Modeling and Economic Evaluation of Effectiveness of Avian Influenza Mitigation Options in Texas

Levan Elbakidze (University of Idaho)
Bruce A. McCarl (Texas A&M)
Michael Ward (University of Sidney)
John B. Carey (Texas A&M)
Aklesso Egbendewe-Mondzozo, (Texas A&M)

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What Was Proposed?

- Concentrate on industry (no wildlife) in Texas
- Evaluate a set of mitigation strategies
  - Heterogeneous commercial poultry flocks
  - Culling, detection, surveillance, movement restriction and quarantine
  - Vaccination
- Adopt a cost minimization approach
  - Welfare losses (PS, CS)
  - Cost of strategy implementation
  - Allocation of *resources* across *ex ante* vs. *ex post* actions

Analytic Conceptualization
Simple Model -Two Stages

STAGE 1

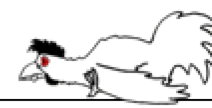
STAGE 2

No Event
Invest in preparedness/prevention
Invest in response capability
Do nothing

Pr

No Event
Do nothing

(1-Pr)



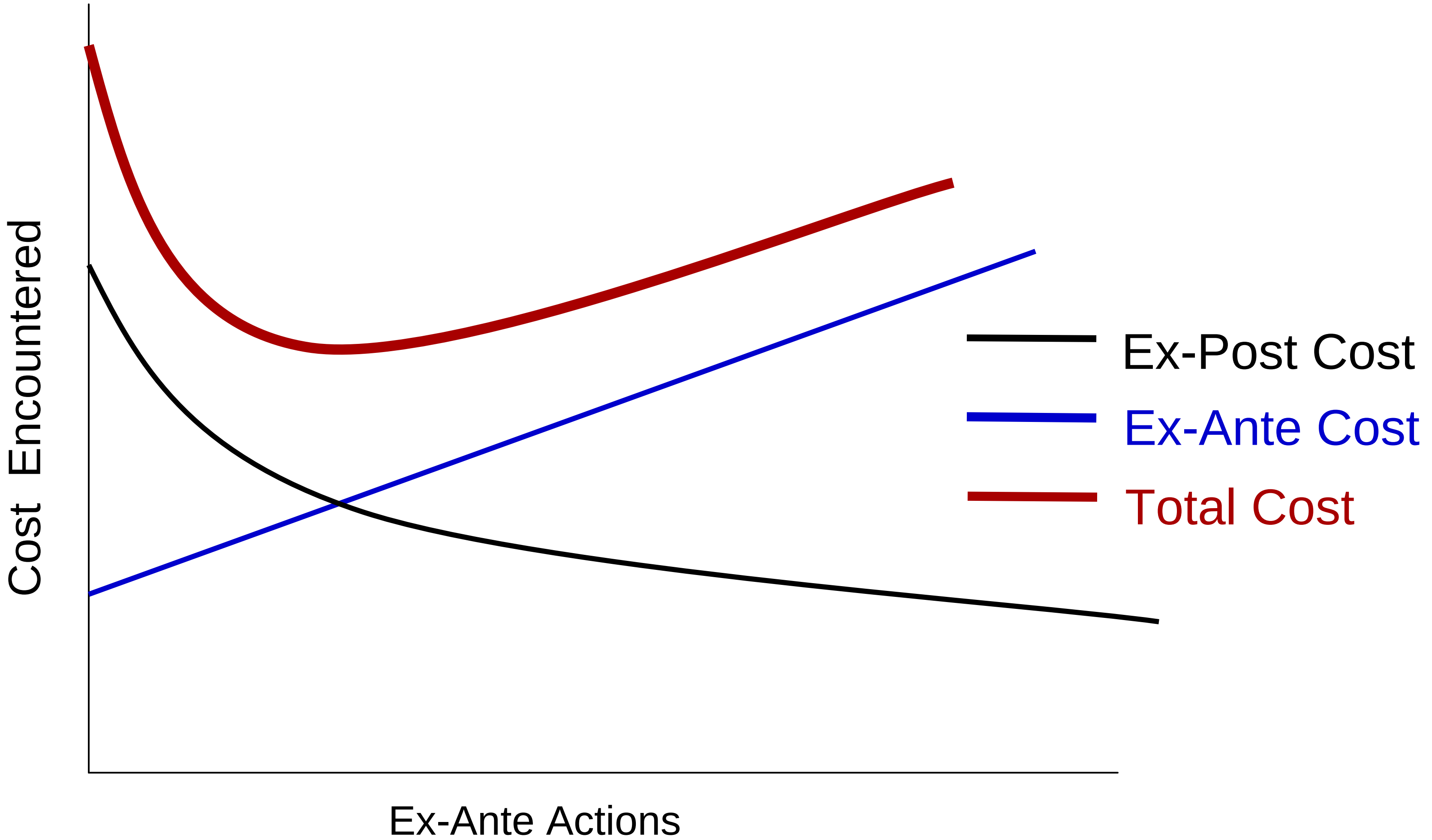
Event
Respond
Do nothing

Ex ante

Ex post

Source: Elbakidze and Mccarl (2006)

Analytic Conceptualization of the Project



Output

- **Publications**
  - Elbakidze, L., “Modeling of Avian Influenza Mitigation Policies Within the Backyard Segment of the Poultry Sector”, *Journal of Agricultural and Resource Economics* (August, 2008):195-211.
- **Presentations**
  - Elbakidze, L., “Modeling of Avian Influenza Mitigation Policies within the Backyard Segment of the Poultry Sector", Western Agricultural Economics Annual Meetings, Big Sky, Montana, June, 2008
  - Elbakidze, L., “Modeling of Avian Influenza Mitigation Policies within the Backyard Segment of the Poultry Sector”, Invited presentation, University of Idaho, October, 2007
- **Posters**
  - Egbendewe-Mondzozo, A., L. Elbakidze, B. A. McCarl, “Stochastic Integrated Economic-Epidemic Modeling of Avian Influenza Mitigation Options: A Case Study of Texas Outbreak”, Poster at Agricultural and Applied Economics Association, Annual Meetings, Milwaukee, July, 2009
  - Elbakidze, L., and A. Egbendewe-Mondzozo, “Critical Components of Preparedness and Response for Avian Flue Mitigation within the Poultry Sector”, Poster presentation at the Annual Meetings of American Agricultural Economics Association, Portland, OR, July 2007
  - Egbendewe-Mondzozo, A., L. Elbakidze, B. A. McCarl, “Stochastic Integrated Economic-Epidemic Modeling of Avian Influenza Mitigation Options: A Case Study of Texas Outbreak”, Poster at Homeland Security Summit, Washington D.C, March, 2009
- **Ph.D. Dissertation**
  - Egbendewe-Mondzozo, “An Integrated Economic-Epidemic Modeling of Avian Influenza Mitigation Options: A Case Study of an Outbreak in Texas”, 2009, Texas A&M University

Journal of Agricultural and Resource Economics 33(2):195–211

Modeling of Avian Influenza Mitigation Policies Within the Backyard Segment of the Poultry Sector

Levan Elbakidze

This study presents a conceptual model for the analysis of avian influenza mitigation options within the small poultry farm sector (backyard flocks). The proposed model incorporates epidemiologic susceptible-infected-recovered (SIR) methodology into an economic cost-minimization framework. The model is used to investigate the implications and interdependencies of mitigation options that influence inter-flock contact rates of asymptomatic and symptomatic flocks, and reduce the duration of symptomatic and asymptomatic periods. The results indicate that for shorter asymptomatic periods the efforts to control inter-flock contact rates should concentrate on symptomatic flocks, while for longer asymptomatic periods the control of inter-flock contacts should be focused on asymptomatic flocks. Efforts to reduce the length of asymptomatic and symptomatic periods and efforts to reduce inter-flock contact rates function as substitute strategies.

Key words: asymptomatic and symptomatic periods, avian influenza, contact rates, cost minimization

Introduction

The spread of the highly pathogenic avian influenza (AI) in many Asian and European countries, and its associated economic consequences (Taha, 2007), has attracted the

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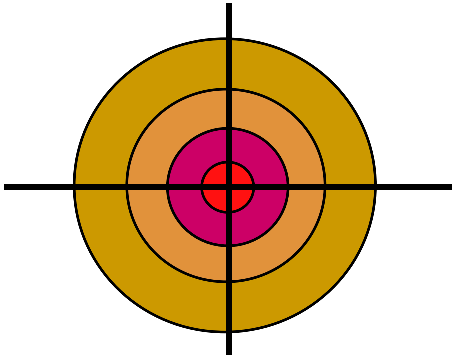
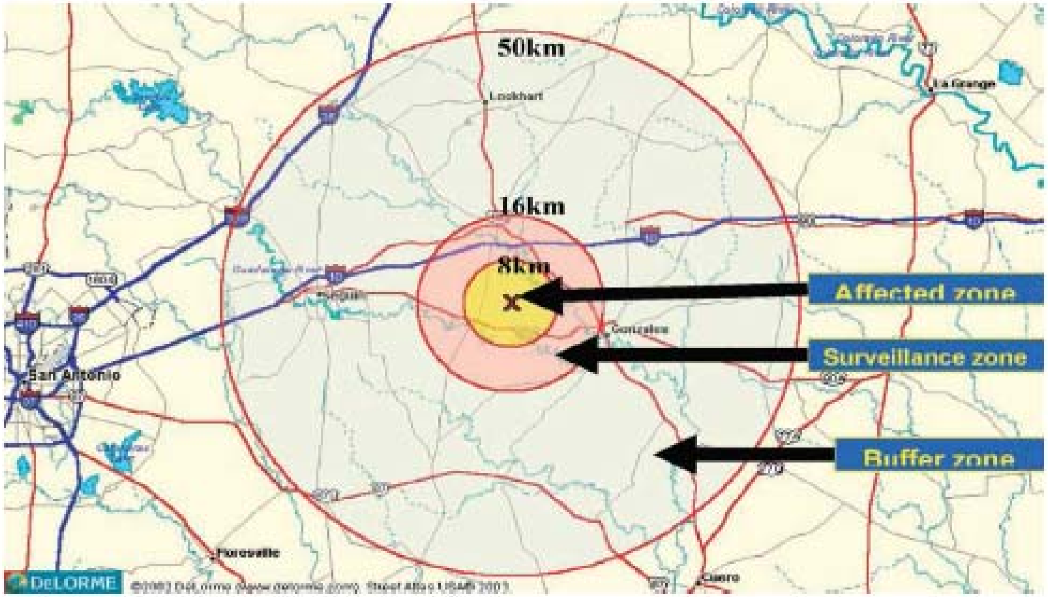
Objective

- Inform the decision makers about optimal AI mitigation strategy formulation in poultry industry
  - Develop an integrated economic-epidemic model
  - Apply the model to study a hypothetical outbreak in Texas under a deterministic AI spread assumption
  - Introduce risk in the analysis and rank control strategies results using stochastic dominance criteria
  - Study ex-ante vaccines production investment decision making (Elbakidze and McCarl, 2006)

Mitigation Strategies



- Current mitigation plans in TX (TAHC)
  - depopulation of the infected flocks
  - and any flocks located within the 5 miles diameter
  - movement restrictions around the affected zone 10 miles
  - surveillance of all flocks within 31 miles of the affected flocks
- Suggested Control Option (OIE)
  - OIE suggests the use of vaccination in the control
  - By applying the current strategy and Vaccinate in a maximum circumference around the affected zone



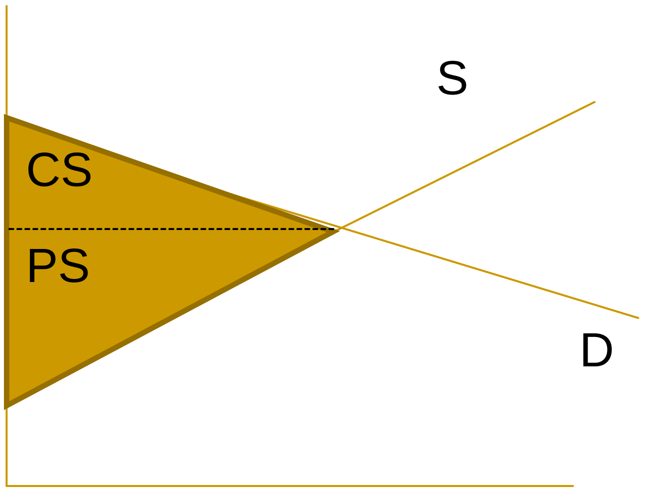
Source: Pelzel (2006)

Some Previous Economics Literature

- AI Econ. studies
  - Paarlberg et al. (2007) – Regionalization (into disease free regions)
  - Djunaidi and Djunaidi (2007) – Trade effects of simultaneous outbreaks in Asia, US, Brazil, and EU
  - Beach et al. (2007) – Producer behavior under livestock disease risk
  - Brown et al. (2007)– Potential effects of AI outbreak on US agriculture
- Applications of SIR in Economics
  - Elbakidze (2008)
    - SLIR
    - AI in backyard flocks
  - Horan and Wolfe (2005)
    - SI framework
    - Bovine tuberculosis among Michigan white tailed deer.
  - Bicknell et al. (1999)
    - SI framework
    - Incentives of profit maximizing producers to control bovine tuberculosis in New Zealand
  - Rich and Winter-Nelson (2007)
    - SIR framework
    - FMD in the Southern Cone of South America
    - Assess economic effectiveness of spatially sensitive control options.

Methodology and Model

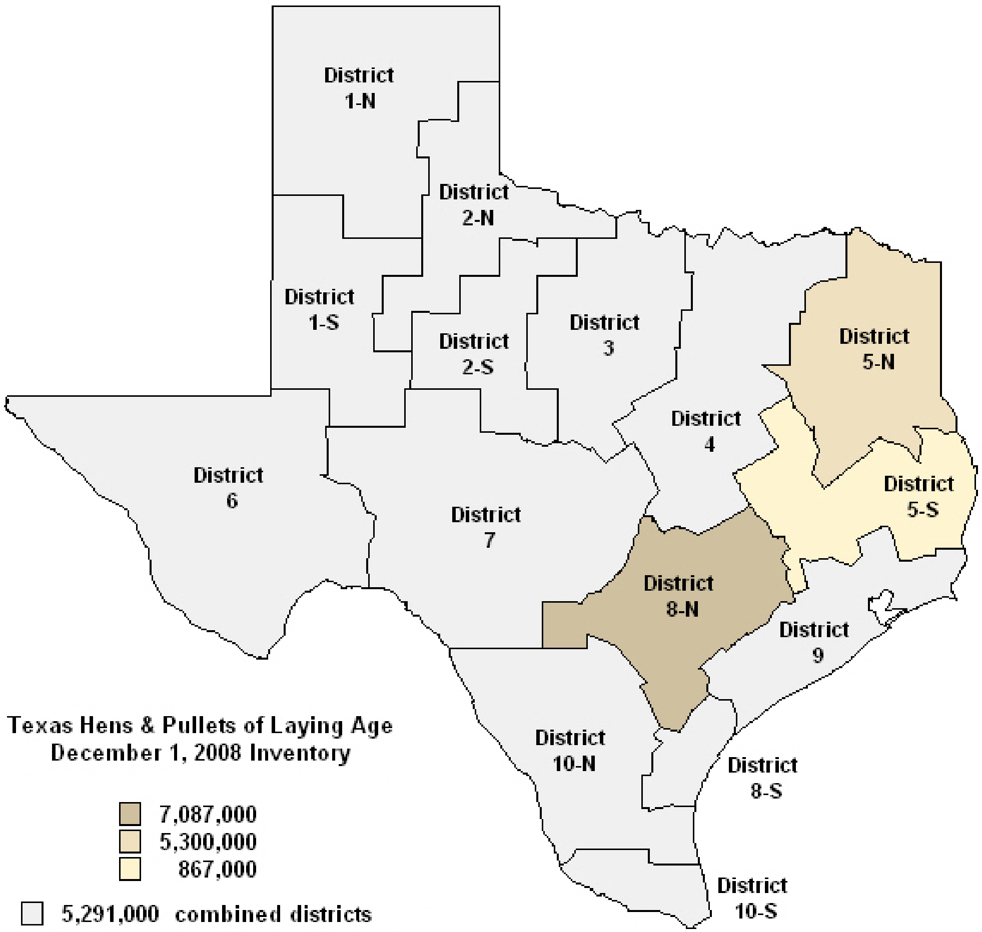
- A partial equilibrium model (Samuelson, 1952; McCarl and Spreen, 1980; Rich and Winter-Nelson 2007) maximizing the total welfare (CS+PS)
  - Collected data on production, consumption prices from USDA-ERS
  - Supply and Demand curves were estimated
    - Simultaneous equations models (3SLS)
    - Log-log and linear specification
  - Stochastic dominance



Methodology and Model

- An epidemic model (SLIR) [Rushton and Mautner (1955); Bates et al.(2003)and Elbakidze (2008)]
  - Collected contact rates data on layer, broiler and turkey farms by direct survey
  - Used contacts rates with flocks statistics data calculated from the Ag Census(2002)
- The resulting model used is a nonlinear mathematical programming that involves multiple poultry markets and risk.
- Monte Carlo simulation of the contact rates

Study Sub-regions



USDA - NASS (2008)

Total costs in million $(under no Demand Shift)

The first basic empirical results are given in the table below:

Strategy	District 8-N	District 5-N	District 5-S
Without Vaccination	49.9	42.4	28.8
With Vaccination	47.1	40.5	27.2
Savings(percent)	5	4	6

- The total costs include $\triangle CS$ and $\triangle PS$ plus mitigation costs
- $\triangle CS$ and $\triangle PS$ are negligible here
- The total costs in this case are mainly mitigation costs
- Vaccination can save

Total Cost (in million $) with Demand Shift

Here consumers are aware of the outbreak.Demand shift scenarios of 10, 20 and 30 percent are analyzed.

Strategy	District 8-N	District 5-N	District 5-S
No Vaccination(0.10 shift)	1,973.0	1,965.6	1,952.0
Vaccination(0.10 shift)	1,970.3	1,963.7	1,950.4
No Vaccination(0.20 shift)	3,684.1	3,676.6	3,663.0
Vaccination(0.20 shift)	3,681.3	3,674.7	3,661.5
No Vaccination(0.30 shift)	5,183.4	5,176.0	5,162.5
Vaccination(0.30 shift)	5,180.8	5,174.1	5,160.8

- The total costs increased because of the losses in consumers' and producers' surpluses
- The more the demand retracts, the higher the total outbreak costs would be
- The vaccination is cost effective

Price Implications

Here changes in prices under demand shifts scenarios are presented.

Table 3.12 Price Changes in the Three Demand Shift Scenarios

Prices	Egg	Chicken	Turkey
Pre-outbreak levels	1.031	1.518	1.045
Small shift (10%)	0.938	1.388	0.941
Percentage change	**- 9%**	**-8.5%**	**-9.9%**
Medium shift (20%)	0.846	1.259	0.837
Percentage change	**-18%**	**-17%**	**-19.9%**
Large shift (30%)	0.753	1.129	0.774
Percentage change	**-26.9%**	**-25.6%**	**-25.9%**

Note: Egg prices are in dollars per dozen, chicken and turkey prices are in dollars per pounds.

Ex-ante Vaccine Production Results

Here threshold probabilities beyond which ex-ante vaccines production investment could be made are presented.

	Texas	District 8-N	District 5-N	District 5-S
Investment(in M)	0.4	0.4	0.4	0.4
Prob.Interval	$[0.07, 1]$	$[0.39, 1]$	$[0.61, 1]$	$[0.68, 1]$

Confidence Intervals (District 8-N)

The results below are based on 250 iterations of the contact rates drawn from estimated distributions in the most dense district.

Strategy	Mean	0.95 CI
No Vaccination(0.00 shift)	45.1	[29.6, 49.9]
Vaccination(0.00 shift)	43.4	[29.1, 47.2]
No Vaccination(0.10 shift)	1968.1	[1952.6, 1973.1]
Vaccination(0.10 shift)	1966.5	[1952.1, 1970.3]
No Vaccination(0.20 shift)	3678.6	[3662.9, 3684.1]
Vaccination(0.20 shift)	3677.5	[3663.0, 3681.4]
No Vaccination(0.30 shift)	5178.0	[5162.2, 5183.5]
Vaccination(0.30 shift)	5176.8	[5162.2, 5158.8]

- under vaccination, mean costs and the upper CI bounds are lower
- Also,vaccination first degree stochastically dominates the current strategy

Stochastic Dominance for District 8-

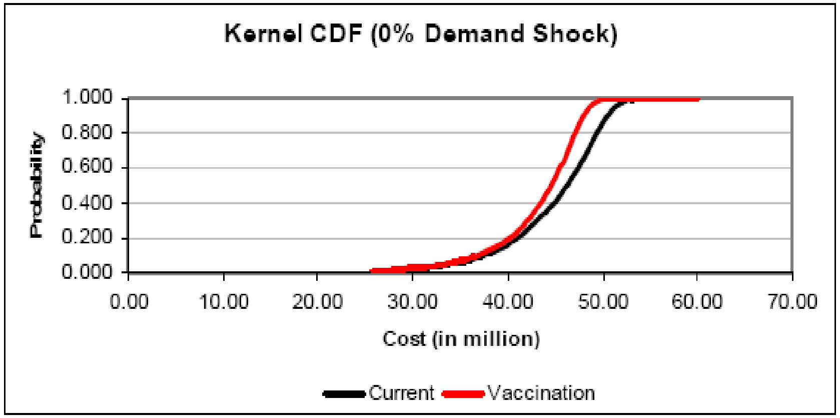


Figure 4.1 District 8-N: total outbreak cost distributions under 0% demand shock

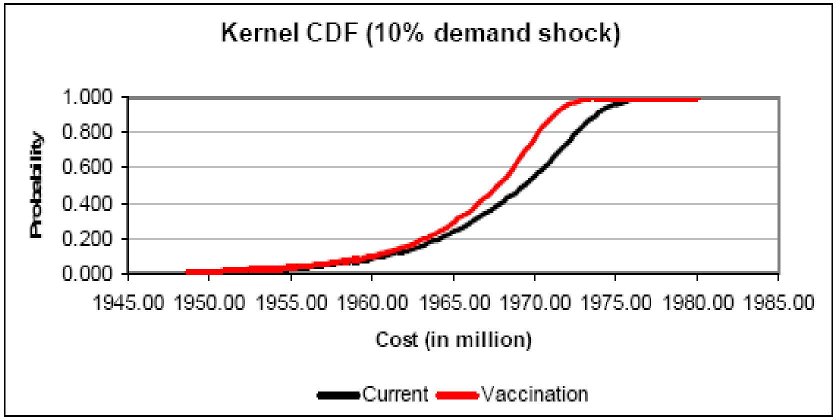


Figure 4.2 District 8-N: total outbreak cost distributions under 10% demand shock

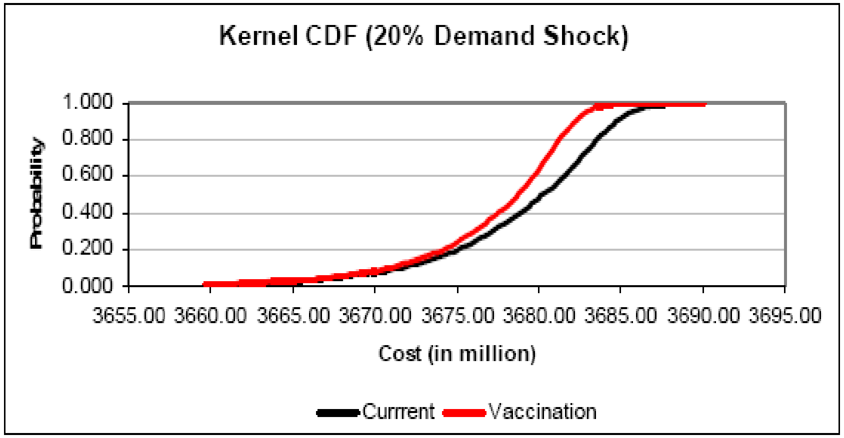


Figure 4.3 District 8-N: total outbreak cost distributions under 20% demand shock

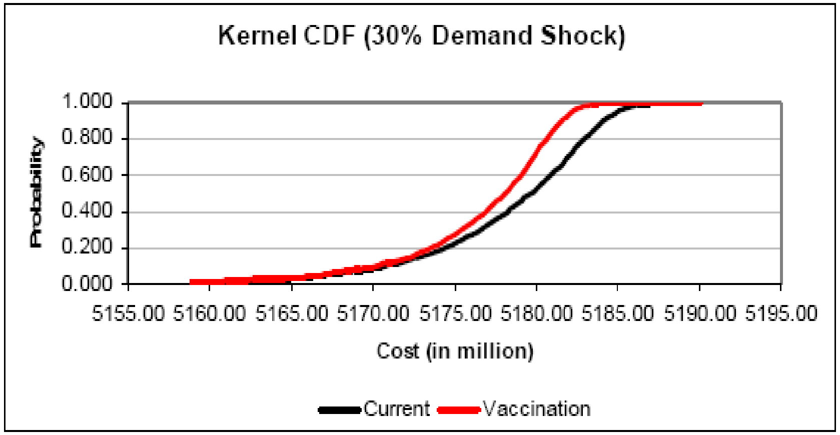


Figure 4.4 District 8-N: total outbreak cost distributions under 30% demand shock

Confidence Intervals (District 5-N)

Strategy	Mean	0.95 CI
No Vaccination(0.00 shift)	27.2	[20.6, 28.9]
Vaccination(0.00 shift)	26.1	[20.2, 27.3]
No Vaccination(0.10 shift)	1950.3	[1944.8, 1952.1]
Vaccination(0.10 shift)	1949.2	[1944.4, 1950.5]
No Vaccination(0.20 shift)	3661.3	[3655.8, 3663.1]
Vaccination(0.20 shift)	3660.2	[3655.4, 3661.5]
No Vaccination(0.30 shift)	5160.7	[5155.2, 5162.5]
Vaccination(0.30 shift)	5159.6	[5154.8, 5160.9]

- under vaccination, mean costs are lower and the CI bounds are smaller
- Also,vaccination first degree stochastically dominates the current strategy

Confidence Intervals (District 5-S)

Strategy	**Mean**	**0.95 CI**
No Vaccination(0.00 shift)	27.2	[20.6, 28.9]
Vaccination(0.00 shift)	26.1	[20.2, 27.3]
No Vaccination(0.10 shift)	1950.3	[1944.8, 1952.1]
Vaccination(0.10 shift)	1949.2	[1944.4, 1950.5]
No Vaccination(0.20 shift)	3661.3	[3655.8, 3663.1]
Vaccination(0.20 shift)	3660.2	[3655.4, 3661.5]
No Vaccination(0.30 shift)	5160.7	[5155.2, 5162.5]
Vaccination(0.30 shift)	5159.6	[5154.8, 5160.9]

- under vaccination, mean costs are lower and the CI bounds are smaller
- Also,vaccination first degree stochastically dominates the current strategy

Ex-ante Vaccines Production Under Risk

Here threshold probabilities are calculated with their likelihoods of realization.

	Texas	District 8-N	District 5-N	District 5-S
Investment(in M)	0.4	0.4	0.4	0.4
Prob. Interval	[0.07, 1]	[0.39, 1]	[0.61, 1]	[0.68, 1]
Likelihood(percent)	82	67	78	68

- There still some chance that the Threshold probabilities are higher than these reported here.
- For instance in all Texas, the other thresholds (0.11, 0.14, 0.21 and 0.32) have respectively 12,2, 2, 2 percent likelihood to be realized

Conclusion

- Vaccination is cost reducing (about 5 percent) compared to the current strategy
- The economic impact of an AI outbreak depends on how much the consumer demand for poultry products is affected
- Sub-regions that have dense poultry populations will yield more damages than less dense sub-regions
- Texas should invest ex-ante in vaccines production if the probability of the outbreak is greater that 0.07

Future Research Opportunities

- A more comprehensive research of epidemic modeling in poultry sector could be developed to understand potential spatial spread of AI
- The economic model could be carried further by using broader partial or general equilibrium frameworks to understand the implications of the AI outbreak on substitute products markets and on the international trade