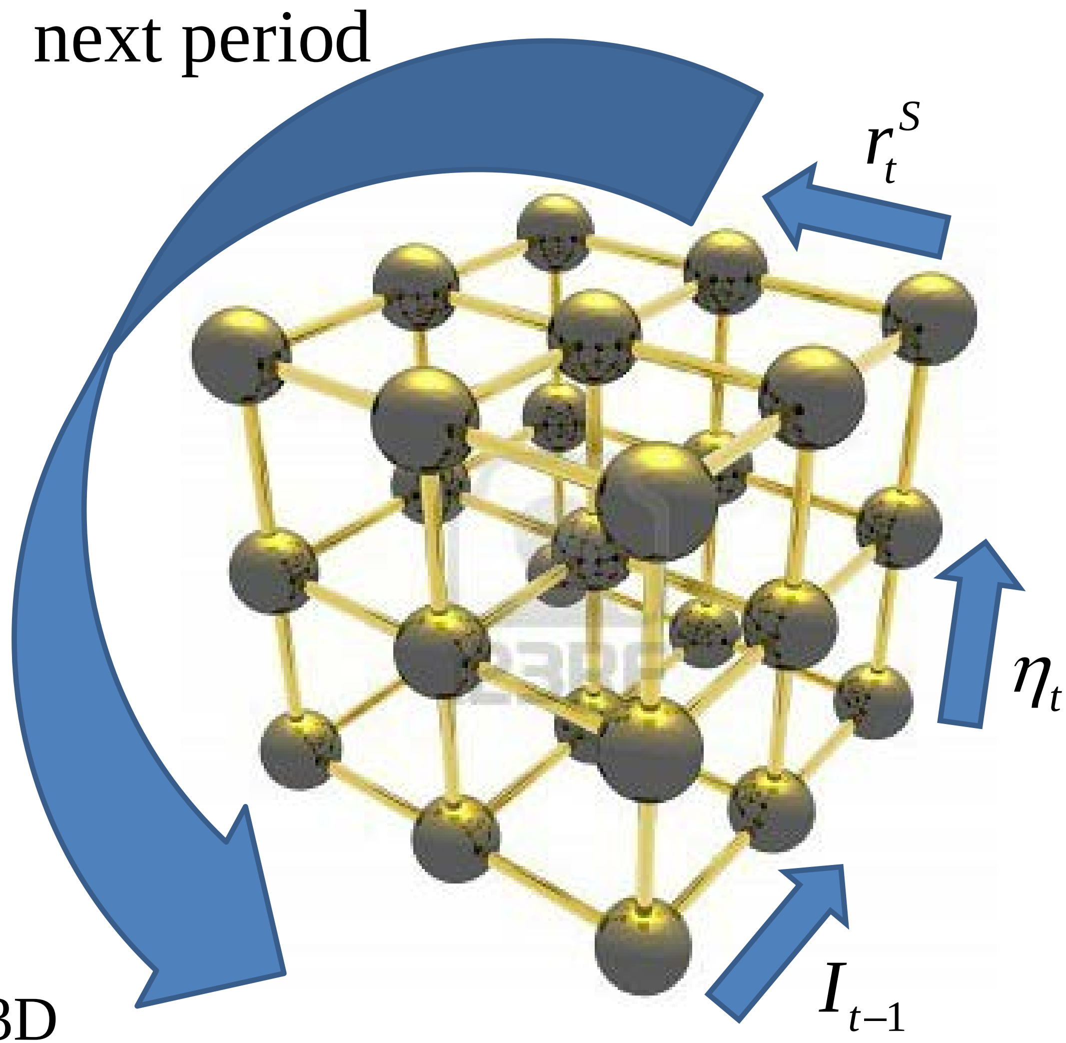
Proportion η_t of producers join the program

Test results revealed, participants decide on disclosure given silent producer disease-free rate, r_{t-1}^S, and premium it supports

r_t^S and so I_t are determined

Move on to period $t+1$

Momentum on a Lattice



Think of a point lattice

that extends indefinitely in 3D

Momentum Result

Over time

i) participation rate rises;

ii) mean disease-free rate of silent producers falls;

iii) premium from program participation rises;

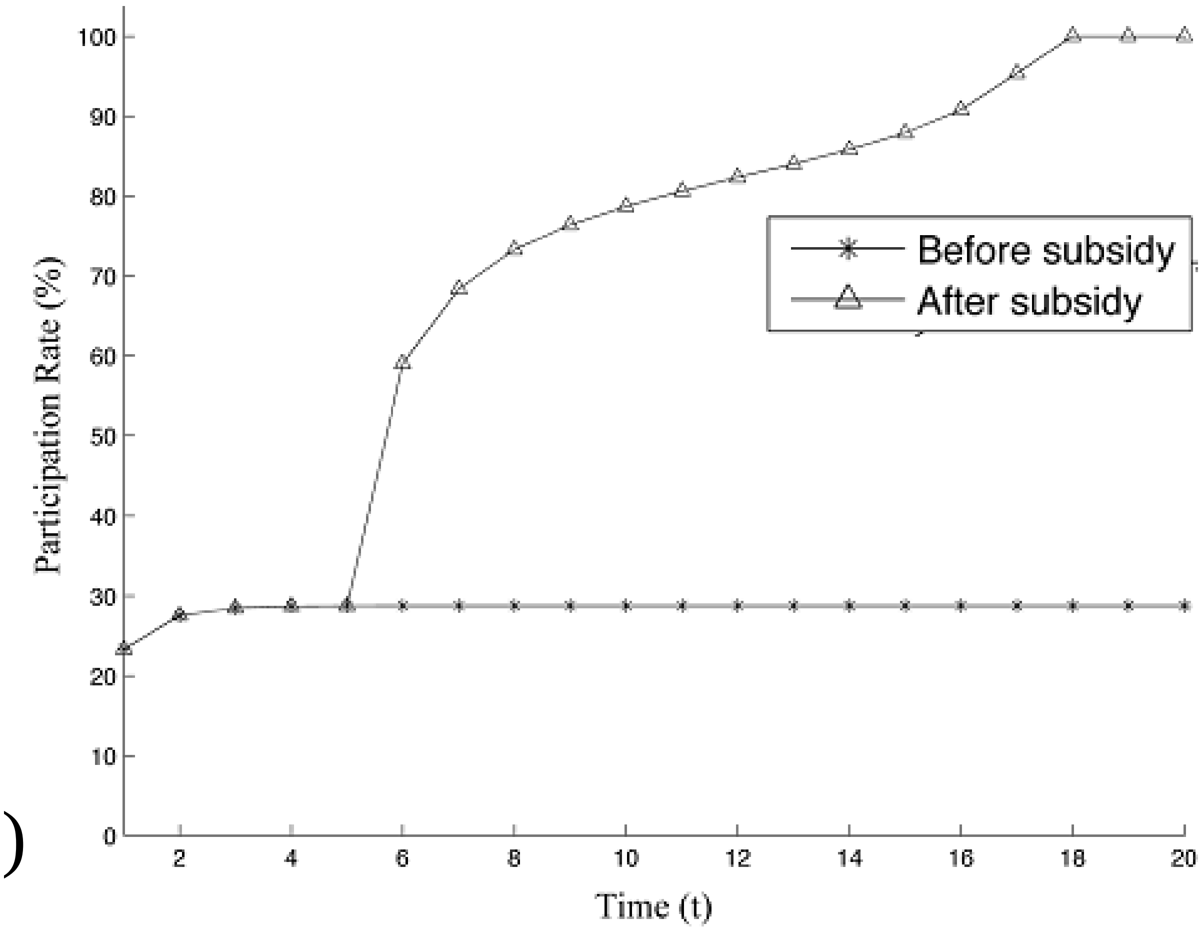
Or $$I_0 \le I_1 \le I_2 \le \quad \dots \quad \le I_\infty$$

$$\eta_0 \equiv 0 \le \eta_1 \le \eta_2 \le \quad \dots \quad \le \eta_\infty$$

$$r_0^S \equiv E[r] \ge r_1^S \ge r_2^S \ge \quad \dots \quad \ge r_\infty^S$$

One Application: Tipping

- Momentum can stall. In our Johne's disease simulations a subsidy to some high cost growers could tip equilibrium, as in theory of Heal & Kunreuther (2006)



Draining the Swamp?

All producers are silent to begin with.
Growers see premium I_0
and make program choice η_1.
As growers enter program, mean
disease-free rate for silents r_1^S falls.
This raises I_1 so more enter program
(or η_2 rises) and so r_2^S falls.
And so on to possible convergence

But better test quality or knowledge on disease transmission, etc., likely to have the same effect. More herds test. Those that don't are most likely problematic; will get low prices; will improve or close down

Prevention & Behavioral Issues

- In past 15 years economics has been taking two reality checks; one on foundational assumption of rationality and other on credibility of data analysis procedures. Both are pertinent to your endeavor
- Data shows people to be poor at rationally assessing risks, especially low prob. events, and so often don’t take rational precautions in human and financial health realms or in concerns about risk to life
- There are reasons to expect similar problems when farmers assess best preventive animal health practices

RCTs

- One matter to be wary about at interface between decision analysis and technology assessment is selection bias. Those who choose technology I over technology II are generally different in crucial ways
- Controlling for that is very problematic, especially when dealing with sporadic diseases where effect is difficult to even identify
- Randomized Control Trials (Duflo, or Cohen & Dupas study of malaria and bed nets) are now considered to be the best, if expensive, way to try identify cause and effect

QUESTIONS?