Compensation Payments and Animal Disease: Incentivising Farmers Both to Undertake Costly On-farm Biosecurity and to Comply with Disease Reporting Requirements

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Contributed presentation at the 60th AARES Annual Conference,
Canberra, ACT, 2-5 February 2016

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Introduction

This paper examines the issue of compensation payments for farmers affected by an animal disease outbreak. Recent literature has questioned the scope for the widely used "single mechanism" of compensation payments to incentivise farmers both to undertake costly on-farm biosecurity and to comply with disease reporting requirements. This paper develops a simple theoretical model of the farmer's decision environment in this situation and uses a numerical analysis to illustrate both the potential for a range of levels of compensation payments to achieve this dual incentivising, and how this range is affected by changes in the parameter values of the farmer's decision environment. Particular attention is given to the problem of spatial variation among farmers in the baseline of likelihood of a disease outbreak, and the findings of the paper are used to suggest a policy solution to this problem.

The Model

The farmer is assumed to be an expected utility maximiser within a decision environment characterised by uncertainty about a disease outbreak. Given this uncertainty, the farmer must make two decisions: i) whether to incur the cost of on-farm biosecurity measures which will reduce the likelihood of a disease outbreak; and ii) whether to report a disease outbreak should one take place. In addition, this decision-making environment has a temporal feature in that information about a disease outbreak is only revealed after the on-farm biosecurity costs are incurred (or not), and after which event the farmer must decide whether or not to report a disease outbreak (should one have taken place).

The Model

In what follows the analysis of these decisions is framed in an ex ante context so that the farmer is evaluating four options:

- Incur biosecurity costs and report any disease outbreak (BR)
- Incur biosecurity costs but don't report any disease outbreak (BNR)
- Don't incur biosecurity costs, but report any disease outbreak (NBR)
- Don't incur biosecurity costs and don't report any disease outbreak (NBNR).

In addition, the (risk averse) farmer faces uncertainty not just in relation to the likelihood of a disease outbreak, but also in relation to the likelihood of non-compliance with the requirement to report a disease outbreak being detected.

The Model

More specifically:

- If the farmer's livestock remain disease free they are assumed to have a value M
- If the farmer chooses to incur the cost of on-farm biosecurity measures (B) then the likelihood of no disease outbreak is increased from q to p (ie $p > q$)
- If the farmer experiences a disease outbreak and chooses to report it, then the farmer is paid compensation of D, where $0 < D < M$, and is the government agency's "single mechanism" for providing incentives both to undertake on-farm biosecurity measures and to report a disease outbreak
- If the farmer experiences a disease outbreak and chooses not to report it, then the livestock can be disposed of for a "quick sale" value of S (where $S < M$). In addition, the likelihood of not being caught so doing is r, but if caught then the government agency imposes a penalty of tD (where $t > 0$).

The Model

On this basis the expected utility of net income (E(U(I))) for each of the farmer's four options is given by:

i) BR:

$$E(U(I)) = E(U(pM + (1-p)D - B))$$

ii) BNR:

$$E(U(I)) = E(U(pM + (1-p)(rS + (1-r)(S - tD)) - B))$$

iii) NBR:

$$E(U(I)) = E(U(qM + (1-q)D))$$

iv) NBNR:

$$E(U(I)) = E(U(qM + (1-q)(rS + (1-r)(S - tD)))$$

The Model

It should be noted that there is a particular complexity to the farmer's decision of whether to incur the cost of on-farm biosecurity measures which relates to the base level of the likelihood of no disease outbreak for the farmer. More specifically, incurring this cost (B) increases the likelihood of no disease outbreak (ie $p > q$). Given this:

$$dE(I)/dq = (M - D) > 0$$

Therefore, for a risk neutral farmer, the decision to incur the cost of on-farm biosecurity measures will depend on the balance between the positive impact of this action on expected income (ie see equation (5)) and the negative impact of the cost itself.

But for a risk averse farmer, this action also has an effect of the variance of income (Var(I)) where:

$$Var(I) = q(M - E(I))^2 + (1-q)(D - E(I))^2$$

More specifically, differentiating equation (6) with respect to q and rearranging gives:

$$dVar(I)/dq = (M - D)^2(1 - 2q)$$

which implies:

$$dVar(I)/dq > \text{ or } < 0 \text{ as } q < \text{ or } > \tfrac{1}{2}$$

Numerical Analysis

It is further assumed that the attitude to risk of the farmer can be represented by the mean-variance framework and the constant relative risk aversion functional form:

$$E(U(I)) = U(E(I)) = \frac{1}{2}.U''(E(I)).Var(I)$$

where:

$$U(I) = I^{(1-R)}/(1-R)$$

and R = constant coefficient of relative risk aversion = $-U''(I).I/U'(I)$

with $U'(I)$ and $U''(I)$ denoting the first and second derivatives respectively of the utility function ($U'(I) > 0$; $U''(I) < 0$).

Numerical Analysis

Given this framework, the assumed parameter values for the Base Case are as follows:

$M = 100$; $B = 10$; $q = 0.55$; $p = 0.75$; $r = 0.9$; $S = 50$; $t = 1$; $R = 0.5$ and $D = 46$.

Numerical Analysis
Table 1

	i) BR	ii) BNR	iii) NBR	iv) NBNR
E(I)	76.50	76.35	75.70	75.43
Var(I)	646.75	706.58	721.71	823.54
E(U(I))	17.25	17.21	17.13	17.06

Numerical Analysis
Table 2

			D		
	43	45.2	46	50.5	52
R = 0.2	BNR	BNR	BR	NBR	NBR
R = 0.5	BNR	BR	BR	BR	NBR

Numerical Analysis
Table 3

			D			
	43	45.2	46	50.5	60.3	61
B = 8						
R = 0.2	BNR	BNR	BR	BR	NBR	NBR
R = 0.5	BNR	BR	BR	BR	BR	NBR
B = 12						
R = 0.2	NBNR	NBNR	NBR	NBR	NBR	NBR
R = 0.5	NBNR	NBR	NBR	NBR	NBR	NBR

Numerical Analysis
Table 4

				D				
	40	40.7	41	46	49.6	50	50.5	52
S = 45								
R = 0.2	BNR	BNR	BR	BR	BR	BR	NBR	NBR
R = 0.5	BNR	BR	BR	BR	BR	BR	BR	NBR
S = 55								
R = 0.2	BNR	BNR	BNR	BNR	BNR	BR	NBR	NBR
R = 0.5	BNR	BNR	BNR	BNR	BR	BR	BR	NBR

Numerical Analysis
Table 5

				D			
	40	43.1	44	47.4	49	50.5	52
r = 0.85							
R = 0.2	BNR	BNR	BR	BR	BR	NBR	NBR
R = 0.5	BNR	BR	BR	BR	BR	BR	NBR
r = 0.95							
R = 0.2	BNR	BNR	BNR	BNR	BR	NBR	NBR
R = 0.5	BNR	BNR	BNR	BR	BR	BR	NBR

Numerical Analysis
Table 6

q = 0.25				D		
	44	45	45.3	46	47.8	48
R = 0.2	BNR	BNR	BR	BR	BR	NBR
R = 0.5	NBNR	NBR	NBR	NBR	NBR	NBR

Conclusion

The findings of this numerical analysis included a demonstration that the potential existed for a range of levels of compensation payments to incentivise both farmer actions. Moreover, this range of levels could be influenced in the following ways by the value of parameters in the farmer's decision environment:

i. The range is larger (smaller) for more (less) risk averse farmers
ii. The range is larger (smaller) for less (more) costly on-farm biosecurity measures
iii. The range is larger (smaller) for lower (higher) values for the sale of (unreported) diseased animals
iv. The range is larger (smaller) for higher (lower) likelihood of being caught not complying.

Conclusion

As a consequence, it seems reasonable to conclude that the existing practice of using the “single mechanism” of compensation payments to incentivise farmers both to undertake on-farm biosecurity and to comply with disease reporting requirements does have analytical support, albeit in a relatively simple theoretical framework, even if it also needs some support from on-farm biosecurity adoption subsidies in regions of high disease prevalence.