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What Price Animal Health - And Whose Problem is it Anyway?

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Introduction

> One has a very hard time persuading a vet that animal disease is not an important phenomenon of veterinary science that also has financial implications, but is fundamentally an economic problem that has some veterinary science aspects (McInerney, 1996, p.301).

The existence of diseases of agricultural animals impose costs on communities, either as costs *of* the disease or as costs of *avoiding* the costs of the disease. In this paper, the focus is on economic ways of thinking about the health of agricultural animals. In part one, the essence of economic approaches to analysis of problems is outlined. Then in part two a common method of analysing the costs and benefits of reducing or preventing agricultural animal disease is shown, and the flaws highlighted. In part three useful economic ways of thinking about the costs and benefits associated with animal disease and its prevention and reduction are explained.

Part One: Economic Perspectives

The production of agricultural animals, and consumption of agricultural animal products, is different in a world with animal disease or the threat of it, compared to a world with no animal disease or the threat of it. How much different? How much might diseases of animals cost society? The answer to these questions helps determine how much resources, both private and public, ought to be invested in reducing or preventing the incidence and impact of animal diseases. People interested in these questions, but with different areas of disciplinary expertise, tend to analyse the questions differently and reach different answers. In that case, whose estimates of the costs and benefits of improvements in agricultural animal health are best?

As a general rule, analyses that best capture the important parts of reality as it could be in the future, and which do not violate basic tenets of theory and logic, provide better guides to decision-makers than analyses that misrepresent the state of parts of the world and how these parts operate, now or in the future, or which violate theory and logic.

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Thus people who bring to bear on practical problems the appropriate balance of disciplinary knowledge, appropriate perspective, sound technical knowledge, and rigorous economic logic, and weigh up the human and unmeasureable factors, can provide more valuable advice than people who do not do these things.

Identifying correctly the problem to be solved, and the goal to strive for, is critical to decision-making about achieving economically efficient use of resources. This is the essential first step in decision analysis. To a considerable extent ‘the question is the answer’. The question properly defined and well understood provides much of the answer. Once the problem or goal is properly identified, the analytical choices and directions to follow become clearer and often, relatively few.

Technical knowledge and understanding can tell most of the story about how significant parts of the agricultural world work. If there were unlimited resources in the economy, and ample technical knowledge, then decisions about the best thing to do about a problem such as animal disease could be made mostly on technical grounds. That is, if resources were not scarce and there were no choices to be made about alternative things to do with resources, then economic analysis would not be needed to help people decide what to do about problems caused by real world phenomena such as agricultural animals not being in the best of health. Technical and social information would suffice.

However, this is not the case in the real world. Analysis of the technical aspects of a situation is the necessary first step, but because of scarcity of resources, this is not sufficiently useful to decision-making to justify neglect of other aspects of the situation, such as economic and risk and human aspects. Once the question arises ‘Should I or we or the public do this or that?’, ‘Should I or we or the public do a bit more of this and a bit less of that?’, ‘More of both?’, ‘Neither?’, ‘Anything but that!’, 'The Government ought to…!' and so on, then economic analysis is needed.

Analysing decisions involves organizing good information into a logical framework to produce specific information to further inform the decision-making process. The information of economics is not narrowly disciplinary in focus - it is an interdisciplinary and an integrating field. The 'whole farm' or 'whole system' approach is used. As the saying goes: 'It is better to solve the whole of the problem roughly than part of the problem precisely'.

One 'logical framework' used in economic analysis to evaluate whether a proposed use of resources to affect a change in the state of a part of the world is sensible or not is Benefit Cost Analysis. Sensible, in economics, means expected to generate a return on the capital that is greater than other potential uses of the resources involved.

Benefit-Cost Analysis involves investigating how the state of some part of the world might look with and without a change that is of interest – a change which will require resources to be devoted to achieving the changed state of affairs. ‘With Change’ and ‘Without Change’ are the appropriate perspectives.

In essence, the correct perspective is that of comparing and choosing between alternative futures. The analyst has to envision alternative future states of the parts of the world that are likely to be affected by alternative uses of the resources in question. The decision-maker’s choice is between alternative Future # 1 and alternative Future # 2 and so on – not between the *status quo* and the future. In a dynamic world, by definition, the *status quo* cannot be an option for the future.

The approach is to establish as best can be done ’what is the situation’, and then investigate ‘what is likely to be the new situation if I-we-the public do this, or that, or nothing different at all’ and ‘am I-we-the public likely to be sufficiently better off, all things considered, for it to be worthwhile doing ‘this’ instead of doing ‘that’ or doing ‘nothing different’ at all?’ Identifying plausible future 'with change and without change' scenarios includes defining the boundaries of the consequences of resource uses aptly. The boundaries of an analysis are defined according to the parts of the world that are likely to be affected by changes that would come about from the solutions being proposed to fix the problem.

Good decisions are based on the best information that can be procured and the best judgements that can be made, at the time of the decision, about the processes involved and their outcomes. Whether a good decision turns out to be a right decision depends in part on events that ensue that are beyond the control of the people making decisions, i.e. on luck.

Success or failure of particular ways of using resources over time is the result of an iterative process of decisions and events. The standard approach to trying to guess well the unknowable future is to make a number of such guesses and explore possible outcomes of possible situations. This process can involve sensitivity analysis (varying one variable), scenario analysis (discreet combinations of circumstances) and breakeven analysis (critical levels of key variables).

No amount of analysis can make the unknowable future knowable. However, it is sensible to think about the range of possible outcomes of doing some particular things in the unknowable future, and to think about how likely these outcomes may be. When it is not known what will happen, it is useful to think about what would need to happen for the action in question to turn out to be a good investment, and to think about how likely it is that the required levels of important parameters in the decision will actually happen. This approach is called the breakeven method, and it is useful when a situation being analysed has some key unknowns, like always.

In conducting analysis, a useful distinction to make is between economic and financial aspects of the question. Economic aspects mean analysis of the efficiency of resource use, that is, profitability and measure of return on capital. Then, financial aspects refer to the liquidity or financial feasibility of a project. Here the focus is on annual and cumulative net cash flows, and on interest and principal repayment arrangements. Seeing investment in these two distinct ways – economic analysis and financial analysis - helps avoid one of the most common problems in investment analysis, where the economic and financial aspects of the proposal are confounded into a meaningless mess of real and nominal terms, capital and annual costs, profit and cash items. Confusing economic and financial aspects of analysis of proposed uses of resources leads to the dubious double of drawing the wrong conclusions about *both* the profitability *and* the financial viability of the resource use in question.

Further, part of any future under consideration is the chance of some level of inflation occurring in the economy and affecting relevant costs and benefits during the life of the resource use in question. If inflation occurs, this will affect the actual dollar values of items and interest rates that will exist at future times. Does this matter? It might, but only if benefits and costs are affected differently.

It will matter if the analyst manages to confound real and nominal terms, such as using real dollars that do not have an inflation component and market interest rates that have an expected inflation component in them. Conduct the economic analysis (dollars and interest rates) either all in nominal terms or all in real terms.

Most decisions about uses of resources have a time dimension to them; thus the relevant logical framework within which to organize information is a budget of the expected future flows of benefits, costs and net benefits for the relevant with-without scenarios. As time is involved in questions about uses of resources, and as people prefer to receive the net benefits from uses of resources sooner rather than later, and as resources can be used to earn different returns in alternative uses, then discounting of future benefit, costs and net benefits to present values is needed so that alternative proposals can be compared validly. The analytical method is termed discounted cash flow (DCF) analysis (see The Farming Game Now, Makeham and Malcolm, 1993)

Most significant decisions can be judged on the basis of a few simple sums in which the measureable bits of the situation are counted, with the results then tempered by consideration of the unmeasureable aspects of the case in hand. In particular, there are always some aspects of decisions about proposed resource-uses which are not measureable because response functions of particular circumstances are not known; because the future is unknowable; and because a price cannot be put on everything. Measure what you can and think hard about that what you cannot measure is one useful rule.

Economists are regularly accused by non-economists of assuming away too much of reality (and it is not hard to find economists for whom reality is a special case!), but the irony of ironies is that it is the non-economists, the analysts who see just the part of the problem that they know most about, or those who regard virtually everything as being important *except* economic aspects of a situation, who are making the biggest assumptions, who are assuming away a significant part of the world.

Good economists look at the whole of the problem, starting with the people and the technology, and get the economics, finance, risk, environmental and institutional bits right too.

Too often economic analyses of agricultural choices can be found in which fundamental principles of economic logic are violated. Unfortunately, non-economists sometimes perpetrate bad economics. Despite determinedly bringing high levels of rigour to their own field, they then accept or perpetrate any old nonsense outside of their field.

For instance, good animal scientists go to great pains to ensure every important bit of immediate reality related to an animal disease and its effects is incorporated in their (reductionist) thinking – and has to be in order to get the diagnosis right. It is ironic if they then assume away many of the other important, related farm and economic system phenomena in estimating say, the costs an animal ill-health phenomena might impose on society.

Why do economists get so agitated with non-economists efforts at economic analysis? A large part of the answer is that it is not too hard to get the economics right. The evidence from history is that the disciplinary rigour of scientific training makes an excellent foundation for applying economic principles and logic.

Nevertheless, elementary errors are frequently made, but even worse, scientists sometimes make up their own economics, blithely ignoring a couple of hundred years of profound intellectual effort which has gone into working out economics as a theoretical and applied discipline. The plaintive plea from the scientist, when told that their pet idea is economic nonsense, of ‘Isn’t there some other sort of economics you could do which would make the idea sensible?’ does not much help either.

To sum up: To provide a sensible economic answer to a farm or whole system question an analyst needs to bring to bear on a well-defined question a whole of system focus and a balance of knowledge about disciplines and their linkages, whilst seeing the question in the appropriate perspective. The theoretical foundations of problem-solving analyses, technical and economic, have to be sound and the alternative futures soundly conceived and well defined. And, generally only a few of the numbers in the analysis really matter. It is folly to think that more and more elaborate analysis somehow change the uncertain into the certain, the unknowable into the knowable. Sophisticated thinking, simple sums, is still a fine recipe for economic analysis.

Part Two: The Traditional but Flawed Historical Average Cost Approach to Assessing Costs of Animal Disease

A common approach to evaluating the impacts of disease of agricultural animals is to try to estimate the historical average costs of reduced animal production caused by the disease. This approach is illustrated in Figure 1. In the past, this approach has had much appeal to non-economists, and especially to accountants and some agricultural and animal scientists. Unfortunately, in the harsh light of economic theory, this approach is revealed to be fundamentally flawed.

Figure 1

The Traditional Historical Average Cost Way of Estimating Costs of Disease

A
Farm production/yr without animal disease

B
Farm production with animal disease/yr

C
Loss of farm production/yr (A-B)

D: $ values
Average current $ per head of animals and animal product
or
Average current annual gross margin per head

E
Cost of disease is C x D x no. of years in the future

Example One:

Suppose an animal farm system has 1000 head. Without disease-management costs being incurred, disease affecting animal health is expected to cause 10 per cent of animals to die each year that would not have died otherwise, and cause 40 per cent of animals to perform at 70 per cent of the level of production achieved by the rest of the herd.

The annual disease costs are thought to be comprised of the annual loss of physical output from disease-affected animals, multiplied by their market price, plus the loss of net value of future production or current capital value of animals that die. In this case, if annual physical output of product for the non-disease affected animals is 300 kg/hd and it is worth $1/kg, the annual loss from disease in this group of animals is 1000 animals x 0.4 x (1-0.7) x 300 kg x $1 = $36 000, plus capital losses of, say, 1000 x 0.1 x $500 = $50 000. Total annual cost is said to be $36 000 + $50 000 = $86 000.

If the disease is spread through a national population of animals of say one million animals, at these rates and with these effects, the annual 'cost' of the disease is multiplied up to be $86,000,000 ($86,000 1000).

Further, the argument often goes, as the annual 'cost' is $86m per annum; the benefit of preventing all the disease effects is $86m per annum. Clearly, it is claimed, the nation could profitably invest $86m per annum to fix the problem.

This is 'folk economics' as sometimes practiced by non-economists and, it is wrong. Writing about the situation in the United Kingdom, McInerney (1996) said:

> It has largely been vets who, realizing that different disease conditions have different economic consequences, or being forced to justify the resources they wish to use in disease control programs, have initiated studies to provide an economic (or, rather, a financial) dimension to their field of endeavour. The result has been a lot of data but not much genuine information. The literature holds an abundance of studies showing 'the costs of' various diseases…..but in most cases the figures are of little value in guiding resource use decisions (p.299).

The flaws in this approach, and the alternative, economic, way of thinking about the costs of animal disease is explained in the following sections dealing with (a) estimating the costs of animal disease at the whole farm level; (b) estimating the costs of animal disease at the whole system level and (c) giving serious consideration to the effects of risk in estimating what might be the costs of animal disease in some future planning period.

Part Three: Economic Ways of Thinking about the Costs and Benefits Associated with Animal Disease

In the economic way of thinking, a cost avoided from an action is a benefit of that action. In the case of animal disease, the benefits of measures to prevent or reduce the deleterious effects of disease on animals include avoiding costs from the effects of disease, which would otherwise have occurred.

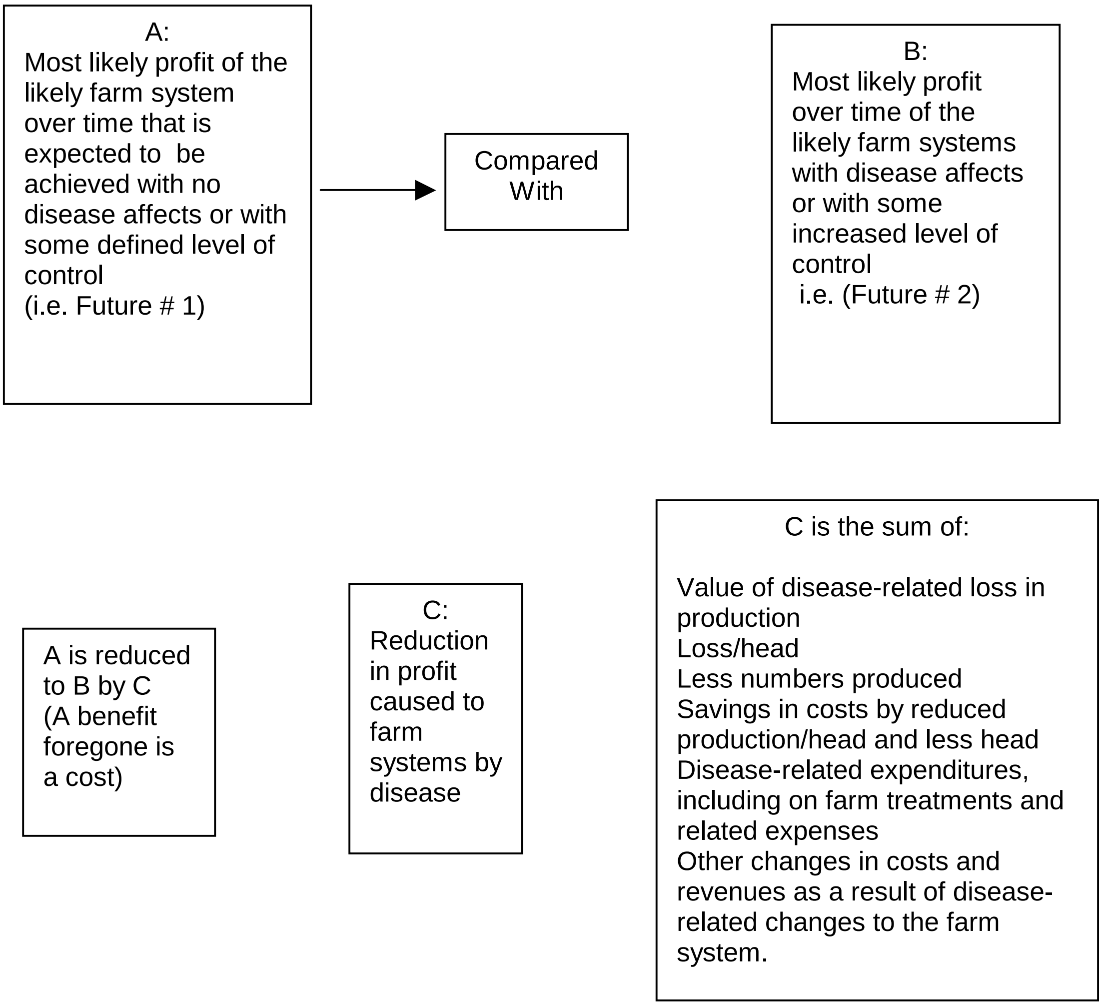
The with-without disease comparison is a much more complicated picture once more of the real world is included for consideration than is the 'folk-economic' case of the non-economists. The non-economic approach outlined above has assumed some important bits of reality out of the analysis. These include:

- Existence of diminishing returns to inputs to farming systems;
- Effects on market prices of changes in animals and animal product supply and demand through the agri-food system;
- Effects on farm systems profits of reduced production costs associated with reduced production;
- Costs related to research and generation of information about animal diseases and their treatment;
- Costs of implementing disease prevention measures;
- Production and profit benefits gained from alternative uses of resources released by lower output of one form of production in the farm system;
- Changes that may have taken place in the future in farm systems regardless of the animal disease;
- Risk associated with levels of output, costs and prices;
- Risk associated with timing of outbreaks of the disease in the future;
- The distinction between profitable levels of disease control and disease eradication;
- Assuming the disease costs can be reduced to zero.

At The Whole Farm Level

In Figure Two is shown a way of estimating the effects of animal disease at whole farm level.

Figure Two: Costs of Animal Disease at Farm Level



Example Two:

The operating profit of the whole farm system as it operates now and is likely to do so into the future, with and without the disease, is defined using the whole farm approach.

If the disease is currently prevalent then the estimates are (i) for the unchanged situation: how the farm system is likely to operate and perform with the disease over time, and without disease management costs being incurred; and (ii) for the changed situation(s): how the farm system could operate and perform with disease control measures used. In another, different situation, where the disease is not yet prevalent, then estimates are made of the (i) unchanged situation; how the farm system could operate and perform over time without the disease and (ii) the changed situation(s); how the farm system might operate and perform over time with the disease, with disease management costs incurred.

Using the example used earlier based on a farm system with 1000 animals, let's say a disease is prevalent and no remedial action is taken. Suppose the annual operating profit of the farm is expected to be $100,000 from a system in which disease management costs are not incurred and 40 per cent of the animals perform at 30 per cent below their peers solely because of the effects of the disease, and 10 per cent of animals die each year directly from the effects of the disease. Most likely expected annual return on total capital before tax is 5 per cent.

Suppose further that disease control technology is available. The annual operating profit of the farm system in the future in which disease control is implemented is then estimated. Note, not only are disease control costs incurred, but with higher production and less deaths, the disease controlled farm system is now a different farm system. As well as changes in income and direct disease control costs, other farm expenditures will also change, e.g. pasture costs, fodder costs, drought reserves, animal replacement costs, labour costs.

Once all the costs and income of the changed farm system are counted, operating profit of the disease-controlled situation in the changed farm system is estimated at say $150,000 per annum and return on capital before tax is an expected 7 per cent per annum.

So far the cost of the disease at the farm level is estimated as the $50,000 annual operating profit foregone in the situation of no disease control compared with the disease controlled situation. This estimate is for one farm system, using most likely figures. Another way to think about it is the extra $50,000 is the extra return to extra capital before tax invested to achieve the degree of disease control achieved.

If, say, $200,000 was invested to achieve control of the disease, the return on this investment is $50,000 per annum or 25 per cent before tax. Sometimes the amount of capital required to fix the problem is not well known before the event.

Here the approach is to say 'If I achieve this degree of control and earn an extra $50,000 per annum, how much could I afford to invest to get this control if I want to earn some defined annual percentage return on capital?' The approach and methods described above involve using whole and partial farm budgets (see The Farming Game Now, by Makeham and Malcolm, 1993).

Risk and time are also usually part of the story. The most likely estimates of changes in operating profits need to be placed in the context of an estimated probability distribution of changed operating profits over time. As well, the analysis needs to be set within a time frame relevant to the decisions being analysed. What is the relevant time to use? Again the answer depends on the question 'why are we conducting the analysis?'.

If the situation is that we are estimating the returns to an individual farmer investing in disease control, the time horizon might be a 5, 10, 15 or 20 year planning horizon, depending on the farmer. If we are wondering about the potential returns to public investment in research to find a treatment for a widespread disease, then a relevant time frame might be the next 10 to 50 years, again depending on the particular case.

With discounting, costs and benefits become quite small as analyses extend further into the future. A part of the rationale for the time frame might be that the disease might be eradicated either by the use of the control measures available or by the expected discovery of eradication technology over the time period used.

Generally, economic analyses cannot stop at the farm gate (unless the analysis is for the case of an individual farm business). What happens on one farm in isolation is different to what happens when a lot of farms are similarly affected. What may be good for one farmer will be a different story for all farmers. The nature of agricultural supply and demand means that outcomes that might be expected for an individual farm change once many farms are affected similarly, because of the affects on aggregate supply and demand, and thus market prices.

Thus, having explored what might happen on individual disease-affected farms with disease control expenditures (or on some non disease-affected farms with an outbreak of a disease), it is necessary to consider beyond the farm. The whole system approach is needed.

The Whole System Approach (McInerney 1996)

A seminal paper about the economics of animal disease, 'Old Economics for New Problems - Livestock Disease' was written by John McInerney (Journal of Agricultural Economics, 1996, Vol 47, no.1, p 295). The essence of McInerney's approach is distilled in the section below.

McInerney (1996) used a systems framework for studying the implications of disease. He pointed out that the negative effects of disease are widely recognised in the production sector of livestock farming because disease destroys the basic resources (mortality of breeding or productive animals); lowers the efficiency of the production process and the productivity of resources used (reduced rates of growth or feed conversion); and reduces the realised physical output of the production process or its unit value (lowered milk yield or quality).

He also argued that a broader view of the food system recognises that animal disease can also lower the suitability of livestock products or processing or generate additional costs in the distribution chain (drug residues, meat inspection), thus affecting human well being directly (p.298-299).

Finally McInerney argued that there could be an array of more diffuse negative economic effects which reduce the total value of society gains from livestock production and consumption. These range from constraints on trade in products to the reduction of consumption benefits or even negative effects people experience when the awareness of the disease changes their image of a food product (p.299).

The economic viewpoint highlights that financial estimates of average costs of reduced production are not the cost of disease, but only a measure of the costs of deaths and reduction in output. As McInerney said, this approach has ‘no reference to demand elasticities or the market price effects of reduced output (p.300). Also, as well as direct financial costs, economic considerations include the opportunity costs of resources, which can be substantial.

McInerney pointed out that:

> the presence of disease caused resources to be used in the control and prevention of its effects - an alternative to incurring production losses - and so the costs of the disease cannot be calculated without including this component as well (p.300)
>
> a limited focus in economic assessment on just the live stock production sector created an impression that animal disease was essentially a problem for farmers and a threat to their profits, rather than an imperfection in the food chain with implication for society concerning the resource use costs of food supply (p.300).

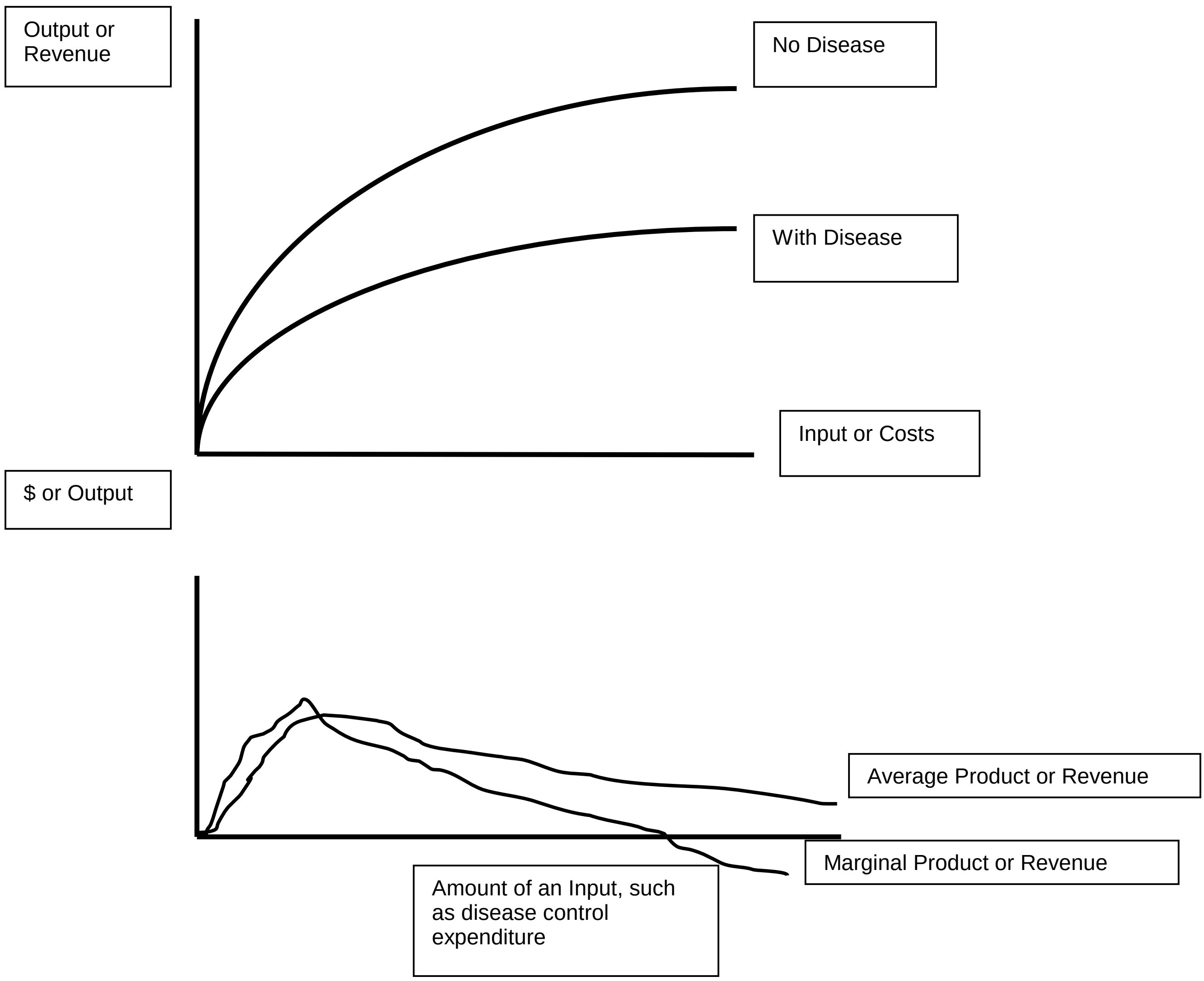
Analysis of disease effects on animal production requires consideration of both the costs and benefits of reducing the effects of a disease. While the costs of disease are also indicators of the benefits to be gained from eliminating the disease, what is also needed is the costs of disease reduction or eradication.

To define the costs of disease reduction or eradication it is necessary to define a control strategy or a range of alternative control option. This is the important, and hard, bit!

Also of fundamental importance is the reality that changes in biological production systems are subject to the law of diminishing returns. As McInerney put it: ‘ loss concepts are a relationship not a number’ (p.302). Thus estimates of effects based on average reductions in output would only be correct if diminishing marginal returns did not apply and average product approximated marginal product (see Figure 3).

Diminishing marginal returns means that an output-reducing effect or an output-increasing effect will be different to the average. It is changes at the margin that matter. And, as responses to disease control demonstrate diminishing marginal returns, this means the most profitable level of disease control is where marginal benefit from disease control expenditures equals the marginal costs of these expenditures.

Figure 3 Marginal Not Average Thinking



Production Function
Diminishing Extra Returns to Extra Inputs
Additions to or Reductions in Output/Revenue are Different to Changes in the Average Output/Revenue or Input/Costs.

Further, marginal changes in market supply of a product might cause prices received to rise or fall. Again, average changes are not necessarily correct. Demand can change too if the existence of an animal disease affects the way consumers view the animal product. For all of the above-mentioned reasons, McInerney concluded:

> Disease losses are a genuinely economic variable that cannot be measured by the simple price times quantity accounting exercises that are conventionally being undertaken (p.304).

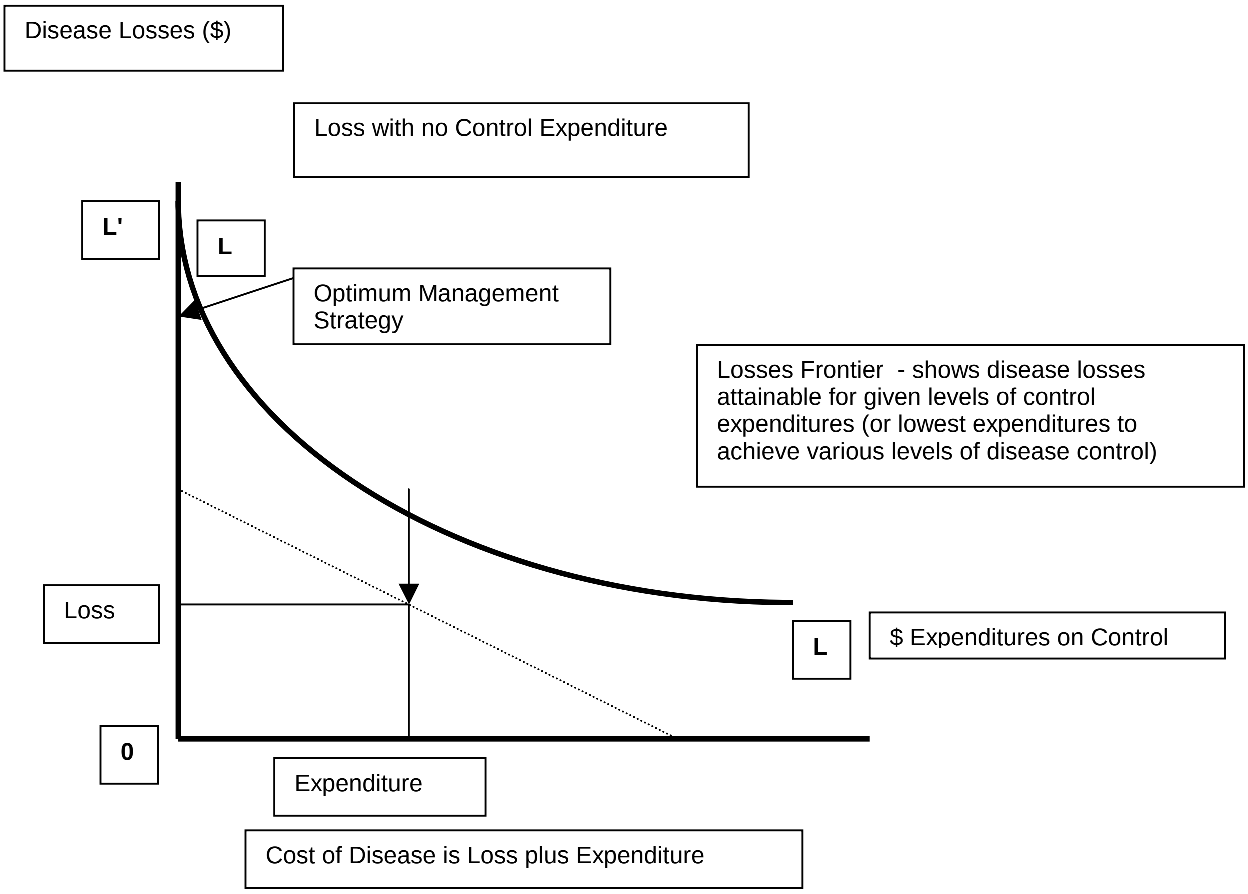
Farmers have to choose between incurring reduced profits, or investing to reduce disease. McInerney defines the costs of disease as being the sum of the economic effects caused by the disease and the expenditures related to the management response.

In McInerney's terms, disease management then involves a choice between levels of loss and levels of treatment expenditures. The important point is that the relevant objective is to minimise the total costs caused by disease and not simply minimize losses of revenue due to disease. The relevant focus is on disease costs that are avoidable – these are the benefits that are attainable.

McInerney (1996) devised an economic framework to define a loss expenditure frontier (p.306). In this approach, Loss (L) is the direct effects caused by disease in the production system. Extra resources used as a consequence are called Expenditures (E). Cost then equals Losses plus Expenditures. The relevant objective then is the minimization of Costs.

The general relationship between L and E for any disease can be represented as shown in Figure 4.

Figure 4 Disease Loss and Expenditure Frontier (McInerney 1996)



Without any Expenditures, Losses are L'. With Expenditures, Losses decline, but at a diminishing rate because of diminishing marginal returns to control effort. The line LL is an efficiency frontier that defines the lowest disease costs attainable for any level of control expenditure

This approach also shows that in many cases there is a level of disease reduction that cannot be achieved. Thus, some disease costs are unavoidable. This highlights limitations of the usual studies that estimate average costs of a disease. It is avoidable costs that are relevant and should be measured. This approach also illustrates whether eradication is the best option. In figure 4, loss and expenditure level Q is the option that has the highest BC ratio - i.e. is the best investment.

The strength of the systems approach of McInerney to questions of the cost of disease of agricultural animals is that all the costs of agricultural animal disease are counted, from producer to consumer to the general taxpayer, and any other collateral cost of damage caused can be captured as well. The answer will be far different to the simplistic average cost approach, and far closer to the truth of the matter.

To sum up: Having derived an estimate of farm level effects, affects throughout the agricultural supply chain must also be counted. Public expenditures associated with the disease, such as for research, compensation and control, are also included in the analysis. As well, relevant related secondary or indirect costs, and benefits if genuine, are counted.

Once the sum of farm, public, supply chain and secondary costs and benefits are estimated per year for the appropriate time, the annual flows of costs and benefits are discounted and summed to give the net present value of the most likely stream of costs and benefits for the event in question. There is then one further angle: finding the truth of the matter in economic analyses almost always involves thinking long and hard about the risky aspects of the issue at hand. In the next section are some observations about considering risk in analyses of disease.

Introducing Risk into Analyses of Animal Disease Costs

Analysis of the costs associated with animal disease are conducted for a range of reasons: to plan to prevent outbreaks, to invest in research into the disease, to control outbreaks, to compensate farmers, to estimate the likely affects on the economy at large and on peoples welfare. Other times, analysis is done after the event to assess the efficacy of measures adopted and to provide information for future responses. The reason why the analysis is being done determines in large part the nature of the analysis that is done.

With forward-looking analysis, risk and uncertainty comes into the question of the cost of disease in a number of important ways. First, the agricultural system that is being or might be affected by disease is notoriously subject to volatility of production and incomes, arising from variability of seasonal conditions and markets. Thus the costs from of disease too vary year by year.

Second, if we are considering the possibility of a disease outbreak in the future, there are two main uncertainties - how big the cost will be and when it will happen. The timing of the outbreak has significant implications for the costs that are caused (and thus for the benefits that are received from preventing the outbreak). For example, preventing a $100m cost from disease in year one is an investment that is worth a lot more than preventing a $100m cost from disease in year 50.

The benefits of investment in reducing or preventing disease derive from changing the expected value over the planning period of costs that would otherwise have occurred. In particular, the loss of sales (quantity by price) of livestock product associated with disease outbreak is usually the major cost of disease. In economic analysis such uncertainties are handled using the standard tools of probabilities, scenario analysis, sensitivity testing, breakeven analysis. Incorporating the probability-weighted value of such losses into the analysis is one means of incorporating some risk into the analyses.

Example Three:

Suppose there is a chance of an outbreak of a disease, and if it happened it is likely to cause a cost to the economy of $1bn in today's dollars. That is, if the disease outbreak happened today, the cost over the duration of the outbreak is expected to be $1bn. However, we do not know when such an outbreak will occur.

We do know however that if it does happen in the future, and if there are, say, public investments that will be made from now until the time of the future outbreak to research and prepare for such an outbreak, then to get an accurate picture of the costs of the disease, we need to discount all the future values back to present values using discounted cash flow budgeting to get an estimate of the total cost of the disease in present value terms. This estimate takes account of the opportunity cost of the resources involved.

Such estimates can be done for a number of discrete independent scenarios; such as ‘if the outbreak occurs in year 5, then this is the total cost of the outbreak in present value terms’. This type of information can be enhanced in value if some thought is then given to how likely is it that any of these scenarios will occur in the future. If probabilities can be attached to a well-defined and complete set of events (representing the whole probability distribution), then the expected value of outcomes from any of those events can be calculated, and summed to give the total expected value of the costs associated with the existence of the disease. For example, see Table 1 below.

Table 1 Expected Value of Costs of Different Scenarios of Disease Outbreak

Year of event	Probability of event	Present value of disease cost	Expected value
1	0.25	$1m	$250,000
2	0.25	$1.5m	$375,000
3	0.20	$1.75m	$350,000
4	0.15	$2m	$300,000
5	0.15	$2m	$300,000
Total expected value of cost			$1,575,000

Another characterisation of the situation is that there exists an annual probability with which an event (in this case a disease outbreak) and associated costs could occur (Read Sturgess 1992). That is, the cost could happen with a given probability each year and the occurrence in one year is independent of its occurrence in any other year. The problem is a ‘one-off’ event with an estimated total cost and an associated probability of occurring sometime in a defined planning horizon, say 20 years. Further suppose that when the loss occurs, policies and practices would be put in place to ensure that it does not happen again. In other words, the benefits and costs due to this cause can happen once and once only in the planning period – the probability of re-occurrence is zero (or some very small probability) (Read Sturgess, 1992).

This type of situation appears to create a problem for benefit-cost analysis because the year in which the benefits and costs occur is unknown, which makes it difficult to obtain an expected present value by discounting the future loss. Applying the discount factor to the probability component of the formula for the expected present value rather than the benefit and cost components can overcome this difficulty (see appendix) (Read Sturgess, 1992).

In essence, as shown in the Appendix, combining the discounting formula (PV= $Cost/((1+discount rate)/100)^the number of years), and the formula for the probability of the random event, the algebra reduces to the sum:100/((number of years x discount rate) +100). For instance, when the number of years is 10, and the discount rate is 4, the solution (the discounted probability) is 100/140 = 0.714. When the number of years is 20 and the discount rate is 5, the discounted probability is 100/200 = 0.5.

The interpretation of the discounted probability number is as follows: a one in 20 year disease outbreak discounted at 5 per cent has a discounted probability of the event occurring of 0.5. This is equivalent to the event occurring in the coming year with a probability of 0.5 or not at all. This figure of 0.5 is multiplied by the cost that has been estimated will be incurred whenever the disease outbreak does occur. Representing the situation of the once-off cost in this way means that the actual timing of the cost is not an issue, only the magnitude of the cost if it were to happen needs to be estimated

Suppose, for example, that the annual probability of the occurrence of the costs associated with a disease outbreak is 0.05 (once in 20 years) and that if it occurs in the planning period of 20 years it will not recur. At a discount rate of 8 per cent, an event with 0.05 probability is equivalent to a (discounted) probability of it occurring now of.100/((20 x 8) + 100) = 0.3846.

Suppose that the net revenue losses and other welfare effects from a disease outbreak would be $10bn in total, regardless of when they occurred over the planning period. With the above assumptions about the discount rate and the probability of occurrence in the absence of the investment in disease reduction, prevention or control, this would mean that the expected present value of costs over the planning period is $3846m.

If, following an investment in disease reduction, prevention or control, it results in changes occurring that reduce the annual probability of net revenue and other welfare losses from 0.05 (1 in 20 years) to 0.025 (1 in 40 years). At 5 per cent discount rate, the equivalent discounted probability is 0.3333. This would result in the expected present value of the loss over the planning period being reduced to $3333m.

An expected cost avoided is an expected benefit. Therefore, if an investment in disease prevention, reduction and control was the sole reason for the subsequent change in the expected present value of costs, the expected benefit of the investment would be $513m ($3846m - $3333m).

The expected benefit of $513m can be compared in the usual way with the present value of the cost of the investment in disease research, prevention, control etc to calculate an expected net present value and a benefit:cost ratio. Again, the rule is not to spend more on an outcome than the outcome is worth.

In the case of investing in research into animal disease, the change in probability required to result from the research to make the investment in research a good investment is calculated simply by (i) calculating the amount of reduction in expected value of losses that would need to be avoided as a result of the research to cover the costs of the research, and estimating the change in the discounted probability that would achieve this change in expected losses (benefits) that covers the costs of the research.

The change in discounted probability of losses that is required for the investment in the research to be profitable is then considered in light of the pre-existing discounted probability of losses, and a judgement formed as to whether the change required is likely to result from the results of the research. This is an example of the approach" How big would a benefit have to be to justify using resources to gain that benefit?'

Conclusion

So, what price animal health – and whose problem is it anyway? As knowledge about the science of animal disease is necessary but not sufficient to assess the costs of animal disease; and as economic ways of thinking, applied correctly to good scientific information, are required to properly estimate the costs of animal disease; it follows that estimating the costs of animal disease is therefore a task for both economists and veterinarians*, but with each doing what they do best*.

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Appendix

To estimate the expected value of losses from a disease outbreak, a probability distribution of disease outbreaks occurring over the relevant planning period has to be estimated. Then the estimated cost of the outbreak is multiplied by the probability of it occurring during this time. If the planning horizon is 20 years, and the disease event which is concluded within one year is considered to have an equal probability of occurring in any of those 20 years, and if it were to occur once it could not occur again, then the probability of the event occurring in any single year would be 1/20. The expected value of the distribution of disease outbreak possibilities would be the discounted cost of the outbreak if it were to occur in each of the years multiplied by the probability of it occurring in the year.

Suppose the loss were to occur in year i with an economic cost $l_{i.}$ With an annual discount rate r and a probability p_i of occurrence and having occurred there is no further loss, then the expected present value of the loss $E(L)$ is:

$$E(L) = SUM_{i=1 \text{ to } \infty}\, p_i\, [l_i/(1 + r)^i] \qquad \text{equation 1}$$

Equation 1 can be re-written as:

$$E(L) = SUM_{i=1 \text{ to } \infty}[p_i/(1 + r)^i]\, l_i \qquad \text{equation 2}$$

The term $[p_i/(1 + r)^i]$ in equation 2 is a 'discounted probability', denoted by p_i^*. The same numerical result for E(L) is obtained using either equation 1 or equation 2. When the loss l_i is constant no matter when the event occurs then:

$$E(L) = SUM_{i=1 \text{ to } \infty}\, p_i^*\, l_i = l\, SUM_{i=1 \text{ to } \infty}\, p_i^* = l\, p^*$$

Where, the total discounted probability is:

$$p^* = SUM_{i=1 \text{ to } \infty}[p_i/(1 + r)^i] < 1.0$$

Notice that SUM p_I = 1.0 but SUM $_\infty\, p_I^*$ < 1.0.

One can interpret p^* as follows. In terms of expected discounted loss an event with a probability distribution (p_I) is equivalent to an event which happens at the present with probability p^* or not at all.

Combining the discounting formula (PV= $Cost/((1=discount rate)/100) x the number of years), and the formula for the probability of the random event, the algebra reduces to:100/((number of years x discount rate) + 100). For instance, when number of years is 10, and discount rate is 4, the solution is 100/140 + 0.714. When number of years is 20 and discount rate is 5, the solution is 100/200 = 0.5.

The interpretation is that in considering the discounted cost of a one in 20 year disease outbreak discounted at 5 per cent, we can equivalently consider the vent to occur in the coming year with a probability of 0.5 or not at all. The discounted probability of the event occurring is 0.5. This figure is multiplied by the cost that it has been estimated will be incurred when the disease outbreak does occur.