

# Bio-Security and the U.S. Livestock Sector: Trading off Prevention and Response

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Invited paper Meetings of Southern Agricultural Economics Association, Orlando,  
2006

This research was supported by the Texas A&M University based National Center for Foreign Animal and Zoonotic Disease Defense (FAZDD) that was established by the Department of Homeland Security. However, views expressed are those of the authors and do not necessarily represent those of the FAZDD. All remaining errors are the authors.

# Acknowledgements

Funded through a grant from the Department of Homeland Security and through the Vice President of Research's Office at Texas A&M

This research was supported in part through the Department of Homeland Security National Center for Foreign Animal and Zoonotic Disease Defense.

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# Protection

Today we have had New Orleans, 9/11, Fire Ants, BSE, Avian Influenza, Earthquakes, the Indian Ocean Tsunami

We fear more terrorism, invading species, AI introduction, FMD, more hurricanes / earthquakes / tsunamis.

In the face of this many sectors of the economy are calling for protection.

The costs involved with the calls for protection far outweigh our resources.

So what activities rise to the level that they merit protection.

# Balancing Problem

The economic problem of protection

Not enough protection money to go around

Modeling to generate insight

Will report on some conceptual investigations and allude to Broader project efforts

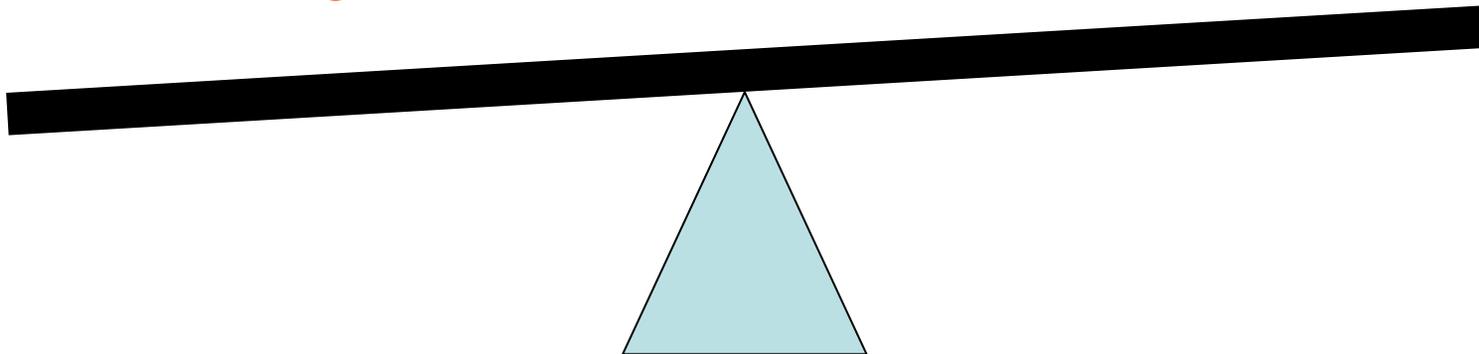
# Economic Analysis the Balancing Problem

Ex-Ante Invest

Anticipation  
Prevention  
Installation  
Screening

Ex-Post Fix

Detection  
Response  
Recovery



# Actions possible for a stochastic risk

- **Anticipation** – actions undertaken to forecast event likelihood – intelligence gathering (**ex ante**)
- **Prevention** -- actions undertaken to try to avoid event introduction or mitigate event implications (**ex ante**)
- **Detection** – actions undertaken to screen for the event to detect it early to allow rapid treatment and lower spread (**ex ante / ex post**)
- **Installation** – pre installed response capability (**ex ante**)
- **Response** –actions to stop the event once it is here designed to lower economic losses. (**ex post**)
- **Recovery** -- actions to restore lost assets or demand shifts due to introduction of animal disease (**ex post**)

# The Economic Problem – one of balance

Anticipation, prevention, detection, installation, response and recovery all take money, much of which is spent in the absence of an event.

So economically how do we

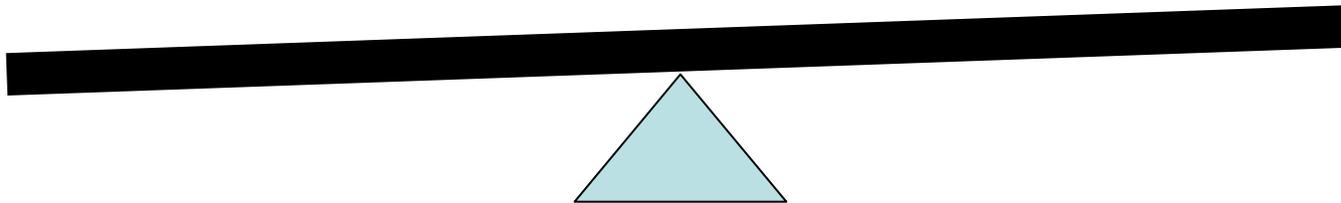
- Form balance between ex ante and ex post strategies considering cost, disease vulnerability, risk, and event characteristics?
- Best respond to an event?

Ex-Ante Invest

Anticipate  
Prevent  
Install  
Detect

Ex-Post Fix

Detect  
Respond  
Recover



# Balance Problem Analytic Conceptualization

## Major elements

Irreversibility – cannot instantly install investments giv event occurs

Conditional response depending on investments

Fixed cost versus variable costs of infrequent occurring events

Large span of possible events

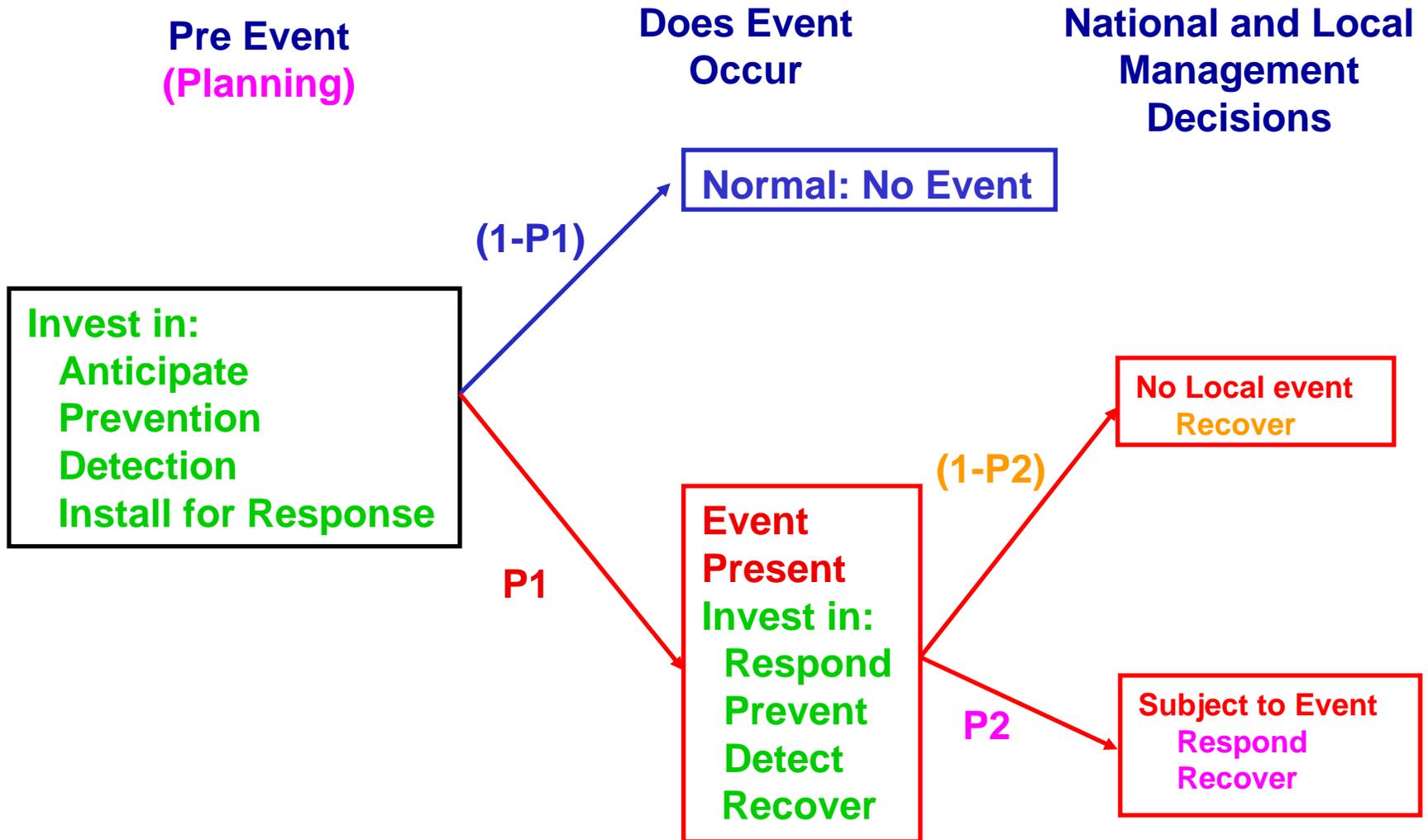
Events differ in nature and severity

Probabilities

Tradeoff between **ex ante action cost** and **occasional ex post event damages and response/recovery costs**

Best strategy depends on investment cost, operating cost potential damages, and probability and is a balance

# Economic Model For Balance Study



# Analytic Conceptualization

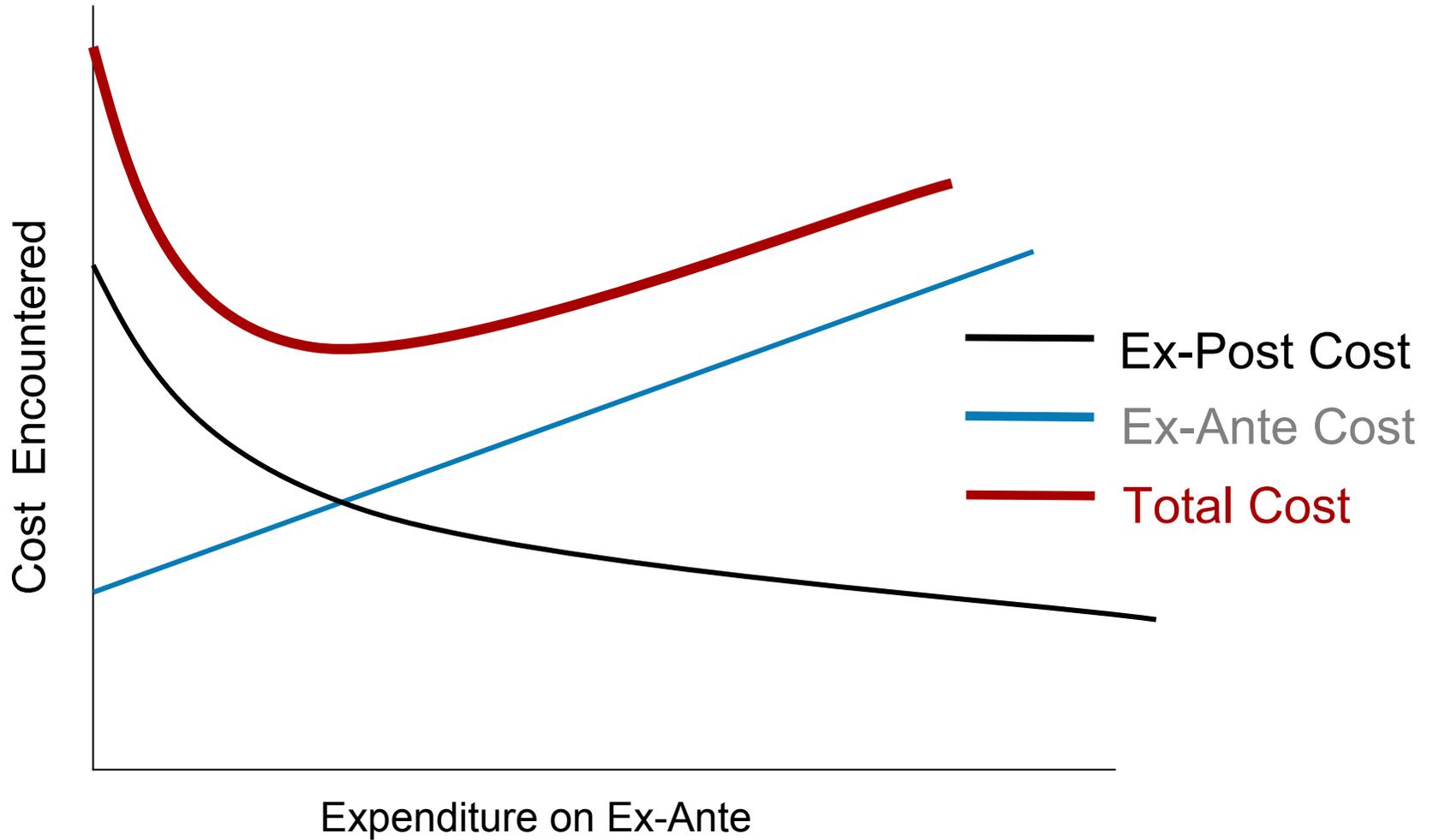
Two Stage (for simplicity)

Maximizing Expected Event related Profits

$$E(\Pi) = P_1 \Pi_{Event} (V - L(\delta, r, s) - w_s s - w_r r) + (1 - P_1) \Pi_{NoEvent} (V - w_s s)$$

- $P_1$  - probability of event,
- $L$  - monetary losses from event
- $V$  - Industry profits,
- $r$  - ex post actions
- $s$  - ex ante actions
- $\delta$  - event severity
- $w_s$  - per unit cost of ex ante actions
- $w_r$  - per unit cost of ex post actions

# Analytic Conceptualization



# Simple Example of model

Suppose we have the following decision. Today we can invest in a facility which costs \$10 and protects 10 units. During the facility life we use it under differing price, and yield events that are uncertain. We have 200 units to protect. Two projected futures exist. At the time we use the facilities we know the conditions. Two states of nature can occur

	<b>Price</b>	<b>Yield with invest</b>	<b>Yield w/o invest</b>	<b>Probability</b>
<b>No event</b>	<b>4</b>	<b>1.2</b>	<b>1.1</b>	<b>(1-p<sub>1</sub>)</b>
<b>Event</b>	<b>3</b>	<b>0.9</b>	<b>0.1</b>	<b>p<sub>1</sub></b>

# Simple Example of model

Problem has 2 stages

Stage 1            Investment stage when we choose whether to construct facility for which we define a single variable  $Y$

Stage 2            Operation stage when we use facility and know event status, and profits which results in variable to operate with (I) or without (NI) the investment under an event (E) or no event (NE) (the 4 variables  $X$ )

# Simple Example of model

$$\begin{aligned}
 \text{Max } & -10Y + p1*3(1.9*X_{E,I} + 0.1*X_{E,NI}) + (1-p1)*4(1.9*X_{NE,I} + 1.8*X_{NE,NI}) \\
 \text{s.t. } & -10Y + X_{E,I} \leq 0 \\
 & + X_{E,I} + X_{E,NI} \leq 200 \\
 & -10Y + X_{NE,I} \leq 0 \\
 & + X_{NE,I} + X_{NE,NI} \leq 200 \\
 & Y, X \geq 0
 \end{aligned}$$

**Result  $Y=20$  (invest in facility) if  $p1 \geq \underline{0.119}$**

# Economic work within FAZD

## Why care about this in an animal setting?

### History shows vulnerability

#### UK FMD outbreak

6.25 million dead animals, loss in billions of \$

#### Netherlands FMD outbreak

#### BSE in England

150 dead citizens

Fear and beef demand

#### US and Canadian BSE

Lost export markets

#### US Avian Influenza events

Slaughtered animals in 100,000's

Regionalized export market closures

#### Asian AI events

Animals and people

#### South American FMD

Changed nature of beef trade

# Hypotheses / Deductions

Goal: The best investment/management strategy

For slow spreading attacks addressed at low-valued targets with low consumer sensitivity would focus investment more on response and recovery.

For rapid spreading attacks addressed at high valued targets with high consumer sensitivity items would focus more on prevention, rapid detection and rapid response (for example foot and mouth).

Would favor alternatives with value both when events occur and under normal operations as opposed to single event oriented strategies (for example a comprehensive testing strategy that would also catch routine animal diseases).

# Very Simplistic Case study

- Impact of prevention and treatment strategies in FMD setting
- Region Texas
- Unknown probability
- Investigate adoption with
  - Ex-ante periodic animal examinations
  - Ex-post ring slaughter of affected animals as response strategy
- Look at expenditure balance as influenced by
  - Probability level
  - Spread rate
  - Costs of implementation
  - Effectiveness of response
  - Recovery programs

# Cost Setup in Case study

$$Cost(N, R) = Y \times FTC + N \times VTC + P \times [V \times H(R) \times D(t) + CR \times R]$$

- N number of ex ante tests performed annually on cattle in the region.
- Y binary variable representing investment in ex ante testing system.
- R ex post animals killed when outbreak occurs.
- P Probability of event
- CR cost of killing animals in response to outbreak including lost market value activities
- FTC fixed cost of implementing testing
- VTC variable cost of implementing testing (a function of number of tests)
- H(R) proportion of animals lost in case of an outbreak per day
- D(t) is the disease spread function expressed in terms of days that the disease is allowed to spread before detection.
- V Value of losses herd
- T Number of days disease is undetected,  $365/(N+1)$

# Assumptions

Cost minimization of ex-ante costs plus probabilistic weighted cost of response.

Response effectiveness

Slaughter (Schoenbaum and Disney, 2003)

Disease spread

Exponential (Anderson and May, 1991) and Reed-Frost (Carpenter et al. 2004)

Fast (0.4) and slow (0.15) contact rates (Schoenbaum and Disney, 2003)

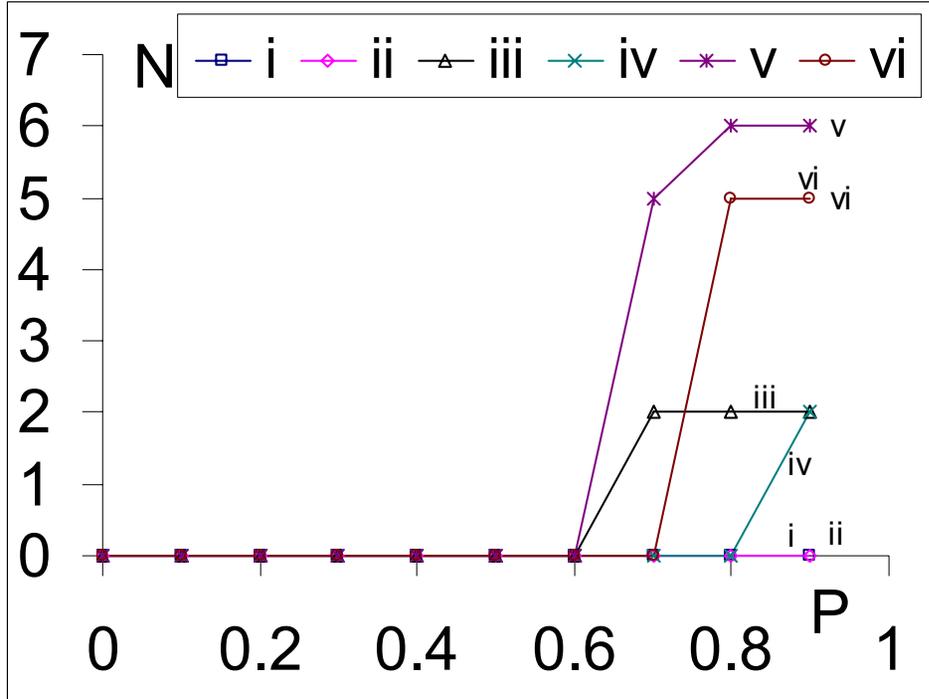
Source: Elbakidze, Levan, *Agricultural Bio-Security as an Economic Problem: An Investigation for the Case of Foot and Mouth Disease*, In process PhD Thesis, Department of Agricultural Economics, Texas A&M University, 2004.

# Model Experimentation

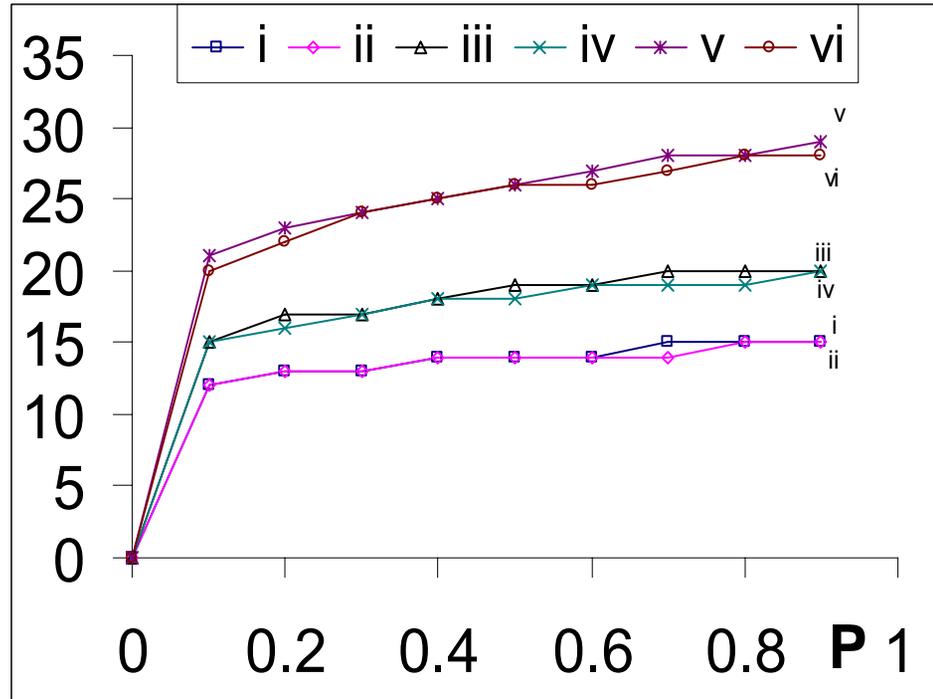
- Event levels: Probability 0.001 – 0.9
- Severity or spread rate: slow vs. fast
- Response effectiveness: 17% - 30%
- Variable costs of detection 0.1TVC, 0.01VTC
- Average herd size: 50 to 400.
- Ancillary benefits: FTC-\$50 per herd
- Recovery actions: decrease loss of GI per animal by 30%

# Results as Spread rate varies

Slow RF



Fast RF



Number of tests on Y axis, Probability on X

No tests unless disease very likely with slow spreading disease

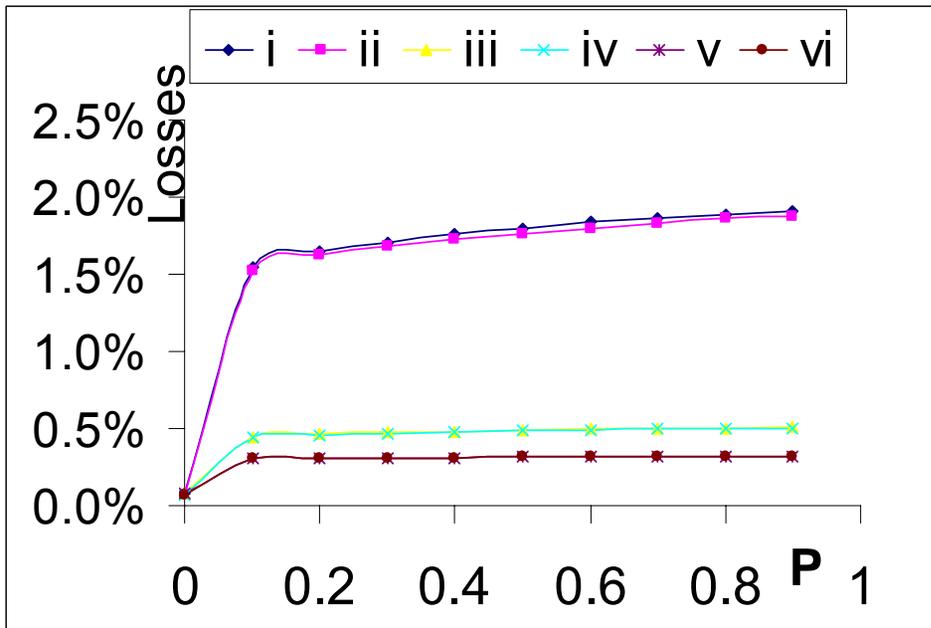
- i – Full variable Costs (VC), Response Effectiveness (RE)=0.17
- ii – VC, RE =0.3
- iii – 0.1VC, RE=0.17
- iv – 0.1VC, RE=0.3
- v – 0.01VC, RE=0.17
- vi – 0.01VC, RE=0.3

# Results

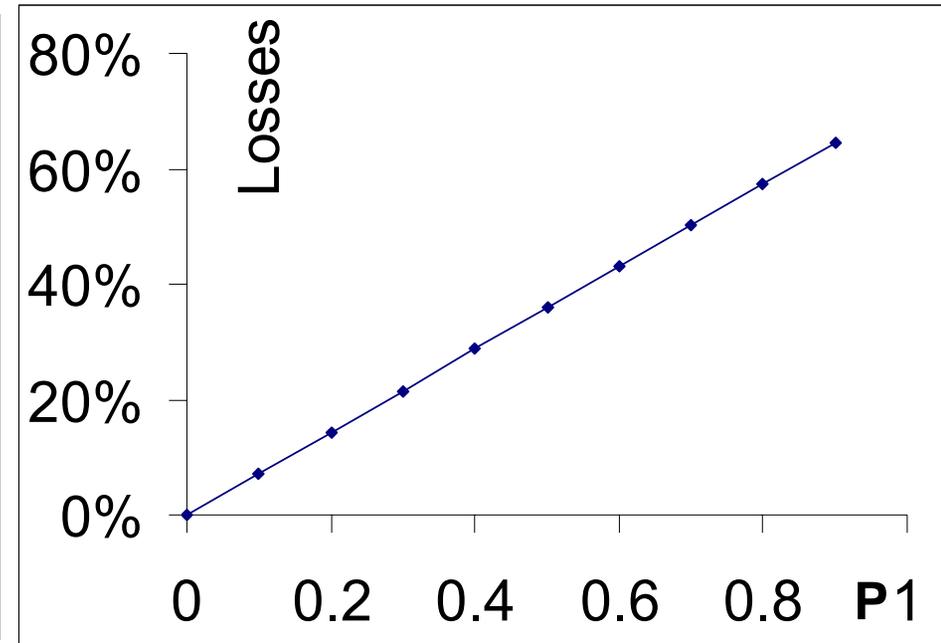
- Herd Size
  - Increasing herd size from 50 to 400
    - increase # of tests. Reached 39 for fast spread.
- Ancillary benefits
  - Decrease FTC by \$50 per herd
    - No change in # of tests
    - Lower the probability of adoption in slow spreads
- Recovery actions
  - Decrease in losses of GI per animal by 30%
    - Did not have a noticeable effect on surveillance intensity.

# Costs of an outbreak with and without ex ante action

With detection

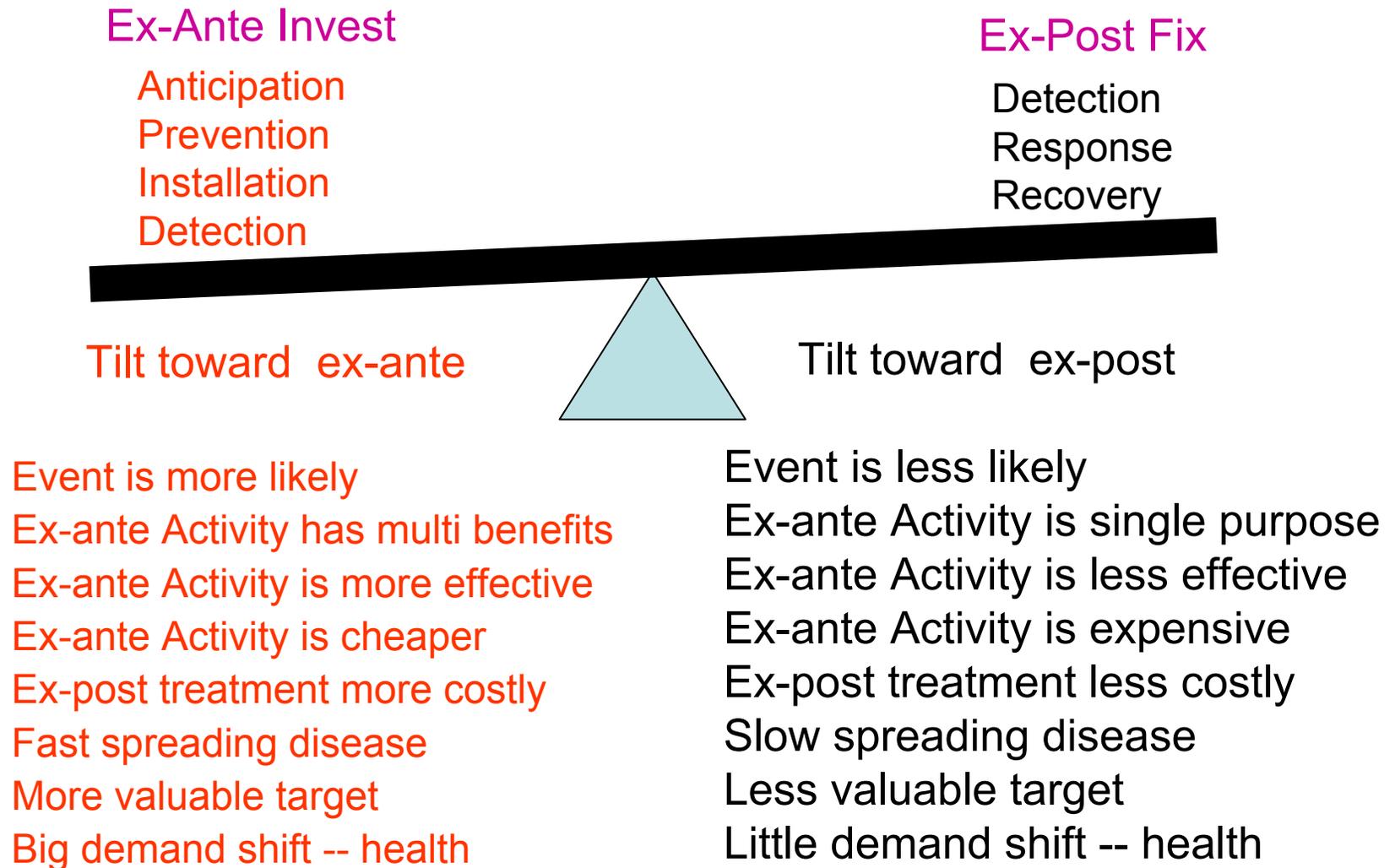


Without detection, Only response



- i – Full Variable Costs (VTC), Response Effectiveness (RE)= 0.17
- ii – VTC, RE=0.3
- iii – 0.1VTC, RE=0.17
- iv – 0.1VTC, RE=0.3
- v – 0.01VTC, RE=0.17
- vi – 0.01VTC, RE=0.3

# Ho on Balancing Problem



## H0: Tilting Factors

# Limitations

- Caution: functional forms, parameters, cost estimates.
- Lower bounds of benefits from ex ante detection systems. Trade, consumer scare, other industries not considered.

# Ongoing Agenda

Explicitly include vaccination, recovery,

Disaggregate to localized strategies

Cooperation/non-cooperation

Include Risk Aversion

Link to epidemiology model

Carcass disposal

Welfare slaughter

Event recovery lag

High Plains

# Future Work: Link to Epidemiology

- An economic model linked to epidemiologic model
  - Disease spread
  - Multiple types of outbreaks
    - Event occurrence and severity
  - Broader mix of strategies
  - Multiple vs. single purpose strategies
  - Risk aversion
    - Effects on optimal mix of strategies
  - Localized decision making
    - Possibly three stage formulation