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The impact of federal indemnification on livestock biosecurity

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Abstract

This paper provided a theoretical framework for analyzing the relationship between federal indemnification and livestock biosecurity. Theoretical results show that the responsiveness of biosecurity to indemnity payments depends on a number of factors. First, the responsiveness of biosecurity will depend on the effectiveness of preventive measures in decreasing the growth in animal susceptibility. Second it was found that the responsiveness of disease abatement to changes in an indemnity was an increasing function of the marginal product of abatement. It was also found that abatement was a decreasing function of the rate at which the marginal product diminishes and that the proportion of damages indemnified has a direct affect on abatement. Lastly, it was shown that losses that extend beyond animals values may decrease the impact of indemnification on abatement levels and under certain conditions the level of biosecurity (with added losses)may exceed the no-indemnity optimal.

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The Impact of Federal Indemnification on Livestock Biosecurity

1. Introduction

In an effort to encourage livestock producers to report outbreaks of invasive and endemic diseases, the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) provides incentives to producers for reporting infected animals for culling. During disease outbreaks, APHIS has compensated producers for the removal of diseased animals. The aim of this compensation is to keep pathogens out of the food supply and to control disease spread. Although the federal government is required by the U.S. Constitution to compensate individuals when private property is taken for public use, indemnities play an important role in encouraging producers to participate in government eradication programs (Ott, 2006).

Biosecurity describes the process and objective of managing biological risk associated with food and agriculture in a holistic manner. Biosecurity is often used in relation to sanitary, phytosanitary and zoosanitary measures applied in food and agriculture regulatory systems. It is a system of management procedures designed to reduce the risk of disease outbreaks on the farm, and the containment and management practices design to reduce the risk of disease spread (Smith et al., 2003). Although biosecurity practices can decrease the probability of animal infection and disease spread, they are not without cost to producers.

Federal indemnification programs may result in decreased biosecurity because indemnity payments implicitly create value for infected animals (Kuchler and Hamm, 2000). This raises concern because the purpose of these programs is to control the spread of animal disease and not to encourage behavior that would increase animal susceptibility. Past studies suggest that indemnity payments directly impact detection and reporting (*ex post biosecurity*); however, it is unclear if payments decrease producer willingness to implement biosecurity preventive measures (*ex ante biosecurity*). This paper provides a theoretical framework for analyzing the relationship between indemnity payments and the biosecurity preventive measures implemented by livestock producers. The theoretical construct in this paper provides the foundation for analyzing the impact of alternative government policies on biosecurity behavior. As policy makers evaluate the effectiveness and possible modification of indemnification and disease eradication programs, the potential moral hazard problem is of great concern.[1]

[1] Given the focus of this study, *ex ante biosecurity* will simply be referred to as *biosecurity*.

2. Background

In compensating producers the market value of euthanized animals, millions of dollars have been paid to livestock producers in indemnity payments (Grannis and Bruch, 2006). The objective of federal indemnification programs is to minimize the number of diseased animals in the food supply. Let D denote the total number of disease animals where

$$D = D(\overset{-}{x}, \overset{+}{\theta}). \tag{1}$$

We expect that D is decreasing in the biosecurity input x and increasing in the disease probability θ. Let R denote the total number of disease animals reported to APHIS for culling where

$$R = R(\overset{+}{D}, \overset{+}{i}). \tag{2}$$

We expect that R is increasing in D since an increase in the number of diseased animals should increase the number of animals reported to APHIS. R is also expected to be an increasing function of the indemnity payment i.

The government's objective is to set the indemnity payment such that $(D - R)$ is minimized. It is the desire of the government to ensure optimal reporting by providing compensation for diseased animals. If the biosecurity input is also function of i, then the impact of the indemnity payment on the number of animals reported (R) can be expressed as follows:

$$\frac{dR}{di} = \frac{\partial R}{\partial D}\frac{\partial D}{\partial x}\frac{\partial x}{\partial i} + \frac{\partial R}{\partial i}. \tag{3}$$

Equation (3) indicates that the impact of indemnity payments on the number of animals reported is the results of two effects. The first term on the right hand side is the indirect effect of the indemnity payment (biosecurity effect). The second term is the direct effect of the indemnity payment. As suggested by Kuchler and Hamm (2000) the direct effect should be positive, that is the greater the compensation, the greater the number of infected animals reported to the USDA. If $\partial x / \partial i < 0$, the indirect effect should also be positive since $\partial R / \partial D > 0$ and $\partial D / \partial x < 0$. Intuitively we would expect that $\partial x / \partial i \leq 0$. Therefore the first term on the right hand side of equation (3) should be greater than or equal to zero.

From equation (3) we see that the increase in the number of infected animals reported to the APHIS is due to the following: (1) more animals being reported because greater compensation increases the incentive for farmers to identify sick animals $[\partial R / \partial i]$ (direct effect), and (2) greater compensation provides a disincentive for biosecurity spending, resulting in an increase in the total number of infected animals, $[(\partial R / \partial D)(\partial D / \partial x)(\partial x / \partial i)]$ (indirect effect). This indirect effect is the potential moral hazard problem associated with indemnification.

The literature on moral hazard and indemnification has primarily been in the area of crop insurance (Turvey, Hoy and Islam, 2002; Coble et al., 1997; Horowitz and Lichtenberg, 1993). Crop production is different from animal production in that target yields can be specified and compensation is given when events cause actual yields to fall below set targets. Specifying animal values are difficult because present values must account for potential offspring. Furthermore, identifying diseased animals often depends on the technology for disease diagnosis making it difficult to properly assess losses.

Moral hazard is relatively less difficult to identify with insurance because there are two identifiable groups, the insured and uninsured. Production practices that differ between the two groups could be identified and moral hazard could be measured. Hoag, Thilmany and Koontz (2006) note that the U.S. is relatively inexperience in livestock insurance and that federal indemnification, as oppose to a federal guarantee on private insurance, is the chosen method of compensation for livestock disease loss. Given that all producers qualify for federal indemnification, group distinctions are not possible.

3. Theoretical Models

Kuchler and Hamm (2000) provides a theoretical approach for analyzing the impact of indemnity payments on the preventive measures employed by producers. Although the focus of their study was the impact of indemnity payments on detection and reporting, their theoretical model need only be modified slightly to account for preventive measures.

Assume that there is a long-lived breeding stock (denoted Q) which is constant overtime with new animals added only as replacements for susceptible animals. Let S_t be the number of susceptible animals in the population, identified or not, during year t. S_t depends on the breeding practices of the farm and the rate of growth in S_t is a function of biosecurity. Let the annual rate of growth in S_t be denoted as g. $g = f(x)$ where x measures the level of biosecurity. Note that $g' < 0$, that is the growth in S_t decreases with biosecurity. It is expected that biosecurity x is not exogenous but a function of biosecurity cost c and the relative indemnity payment p (the indemnity payment relative to the market price), where $\partial x / \partial c < 0$. The sign and magnitude of $\partial x / \partial p$ is the focus of this analysis. Let F_t be the number of animals found and replaced. Assume that the number of the susceptible animals are found and replaced in fix proportions such that $F_t = f\,S_t$ where *f* is a non-decreasing function of *p*. If the proportion of susceptible animals within the set of replacements is identical to the proportion of susceptible animals within the current population, then S_t can be expressed as follows:

$$S_t = (1+g-f)S_{t-1} + \frac{f\,S_{t-1}^2}{Q}. \qquad (4)$$

Taking the derivative of equation (4) with respect to *p* and solving for $\partial x / \partial p$ results in the following:

$$\frac{\partial x}{\partial p} = \frac{1}{g'}\left[f'\left(1-\frac{S_{t-1}}{Q}\right) + \frac{\partial S_t}{\partial p}\frac{1}{S_{t-1}} \right]. \qquad (5)$$

Note that $f' \geq 0, S_{t-1}/Q \leq 1,$ and $\partial S_t/\partial p \geq 0$. Thus, the term in brackets is positive. Given that *g* is decreasing in biosecurity (or at least non-increasing), equation (5) should be less than or equal to zero suggesting that biosecurity is decreasing in the relative indemnity payment. More importantly, note that as $g' \to 0, \partial x / \partial p \to -\infty$ and as $g' - \infty, \partial x/\partial p \to 0$. With this model we get an important result. The biosecurity response to indemnity payments depends on the effectiveness of biosecurity in decreasing animal susceptibility. Therefore the greater the effectiveness of a preventive measure, the less likely a producer will discontinue the use of that measure with rising indemnity payments. This suggests that perceptions about preventive measures are important determinants of the responsiveness of biosecurity to indemnity payments.

Lichtenberg and Zilberman (1986) provide a theoretical framework for analyzing abatement inputs. Damage control agents in production or abatement inputs are unique in that they affect the potential output of the firm but may have no impact, or a negative impact, on actual output. Biosecurity inputs fall in this category because they impact output in the event of a disease outbreak; however, unlike productive inputs, biosecurity inputs are not necessarily output-increasing. Given a single measurable biosecurity input *x*, we can specify an abatement function $G(x)$ which measures the proportion of the disease destructive capacity eliminated by the application of the biosecurity input. Note that $G \in [0,1]$, with $G = 1$ being complete eradication of destructive capacity and $G = 0$ being zero elimination or maximum destructive capacity. G is monotonically increasing and as $x \to \infty$, $G(x) \to 1$. Given the relationship between actual and potential output, the production function for the firm is defined as

$$Q = F[Z, G(x)]. \qquad (6)$$

Q is actual output, Z is the productive input and $F(.)$ has the standard properties of a production function. Actual output equals potential output only when $Q = F[Z,1]$ and minimum actual output occurs when $Q = F[Z,0]$.

Assume a two-step procedure for profit maximization where the producer first determines the optimal level of abatement *G*. Given *G*, the firm then determines the optimal level of the biosecurity input *x*. From the profit maximization problem the impact of the indemnity payment on the level of abatement is derived. Let the proportion of damages paid to producers be δ, where $\delta \in [0,1]$. If losses are fully compensated then $\delta = 1$. $\delta = 0$ implies no compensation. The indemnity payment to a producer can be defined as

$$i = \delta\left\{PF[Z,1] - PF[Z,G(X)]\right\}. \tag{7}$$

The indemnity payment is equal to a proportion of the value of potential output minus the value of actual output. Let *r* be the per-unit input cost and *s* the per-unit abatement cost, the profit maximization problem with and without the indemnity is specified as

$$\max_{Z,G} \Pi = P\,F[Z,G] - rZ - sG \tag{8}$$
$$\max_{Z,G} \Pi = (1-\delta)P\,F[Z,G] + \delta P\,F[Z,1] - rZ - sG.$$

The first order conditions are respectively

$$P\,F_Z = r,\ P\,F_G = s \tag{9}$$
$$P\,F_Z = r,\ P\,F_G = s/(1-\delta).$$

The marginal cost of abatement without the indemnity is *s*. With the indemnity, the marginal cost is $s/(1-\delta)$. Note that $(1-\delta) \le 1 \Rightarrow s/(1-\delta) \ge s$; this indicates that the optimal level of abatement with the indemnity is at a higher marginal value product (lower level of abatement). As shown in Figure 1, the indemnity proportion decreases the optimal level of abatement from G' to G''. Without the indemnity, the firm will increase the level of abatement as long as the marginal value product of abatement is greater than the per-unit cost of abatement *s*. With the indemnity, the marginal value product must be at least greater than the sum of the per-unit cost of abatement and the marginal indemnity loss (di/dG). The reason being is that a decrease in the number of infected animals decreases the indemnity payment received by a producer, thus making the indemnity loss an implicit cost of abatement.

Taking the total differential of the first order condition (with the indemnity) yields

$$F_G dP + P\, F_{GZ} dZ + P\, F_{GG} dG - \frac{1}{1-\delta} ds + \frac{s}{(1-\delta)^2} d\delta = 0 \,. \qquad (10)$$

Letting $dP = dZ = ds = 0$ and substituting PF_G for $s/(1-\delta)$ results in

$$P\, F_{GG} dG - PF_G \frac{1}{1-\delta} d\delta = 0 \,. \qquad (11)$$

Solving for $dG / d\delta$ yields

$$\frac{dG}{d\delta} = \frac{F_G}{F_{GG}} \frac{1}{(1-\delta)} \,. \qquad (12)$$

Assuming that output is non-decreasing in abatement ($F_G \geq 0$) and that the sufficiency condition for a maximum holds ($F_{GG} \leq 0$), equation (12) will be negative indicating that the level of abatement and the indemnity proportion are inversely related. Equation (12) shows that the responsiveness of abatement to changes in the indemnity proportion is an increasing function of the marginal product of abatement F_G, a decreasing function of the rate at which the marginal product diminishes F_{GG}, and an increasing function of the indemnity proportion δ. Given that F_G decreases in G, lower levels of abatement correspond to higher marginal products. The fact that $dG/d\delta$ increases in F_G suggests that the less abatement used by producers the more responsive those producers will be to the indemnity. F_{GG} is the rate of change in F_G. As F_{GG} increases in absolute value, G becomes less responsive to changes in δ. This is illustrated in Figure 2. Lastly, it is easily shown that as $\delta \to 1, \partial G / \partial \delta \to -\infty$.

Potential losses beyond animal values could result in a sufficient level of biosecurity, even with government indemnification. Losses beyond animal values include the following: a decrease in the demand for the product due to reported disease outbreaks, damages to a producer's reputation from selling infected animals, and the cost of damages that extend beyond animal values such as clean-up cost and business interruption. Suppose that the selling price of an animal is a function of the level of abatement such that $P_G \geq 0$. It can be easily shown that the level of abatement will increase under these circumstances. If P is also a function of G then the first order condition can be restated as

$$P\, F_G = (s - P_G F)/(1-\delta) \,. \qquad (13)$$

Equation (13) shows that as long as there is a positive impact of abatement on prices, or a negative impact of non-abatement on prices, the optimal level of abatement will increase since $(s - P_G F)/(1-\delta) < s/(1-\delta)$ (See G^{**} in Figure 1.). If $P_G F > s\delta$ then the optimal level of abatement will be even greater than the optimal level without the indemnity (See G^{*} in Figure 1).

Taking the total differential of equation (13) yields

$$P_G F_G dP + PF_{GG} dG = \frac{1}{1-\delta} ds - \frac{P_{GG} F}{1-\delta} dP - \frac{P_G F_G}{1-\delta} dG - \frac{s - P_G F}{(1-\delta)^2} d\delta \qquad (14)$$

Solving for $dG/d\delta$ results in the following:

$$\frac{dG}{d\delta} = \frac{PF_G}{(2-\delta)P_G F_G + (1-\delta)PF_{GG} + P_{GG} F}. \qquad (15)$$

The first and third terms in the denominator of equation (15) are due to P being a function of G. If these terms are zero, then equation (15) is identical to equation (12). The first term in the denominator of equation (15) is positive since $\delta \le 1$ and P and F are increasing in G. If $P_{GG} \ge 0$ (or at least not to negative), then the responsiveness of abatement levels to the indemnity proportion is relatively smaller in equation (15) when compared to equation (12). This is primarily due to the negative impact of non-abatement on the output price.

4. Concluding Remarks

This paper provided a theoretical framework for analyzing the relationship between federal indemnification and livestock biosecurity. During disease outbreaks, APHIS has compensated producers for the removal of diseased animals; however, this type of compensation could result in a decrease in biosecurity preventive measures. As policy makers evaluate the effectiveness of indemnification programs, this potential moral hazard problem is of great concern.

Theoretical results show that the biosecurity response to indemnity payments depends on a number of factors. First, the responsiveness of the level of biosecurity will depend on the effectiveness of preventive measures in decreasing the growth in animal susceptibility. The greater the effectiveness of a preventive measure, the less likely a producer will discontinue the use of that measure with rising indemnity payments. Second, it was found that the responsiveness of abatement to changes in an indemnity was an increasing function of the marginal product of abatement. Therefore, producers with lower abatement levels should be more responsive to indemnity payments. It was also found that abatement responsiveness was a decreasing function of the rate at which the marginal product diminishes and that the proportion of damages indemnified had a direct affect on abatement responsiveness. Lastly, it was shown that losses that extend beyond animals values may decrease the impact of indemnification on abatement levels and under certain conditions the level of biosecurity (with potential additional losses) will exceed the no-indemnity optimal.

Figure 1. The Optimal Level of Abatement with and without Indemnification

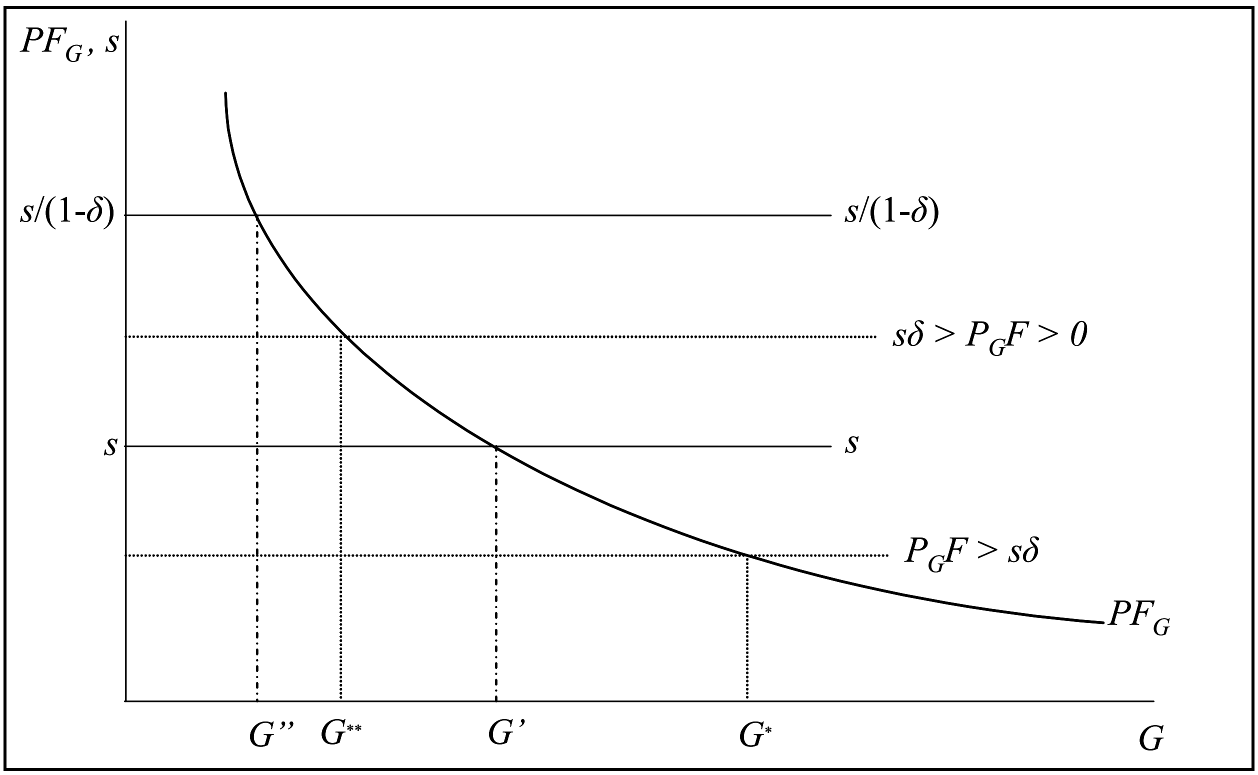
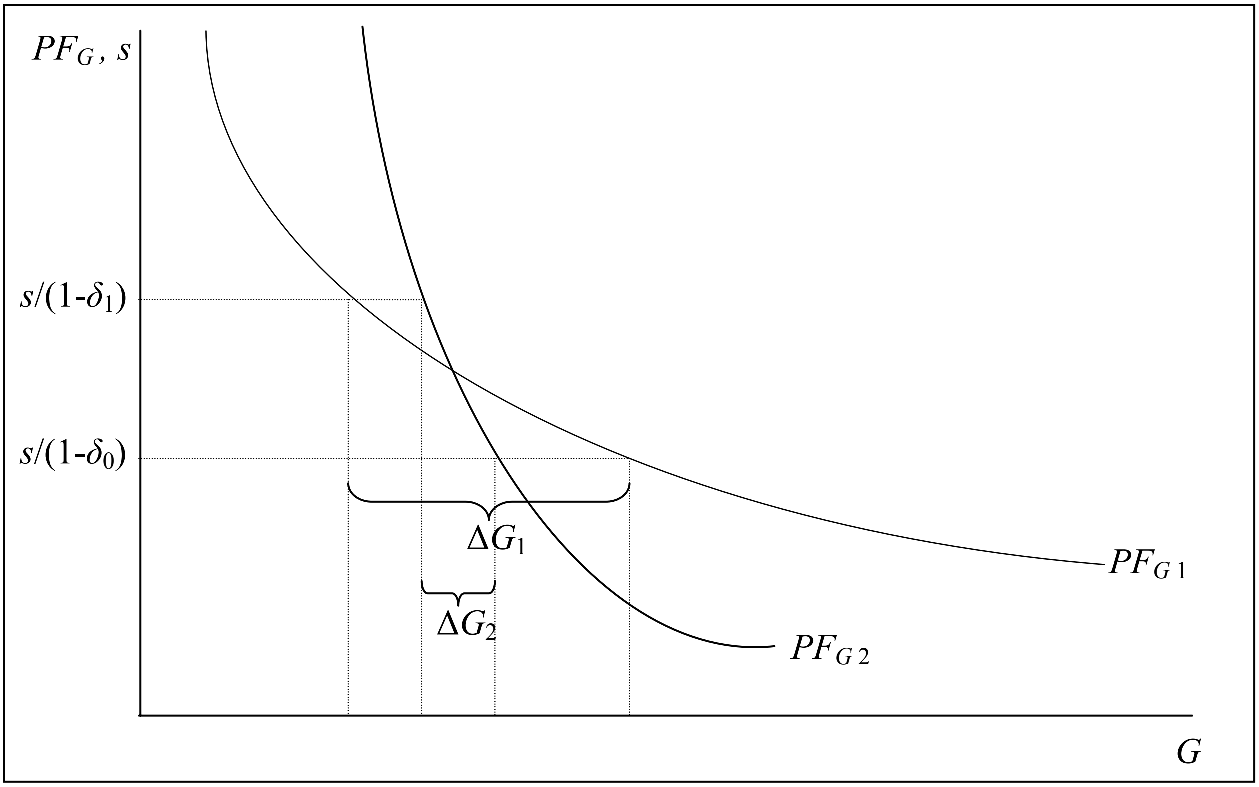


Figure 2. The Responsiveness of Abatement Given the Rate of Change in the Marginal Value Product



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