

# The economic value of animal disease control measures in Australia

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*Exports of livestock and livestock products contribute close to half of Australia’s total agricultural exports. Levels of productivity and competitiveness in the livestock sector hinge to a great extent on the favorable animal health status that Australia enjoys relative to the situation in most other countries.*

*Expansion in both extensive and intensive commercial animal production, the consequent increase in contact with wildlife habitats, and increased integration of the world economy are likely to result in higher disease risks. These are likely to place heavier demands on national resources for disease control.*

*In this paper, aspects of economic assessments of disease control measures are presented, along with approaches for efficient resource use in disease control to maximise social welfare. Components of the costs and benefits of disease control are discussed. Overall, the analysis indicates that meeting the economic viability criterion is an important requirement in implementing animal disease control measures to ensure resources are channeled to their best use.*

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## Introduction

Australia enjoys a favorable animal health status compared with that of many of its trading partners. The geographic isolation of the country, together with strict quarantine protocols and contingent rapid response disease eradication programs, means that Australia is at a relatively low risk from outbreaks of animal diseases.

However, greater economic integration around the world, along with noncommercial disease pathways such as human dispersal through increased passenger traffic, could increase the risk of disease outbreaks. Coupled with the expansion in both extensive and intensive commercial animal production, the potential losses from disease outbreak for the Australian economy are substantial.

As the costs of eradicating animal disease and its risks rise, policy makers need to ensure that the benefits of animal disease control measures justify their costs. In this paper, the cost–benefit analytical process required to establish the economic viability of animal disease control measures is presented.

## The importance of a favorable health status in livestock industries

The gross value of Australian farm production of livestock products was estimated to be almost \$13.4 billion in 1999-2000 (table 1). In the same period, exports of meat and live sheep for slaughter, wool, dairy products and other livestock products earned around \$11.5 billion and accounted for 48 per cent of the value of total farm exports.

Achieving productivity growth and producing the types and quality of product that maximise returns to producers are continuing challenges to agricultural industries. An

**Table 1: Value of Australian livestock exports (fob) and gross value of Australian livestock production**

	1997-98		1998-99		1999-2000 <sup>p</sup>	
	Export value	Gross value of production	Export value	Gross value of production	Export value	Gross value of production
	\$m	\$m	\$m	\$m	\$m	\$m
Meat and live animals	3 916	6 579	4 171	6 931	4 672	7 504
Wool	4 020	2 754	2 583	2 139	2 960	2 649
Dairy products	1 937	2 817	2 257	2 897	2 438	2 850
Other livestock exports	1 417	377	1 444	384	1 451	392
Total livestock	11 289	12 527	10 455	12 352	11 521	13 395
Per cent of total farm	49	45	46	44	48	45

<sup>p</sup> Preliminary.  
Source: ABARE (2000).

important influence on the productivity of the livestock farming sector is the prevalence of animal disease. Other than leading to productivity losses, disease contamination of animal products that pose a threat to the health of consumers could also reduce demand for the product and potentially affect market access. Australia's live sheep exports to Saudi Arabia, for example, were discontinued in late 1989 in response to animal health concerns and Saudi's rejection of some shipments. Annual exports to Saudi Arabia before 1989 were worth well over \$100 million, so this incident highlights the importance of animal health status to Australia's export reliant livestock industries.

In the event of a foot and mouth disease outbreak, Barry et al. (1993) indicated that significant costs associated with forgone export earnings could be incurred (apart from the direct costs of eradication and compensation payments) if major beef importers banned the entry of Australian beef. Lembit and Fisher (1992) estimated a fall of \$25 000 in the cash income of an average farm in Australian broadacre agriculture during the first year of a foot and mouth disease outbreak.

## Economic impacts and costs of disease control

### **Economic impacts of disease**

As an economic concept, disease is a negative influence on value creating processes that are based on using livestock, crops, fish and forests as economic resources. The economic impact of disease encompasses more than the direct monetary cost that is usually associated with livestock deaths and output or quality reductions in the production process. It can also be manifested in the following areas.

#### ***Production***

The primary impact of a disease incursion is the loss in commercial agricultural production. A production loss may be defined as the reduction in output (from a given level of inputs) that a producer would incur after a disease has become established. Production losses may result from the death of animals or reduced conversion efficiencies (such as lower feed conversion ratios).

#### ***Related industries***

Production losses may also indirectly influence other industries (MacDonald and Roberts 1998) — for example, the grains industry provides feed grains to the intensive livestock industries, so a contraction in livestock supply due to disease losses could lower feed demand and, consequently, lower prices in the feed grains industries. A contraction in livestock supply would also be likely to have an impact on downstream livestock processing industries.

### *Consumption*

The presence of disease may impose costs on consumers in terms of inferior product quality and possible health risks. As a result, industry could incur additional costs through reduced demand and lost sales.

Consumers in either domestic or export markets may react adversely to the presence of disease and, consequently, reduce their consumption. One example is the decrease in meat consumption following the diagnosis of bovine spongiform encephalopathy in the United Kingdom and the subsequent effect on the domestic and overseas beef markets. The effects were substantial because of the suspected link between beef consumption and Creutzfeld-Jakob disease in humans.

### *Natural environment*

There is considerable uncertainty about the extent to which diseases may affect Australia's natural environment. Issues of concern to society may involve the loss or degradation of environmental amenities such as native wildlife and the deterioration in Australia's biodiversity. If disease severely damages the environment, then it may also have a long term impact on the sustainable use of Australia's agricultural land base and therefore on future agricultural production.

### **Disease control costs**

Control costs include all the costs of implementing policies and measures that are designed to avoid, eliminate or reduce the impacts of disease. These costs generally fall into four main categories.

- The first category includes costs stemming from policies that are aimed at preventing or reducing the risk of disease outbreaks. Examples are the costs of disease surveillance and vaccination and testing.
- The second category includes the costs of measures designed to reduce or eliminate losses caused by an existing disease. Disruptions in sales as a result of a quarantine policy restricting animal movement to contain disease and additional expenditure on veterinary services are examples of *ex post* control costs.
- Third, all disease control policies have an administrative cost. This needs to be taken into account in any assessment of the economic feasibility of a control policy.
- Fourth, some measures that restrict trade involve forgoing some benefits of international trade, meaning consumers may pay more for imported substitutes. These forgone trade benefits are also part of disease control costs.

Figure 1: A framework for analysing disease control policies

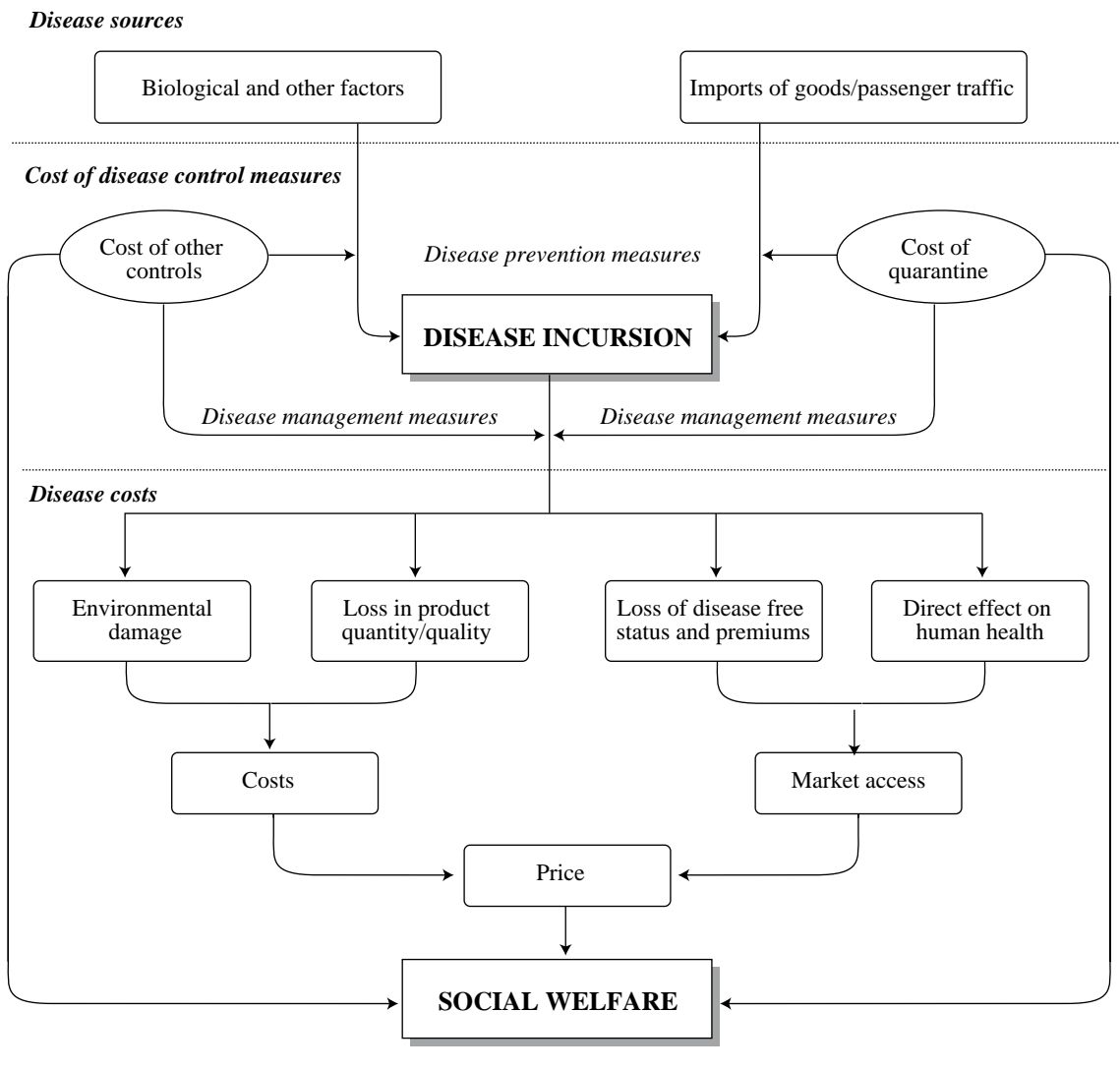


Figure 1 represents a generic framework for assessing the impacts of disease and control policies on social welfare.

## The social objective of disease control

### Optimal acceptable level of risk and level of disease control

The objective of disease control measures is to reduce the chance of a disease outbreak. Thus, the optimal level of disease control must be consistent with the acceptable level of risk.

Figure 2: Costs and benefits of disease control at different levels of disease risk

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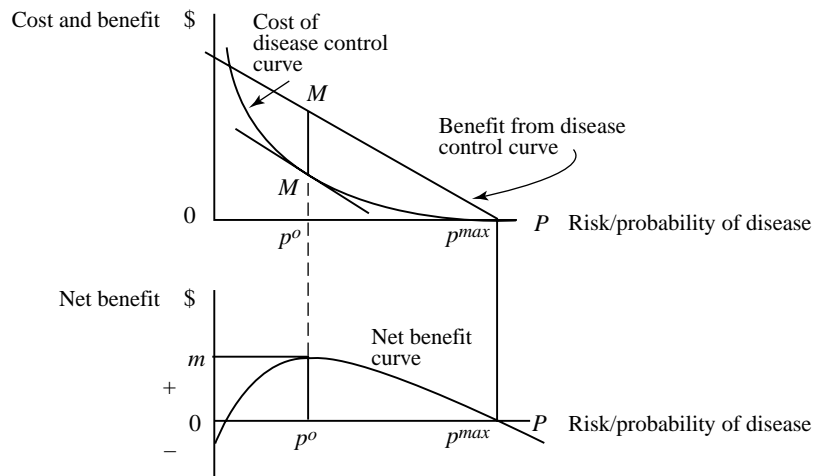


Figure 2 (adapted from Hinchy and Fisher 1991) illustrates the socially optimal level of control given the costs and benefits of disease control measures, together with the chances of disease introduction. Costs and benefits are plotted against the vertical axis. The probability of disease introduction is represented along the horizontal axis, ranging from zero at the left to the maximum probability at the right.

It is assumed that, to reduce the probability of disease introduction to lower and lower levels, the cost would rise at an increasing rate. Thus, the cost curve projects the pattern in figure 2. For simplicity and illustrative purposes, it is assumed that the benefit curve is continuous and linear. It is also assumed that forgone benefits increase as control measures tighten.

The optimal acceptable level of risk is  $p^o$ . At this risk level, maximum net benefit is attained as indicated by the maximum vertical distance between the benefit and cost curves  $MM$  or  $m$  in the lower panel of figure 2. At  $p^o$  both curves have the same slope, indicating that the marginal benefit and marginal cost of disease control are equal. The disease control level that is consistent with  $p^o$  would be the most efficient measure.

Although both benefits and costs are rising when the disease risk is reduced, at probability levels above  $p^o$  the costs are rising at lower rates than the benefits, resulting in progressively higher net benefits at the margin as the level of risk decreases. However, at risk levels below  $p^o$ , costs are increasing at higher rates than benefits are, causing successive declines in net benefits at the margin. Control measures not corresponding to  $p^o$  are not optimal because social welfare would not be maximised.

## **The nature of disease impacts and the government role in control**

The socioeconomic impacts of disease can vary considerably, depending on the nature of the disease. In terms of their impacts, diseases range between those confined to a specific locality or herd, with minimal or no effects elsewhere, and those that have substantial multisectoral, trade and/or environmental and human health impacts, thus affecting the national economy and the society as a whole.

Broadly, four types of disease can be identified by their socioeconomic impacts (Animal Health Australia 1999). The first type includes diseases that predominantly affect human health and/or the environment but may have only minimal direct impact on the livestock industries. The second type has the potential to cause major national socioeconomic consequences through serious international trade losses, domestic market disruptions and severe production losses in the affected livestock industries. These diseases may also have significant public health and/or environmental consequences. The third type includes diseases of moderate economic impact. They have the potential to cause significant national socioeconomic consequences but have minimal or no effect on human health or the environment. The last type mainly causes production losses. They may lead to some market disruptions, but these would not be expected to significantly affect the national economy.

For diseases of major socioeconomic importance, their impacts on society (beyond those affecting production and returns) are external to the production process and therefore would not enter in the industry's profit maximising decisions on disease control. The community may be willing to pay for additional control services to avoid these impacts, yet the socially desirable level of disease control services may not be realised through private investment alone because the social benefits from disease control are highly diffuse and private investors would be unable to appropriate returns to their investment through the market.

Thus, due to the presence of externalities associated with livestock diseases and the 'public good' nature of benefits generated from prevention and control, most governments intervene to implement policies to reduce disease prevalence (Bicknell, Wilen and Howitt 1992). Generally, the higher the consequences of disease beyond the production level, the greater the role that government is expected to play in disease control policy.

## **Economic valuation of animal disease control measures**

The value of animal disease control measures is viewed differently by the various stakeholders. For consumers, the value would lie in their access to disease free animal products at the cheapest prices. For livestock producers, it would be the benefit arising from avoiding the damages and risks of disease outbreaks. Thus, to a certain extent, the value of animal disease control measures is equal to the benefits to consumers and producers (box A).

**Box A: Valuing an animal disease eradication campaign**

Implementation of an eradication campaign must consider the losses for both producers and consumers due to disease outbreaks. Producer losses are the forgone profits due to the disease, which are measured by changes in the returns to fixed factors owned by producers (the producer surplus). Abstracting from food safety considerations, the consumer loss from the disease is the potential rise in their expenditures (the consumer surplus) due to a higher retail price of the disease free commodity. The sum of changes in producer and consumer surpluses reflects the benefits of an eradication campaign.

The costs of an eradication campaign include items such as spraying and testing inputs. From a social perspective, an eradication campaign is only desirable on economic grounds if its benefits exceed its costs.

**An example: estimating the benefits of an eradication campaign**

The estimation of the benefits of a campaign that completely eradicates disease is illustrated by a simple model.

Assume that the producers' supply is:

$$Q_s = P_p^\alpha$$

where  $Q_s$  is the quantity supplied at a given producer price,  $P_p$ . The change in production for a given change in prices is measured by the supply elasticity parameter,  $\alpha$ .

Further, the consumer demand for the animal product is:

$$Q_d = P_c^{-\beta}$$

where  $Q_d$  is quantity demanded at a given consumer price,  $P_c$ . The changes in consumer demand due to changes in prices are measured by the elasticity parameter,  $\beta$ .

The change in the producer surplus (PS), or the producer loss due to the presence of a disease, is:

$$\Delta PS = (1 - k) \left( P_{bd}^{\alpha+1} - P_{ad}^{\alpha+1} \right) / (\alpha + 1)$$

where  $P_{bd}$  and  $P_{ad}$  are the market equilibrium social prices before and after the disease incursion respectively. In this example, the damage arising from the disease is assumed to be a constant proportion of supply and is indicated by the unit parameter,  $k$ .

The change in consumer surplus (CS), or the consumer loss due to the presence of disease, is:

$$\Delta CS = \left( P_{bd}^{1-\beta} - P_{ad}^{1-\beta} \right) / (1 - \beta) \text{ for } \beta \neq 1,$$

$$\text{Otherwise, } \Delta CS = \ln(P_{bd}) - \ln(P_{ad}) \text{ for } \beta = 1.$$

For illustrative purposes, it is assumed that the demand and supply elasticity parameters are unitary, equilibrium prices before and after disease ( $P_{bd}$  and  $P_{ad}$ ) are 2 and 1 respectively, the unit damage parameter ( $k$ ) is 10 per cent and the discount rate is 8 per cent.

The benefit of a complete eradication campaign is the elimination of the discounted producer loss ( $[0.90 * 3/2]/0.08 = \$17$ ) and consumer loss ( $\ln [2]/0.08 = \$9$ ). Thus, the total unit benefits accruing from a complete eradication campaign would be \$26, which would thus be the value of an animal disease control measure in terms of the benefits of the eradication campaign. This would need to be compared with the estimated cost of the eradication program to gauge whether it was worthwhile proceeding from a social perspective.

In valuing disease costs, an affected industry would be primarily concerned with financial losses. Observed private losses could differ from economic losses (MacDonald and Crutchfield 1997). From an economic perspective, disease costs to society are measured in terms of the opportunity cost of inputs used in the production of contaminated outputs — that is, the value of inputs where best used.

### Disease control at the farm–firm level

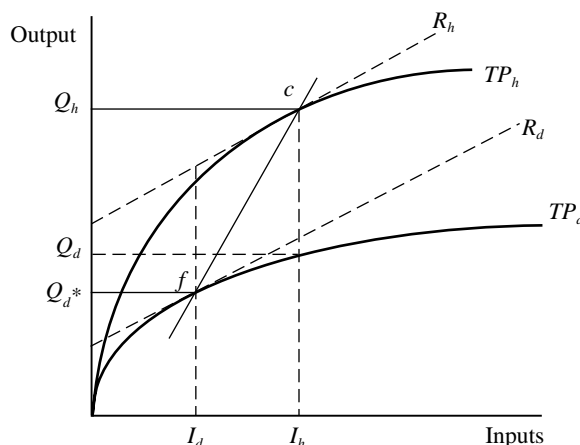
The primary impact of disease on producers is the loss in commercial agricultural production. A production loss may be reflected by the reduction in output for a given level of inputs after a disease has become established. The aim in this section is to illustrate how the efficient use of resources in disease control could minimise the economic cost of disease.

Figure 3 (based on McNerney 1996) illustrates the production effects of a disease and the effect of consequent resource use on economic costs. Levels of livestock output are given on the vertical axis, while the levels of inputs are given on the horizontal axis.  $TP_d$  and  $TP_h$  are the total product curves with and without disease respectively. In the absence of disease, profit is maximised when the value of the marginal product of input is equal to its marginal cost. This occurs at  $Q_h$ , where the slope of the total product curve  $TP_h$  at point  $c$  equals the ratio of input price to output price ( $R_h$ ).

The effect of disease is to lower the producers' total product curve from  $TP_h$  to  $TP_d$ . Overall, less output is produced with the same level of inputs used in a disease free environment; for example,  $I_h$  now yields an output of  $Q_d$ . In the presence of a disease, the optimum output level is  $Q_d^*$ , which is lower than  $Q_d$ . Output losses are lower in the absence of the adoption of the first best practice ( $Q_h - Q_d$  compared with  $Q_h - Q_d^*$ ) and additional economic costs are incurred because inputs are not allocated to their best use.

Figure 3: Economic adjustment associated with disease cost

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The previous discussion focused on disease costs in terms of incurred losses when no remedial action was taken to mitigate these losses. In practice, veterinary services and other technical and managerial measures could be implemented to reduce disease losses. As such, the total cost of disease has two components: the loss in revenue due to disease and the expenditure required to eradicate or control the disease. The higher the expenditure on measures of disease control, the lower the loss in revenue, and *vice versa*. There is a tradeoff between losses from disease and the expenditure on measures to reduce them. The economic approach in choosing disease control or eradication measures is to select the strategy that minimises total disease cost.

The expenditure on disease control is likely to shift the total product curve upward under disease situation  $TP_d$  to increasingly healthier states, such as toward  $TP_h$  (figure 3). The average value of the changes in health status arising from the disease control program is the slope of the line from  $f$  to  $c$ . Expenditures on disease control would be worthwhile if the value of the benefits of improved health status were greater than the cost of achieving that change in the health status.

Disease costs over time also depend on the epidemiology of the disease and its rate of spread. The reduction or elimination of these costs represents the benefits from disease control. Rates of spread and production losses under different control strategies may be obtained from scientific analysis. The costs over time of implementing different control strategies would also need to be estimated. Estimates of the benefits and costs over time would then be discounted, at a rate that reflects the opportunity cost of capital, to obtain the value of the net present benefits. A disease control strategy would be economically feasible if the net discounted benefits were positive, and the strategy that offered the greatest discounted net benefits would be preferred.

Such an economic framework has been used to assess the costs and benefits of existing and alternative management and control strategies for both ovine and bovine Johne's disease.

ABARE (1997) analysed different policy options used to manage the ovine strain of Johne's disease. The study assessed farm costs arising from increased mortality in adult sheep. Given the lack of reliable knowledge on the spread rate of ovine Johne's disease, a range of different rates was used in the analysis. Farm costs of the disease were found to be sensitive to changes in the rate of disease spread, with the present value of farm costs over 20 years increasing from \$15 million to \$117 million as higher rates of disease spread were assumed. The present value of the movement restriction or quarantine costs was estimated to be \$27 million. Benefits, in terms of avoided farm losses, were found to exceed control costs only under the assumption of a high rate of disease spread.

ABARE (1999) estimated that the present value of losses from the bovine Johne's disease ranged from \$93 million to \$256 million, given a range of annual rates of disease spread of 1–10 per cent. Thus, for the Johne's eradication program to be economically viable, its cost of implementation must be no more than the previously mentioned farm costs.

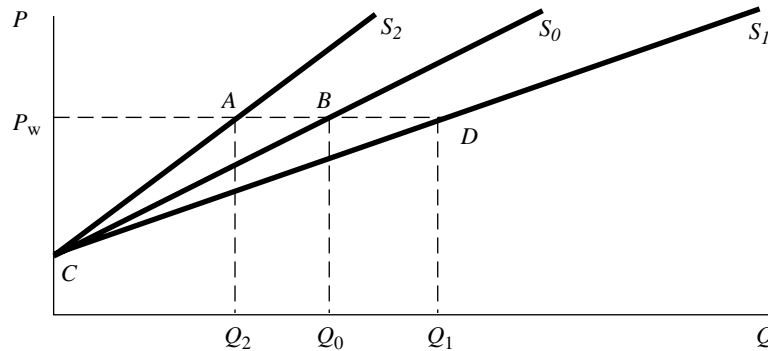
### Economic effects of disease outbreak in an open economy

The economic effects of disease incursions can differ widely between import competing and exported goods. Figure 4(a) illustrates the economic effects of allowing imports potentially carrying a disease that inflicts damage on an export industry of a small economy. The supply curve without trade is  $S_0$ . With trade allowed, some producers may gain through the imports of cheaper intermediate inputs such as improved genetic materials. Importing producers may be able to obtain advantages on export markets for their finished products. If this is the case, the supply curve will shift out to  $S_1$ , provided there is no disease incursion. Based on these supply relationships and a world price of  $P_w$ , domestic production will be at  $Q_0$  in the absence of trade. With trade, production will shift to  $Q_1$ , resulting in a net gain in producer surplus equal to the area  $BCD$ .

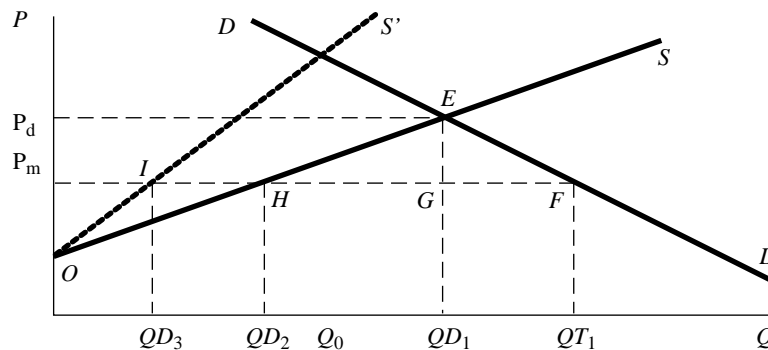
Figure 4: Impact of pest contaminated imports on a small economy

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(a) Impact of a pest on an exporting industry



(b) Impact of a pest on an import competing industry



However, if there is a disease incursion (or risk of incursion), then the supply curve will shift back to  $S_2$ . Production will fall to  $Q_2$ , with a net loss in producer surplus equal to the area  $ABC$ . Overall, there will be a tradeoff between the production gains  $BCD$  and the likely loss ( $ABC$ ) if a disease incursion occurs.

For an import competing commodity in a small economy, domestic production will be at quantity  $QD_1$  and price will be at  $P_d$  in the absence of imports (figure 4b). With the advent of imports, domestic prices will fall to the landed import price  $P_m$ , causing domestic production to contract to  $QD_2$ . However, total supply (consisting of domestic production and imports) will expand to  $QT_1$ . As a result, consumer benefits will increase by the amount represented by  $PdEFPm$ , given lower prices and increased consumption. Domestic producers would forgo income as a result of the decrease in prices received.  $PdEHPm$  indicates the producer losses. The net gain from free trade is  $EFH$ .

In the event of disease outbreak, the cost of the disease is represented by a shift in the domestic supply curve to  $S'$ . Disease costs to the domestic industry are associated with declines in production (the difference between  $QD_2$  and  $QD_3$ ) and the cost of disease control and eradication. The loss to the domestic producers due to disease outbreak is the area  $OIH$ , while the net gain from trade is  $EFH$ . The net gain from trade ( $EFH$ ) will likely exceed the disease cost ( $OIH$ ) when the higher the domestic price relative to the world price, the higher the price response of producers and consumers below point  $E$ , the lower the likelihood of disease incursion, and the smaller the losses from the disease.

The above analysis is based on the assumption that each good is either an export good or an import competing good. For most goods there is potential for both imports and exports to occur at the same time. Thus, a combination of the above analyses is usually applicable. It is also assumed that a disease (and/or the import controls) only affects the good being imported. This is frequently not the case and there may be additional costs from other sources.

## Conclusion

Australia has managed to stay relatively free from animal diseases by effectively implementing animal disease protocols. Consequently, it has been able to bolster the productivity and trade competitiveness of its livestock and livestock products. However, expansions in commercial animal production, coupled with global moves to freer world trade, have increased the risk of disease incursions and spread. This risk is likely to place heavier demands on national resources for disease control. However, this does not justify the implementation of policies to preserve Australia's animal health status regardless of the costs.

To achieve the social objective of maximising community welfare from disease control, careful assessment of the costs and benefits to all stakeholders of eradication and control policies of animal disease is needed to determine the optimum level of investment in disease control. Inefficient use of resources through either overinvestment or underinvestment would result in lower social welfare, and this is likely when inappropriate methods are used to estimate the potential economic cost of disease incursions.

This paper discussed the components of the costs and benefits of animal disease control, and presented approaches to analysing them within a cost–benefit framework. These approaches indicated the importance of recognising the tradeoffs in these components when selecting an appropriate animal disease control measure.

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