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Tradeoffs and Resource Allocation Effects for Alternative IS Management Policies

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Overview

- Objectives of the Project
- Beef model
  - BSE
  - Foot and mouth
- Perennial fruit model
  - Apple maggot

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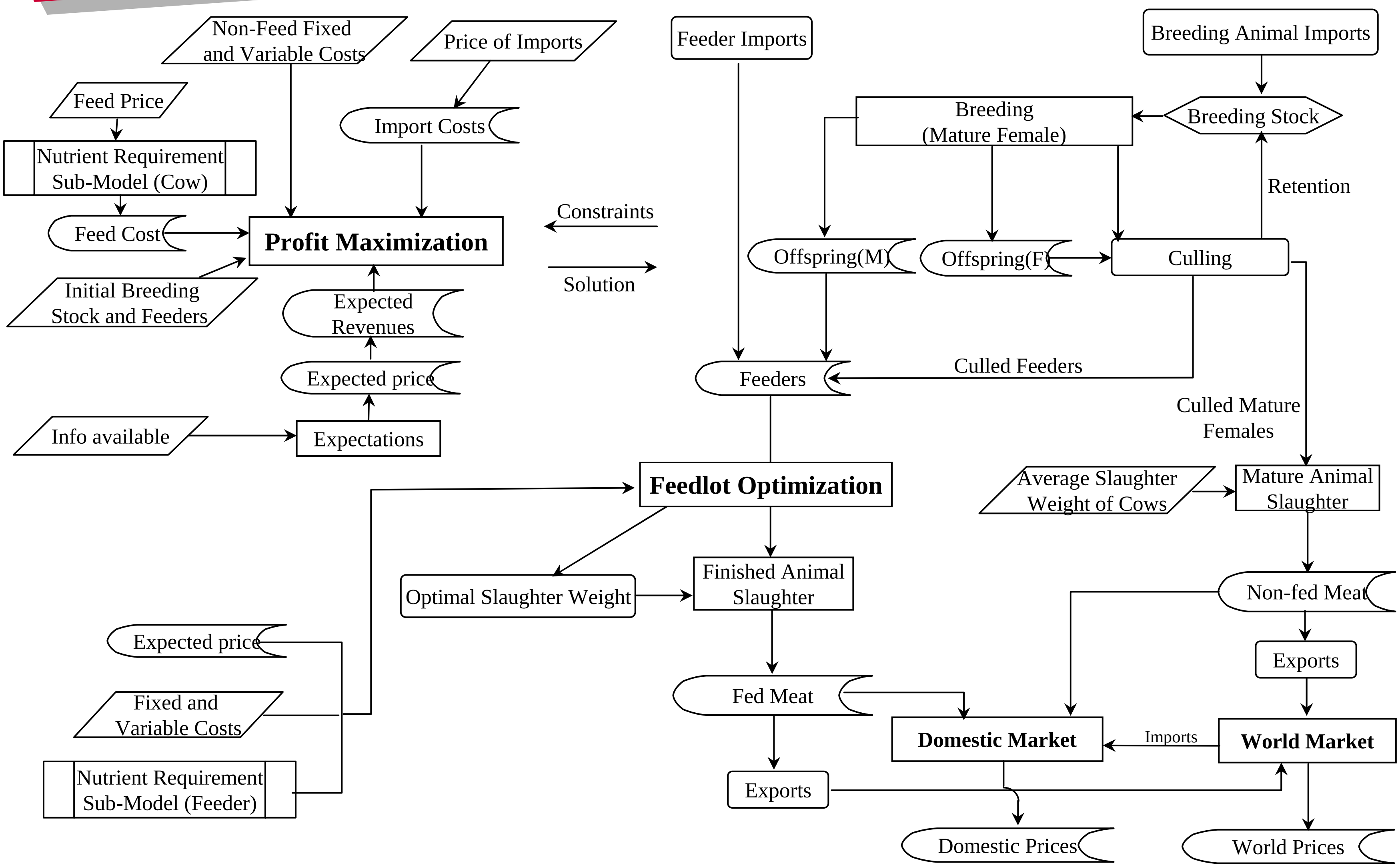
Objectives

- Develop a bioeconomic livestock model to evaluate the effect of livestock disease outbreaks and alternative prevention and mitigation strategies
- Develop a bioeconomic model for perennial fruit production and consumption for evaluating plant pest invasions
- Both characterized by productive stocks with long production cycles


Non-Feed Fixed and Variable Costs
Price of Imports
Feeder Imports
Breeding Animal Imports
Feed Price
Import Costs
Breeding (Mature Female)
Breeding Stock
Nutrient Requirement Sub-Model (Cow)
Retention
Feed Cost
Profit Maximization
Constraints
Offspring(M)
Offspring(F)
Culling
Solution
Initial Breeding Stock and Feeders
Expected Revenues
Expected price
Feeders
Culled Feeders
Culled Mature Females
Info available
Expectations
Feedlot Optimization
Average Slaughter Weight of Cows
Mature Animal Slaughter
Optimal Slaughter Weight
Finished Animal Slaughter
Non-fed Meat
Expected price
Exports
Fixed and Variable Costs
Fed Meat
Domestic Market
Imports
World Market
Nutrient Requirement Sub-Model (Feeder)
Exports
Domestic Prices
World Prices

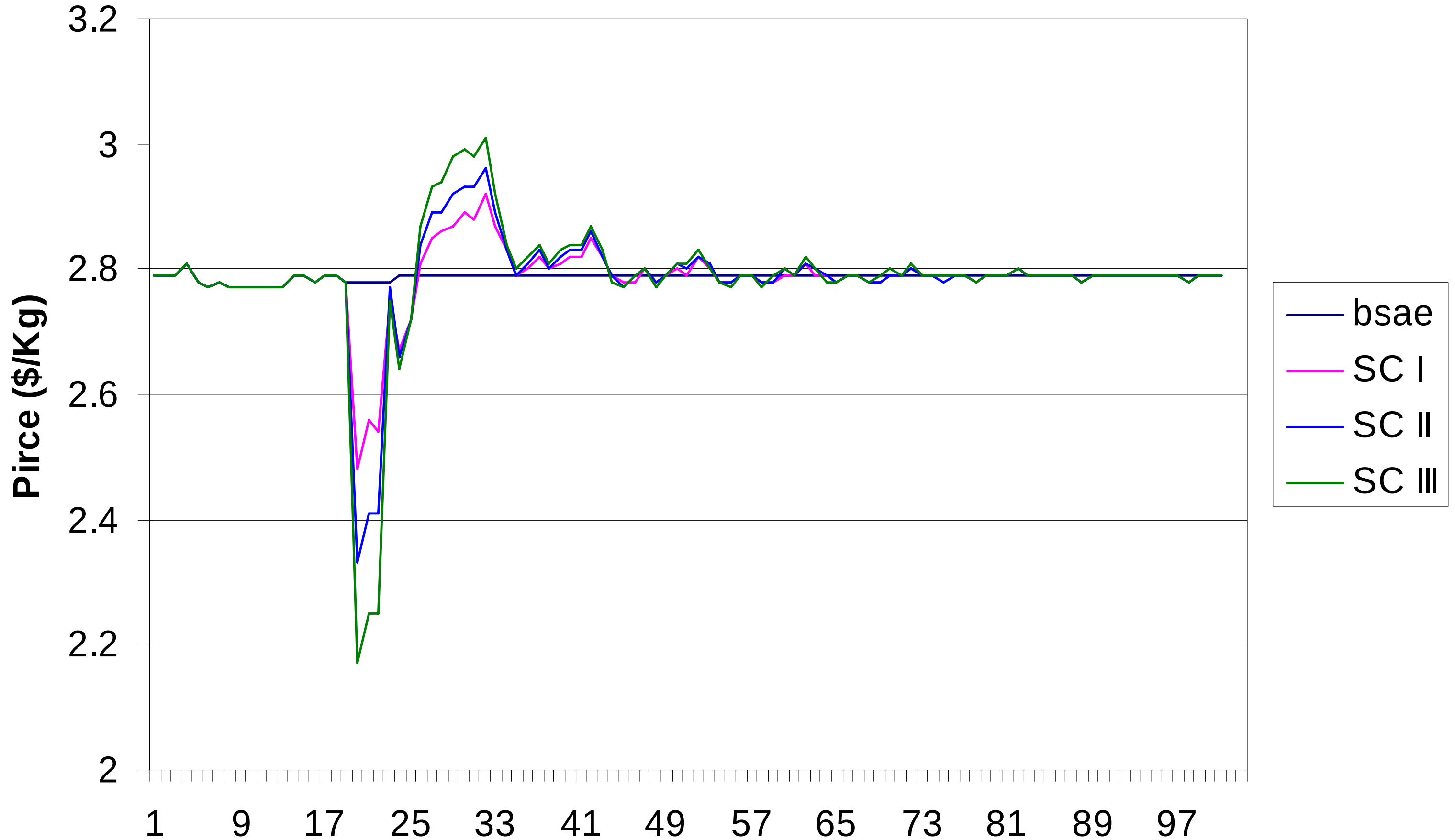
BSE Outbreak

- **A beef production and trade model is implemented to evaluate the impact of isolated BSE incidence**
- **Alternative consumption and policy response scenarios**

BSE Outbreak Scenarios

- **Assumption—Incidence results in loss of all beef and live cattle exports for 3 years**
- **Scenario I: no domestic demand loss**
- **Scenario II: 5% proportional decrease in domestic demand**
- **Scenario III: 10% proportional decrease in domestic demand**

Simulation Result—Price Response



Simulation Results—Welfare Changes

Scenario	Consumer (Billion $)	Producer (Billion $)	Total (Billion $)
I (No Demand Reduction)	4.4	-3.0	1.4
II (5% Demand Reduction)	-3.2	-4.8	-7.9
III (10% Demand Reduction)	-10.5	-6.9	-17.5

Scenarios—Government Intervention

- **Government implements a deficiency payment scheme for feeder cattle for the period of export loss**
- **Scenario III, 10% demand reduction without the deficiency payment**
- **Scenario IV, same shock but with price support**
- **Scenario V and VI: a moderate, 2%, permanent demand reduction**

Simulation Results

Scenario	***Consumer*** ***(Billion $)***	***Producer*** ***(Billion $)***	***Gov't*** ***(Billion $)***	***Total*** ***(Billion $)***
III (10% Demand Reduction)	-10.5	-6.9	0	-17.5
IV (III+Deficiency Pay)	-2.4	.05	-13.3	-15.7
V (III+2% Permanent Demand Reduction)	-28.1	-10.3	0	-38.3
VI (V+Deficiency Pay)	-19.9	-3.3	-13.3	-36.6

FMD Outbreak in Beef Cattle

- The FMD spread model is defined as a weekly deterministic state transition model
- States include:
  - susceptible, latent infectious, 2nd week infectious, 3rd week infectious, immune, and dead
- Upon effective contact, an animal enters latent infectious state
- 26 weeks of immune period after recovery or vaccination

IS Dissemination

- **Dynamics of infectious inventory**

$$I_{\tau+1} = \frac{\varepsilon_\tau I_\tau}{N_\tau} S_\tau + I_\tau - R_\tau$$

I_t : infectious

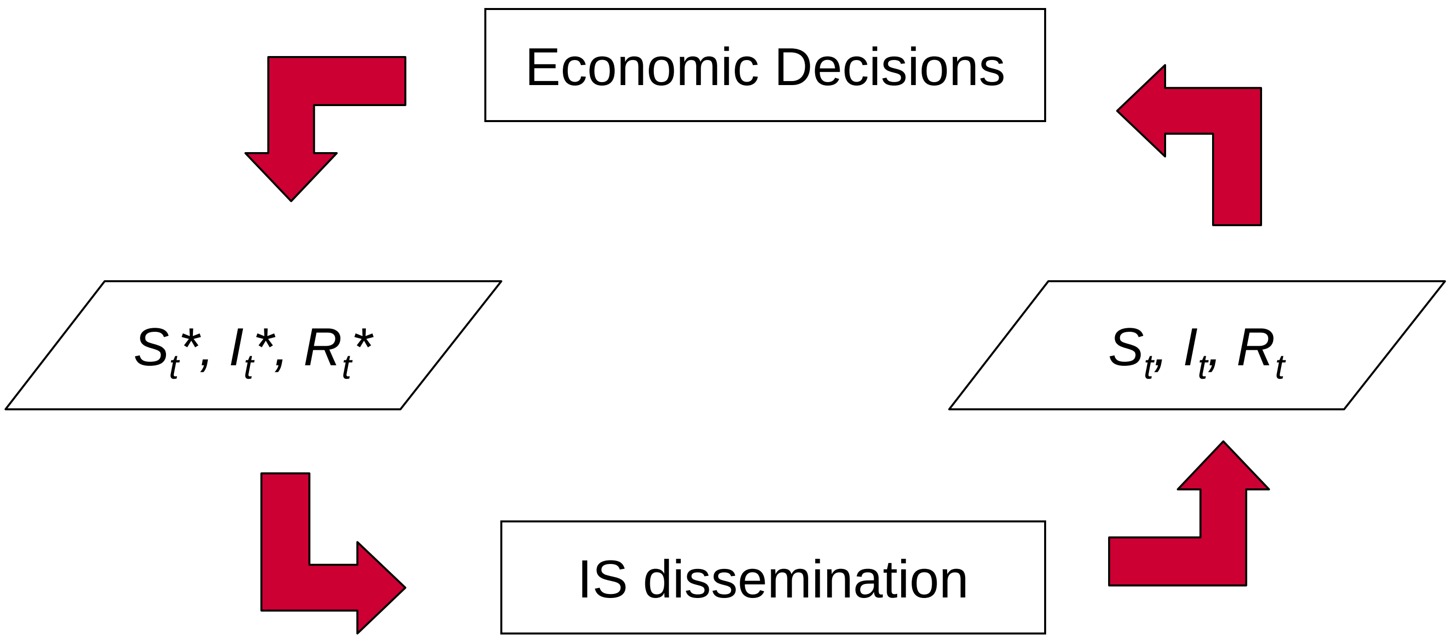
S_τ : susceptible

R_τ : Removed

ε_τ : number of contact per infectious animal

$N_\tau = S_\tau + I_\tau + R_\tau$: total

Interactions between IS dissemination and Economic Decisions



FMD Outbreak in Beef Cattle

- Dissemination rate 20 herds/week for the first two weeks
- From the 3rd week and on, dissemination rate is halved until it reaches 2.5 in the 6th week, 0.7 afterward
- FMD cause 2% death in adult cattle and 20% death in calves
- No other changes to productivity and cost parameters

Scenarios of Alternative Policies

- **Assumptions in all scenarios**
  - **All beef export markets close upon discovery of FMD**
  - **5% proportional reduction in domestic demand**
  - **Domestic and export markets return to normal 2 years after eradication**
  - **90% of the 2nd and 3rd week infectious herd discovered and depopulated**

Alternative Targeted Surveillance Scenarios

- In scenarios 1-7:
  - Depopulation rate of latent infectious herd increased from 30% to 90% in the first week by increments of 10%
  - Represents increasing effort in tracing and surveillance (targeted surveillance)

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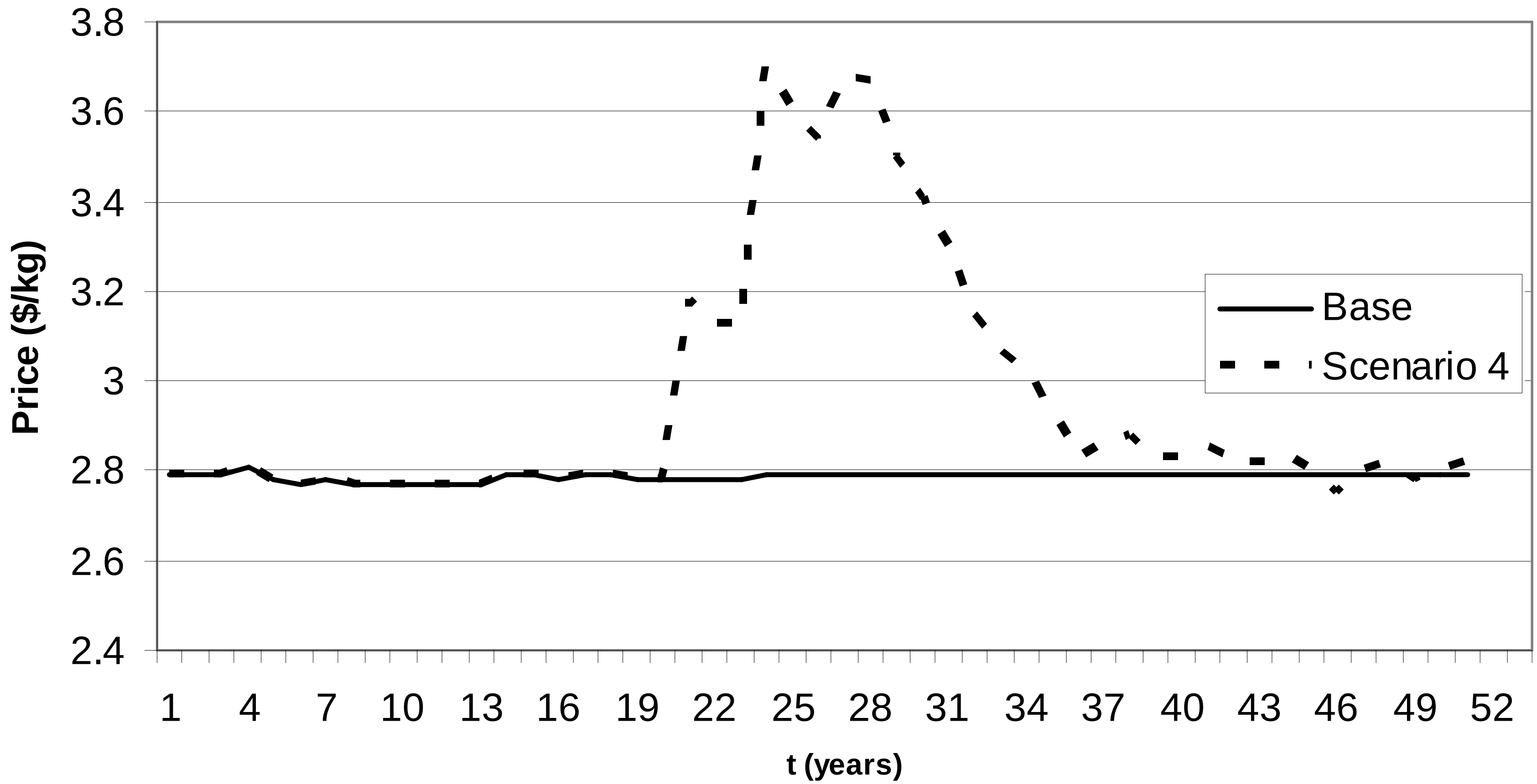
Price Response
60% discovery rate for latent infectious



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Increased Targeted Surveillance Welfare Effects

Scenario	Discovery Rate	Depopulated (% of total inventory)	Depop Cost* (Billion$)	Consumer (Billion $)	Producer (Billion $)	Total (Billion $)
1	0.3	76.92	-6.83	-186.22	-73.26	**-266.31**
2	0.4	55.27	-4.91	-123.93	-9.90	**-138.74**
3	0.5	39.46	-3.50	-91.87	16.54	**-78.84**
4	0.6	27.94	-2.48	-66.46	18.64	**-50.30**
5	0.7	19.51	-1.73	-47.36	14.80	**-34.29**
6	0.8	13.41	-1.19	-33.51	10.01	**-24.68**
7	0.9	9.04	-0.80	-23.53	5.79	**-18.54**

* Cost of increased surveillance not included

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Ring Vaccination Simulation Scenarios

- **Ring vaccination is often used to control the spread of highly contagious disease**
- **Scenario 1: 60% of the latent infectious herds are removed *WITHOUT using ring Vaccination*.**
- **Scenario 2-4: 70%, 80%, and 90% of the latent infectious herds are removed by vaccinating an increasing number of susceptible herds**
- **All vaccinated animals are depopulated as soon as possible to regain FMD free country status**

Ring Vaccination—Welfare Effects

Scenario	Equivalent discovery Rate	Depopulated (% of total inventory)	Depop Cost (Billion $)	Consumer (Billion $)	Producer (Billion $)	Total (Billion $)
1	0.6	27.94	-2.48	-66.46	18.64	**-50.30**
2	0.7	32.91	-2.92	-77.65	18.99	**-58.66**
3	0.8	34.25	-3.04	-80.62	18.79	**-61.83**
4	0.9	36.32	-3.23	-85.12	18.17	**-66.96**

Summary of Livestock Model

- A conceptual framework that integrates IS dissemination, population dynamics of livestock, and economic decisions is presented
- A implementation of beef production with potential BSE and FMD outbreaks is used to illustrate the use of the model in evaluating alternative IS policies

Perennial Fruit Production and Consumption Model

Motivation

- **Long productive life of perennial fruit trees makes dynamics of productive stocks important for fruit supply**

Model Structure

- **Fruit producers maximize profit subject to the constraints of population dynamics**
- **Fruit product is sold on domestic and international markets. Fruit can also be imported**
- **IS dissemination—population front advance model proposed by Sharov and Liebhold (1998)**

$$\frac{cn_0V}{r^2}\left[\exp\left(\frac{r}{V}\right)-\frac{r}{V}-1\right]=K$$

c: colonization rate

n_0: initial numbers of individuals in a colony

K: carrying capacity

r: rate of population increase

V: relative speed of population spread

Implementation of Apple Production

- Two regions
  - Washington—accounting for about 70% fresh market apple production
  - Rest of US
- Two types of production system
  - High density—for Washington new plantings
  - Low density—for rest of US new plantings

Apple Maggot

- A major apple pest that's native to North America
- Untreated orchard could lose 30-70% of total production
- Introduced to Portland area in 1979 and began to spread to California, Washington, and Idaho

Apple Maggot Introduction and Spread in Washington State

- Apple maggot was first discovered in Washington state in 1980
- Apple maggot is established in most counties west of the Cascades by the mid 90's
- Apple maggot flies have been found in Yakima and Kittitas, two of the major apple production counties
- In 2004, parts of Kittitas and Yakima were quarantined

Simulation of Apple Maggot Spread

- If apple maggot continues to spread at its historical speed, all apple production in Washington would be affected in 34 years
- Effects on production and trade
  - $45/acre increase in cost (assuming 3 sprays, each costs $15/acre)
  - Cost of exporting to Canada increase by 30% of the farm price for fresh apple to reflect costs of cold treatment

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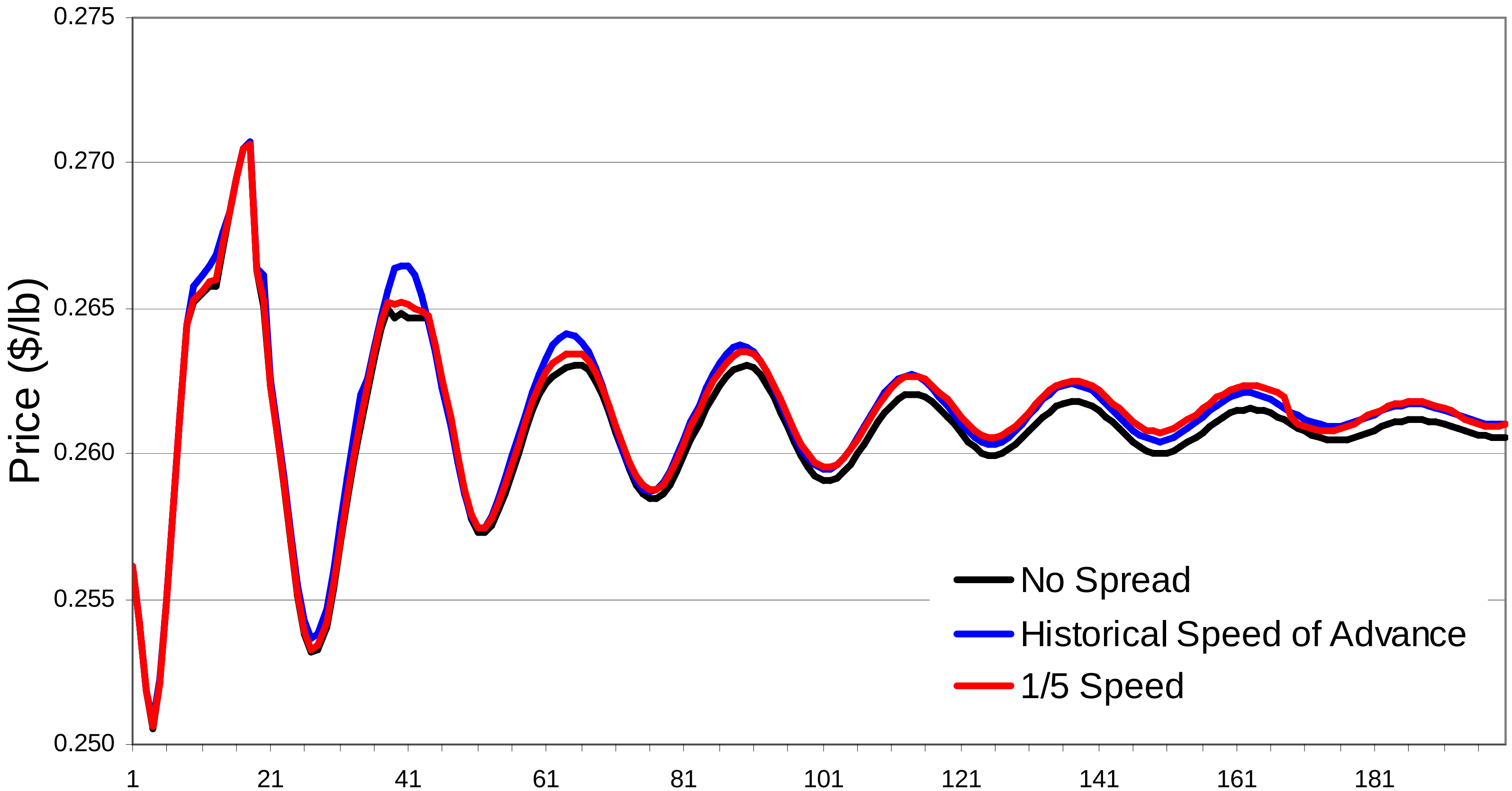
Price Response to Apple Maggot Spread



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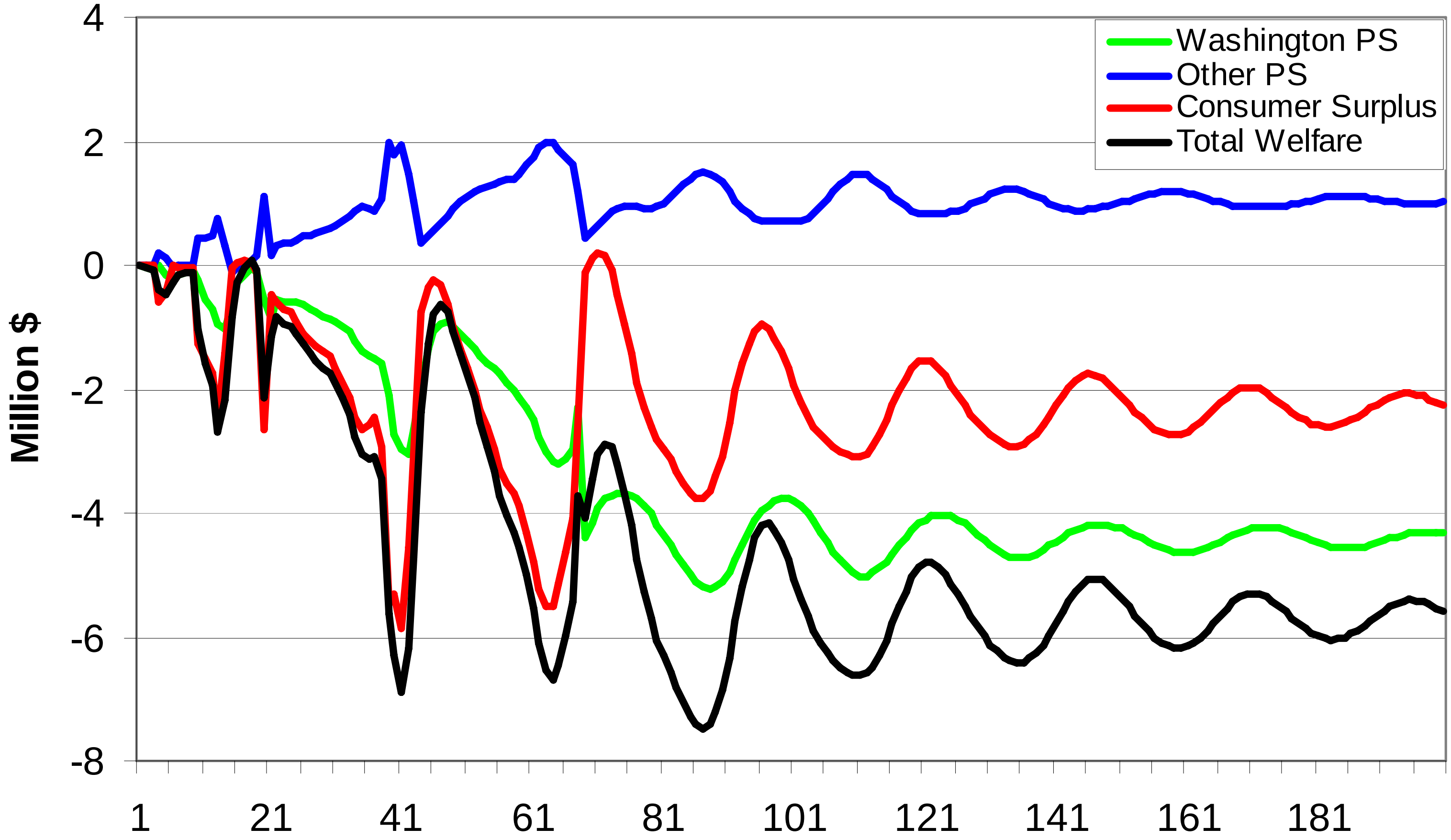
Welfare Response to Apple Maggot Spread (At historical speed)



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Simulation Results

Speed of Spread	Total Welfare Loss (Million $)	Benefit of Control (Million $)	Break-even Annual Spending (Million $)
Historical Speed (V)	-14.76	-	-
0.9 V	-13.47	1.30	0.13
0.8 V	-12.00	2.76	0.28
0.7 V	-10.58	4.18	0.42
0.6 V	-9.11	5.66	0.56
0.5 V	-7.61	7.15	0.71
0.4 V	-6.10	8.67	0.86
0.3 V	-4.58	10.19	1.01
0.2 V	-3.05	11.71	1.16

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Conclusions

- **Dynamics play an important role in economic analysis of biological invasions**
- **Integrated modeling framework makes economic decisions accurately reflect changes to production and market environment**
- **Interaction between economic decisions and IS spread allows the course of spread be modified by rational choice of economic agents**

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