Integrating Contagion and Human Behavior into Animal Health Economics

Inaugural Meeting of International Society for Economics & Social Sciences of Animal Health

March 27-28, 2017

Aviemore, Cairngorms, Scotland

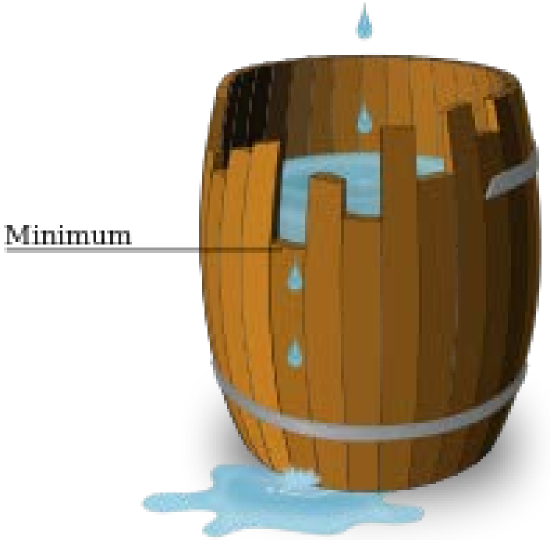
David Hennessy

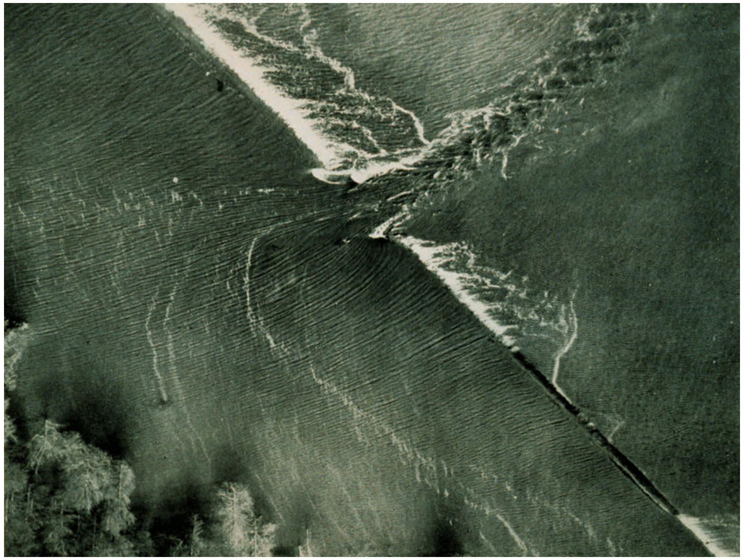
Michigan State University

Motivation & Outline

- Potential area is, in my view, large and I will only seek to illustrate
- Emphasis on behavioral issues as they pertain to managing potentially contagious diseases
- Will start with a game setting and will move to comment on policies to manage behavior

Weakest Link & Exotic Disease





- Point: if a grower thinks others will
  - do their part then grower has strong private incentive to do so too
  - slack off then grower has weak own incentive to act
- Disease manager's role: to coordinate/cajole to get everyone on the best same page, namely likely all taking the action. Share, communicate, trust

Another Way to Look at Keeping Disease Out

- Standard loss benefit analysis setting for a disease: a farmer faces loss at level L with probability p and can take an action at cost c to eliminate the risk of <u>direct</u> entry onto a farm.
- For a risk-neutral farmer, the action should be taken if and only if

$$pL \geq c$$

- But infectious diseases create externalities

What is the issue?

- Suppose now that there are two farms, A and B, in a region. Either 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

Static Game

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

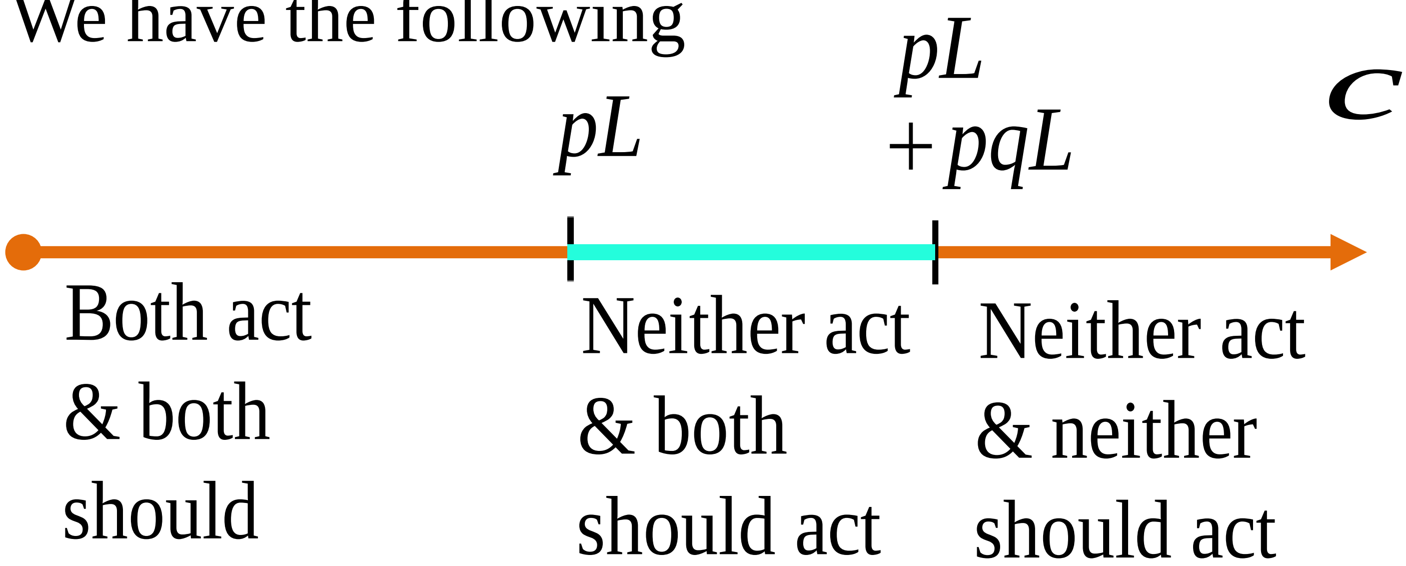
- This can be put in a game theory payoff matrix as follows. All entries are losses, so high is bad.

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 B
- When farm B does not act then A acts if and only if $pqL+c \leq pL+pqL$, i.e., $c \leq pL$
- When farm B acts then 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

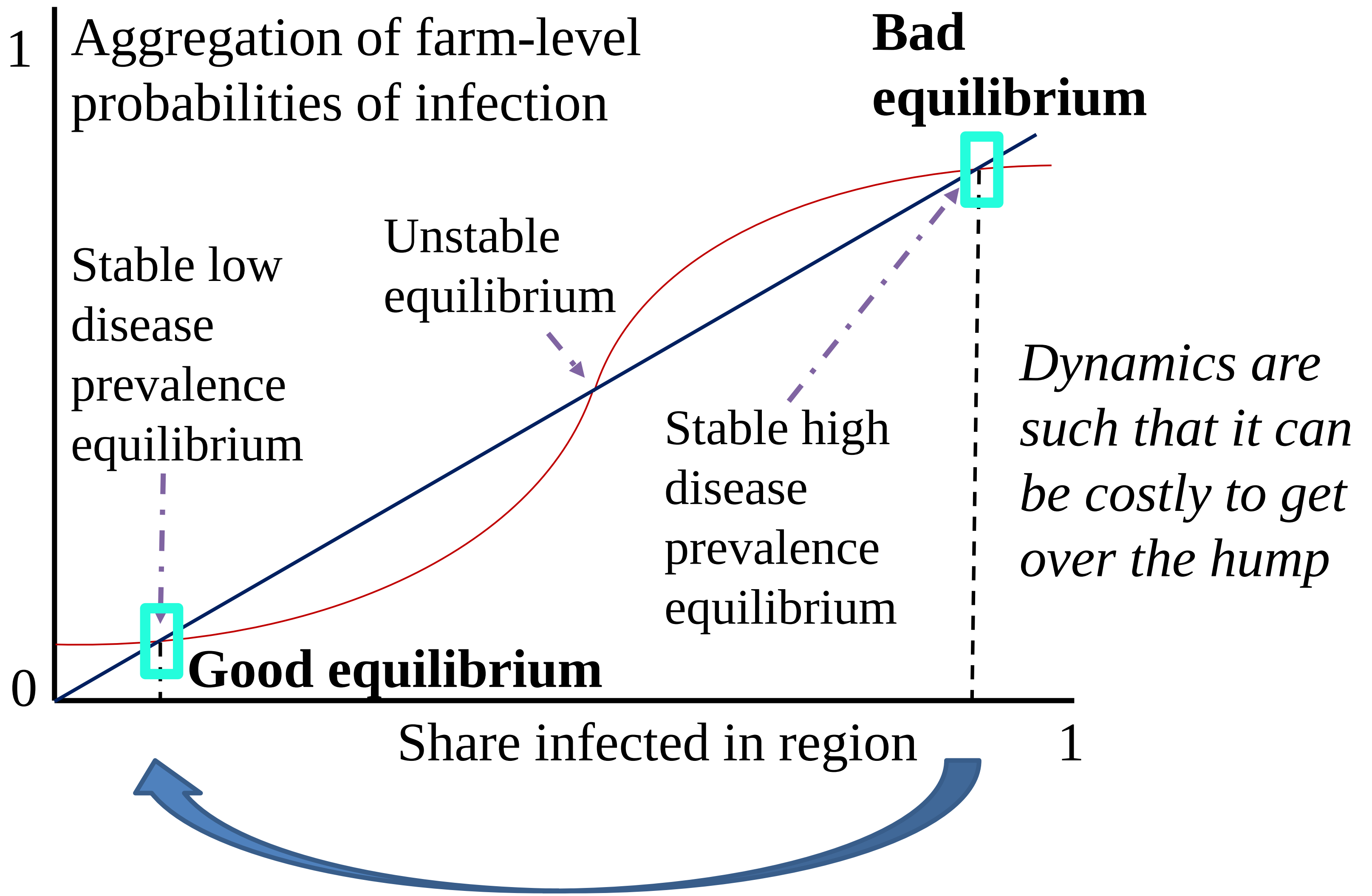


- As infectiousness q increases, the problematic gap increases

Ising-type models, social interactions

- *Bad equilibria and positive interactions can also be argued for endemic contagious disease*
- Durlauf (1999) and Brock and Durlauf (2001) have adapted models seeking to explain polarity of magnets or the earth to cases where two effects matter for the outcome at a location in space.
- Each location receives independent shocks, and each receives reinforcement from neighbours.
- In contagious animal disease, these would be say disease carried in after distant travel and then aerosol/water local dispersion

Stable, unstable equilibria in Ising-type models



Voluntary Control Program: Participation Incentive

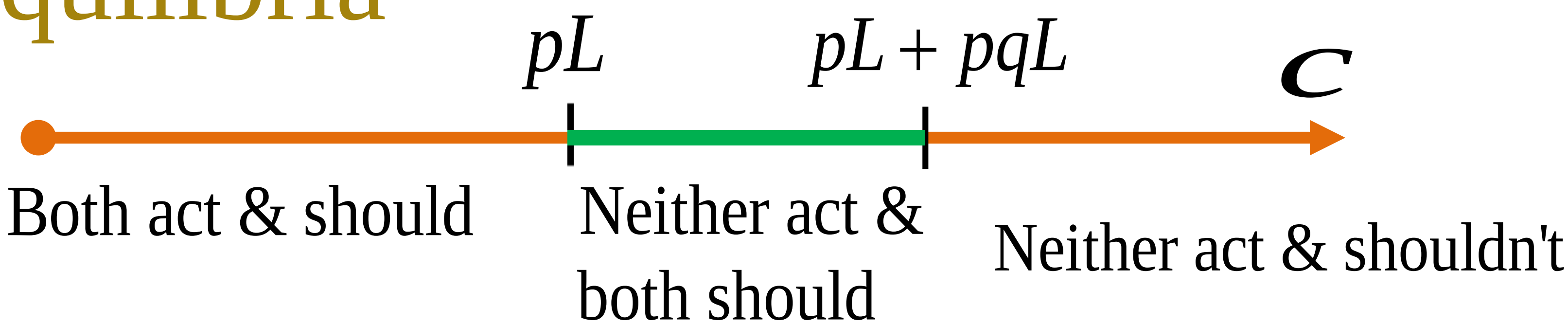
- The success of a voluntary program hinges on producer participation
- Most voluntary programs span multiple years, with evolving participation rates
- It is important to consider dynamic interactions among participant choices
- A great book is “Arresting Contagion,” Olmstead & Rhode
- Below are 4 examples, all from US

Interesting Dynamics of Disease Control & Related Programs

- Texas Tick Fever
- National Animal Identification System
- NPIP (Nat. Poul. Imp. Prog.)
- Voluntary Johne's Disease Herd Status Program

- Good (Texas Tick Fever, NPIP) worked. Bad (USNAIS for bovines) failed. Ugly (Johnes) a grind

On behavioral Issues and multiple equilibria



- What to do with the green area?
- Behavioral economics suggests the relevance of starting points and endowment effects
- Bounded self-control, imperfect optimization, etc., may explain why we have inertia when it seems costless to change, e.g., savings defaults, pension choices, government program uptake (Madrian 2014)
- Where am I going with this? I didn't come to UK to talk about getting NUDGE UNIT onto animal health

Nudging and other issues

- But, given difficulties encountered with controlling a variety of animal diseases, perhaps one could think about voluntary opt outs
  - Sign people up to participate in a control program and pay them $150 for the hassle
  - Let them opt out (and back into earlier disease control rules) out if they want, no questions asked
  - See if they stick with the endowed position

Other possibilities for behavioral economics in animal health

- Much of behavioral economics in human medicine addresses unfortunate choices; diet, exercise, failure to follow health management regimes. Not so relevant to managing farmed animal diseases as we impose choices on animals
- But antibiotics use. Some evidence suggests that they are no longer of much use in parts of farming, but we persist in use
- The way we process information. Much of animal health management is about processing information

Thinking Fast

- Kahneman ‘Thinking, Fast & Slow” sees two selves; one lazy, effort-conservating, associative, emotional and heuristic; the other calculating when aroused
- As far as animal health events go, there are cognitive issues
  - can be rare with poorly understood causes
  - interconnected with behavior of others
  - may falls into box the ‘heuristic self’ deals with
- Availability bias: ascribe likelihood to events one can think of and so subjective probability declines as one goes further from last comparable event

& Seldom Slow

- Prone to anchoring and most likely anchor is normal year so edit out disease risk
- 'What You See Is All There Is,' ignoring information not presented to you. When told a story that someone is shy and bookish then assumed to be librarian, not factory worker even though far more of latter
- We like sorting out a simplistic narrative for cause and effect and going with it so that we can function in business
- We can be horrible at Bayesian statistics, which is a problem for insurance demand because we can't take conditional expectations

Insurance issues

- Kunreuther et al. (2013) document the following demand-side insurance anomalies in high income country markets
  - Failure to protect against low-probability, high-consequence events
  - Purchasing insurance after a disaster occurs
  - Cancelling insurance if there has been no loss
  - Preference for low deductibles
  - Status quo bias
  - Preference for insurance on highly salient events such as cancer and death/maimed while flying

Conclusion

- Lots of important issues to explore in
  - strategic dimensions to management of contagious diseases
  - behavioral economics of animal health, to do with heuristic rules for drug administration, information processing, insurance choices
  - Even in interface, when it comes to trust and coordination

THANK YOU

References

Anderson, D.P. 2010. The U.S. animal identification experience. J. Agric. & Appl. Econ. 42:543-550.

Barnes, A.P., A.P. Moxley, B. V. Ahmadi, & F.A. Borthwick. 2015The effect of animal health compensation on ‘positive’ behaviours towards exotic disease reporting and implementing biosecurity: A review, a synthesis and a research agenda. Prev. Veter. Med. 122:42-52.

Brock, W.A. & S.N. Durlauf. 2001. Discrete choice with social interactions. Rev. Econ. Stud. 68:235-260.

Durlauf, S.N. How can statistical mechanics contribute to social science? Proc. Nat. Acad. Sci. 96:10582-10584.

Kunreuther, H.C., M.V. Pauly, & S. McMorrow. 2013. Insurance & Behavioral Economics. Cambridge Univ. Press.

References

Madrian, B.C. 2014. Applying insights from behavioral economics to policy design. Annu. Rev. Econ. 6:663-688.

NAIS benefit-cost research team. 2010. NAIS Benefit-cost analysis of the NAIS, https://www.google.com/search?q=NAIS+Benefit-Cost+Research+Team+2009&ie=utf-8&oe=utf-8

Olmstead, A.L. & P.W. Rhode. 2015. Arresting Contagion. Harvard Univ. Press

Wang, T., & D.A. Hennessy. 2014. Modelling interdependent participation incentives: dynamics of a voluntary livestock disease control programme. Eur. J. Agric. Econ. 41:681-706.

Texas Tick Fever

- Texas tick fever was a major threat to the U.S. cattle industry from the Civil War until end of World War I
- Efforts to eradicate tick carriers started as early as 1898
  - Active resistance to the programs emerged after participation became mandatory in 1906
  - larger ranchers began to see the benefit as sources for re-infection diminished and returns on treated animals increased
  - a virtuous cycle of events led to a better equilibrium for those who could bear eradication costs
- By 1933 Texas fever was no longer a major problem for the cattle industry

National Animal Identification System (NAIS)

- Estimated benefit from NAIS implementation increases as participation levels increase
  - in event of F&M disease outbreak producer losses for a program with a 90% participation rate would be $4.5 billion less than a program with a 30% participation rate (NAIS Benefit-Cost Research Team 2009)
- Participation rates in the premises registration step reached only 18% for cattle, and stalled in mid 2000s
- For bovines this program was largely unsuccessful, due partly to failure by the USDA to communicate program benefits to producers (Anderson 2010)

NPIP

- Voluntary and set up in 1930's as a cooperative program between industry, state, and US federal government, initially to eliminate Pullorum Disease, widespread and could cause devastating losses
- Program later extended to testing/monitoring for other diseases, incl. AI
- Covers commercial hens and broilers, turkeys, waterfowl, show and backyard poultry, and birds for shooting
- Participation requires Annual P-T Testing, AI Testing, Annual Premises Inspection and Records Audit
- Widespread participation and has been very successful in cleaning up disease

Johne’s disease

- Paratuberculosis, bovine disease U.S. government seeks to control through 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

Table 3. NAIS Premises Registration Statistics, as of September 6, 2009

State	Premises	Premises Registered	Percent
Massachusetts	3,555	8,082	>100.0%
Wisconsin	51,373	62,802	>100.0%
Indiana	34,790	35,200	>100.0%
Idaho	18,754	18,752	100.0%
New York	25,559	22,441	87.8%
Utah	12,460	10,184	81.7%
Michigan	29,011	22,447	77.4%
Pennsylvania	42,302	30,749	72.7%
North Dakota	14,085	8,904	63.2%
Nevada	2,522	1,485	58.9%
Nebraska	30,841	17,606	57.1%
Iowa	47,273	26,741	56.6%
West Virginia	17,670	9,509	53.8%
Illinois	30,046	15,094	50.2%
Delaware	1,553	661	42.6%
Colorado	22,951	8,650	37.7%
North Carolina	36,142	13,491	37.3%
Minnesota	44,193	15,593	35.3%
Alaska	354	117	33.1%
South Carolina	16,120	4,976	30.9%
Tennessee	68,010	20,577	30.3%
Hawaii	1,391	406	29.2%
Virginia	37,673	10,619	28.2%
New Mexico	11,250	3,102	27.6%
Arizona	5,170	1,425	27.6%
Florida	28,731	7,826	27.2%
Alabama	35,538	9,284	26.1%
Kentucky	61,251	15,565	25.4%
Arkansas	37,614	9,501	25.3%
South Dakota	22,356	5,549	24.8%
California	32,500	7,763	23.9%
Mississippi	29,312	6,751	23.0%
Wyoming	8,227	1,840	22.4%
Kansas	39,346	8,430	21.4%
Ohio	48,073	9,995	20.8%
Maryland	7,837	1,559	19.9%
New Jersey	5,315	1,041	19.6%
Missouri	79,018	15,166	19.2%
Texas	187,118	33,022	17.6%
Oklahoma	71,420	12,184	17.1%
Louisiana	19,677	3,307	16.8%
Georgia	35,431	5,108	14.4%
Maine	4,213	444	10.5%
Oregon	28,634	2,877	10.0%
Washington	22,155	2,131	9.6%
Vermont	4,438	389	8.8%
Montana	19,708	1,699	8.6%
Connecticut	2,539	164	6.5%
Rhode Island	504	15	3.0%
New Hampshire	2,277	61	2.7%
Subtotal	**1,438,280**	**531,284**	**36.9%**

Momentum and markets, reverse lemons problem

Under plausible conditions, over time

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

ii) premium from program participation rises;

iii) participation rate rises;

Or $$r_0^S \equiv E[r] \geq r_1^S \geq r_2^S \geq \ \ldots \ \geq r_\infty^S$$

$$I_0 \leq I_1 \leq I_2 \leq \ \ldots \ \leq I_\infty$$

$$\eta_0 \equiv 0 \leq \eta_1 \leq \eta_2 \leq \ \ldots \ \leq \eta_\infty$$

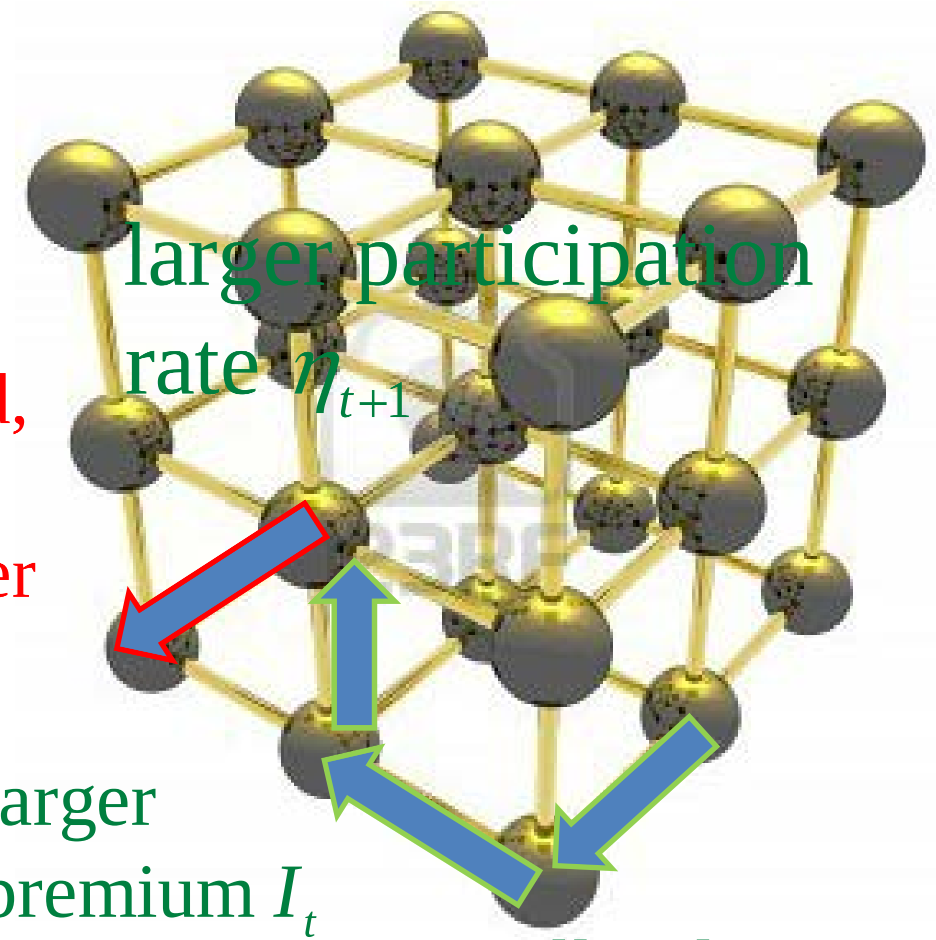
Problem: may be multiple equilibria (Wang & Hennessy, 2014)

Momentum on a Lattice

Hope it attains escape velocity

Think of a point lattice that extends indefinitely in 3D

next period, even smaller r_{t+1}^{S}



larger participation rate η_{t+1}

larger premium I_t

smaller disease-free rate r_t^S for silents

Bayes' Rule

- Suppose that a farmer sees a signal on disease status as follows

	True state	
Signal	Healthy	Diseased
Good	q	1-q
Bad	1-q	q

- Unconditional probability of being diseased is p and the signal is informative in that $q > 0.5$. Then

$$\Pr(\text{Dis} \mid \text{Bad}) - p = \frac{(2q-1)(1-p)p}{pq + (1-p)(1-q)}$$

- When we use information on health status, we don't understand how to adjust probabilities

Barnes et al. Review

- Little empirical research on infectious animal disease economics. Disease data limited/messy
- In economics literature, some highlighted items are
  - risk of public action crowding out private action, + concern about perverse response to excess payment. Latter is overblown; farmers face uncovered costs and still have ‘skin in the game’
  - Condition payments on early reporting?
  - Importance of information and education
  - Scale economies and large-scale farming
  - Bureaucratic nightmare of being flagged as diseased herd can promote biosecurity
  - Insurance schemes operationally problematic
  - Need to think about how neighbors are thinking

Cumulative Prospect Theory

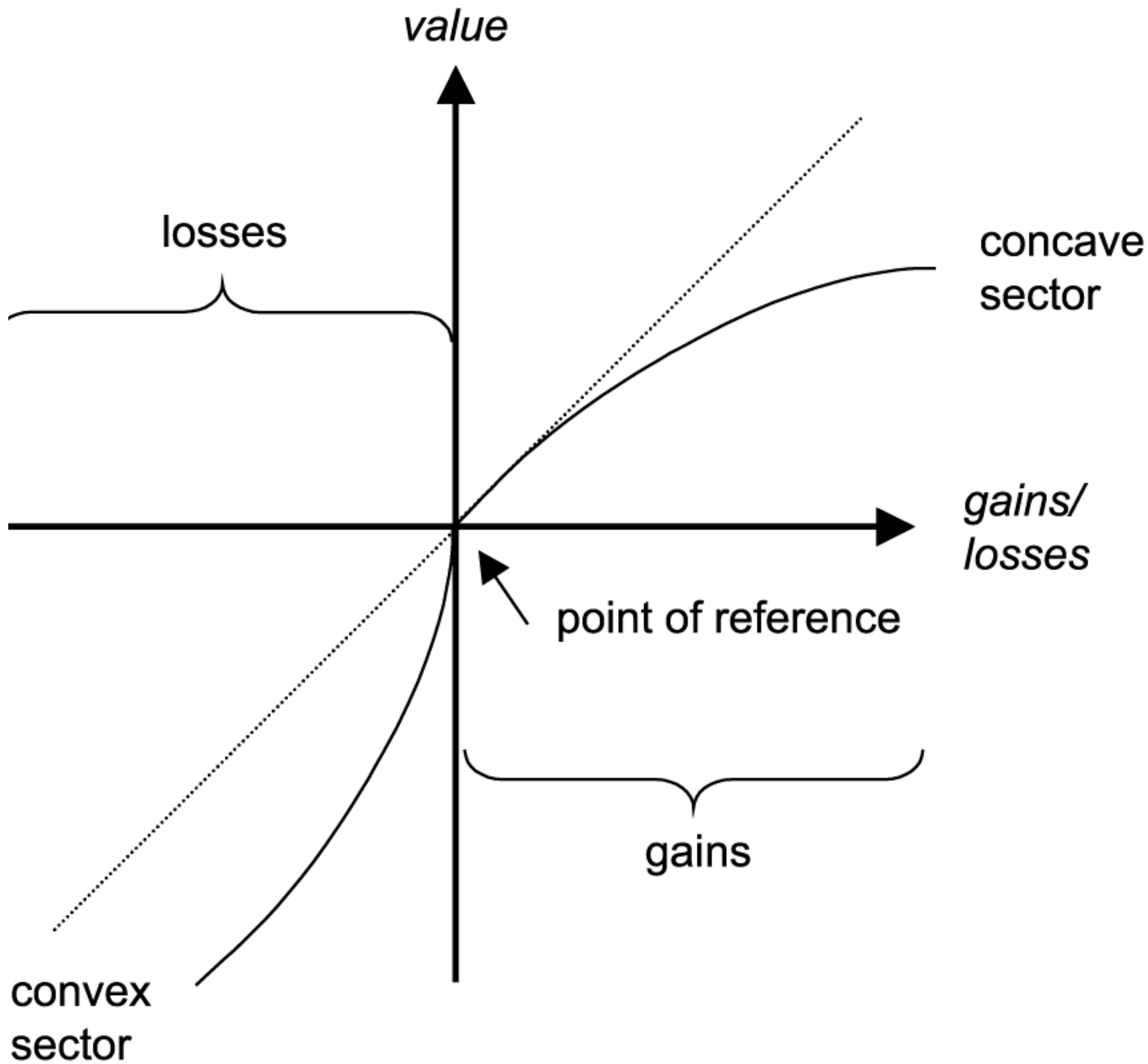
Cumulative Prospect Theory asserts that individuals

- – like risk over losses and are averse to it over gains
- – place too much/little weight on low/high probability events

- This leads to the fourfold pattern: people
  - – Seek risk when faced with low-probability gains,
  - – Averse to risk when faced with high-probability gains,
  - – Averse to risk when faced with low-probability losses,
  - – Seek risk when faced with high-probability losses
- Barnes and others have explored bonuses and incentives to report

Barnes et al. Prospect Theory

- Prospect theory and loss averse behavior suggests problems for insurance as farmers may not demand it. Further, covering losses may deter farmers from aversion to loss



Barnes et al. Sociological Literature

- For disease reporting there is *habituation effect* (complacency over time) + unclear awareness of purpose
- For reporting, Elbers et al. interviewed Dutch pig farmers. Reasons for not reporting include
  - Don't know signs
  - Guilt, shame and fear of prejudice
  - Haven't bought into control measures in place in general and for reporting farms
  - Opaque reporting procedures
  - Distrust in government bodies

Barnes et al. Trust, Transparency and Cooperation

- Trust may be an issue
  - Are neighbours pulling weight?
  - Is government technically competent in design and management?
  - Is program designed for farmers like me or for other (e.g., larger, or more mainstream) farmers?
  - Have viewpoints of people like me been incorporated into program design?
  - Will indemnities be paid?
  - Has government other goals, such as seeking to impose environmental regulations, to tax or to steal?

Barnes et al. Trust

- Trust will be stronger when farmers
  – are better educated and technologically sophisticated,
  – are already embedded in complex production systems such as contracting, and
  – have evidence that schemes are effective
- Trust is a funny thing. If you are thrust into someone else's arms you may learn to trust, at least at a functional level. EU and US have used farm commodity subsidies and environmental payments to leverage cross-compliance on other issues