

Risk, Animals, AgroTerrorism and Economics

Adapting Economic and Management Methodology to an Old Problem

For discussion at USDA ERS

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Basic Components of Talk

The economic problem

Some theoretical deductions - hypotheses

Conceptual modeling

A simplistic first cut

Broader project efforts

The Economic Problem

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

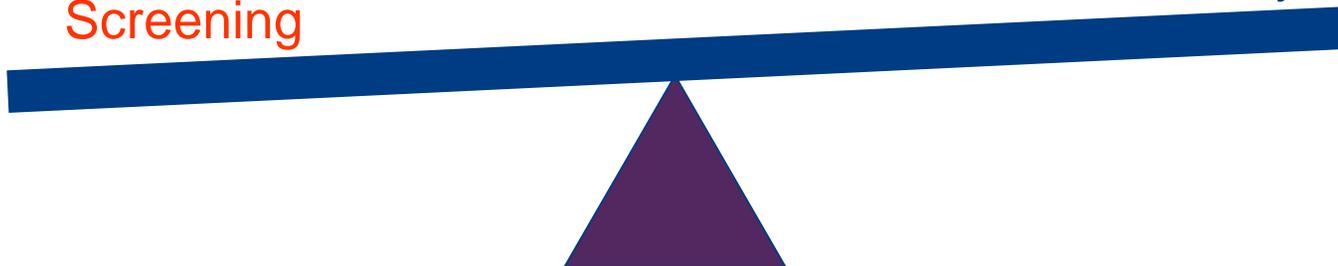
- Form best investment strategies considering cost, disease vulnerability, risk, and event characteristics?
- Best respond to an event?
- Assess effects on markets?
- Manage market information to minimize impacts?

Ex-Ante Invest

Anticipation
Prevention
Installation
Screening

Ex-Post Fix

Detection
Response
Recovery



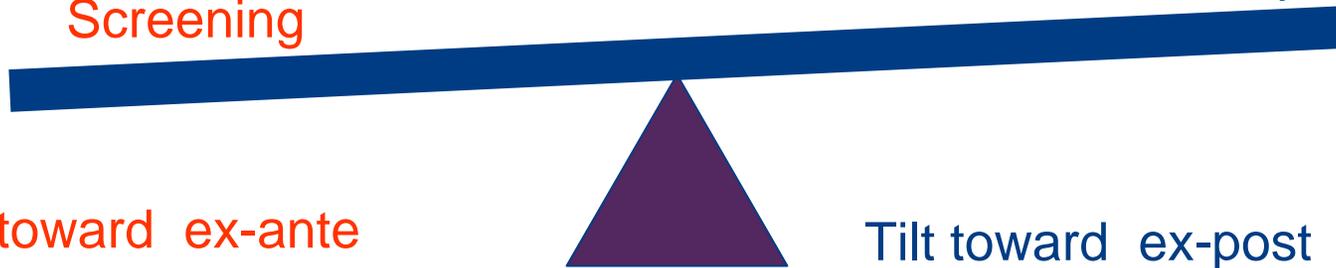
H₀: Tilting Factors

Ex-Ante Invest

Anticipation
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Ex-Post Fix

Detection
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Recovery



Tilt toward ex-ante

Tilt toward ex-post

Event is more likely
Ex-ante Activity has multi benefits
Ex-ante Activity is more effective
Ex-ante Activity is cheaper
Ex-post treatment more costly
Fast spreading disease
More valuable target
Big demand shift -- health

Event is less likely
Ex-ante Activity is single purpose
Ex-ante Activity is less effective
Ex-ante Activity is expensive
Ex-post treatment less costly
Slow spreading disease
Less valuable target
Little demand shift -- health

Background

Is the Problem a New One?

No, has many well known variants

- Food Quality/Safety from contaminants
- Invasive species
- Veterinary disease control
- Water management and impoundment construction
- Farmer machinery investment, crop mix
- Inventory theory, quality control, waiting line design
- Capital budgeting

But with added features of deliberate actions at max points of vulnerability. Not an accident.

All involve ex ante decisions but the ex post consequences occur only when event occurs - probabilistic

Project Goals

Examine the optimal economic allocation of portfolio of anticipation, prevention, detection, response and recovery actions

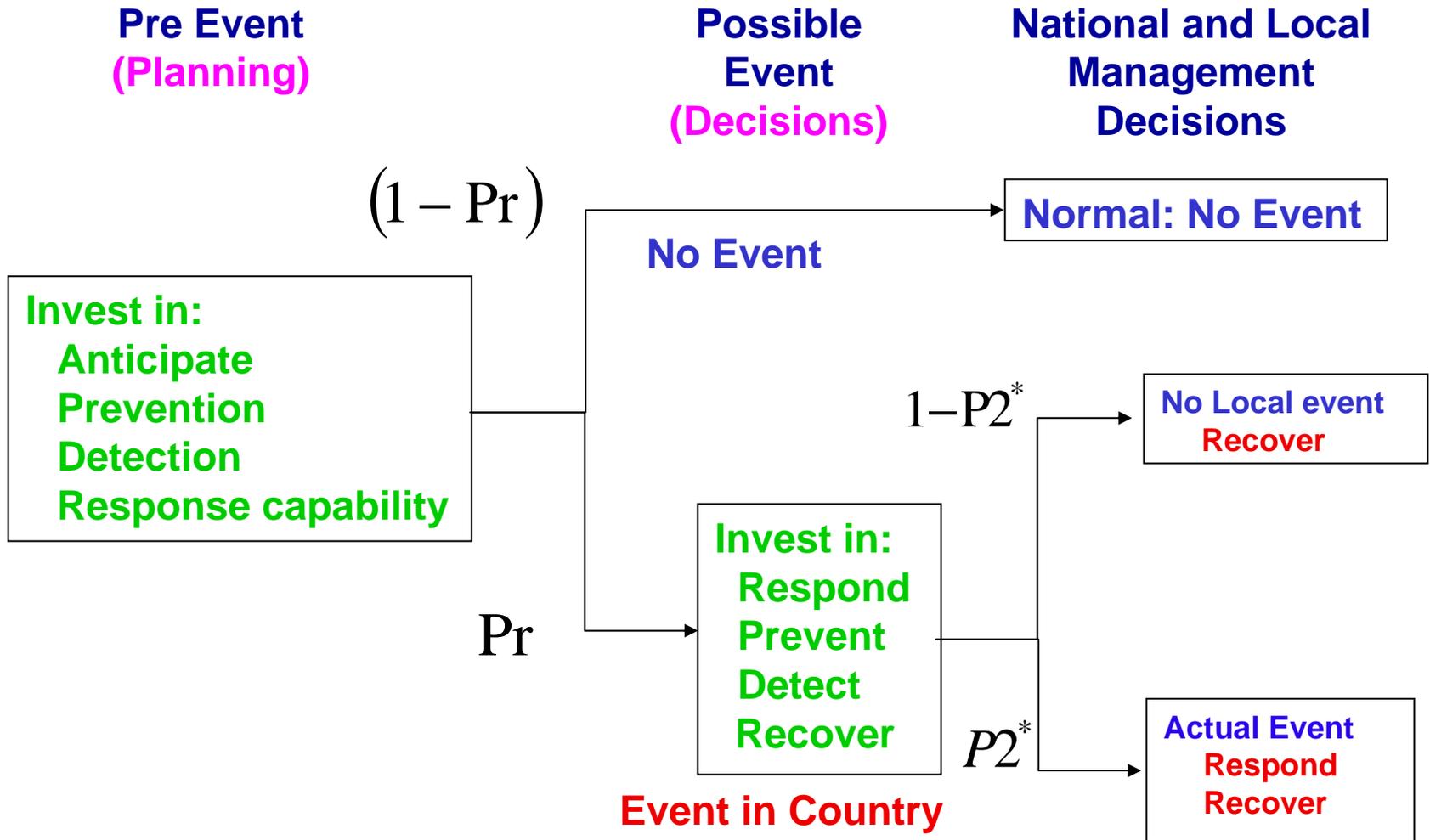
Look at event characteristics (disease spread and economic damage consequences) under which strategies dominate

Evaluate anticipation, prevention, detection, response and recovery strategy alternatives in a value of research or technology adoption context

Look at market effects and recovery enhancement strategies

Educate on economic principles

Analytic Conceptualization

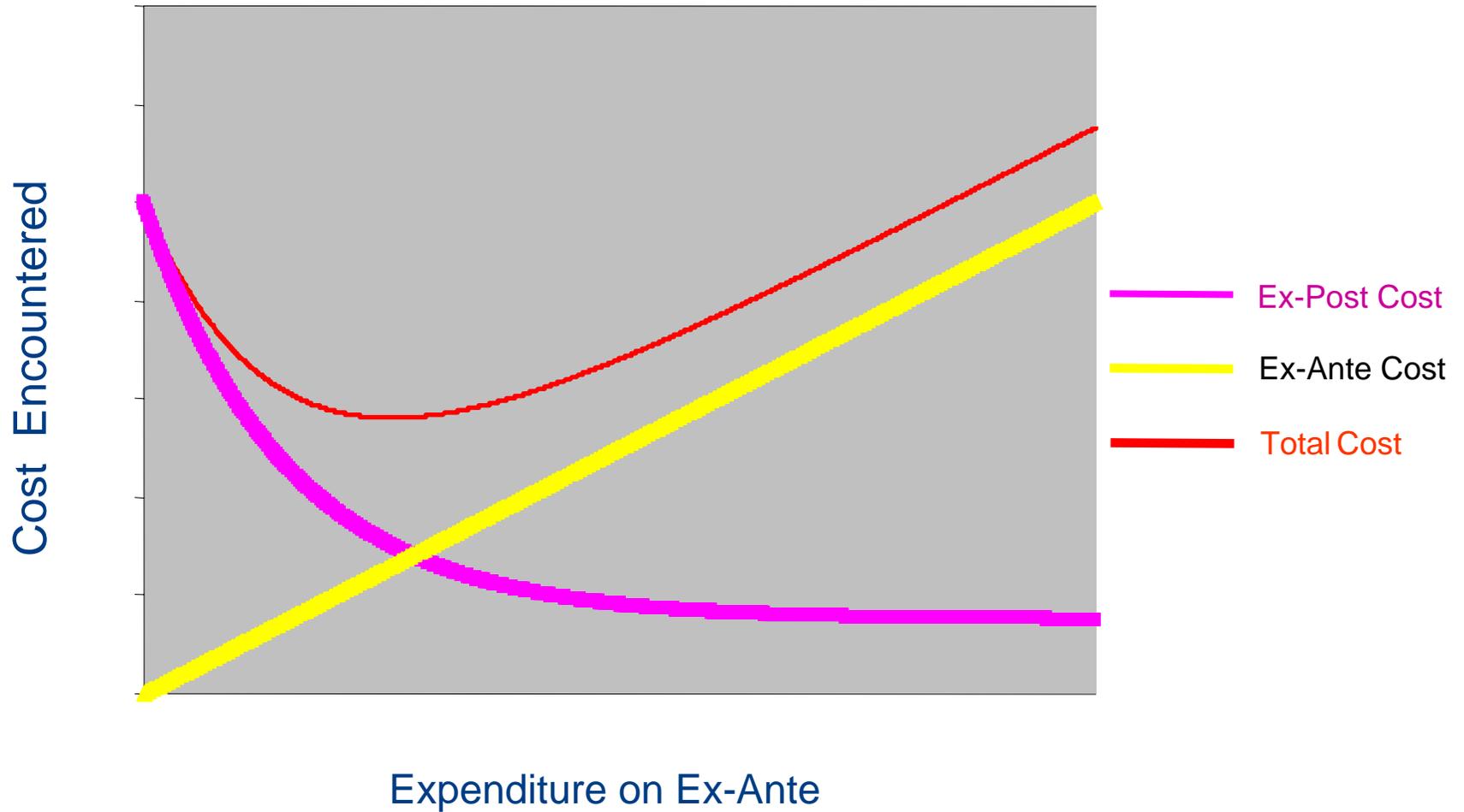


Analytic Conceptualization

Major elements

- Irreversibility – cannot instantly install investments when an event occurs
- Conditional response depending on investments
- Fixed cost versus infrequent occurring events
- Income depends on event and there is a large span of possible events
- Tradeoff between ex ante investment cost and occasional ex post event needs and associated costs
- Best strategy depends on investment cost, operating cost and probability

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

	Price	Yield with invest	Yield w/o invest	Probability
No event	4	1.2	1.1	(1-pr)
Event	3	0.9	0.1	pr

Simple Example of model

Problem will have 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 prices, and yield which results in variable to operate with (I) or without (NI) the investment under each state of nature (the 4 variables X)**

Simple Example of model

$$\text{Max } -10Y + (1-\text{pr}) * 4(1.9 * X_{1,I} + 1.8 * X_{1,NI}) + \text{prob} * 3(1.9 * X_{2,I} + 0.1 * X_{2,NI})$$

$$\begin{aligned} \text{s.t. } & -10Y && + X_{1,I} && && && \leq 0 \\ & && + X_{1,I} & + X_{1,NI} && && \leq 200 \\ & -10Y && && & + X_{2,I} && \leq 0 \\ & && && & + X_{2,I} & + X_{2,NI} & \leq 200 \\ & X, Y & \geq & 0 && && & \end{aligned}$$

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

Very Simplistic Case study

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

Assumptions

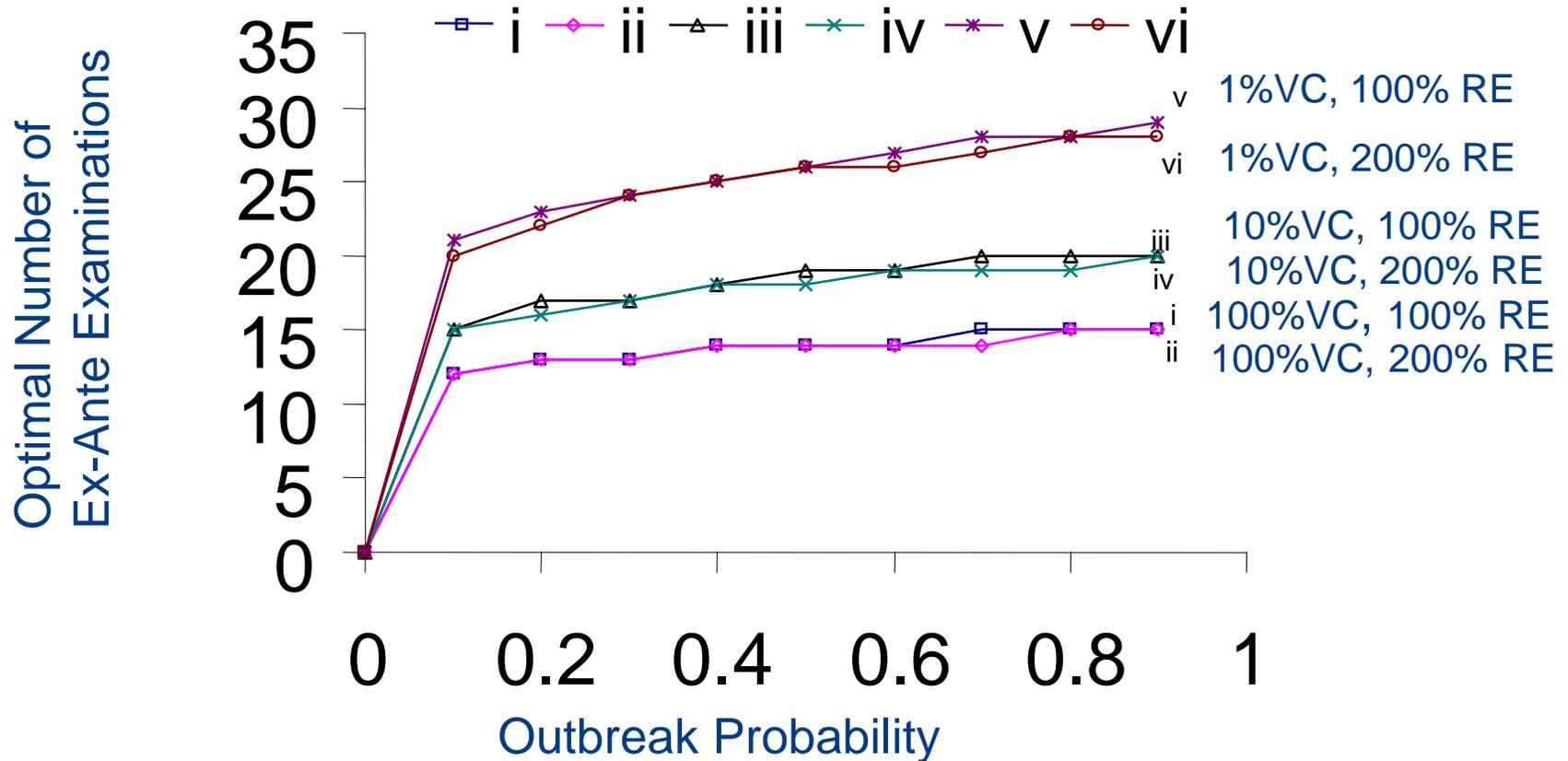
- Cost minimization of ex-ante costs plus probabilistic weighted cost of response.
- Response effectiveness
 - Slaughter (Schoenbaum and Disney, 2003)
- Disease spread
 - Exponential (Anderson and May, 1991) and Reed-Frost (Carpenter et al. 2004)
 - Fast (0.4) and slow (0.15) contact rates (Schoenbaum 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%

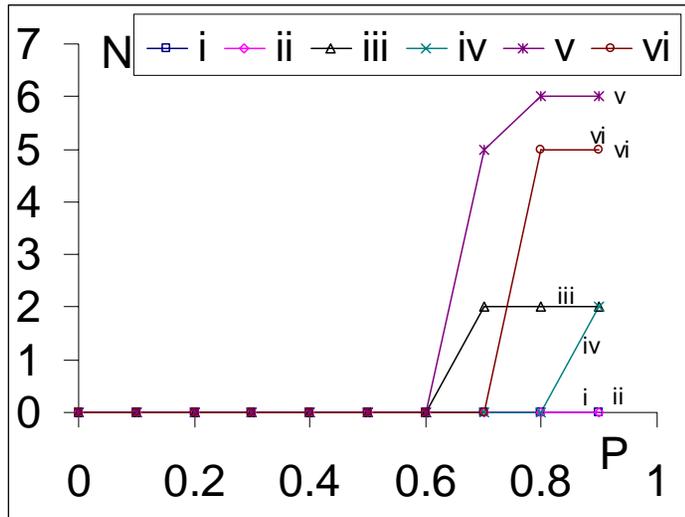
Event and Response Effectiveness(RE) Probability(P), Ex-Ante cost(VC)



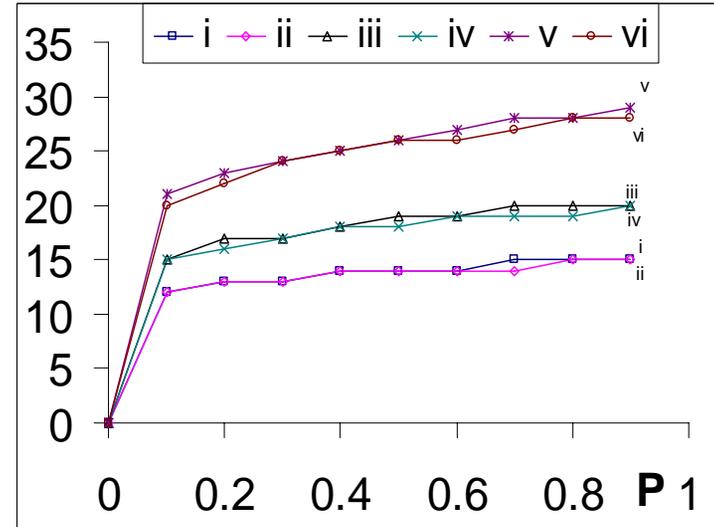
Ex-ante increases with prob, decreases with ex ante cost and ex post Treatment effectiveness

Effect of Altered Spread Rate

Slow



Fast

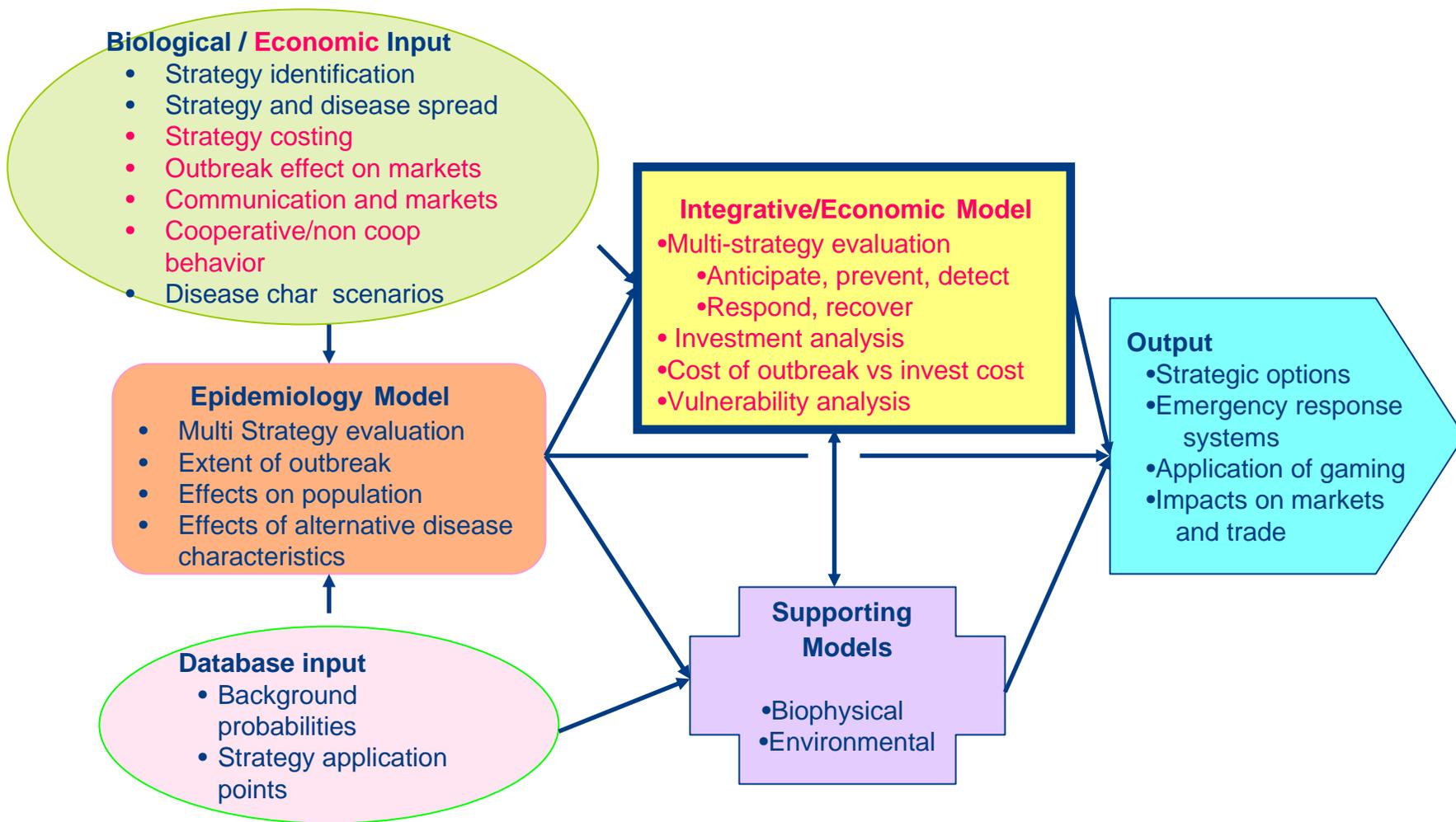


Legends as before

Ex-ante increases with disease spread

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.

More General Modeling Conceptualization



Red areas are economists playground

Expands on existing regional, trade and national modeling (ASM)

Items of Economic Concern

Animal categories

- Unaffected
- Euthanized
- Dead from disease
- Impaired by disease
- Vaccinated

Affected animal disposal

- Market value and use
- Carcass disposal

Investment study

- Strategy costing
- Risk distribution
- Fixed vs event specific costs

Markets

- Information management and demand
- Dynamic response
- Demand suppression

Policy design

- Cooperation
- Ex ante -- ex post balance

Modeling Conceptualization

Big elements

Multi disciplinary study

Domain experts, Veterinarians, Epidemiologists,
Information technologists, Economists ...

Ties together a number of models

Designed for insights not numbers

Will run backwards to see what characteristics of diseases
and event probabilities merit what types of strategies

Hypotheses / Deductions

The likely difference in the severity of the consequences from an attack consequences depend on the

Speed with which the damage agent used in the attack spreads,

Value of the target of the attack,

Consumer sensitivity to food items involved

Hypotheses / Deductions

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

Contemplated Studies

Vulnerability / risk assessment

- Effects of events without new strategies
- Cost of waiting in detection
- Attack scope and costs thereof

Component strategy evaluations

- Anticipation
- Prevention
- Detection
- Response
- Recovery

Investment / strategy mix study

- Strategy use
- Effects of disease characteristics
- Event probability that mandates actions
- Event specific vs multi outcome strategy value
- Risk / investment assessment

Other

- Recovery information management
- Carcass disposal
- Policy design and cooperative behavior

Plans

Economists will participate in multidisciplinary efforts:

- **Examination of possible events assessing costs/losses and identifying key sources of vulnerability**
- **Study of optimal investment patterns across prevention, detection, response and recovery to see how "best" total threat management is altered by threat characteristics.**
- **Investigation of the consequences of different management strategies for prevention, detection, response and recovery investments and operating rules.**
 - **Managing information to facilitate faster recovery.**
 - **Size of circles of treatment surrounding event – how far out to euthanize, vaccinate, quarantine, test etc.**
 - **Compensation schemes to facilitate compliance and discourage concealment.**

Plans

Economists will participate in multidisciplinary efforts directed toward:

- **Development of modeling approaches simulating events and consequences of strategy use to facilitate event planning and overall agri-food terrorism management approaches.**
- **Construction of a threat simulation gaming environment that can be used in training decision makers, responders and industry members.**