Conceptual models underlying economic analysis of animal health and welfare with the inclusion of three components: people, products and resources

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Summary
Infectious animal diseases can spill across farm boundaries, so effective management requires coordinated responses. Costs and benefits from the management of infectious diseases are such that those who make the decisions have weak incentives to act, the levels of goods and services produced from animal agriculture are probably smaller than is socially optimal and resources are likely wasted. This work provides an overview of the existing literature on conceptual economic models in animal disease management, paying particular attention to inadequate incentives to make the required biosecurity efforts. A disease transmission model follows, emphasising policy and management issues which need to be addressed to enhance the benefits that consumers and producers obtain from animal protein markets. The article concludes with comments and suggestions on tackling infectious disease as a public good, and on directions for future research.

Keywords
Disease management – Externality – Incentive – Public good.

Journal of Economic Literature **classifications:** H40, Q10, D60.

Introduction

Although concerns about the health of farmed animals have largely focused on economic losses, the veterinary and production agriculture professions have dominated animal health management and administration research through much of the literature's history. Remedies have been viewed as largely technical, and the role of economics, in particular, has been confined to two general areas (1, 2). One has been to characterise and quantify economic losses, including losses to domestic and international consumers, producers, taxpayers and those contracting a zoonotic disease, among others. The second has been to provide guidance for the efficient allocation of very limited resources across alternative disease management uses. These lines of research are by now quite well developed so that many tools are available, although they may prove demanding of the analyst (e.g. 3, 4, 5).

McInerney has envisioned a more detailed framework in which to view the role of disease in determining net social benefits from animal production (2). As a first point of departure, losses in this framework can best be viewed as a problem of control so that standard production economics can be applied to such choices as vaccine strategy on the farm (6) or managing mastitis in a dairy herd (7). As these and so many other works show, our state of knowledge in this area has advanced markedly in recent years. Although perhaps not readily apparent from the outside, much excellent work is occurring in which economists and animal scientists collaborate as an integrated team to facilitate better animal health management at the farm level. A challenge for this thrust of enquiry is that insights and models may not necessarily translate directly from one issue to another, obscuring their undoubted relevance and so limiting their impact. When assessing why the study of livestock system economics has lagged in comparison with that of crop system economics, Rushton *et al.* (8) noted that livestock production systems are typically more complex, for a wide variety of reasons, to do with the length of production cycles, heterogeneity in production systems and the variety of losses.

More broadly, McInerney has argued that economists should take a 'bigger picture' view in asking how animal

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disease affects the extent to which social wants are met by animal products and services produced by scarce resources. Demands are met by markets and government actions which guide resources to meet these needs. Issues in the area are multifarious, where protein availability, animal welfare, the nature of production, and human health risks are among the concerns that shape markets and call for policy perspectives. Incentives also matter. Disease does not just generate a loss in production but also in productivity (8), and thus can change incentives. It is not happenstance that the growing global footprint of large-scale animal production in the poultry, swine and bovine sectors has involved intensive efforts to close off animals from infectious disease risks. Scale economies in animal agriculture have been predicated upon strategies to limit the extent of exposure to morbidity.

Many recent advances in this broader programme have been motivated by policy, focused on a specific issue. Others have had a more methodological approach. As an example of the former, but with methodological contributions, Laxminarayan and Brown (9) have adapted the susceptible–infected epidemiological model of infection to clarify rules for the optimal conservation of an antimicrobial resource. Motivated by concerns that trade promotes infection (10), Horan *et al.* (11) have shown that trade could also reduce disease prevalence. Several papers have also sought to embed incentives into epidemiology models (12).

Studies of policies as incentive mechanisms and of external effects have also emerged. Kuchler and Hamm's approach (13) is particularly interesting in that it identifies a negative relationship between the number of scrapie-affected sheep turned in under an indemnification programme, and the relevant market price. Recent literature has also tied the private nature of knowledge about animal disease status, or information asymmetry, to failed incentives to protect animals against disease (14, 15).

The more methodological papers have also emphasised the public-good nature of some choices. Infectious diseases expose those who have not otherwise been affected to adverse outcomes, i.e. they create negative externalities. People intent only on directly managing their own affairs do not take such spillovers into account in making their decisions, and are not likely to pay much attention to social well-being (16). Consequently, as has long been recognised (17), efforts to reduce infectious animal disease contribute to the public good and are an example of a public good. When addressing problematic outcomes from voluntary vaccination among humans, Galvani *et al.* (18) clarify how privately optimal and socially optimal incentives to vaccinate diverge, to the especial detriment of certain human sub-populations. Another strand of the literature has pointed to policy-relevant distinctions between activities that protect against disease entry, where the vulnerable have incentives to work together (19, 20), and activities that control damage, where the afflicted have incentives to shirk by free-riding on the actions of others (21).

Economic frameworks intent on characterising the decision-making environment are not, in themselves, necessarily ones that animal health professionals find to be especially useful, because they likely do not directly address the management of any particular problem – if, indeed, they directly address management at all. Their contribution may be very indirect: for example, providing information on trade-offs that society may have to make or positing the existence of an unrealised benefit of disease management.

However, the remainder of this paper will focus on one such framework, one that speaks to the origin and continuing mission of national and international animal health endeavours. This is the matter of public goods. Others have provided clear guidance on what are public and what are private veterinary services, as well as explaining how they are sometimes difficult to separate. (For example, see Table 12.1 in 22.) This paper is intended to formalise the public-good feature. The public-good dimension cannot be stressed enough because it is the best motivation for allocating more public attention and funding towards animal disease management. It may also be the most politically saleable reason, if messaged consistently and in accessible language.

A public good is one in which: *i)* many share without substantially diluting the benefit to each, and *ii)* exclusion from consumption is impractical. It is a particular example of a positive externality, i.e. when the actions of some entity create benefits to others but the entity does not receive rewards for doing so. Since exclusion from consumption is impractical, a public-good provider cannot compel the recipient to pay. The marketplace is ineffective in delivering public goods because users can take what is available for free and the provider cannot cover the costs incurred through market revenues. Epizootic events require public management, in large part, because private-market incentives to manage these events are inadequate. Herd owners may appreciate endeavours by others to work for the public good but the private incentive to make the level of effort that is best for society is attenuated because much of the benefit accrues to others. In addition, even if exclusion were possible, excluding some from the benefits of a containment programme would risk undermining disease containment as a whole. Thus, the control of infectious animal diseases is a public good and the basis for public involvement is strong (22).

The main body of this paper will integrate the classical public goods model (see Chapter 23 in 23) and McInerney's disease-loss framework into a production model of disease management that articulates loss in the manner of McInerney. Each livestock farmer in a specific region has two management choices: a disease management input and a production-level decision. The disease management input contributes to control of an infection pool where the herd owners are only partially compensated for benefits that they provide to the region as a whole. When uncoordinated, livestock farmers will take disease management actions that are insufficient for the public good. In light of the large resultant losses, production incentives will decline so that producers and consumers will be worse off. The role for public disease management will be shown through the use of a subsidy to support disease control. The author will also show that this subsidy cost can be defrayed by an appropriate industry. A levy on that industry is actually appropriate, in that it mitigates excess production that would result from a stand-alone disease protection input subsidy. Benefits will accrue to livestock owners who become more productive, and also to consumers, who will see an expansion in the availability of wholesome protein sources, as well as lower prices as a result of expanded supply. The paper concludes with some comments on the state of the literature on external effects and how developments in this literature can usefully inform calls for funding from the public purse.

Model

This section has three parts. A model of disease protection choices without any externality will be introduced. Then the externality will be introduced and its impact on choices will be discussed. The third part will compare protection choices when government intervention is absent with the socially optimal level of protection, and will show how policy interventions can support socially optimal disease prevention and planned production levels.

Absent externalities

With intended output q, farm production costs are given by the twice continuously differentiable, increasing and convex cost function $C(q)$. Owing to disease-related losses, the expected loss in output upon the advent of a disease is given as $qe^{-\tau x}$ where x is the representative disease management input and $\tau > 0$ so that the loss is convex, ensuring that any loss-minimising input choice is unique. The input in question might be a vaccine. It is assumed to be available in the market, which may not always be the case. For example, biosecurity training may best be provided by government programmes because public veterinary authorities may have data, trust and spare facilities to advertise and deliver such training. The cost of this market input per unit intended output is v so this model does not admit scale economies in protection. Let there be N identical producing farms, where N is determined through free entry. With the market price as P, farm profit is $\pi = Pq - Pqe^{-\tau x} - C(q) - vqx$.

Once the protection choice has been made to maximise profit, profit may be rewritten as

$$\pi(q) = \left\{ P - \frac{v}{\tau} + \frac{v}{\tau}\ln(v/\tau) - \frac{v}{\tau}\ln(P) \right\} q - C(q) \qquad (1)$$

Writing the marginal cost as $C'(q)$, competitive equilibrium requires:

$$P - K^{m} = C'(q); \qquad K^{m} = \frac{v}{\tau}\ln(P) + \frac{v}{\tau} - \frac{v}{\tau}\ln(v/\tau); \qquad (2)$$

with solution q^{*}. This is the setting's analogy to the standard 'price = marginal cost' rule for making profit-maximising choices. It is readily shown that $K^{m} \geq 0$ so that $P > C'(q) = C'(q)$, and intended output is less than intended output when disease is absent. Furthermore, disease losses ensure that intended output q is larger than actual output, so that there are two reasons why the intended output 'absent disease' is larger than the actual output.

With disease externalities

Disease transmission externalities are now introduced. The N farms in a region influence the disease pool but, since there are many regions, the output price is taken as given. Actual production depends on the extent of damage and how it is managed. The paper's concern is in the management of endemic infectious diseases, which is a form of the commons problem (24) because private efforts to manage the disease substitute for each other.

The proportional damage function is specified as $J(x_i, \bar{x}_{\setminus i})$ where x_i is the number of resources allocated to disease control in the ith herd and $\bar{x}_{\setminus i} \equiv (N-1)^{-1}\sum_{j=1, j\neq i}^{N} x_j$ represents the average amount allocated to disease control on each of the other $N-1$ herds in the region. It will be shown that the value of $x_{\setminus i}$ directly affects choice x_i and vice versa, so that choices can be viewed as being made in part to manipulate others into taking up more of the disease management burden. Because farms are identical and intended output choices do not have strategic implications, the farm subscript is dropped on intended production choice q. A proportional subsidy at rate s is provided for the disease management input so that the true cost to the livestock farmer is $(1-s)v$. The actual proportional production loss is given as $qJ(x_i, \bar{x}_{\setminus i})$.

The ith farm's contribution to managing its own risk is given as $\Pr[\text{ND}] = e^{-\tau x_i}$ where ND abbreviates 'entry down'. Disease exit from another farm is specified as the risk $\Pr[\text{XD}]$ where XD abbreviates 'exit down'. This is modelled as $\Pr[\text{XD}] = e^{-\lambda \bar{x}_i}$ where $\tau > \lambda > 0$ is assumed, in order to capture the greater attention that herd owners give to protecting against entry in comparison to protecting against exit. An alternative perspective on assumption $\tau > \lambda$ is that protection inputs are impure public goods, since the action-taker benefits more from his or her own actions than others in the region do.

The size of λ can be taken to represent the size of disease externality imposed by other herds on any given herd. The magnitude will, of course, depend on the context, since some diseases are rarely transmitted, some are highly contagious, and some are only contagious when conditions allow. Public animal health authorities will have to decide whether losses due to the disease externality, as crudely represented by λ, justify the costs of programme administration. Disease transmission occurs if both entry and exit controls are down. These failures are held to be independent events so that the probability that both will occur is the product of probabilities. Thus, $J(x_i,\bar{x}_{\setminus i}) = \Pr[ND]\Pr[XD] = e^{-T(x_i,\bar{x}_{\setminus i})}$ where $T(x_i,\bar{x}_{\setminus i}) = \tau x_i + \lambda \bar{x}_{\setminus i}$ is the total effective effort.

The disease loss minimisation problem posed to the livestock farmer is then:

$$L^{ne} = \min_{x_i} Pqe^{-T(x_i,\bar{x}_{\setminus i})} + (1-s)vqx_i, \quad (3)$$

where 'ne' refers to Nash equilibrium. Nash equilibrium means that the herd owner is assumed to view the actions taken by others as fixed, such that the herd owner cannot influence them. While each herd owner would like other herd owners to take more protective action so as to better protect all herds in the region from the disease, each herd owner will make choices that minimise own-herd loss and has no incentive to account for the benefits provided to other herd owners. Thus the herd owner seeks to minimise herd losses conditional on the actions of others (see Chapter 15 in 23).

The first-order optimality condition is $\tau Pqe^{-T(x_i,\bar{x}_{\setminus i})} = (1-s)v$. Assuming symmetry, Nash equilibrium solutions are given as $x_i^{ne} = \bar{x}_{\setminus i}^{ne}$. Thus, $T(x_i^{ne} = x_{\setminus i}) = -\ln[(1-s)v/(\tau P)]$ and $\bar{x}_i^{ne} = -\ln[(1-s)v/(\tau P)]/(\tau + \lambda)$ for all farms. Under Nash equilibrium, the expected minimised disease loss for each farm becomes:

$$L^{ne} = \frac{(1-s)vq}{\tau} - \frac{(1-s)vq}{\tau+\lambda}\ln\left(\frac{(1-s)v}{\tau P}\right) \quad (4)$$

With $\pi(q)$ as the profit for output level q, production is determined by the choice of output q that maximises:

$$\pi(q) = Pq - \frac{(1-s)vq}{\tau} + \frac{(1-s)vq}{\tau+\lambda}\ln\left(\frac{(1-s)v}{\tau P}\right) - C(q) \quad (5)$$

so that:

$$P - K^{ne} = C'(q);$$

$$K^{ne} = \frac{(1-s)v}{\tau+\lambda}\ln(P) + \frac{(1-s)v}{\tau} - \frac{(1-s)v}{\tau+\lambda}\ln[(1-s)v/\tau]. \quad (6)$$

The solution is given by $q = q^{ne}$ Notice that equation (6) differs from equation (3) in several ways. One is that equation (3) does not include the λ term, as there are no protection spillovers in the earlier setting. In addition, the subsidy was set at zero in the earlier model. Of course, condition (6) reduces to equation (3) whenever $\lambda = s = 0$, i.e. whenever there is no disease externality problem and no government intervention.

Social optimality

What then are socially optimal choices, i.e. when protection efforts are chosen, as if by a central planner, to maximise the total efficiency to society? With 'so' standing for 'socially optimal', then problem (3) is modified to:

$$\min_x NL^{so}(x) = \min_x NPqe^{-(\tau x+\lambda x)} + Nvqx \quad (7)$$

In this case, all losses are accounted for when the level of disease control is chosen, not just a herd owner's loss on his or her farm. That is, both x_i and $x_{\setminus i}$ are chosen in a coordinated manner and, as all herds are essentially identical, the protection input choice level should be the same across herds, so that it suffices to write $x_i = x_{\setminus i} = x$. The central planner coordinates preventative actions across herds so that actions taken in each herd duly recognise the prevention benefits provided to other herds.

The social welfare level of protective effort is calculated as $x^{so} = -\ln[v/((\tau+\lambda)P)]/(\tau+\lambda)$, so that:

$$x^{so} - x_i^{ne} = \frac{\ln[(1-s)(\tau+\lambda)/\tau]}{\tau+\lambda} \quad (8)$$

The level of protection taken under Nash equilibrium equals the socially optimal level whenever $\ln[(1-s)(\tau+\lambda)/\tau] = 0$, i.e. whenever $s = s^{so} = \lambda/(\tau+\lambda)$. The proportional subsidy required to maximise welfare increases with the extent of the externality, as reflected by the size of λ.

The loss per herd under the social optimum is $L^{so}(x)$ when evaluated at x^{so}, or:

$$L^{so} = \frac{vq}{\tau+\lambda} - \frac{vq}{\tau+\lambda}\ln\left(\frac{v}{(\tau+\lambda)P}\right) \quad (9)$$

On the other hand, when the loss under Nash equilibrium is evaluated at subsidy level $s = s^{so} = \lambda/(\tau+\lambda)$, then:

$$L^{ne}\big|_{s=s^{so}} = \frac{vq}{\tau+\lambda} - \frac{vq}{(\tau+\lambda)^2}\ln\left(\frac{v}{(\tau+\lambda)P}\right) \quad (10)$$

Comparing losses in equations (9) and (10), the difference in loss per intended unit of output is:

$$\frac{L^{so} - L^{ne} \,\big|_{s=s^{so}}}{q} = \frac{\lambda v x^{so}}{\tau+\lambda} > 0 \qquad (11)$$

In other words, the subsidy has done two things. It has appropriately increased protective actions by all parties. It has also transferred money to herd owners so that the loss per unit of intended output is now lower than under the reference case of social optimality.

To understand why this transfer matters in terms of production efficiency, compare the incentives for production that would apply under social optimality with those under the optimal subsidy. Under social optimality, the marginal cost rule is:

$$P - \frac{v}{\tau+\lambda}\ln(P) - \frac{v}{\tau+\lambda} + \frac{v}{\tau+\lambda}\ln\left(\frac{v}{\tau+\lambda}\right) = C'(q) \qquad (12)$$

Under Nash equilibrium and optimal subsidy rate, the marginal cost rule is:

$$P - \frac{\tau v}{(\tau+\lambda)^2}\ln(P) - \frac{v}{\tau+\lambda} + \frac{\tau v}{(\tau+\lambda)^2}\ln\left(\frac{v}{\tau+\lambda}\right) = C'(q) \qquad (13)$$

The difference between the left-hand side of the rule in equation (12) and that in (13) is precisely $-\lambda v x^{so}/(\tau+\lambda)$, the negative of equation (11) above. An industry levy of $\lambda v \ln[v/((\tau+\lambda)P)]/(\tau+\lambda)^2$ per unit of intended output is in order, to correct the incentive to overproduce that would be created by the subsidy on the protection input. The levy would balance the budget in that it would exactly cover the costs of the input subsidy. Only administrative costs would have to be covered. It is interesting to note that such levies do exist in many countries (25) and their merits have been widely discussed (e.g. 26), while a levy on internationally traded meat has been advocated to support global surveillance of zoonotic diseases (27). The author is not aware that anyone has pointed out how publicly subsidised biosecurity goods can be self-financed in an efficient manner.

Discussion

Like weather and price information, financial stability, appropriate rules and standards, the provision of security, environmental protection and the control of infectious human disease, the control of infectious animal disease amounts to a public good. Although they may have the best of intentions, decision-makers understand that their private benefit from conducting prevention activities at socially optimal levels is lower than the private cost of doing so. These businesses have other pressing needs for their available resources and so it is hard for herd owners to make the case for further allocations towards protection. Insufficient protective activity will occur without the intervention of a public authority. Indeed, as animal diseases often show little respect for borders, public interventions within administrative areas will provide inadequate support for protection unless coordination occurs between these administrative regions.

Without public intervention of some sort, the outcome will be a less efficient production system, more expensive proteins for human consumption and, arguably, greater zoonotic risks. In comparison with funding for other global public goods, the economic argument for more public intervention to manage infectious animal diseases can be strengthened. It is true that the World Organisation for Animal Health (OIE) is funded in part for this purpose, while the World Bank, Food and Agriculture Organization of the United Nations (FAO) and other publicly funded international agencies are also active in this area.

However, and notwithstanding some notable exceptions that have seized public attention through graphic imagery or severe market disruptions, more prosaic animal health issues seldom register among voters in the developed world as being relevant to food prices, food security or zoonotic risk. Unlike scenes of human hunger, security breakdowns, or limited access to human health and education services, animal health issues may not engage the empathy of donors. In addition, a logical path between reforming animal health and human well-being may seem remote to funders while, in any case, animal protein is often viewed as a luxury version of plant protein with a heavier environmental footprint.

Consider that, over the years, the Copenhagen Consensus project has formally ranked and graded, for fund allocation, many projects intended to promote global welfare. These have included such public goods as public education, dissemination of information, gender empowerment, strengthening physical security, nutrition and research to enhance plant yields, improving water supply and quality, protecting against natural disasters, the provision of environmental goods, and many human infectious disease projects. Addressing animal health issues has not featured prominently on these lists.

Yet, in the 1990s, concluding that the time might be ripe, the OIE, FAO and other partners brought national governments and livestock owners (28) on board for an ultimately successful campaign to eradicate rinderpest. Given the shadow that this disease had cast over livestock production in many parts of the world, few now question whether it was a worthwhile collaborative endeavour. Furthermore, benefit-to-cost assessments strongly supported local and global management and eradication programmes, though these assessments only partially accounted for the benefits (29). At the qualitative level, the argument that infectious animal disease control is a public good that needs support is just as valid as it is for all other projects mentioned in the previous paragraph. Other plausible candidates for global curtailment and elimination exist, e.g. foot and mouth disease (29). So, the case may be there for prioritising animal disease control for public funding but the arguments need attention.

Where then does the 'disconnect' occur? Perhaps it is because the prospects for success are beyond the control of one funder and are hard to assess, while the indirect benefits are multifarious, diffuse and imponderable (30). Bovine tuberculosis has proven to be stubbornly difficult to eradicate in the British Isles and the United States, in part because of suspected wildlife interactions. The complexity of many animal production systems may well obscure our ability to discern and measure the public-good dimension to protecting against infectious animal disease. Compulsory herd liquidations and ruined family businesses in the public good may not be included in the set of tools that private funders of disease control programmes are willing to support. Many requisite investments involve capacity-building, for which funders may receive little credit if and when these investments pay off, many years later.

Perhaps the disconnect also has something to do with views about animal production in comparison with plant production. Or maybe it has to do with a view that these problems are unimportant, which would be fine if there were evidence to support this notion.

What then is needed? Not, directly at least, a set of equations by unworldly economists. However, if the case is to be made that larger public expenditures on managing these diseases are in the public good, then lucid explanations for why markets fail to support adequate expenditure on control are needed. Better methods for measuring indirect costs and benefits are also needed, together with more and better data on these costs and benefits. The economics of human health has shown opportunities in this regard. Measuring how preventative actions affect the presence and magnitude of external effects in real-world environments is not generally easy, but the case of communicable diseases is particularly problematic because diseases can have multiple interacting causal factors, and outbreaks may be infrequent. However, carefully designed field trials have provided insights on how, for example, public deworming programmes affect health and schooling opportunities for untreated people in the treatment locality (31). If experts trained in pertinent methods are included in the design of control programmes, then similar opportunities may exist to shed light on the presence and extent of any indirect benefits that could arise from animal disease control programmes.

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Modèles conceptuels sous-jacents des analyses économiques de la santé et du bien-être animal intégrant trois composantes : les individus, les produits et les ressources

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Résumé

Les maladies animales infectieuses se propageant au-delà des limites des exploitations, leur gestion efficace requiert des réponses coordonnées. En raison de la nature même des coûts et des bénéfices induits par la gestion des maladies infectieuses, les personnes qui prennent les décisions ne sont pas nécessairement les plus motivées, ce qui se traduit par un niveau médiocre de production de biens et de services dans les élevages et par un gaspillage des ressources. L'auteur propose une synthèse de la littérature existante sur les modèles économiques théoriques en matière de gestion des maladies animales, en soulignant particulièrement l'inadéquation des incitations en faveur des mesures de biosécurité. Il fournit ensuite un modèle de transmission des maladies et met en exergue les problématiques de stratégie et de gestion à prendre en compte pour améliorer les bénéfices apportés aux consommateurs et aux producteurs par la filière de production de protéines animales. Pour conclure, l'auteur fait quelques commentaires et propositions pour la prise en compte en tant que bien public de la lutte contre les maladies infectieuses ainsi que sur les orientations futures de la recherche.

Mots-clés
Bien public – Externalités – Gestion des maladies – Incitations.

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Modelos teóricos subyacentes al análisis económico de la sanidad y el bienestar animales con inclusión de tres componentes: personas, productos y recursos

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Resumen
Dado que las enfermedades animales infecciosas pueden extenderse más allá de las lindes de una explotación agrícola, para combatirlas eficazmente se requieren respuestas coordinadas. Los costos y beneficios vinculados a la gestión de las enfermedades infecciosas son tales que: los responsables de adoptar decisiones se ven poco incentivados; los bienes y servicios resultantes de la actividad agropecuaria son probablemente demasiado escasos; y seguramente se despilfarran recursos. El autor hace un repaso general de la bibliografía existente sobre modelos económicos teóricos de gestión zoosanitaria, prestando especial atención a la endeblez de los incentivos existentes para dedicar los esfuerzos necesarios a las cuestiones de seguridad biológica. Después expone un modelo de transmisión de enfermedades, haciendo hincapié en las cuestiones normativas y de gestión que es preciso abordar para que consumidores y productores se beneficien en mayor medida de los mercados de proteínas animales. A modo de conclusión, el autor formula observaciones y sugerencias sobre la lucha contra las enfermedades infecciosas como bien de interés público y sobre las líneas de investigación que convendría seguir en el futuro.

Palabras clave
Bienes de interés público – Externalidades – Gestión de enfermedades – Incentivos.

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