Biosecurity Review

Key economic issues facing New Zealand's biosecurity system

Report to the Parliamentary Commissioner for the Environment

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Preface

The New Zealand Institute of Economic Research (NZIER), based in Wellington, was founded in 1958 as a non-profit making trust to provide economic research and consultancy services. Best known for its long-established *Quarterly Survey of Business Opinion* and forecasting publications, *Quarterly Predictions* and the annual *Industry Outlook* with five-yearly projections for 25 sectors, the Institute also undertakes a wide range of consultancy activities for government and private organisations. It obtains most of its income from research contracts obtained in a competitive market and trades on its reputation for delivering quality analysis in the right form, and at the right time, for its clients. Quality assurance is provided on the Institute's work :

- by the interaction of team members on individual projects;
- by exposure of the team's work to the critical review of a broader range of Institute staff members at internal seminars;
- by providing for peer review at various stages through a project by a senior staff member otherwise disinterested in the project;
- and sometimes by external peer reviewers at the request of a client, although this usually entails additional cost.

Authorship

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1. INTRODUCTION

Although economics is commonly viewed as being concerned with the workings of "the economy", it is more fundamentally the study of how choices are made under conditions of scarcity, and how limited resources of labour, capital and time are allocated to satisfy potentially unlimited human wants. Action to maintain biosecurity is a resource-using process which raises the same economic questions about efficiency and optimal allocation as in any other area of human activity, and can be investigated using the same economic principles and techniques, as explained in this report.

The Biosecurity Act (1993) sought to "restate and reform the law relating to the exclusion, eradication and effective management of pests and unwanted organisms". Although the term "biosecurity" is not specifically defined in the legislation, it has been referred to as:

"the cost effective protection of any natural resources from organisms capable of causing unwanted harm. In the Act *natural [and physical] resources* means

- organisms of all kinds
- air, soil, water in or on which any organism lives or may live
- landscape or landform
- geological features
- systems of interacting organisms and their environment".[1]

The Act essentially provides for such regulatory intervention within a cost-benefit framework. Economics is therefore relevant to a range of issues related to biosecurity policy under the terms of the legislation.

1.1 Why have a biosecurity policy?

As economics is fundamentally concerned with the enhancement of human welfare, there are a number of reasons why it may be economically worthwhile to protect biosecurity. These include:

- protecting human health and safety: unwanted organisms and diseases can impact directly on human well-being through sickness, debilitation and death.
- protecting production standards: unwanted organisms may disrupt production processes by reducing the productivity of pasture, plants and livestock; or by necessitating greater process inputs against the effects of contamination. Such incursions of unwanted organisms may impact on production through increased costs, reduced output volumes or lower prices from products perceived as of inferior quality.
- protecting access to overseas markets: other countries may use the presence of potentially damaging organisms in New Zealand as a reason to erect trade barriers against New Zealand produce. This primarily impacts on prices for exports, as produce is diverted from the most demanding markets to those with lower prices, but in the long term it may also lead to changes in the volume of particular produce sent to export.

[1] Hon. John Luxton, Minister of Biosecurity, 1998, at NZ Biosecurity Conference.

- protecting a sense of security and cultural identity: such impacts are difficult to quantify, but there can nevertheless be a real reduction in well-being for the population at large from biosecurity incursions which damage parts of the environment significant for national or cultural identity, such as native wildlife susceptible to introduced predators.

Biosecurity therefore fulfils a similar function of protecting against risk to some other areas of government activity, such as national security and civil defence.

Regarding the last bulleted point above, the *New Zealand Biodiversity Strategy* stresses the importance of maintaining, and indeed improving, the country's highly distinctive indigenous biodiversity[2]. With a high proportion of native species in decline or in threatened status, preserving New Zealand's biodiversity has become a policy priority. As many of the country's native flora and fauna are not found anywhere else in the world, protecting these endemic organisms contributes to global as well as national biodiversity. Due to evolution over long periods of isolation, these species are particularly susceptible to introduced pests and predators, hence the importance of biosecurity control in any measures to preserve indigenous biodiversity.

Increasing levels of trade with other countries, and the speed with which people and goods are transported, raise the likelihood of unwanted organisms arriving in New Zealand. Active management against the risks to biosecurity imposes resource costs, either in terms of actual expenditures on preventive and control measures, or in the hidden costs of opportunities forgone when particular activities are precluded because of the risks they pose. So it is important that any such resource costs imposed by biosecurity policy should be so arranged as to obtain the maximum possible reduction in biosecurity risk. This is fundamentally an economic question.

1.2 How to protect biosecurity?

Possible biosecurity activity areas include:

- *ex-ante* measures including import health standards, surveillance and pre-border, preventative actions;
- border control, such as screening, interceptions and procedures applying to imported goods; and
- *ex-post* identification, containment, control and eradication of pests on arrival in New Zealand, and emergency responses.

Since any measure to improve biosecurity has resource use implications, it is pertinent to ask whether some other choice of allocation would better achieve the desired aims of biosecurity policy. Such resource allocation decisions are the cornerstone of economic analysis, and raise a series of subsidiary issues.

1. How much is it worth promoting biosecurity, taking account of both the benefits and costs associated with such activities?

2. What measures are best able to provide biosecurity? Choices involved in resource allocation include:
    - efficiency of delivery;
    - the particular channel of activity (pre-border, border, post-border and internal);

[2] Biodiversity can be described as the "variety of life", and refers to genetic diversity, the variety of species within an environment, and the diversity of natural communities of species and functioning ecosystems.

- the resulting incentives to evade or avoid different biosecurity measures, which in turn affect the probability of biosecurity breaches and effectiveness of the system.

3. Who should bear the cost of biosecurity measures, given that the available pathways tend to be concentrated on relatively few participants, whereas the potential benefits are widespread and diffuse? This raises further considerations about how much of the cost should be recovered from exacerbators of biosecurity risk, the beneficiaries of risk reduction, or the taxpaying community at large.

The rest of this paper summarises the economic frameworks and principles relevant to analysing biosecurity risk, precautionary measures and remedial responses. It examines the way in which economics approaches the analysis of resource use decisions, including a discussion of the strengths and weaknesses of cost-benefit analysis. It describes the ways in which economic analysis can aid decision-making when there is uncertainty, when the risks are indeterminate, and the benefits are largely intangible, as is often the case with biosecurity risks. It also considers how economics can illuminate the distributional implications, the resulting incentive effects and the implications for efficiency of particular resource use decisions.

2. FUNDAMENTAL ECONOMIC PRINCIPLES

A central economic question about biosecurity is whether a particular set of policy measures is worthwhile, that is whether society gains more with the policy in place than it would in its absence. Economic assessment aims to improve decision-making, by determining an "optimal level" of control or activity, and establishing where to draw the line between "doing something" and the *status-quo*, or "do nothing", decision. In practice it may mean comparing some existing set of measures with proposed modifications to those measures.

2.1 How much biosecurity is economically optimal?

From an economic perspective, the optimal level of biosecurity control may not be that which seeks to exclude *all* incursions or preserve indigenous biodiversity at all costs. The amount of resource that any community can put into biosecurity will be constrained by considerations of affordability. There are two basic economic principles involved in this line of reasoning:

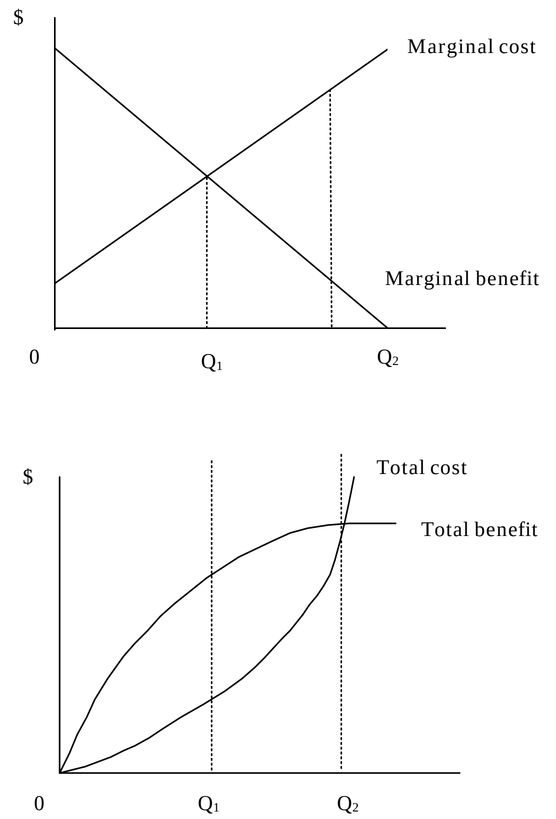
- efficient expenditure on biosecurity activities is where the marginal costs of control equal the marginal benefits obtained i.e. it is worthwhile to expend resources to the point where an additional unit of expenditure just equals the value of additional benefit obtained;
- the law of diminishing returns states that the cost of each successive unit reduction in biosecurity risk is likely to rise and become very large, the closer the risk approaches zero; in much the same way as it may be relatively cheap to remove the first 80 or 90% of pests in a given area, but moving to total eradication incurs increasing costs with each successive pest removed.

These principles are illustrated in Figure 1 (below). The uppermost diagram compares the marginal costs and benefits with each successive increment of quantity of biosecurity activity, and shows the efficient level of expenditure on biosecurity control to provide activity of Q_1, where marginal costs equal marginal benefits. For any activity beyond this quantity, the costs incurred will be greater than the benefits reaped. A principal benefit of biosecurity measures is the avoidance of damage costs that would be incurred in their absence. Economic analysis therefore focuses on the question: what level of costs (of biosecurity measures) is it worth incurring, to avoid the likely consequences of not having them?

The second diagram compares the total costs and benefits experienced with successive levels of biosecurity activity. It shows that the net benefit (the distance between the total benefit and total cost curves) is maximised at the optimal level of Q_1. It also illustrates the principle of increasing marginal cost, as the total cost curve rises with increasing steepness towards the higher level of biosecurity activity, Q_2; and also diminishing returns, as the benefit derived from later units of expenditure will not be as much as from the initial units when approaching the optimum at Q_1.

Figure 1: Economic efficiency

Determining the optimal level of biosecurity expenditure



Source: Adapted from Tom Tietenberg *Environmental and Natural Resource Economics* (1998: Scott, Foresman and Company, USA), p.66.

The optimum level of biosecurity is an efficient allocation of resources in the sense that it maximises the return from unit inputs, provided the costs and benefits accurately represent the full value of resource inputs in their other possible uses. In this context, a single border incursion by an unwanted organism may not signify a system failure: it may concur with the risk level accepted by undertaking an economically efficient level of control. Even several detected incursions need not necessarily signify failure, since statistically, even random occurrences occasionally cluster in time and space. When such incursions occur, it is important to establish whether exceptional circumstances may have led to the incursion, and what that incursion implies to the long term risk of incursions taking place.

2.2 The implications of collective provision of benefits

Biosecurity, or the ends it seeks to achieve, may provide purely private benefits. For instance, individuals may protect themselves against diseases by seeking appropriate vaccination, as has occurred with various influenza strains in recent years. In such cases individuals may be left to choose for themselves whether they run the risk of infection or pay for the appropriate preventive measures. Government may choose not to intervene unless it believes that doing so fails to account for wider implications. For instance, it may consider intervening because it believes people do not have access to the information required to accurately assess the risks they face; because the disease has an external effect in enhancing the risk of contagion of other people, the consequences of which could be very severe; or because the individual responses are inherently wasteful and inefficient in the sense that they require far more collective resources than would be needed by a widespread intervention.

Much biosecurity activity falls into the latter category: the cost of excluding unwanted organisms at the border is expected to be less than the cost of allowing them in and living with the consequences. Biosecurity incursions left untreated often represent an irreversible change: once an unwanted organism becomes established in a territory, it may be prohibitively costly to contemplate its eradication. But biosecurity measures, such as border controls, surveillance and response capabilities, have the characteristics of an economic public good in that they are:

- Non-rival in consumption: the service provided by biosecurity is such that one person's use does not detract from that available for others to use;
- Non-excludable in consumption: the service is such that it is impossible to exclude non-payers from the benefits obtained by paying subscribers (the "free-rider" problem).

In general, the benefit of biosecurity services in reducing the risk of disease or economic disruption from unwanted organisms is indivisible, logistically difficult to charge for on a user pays basis, and a candidate for funding through compulsory taxation of the wider community that benefits. But clearly the activities undertaken to protect biosecurity more directly benefit some communities of interest within New Zealand (e.g. primary producers) than others. Moreover, spreading the costs across a wide taxpayer base may lessen incentives for those most directly able to reduce the risks: for instance, making the costs of treating livestock disease outbreaks a government responsibility may reduce the incentive on individual producers to take reasonable steps to prevent the spread of disease in the first place.

In practice, therefore, not all biosecurity measures need be regarded as a national public good, and there is a case for distinguishing different types of public good and recovering costs from the community of interest: production sector interests, regional and local communities, as well as the national community of taxpayers. The Biosecurity Act recognises this by providing for national and regional pest management strategies, according to the incidence of each particular pest's threat. As in all such cases of cost sharing, how far down the road of charging individual users or groups of users it is feasible to go depends on consideration of the administration costs imposed on those collecting the charges, and the compliance costs on those paying it. If these are large enough to outweigh the incentive effects of more precise user charging, it can still be economically worthwhile to fund out of a less targeted group levy or general taxation.

2.3 Allocating resources for emergency response purposes

The probability of a biosecurity emergency may be small, but the expected magnitude is very large. There is the question, therefore, of how to provide for emergency responses which may be large but very infrequent. One option is to establish a contingency fund, but a biosecurity agency alone may not be able to finance a fund sufficiently large enough. Not only would such a fund take time to build up, but it may not be adequate to fully cover emergency responses. It may be more worthwhile to spread the risks over a number of government departments (or the government budget as a whole), or even for the government to take out insurance offshore to spread the risk over an even larger and more diversified pool of contributors. In the latter case, the government would need to be quite clear as to the coverage of the policy. Overall, it needs to be decided whether there is more to be gained by providing a contingency fund, or by developing response abilities in other ways. If the size of the fund able to be maintained is inadequate for the expected costs of an emergency, it may well be more efficient to deploy resources into more active management of biosecurity risk through precautionary measures. Such a contingency fund may also appear "unproductive" when not actually called upon, and its benefits – which consist of the cover it provides, rather than payouts made may be harder to justify in a political setting against continuously needed services such as border control.

Maintaining a contingency fund explicitly for emergency response purposes would involve estimating the risk of a biosecurity emergency and the likely magnitude of such an event, in order to determine the required size of the fund. It would also be necessary to make explicit the parameters of cover: to whom assistance is available (does it cover private individuals?), in what quantities, in which specific circumstances and so on. The speed at which funds can be accessed will also be crucial to the effectiveness of emergency response measures. There is a risk that such a fund itself may be badly managed, or become prey to political imperatives siphoning off funds for other purposes. Practice to date in New Zealand has been for emergency response funds to be relatively modest, and supplemented by reallocations from elsewhere in government's biosecurity and other budgets, should the occasion arise.

2.4 Allocating resources to biosecurity and other public activities

Various pieces of legislation now express an aim of achieving efficient use of resources, taking account of costs and benefits and weighing them up with other considerations (such as sustainable management in the Resource Management Act). This quest for efficiency is partly in recognition that government's own resources are limited and need to be used to greatest effect: revenue raised through taxation has an opportunity cost in depriving other productive activities of funds, and raising tax rates has wide ramifications throughout the economy, reducing the attraction of new investment and employment. Biosecurity therefore competes for limited public funding with other types of public service provision, such as health services, education and defence.

Given this situation, government's allocations to biosecurity should aim to obtain the same net benefit at the margin as from its allocations to any other public expenditure activity. This begs the question of what are the benefits obtained from all other public activities? There is as yet no comprehensive way of comparing the economic net benefit across all government activities, and in practice allocations are determined through a political process, in which there has been little tradition of tying political decisions to some externally determined technical estimate of each activity's "worth". An exception is the decision to tie the annual roading budget to the level required to fund all new road projects achieving a target benefit-cost ratio. Such target cut-off ratios are specific to the risks of the particular activity, and do not imply that other government activities are necessarily required to meet the same ratio.

The principle of equating the net benefit at the margin from each activity applies in making choices within the biosecurity budget as well as between biosecurity and other uses of public funds. Ideally resources put into pre-border, border and internal biosecurity measures would reflect equal marginal return to effort in each of these areas, where return is some measure of the reduction in risk or in expected damage from incursions under each set of measures.

In practice, applying these principles is a little more complicated because of uncertainty about many of the effects and values required in assessing the return. Decision-makers have to approximate values in order to determine an appropriate cut-off point for expenditures, where to most effectively channel funds, and whether to proceed with an activity at all. In any community, the level of biosecurity activity is constrained by considerations of affordability and value for money relative to other possible uses of resources. An economic framework to support such decision-making is outlined in Section 3.

3. ECONOMIC DECISION-SUPPORT TECHNIQUES

A number of techniques exist for evaluating whether it is worthwhile for society to pursue a particular policy or project. The predominant method used internationally is that of applied “welfare analysis”, which compares costs and benefits beyond those captured in market transactions, and approves measures only where the benefits exceed the costs.

3.1 Cost-benefit analysis

Cost-benefit analysis (CBA) can be viewed as an adaptation of the financial analysis undertaken by businesses to determine the relative profitability of different investments. Instead of maximising profits, CBA is concerned with social welfare, the net sum of the economic costs and benefits borne by all those affected by the decision being considered. It involves assigning a value to the stream of these costs and benefits over time. A form of applied welfare economics, CBA recognises that social appraisals need not coincide with private appraisals, because of effects external to the private decision-maker, such as opportunity costs which fall involuntarily on third parties, or benefits outside the observable market transactions.

Conducting a CBA involves:

- identifying all relevant effects of a policy;
- quantifying and valuing these effects, and sorting into costs and benefits;
- reducing effects which occur at different periods into commensurable monetary units, through a process such as discounting to present values;
- testing the sensitivity of the results to changes in key values or assumptions made.

3.1.1 Dynamic efficiency and decision criteria

There are three alternative decision rules for accepting a project/policy activity under CBA. All of these involve considering the flow of costs and benefits over time, and discounting these to reflect their present value. This process of discounting realises the changing value of money over time: that $100 worth of benefits earned today is not equivalent to the same nominal amount received in, say, five years’ time. A discount rate, typically 10% in New Zealand public appraisals, is used to adjust the stream of costs and benefits, yielding a single “net present value”. Alternative decision rules are therefore:

- selecting the activity with the highest net present value;
- selecting a project if the ratio of present value benefits to present value costs exceeds 1, under certainty (or some other pre-determined acceptable ratio greater than 1, under uncertainty);
- accepting a project providing it has a positive net present value.

3.1.2 Identifying the relevant effects

The effects of a biosecurity policy may include both direct and indirect costs, and benefits which accrue to individuals and/or communities:

- direct costs of biosecurity activity include surveillance, border inspection, and eradiction measures such as spraying and trapping;
- indirect costs include human health risks of some eradication activities (eg aerial spraying, inspecting incoming tourists), and modifications of farm practices to monitor organism spread;
- benefits may be costs avoided, such as damage to trade relations and export restrictions following an incursion; damage to native flora and fauna; damage to commercial (e.g. horticultural) operations; risks to human health from disease vector species.

3.1.3 Quantifying these effects

Ex-ante estimation of direct costs may rely on information from expert and specialised data, as well as experience and historical precedent. Assessing costs also involves considering the changes in opportunity cost, or value foregone by not using resources in some other activity.

There are a number of methods available for estimating benefits. For assessing biosecurity measures, where the potential consequences range across both market and non-market impacts, the broad categories of valuation are:

- opportunity cost of lost outputs, usually derived from market prices with taxes and subsidies removed;
- so-called “defensive” expenditures or indirect costs of biosecurity responses, derived from market prices;
- “shadow project” estimates of the cost of replacing, relocating or recreating a threatened resource as a proxy for its lost value, using market prices for all inputs;
- willingness to pay (or accept compensation) for changes, derived from “revealed preference” non-market valuation techniques (travel cost analysis, hedonic pricing);
- willingness to pay (or accept compensation) for changes, derived from “stated preference” non-market valuation techniques (contingent valuation, con-joint analysis).

Effects under the first three bullet points above can all be valued from cost-based estimates based on market prices. The last two approaches are non-market valuation techniques, which impute values for unpriced or intangible effects. This can be done either by getting people to state how much they would be willing to pay in the hypothetical case they had to, or indirectly by inferring revealed preferences from observed expenditures on activities associated with the intangible values in question.

Some of the benefits of precautionary activities (i.e. an absence of pests) will be virtually invisible and therefore difficult to quantify. Measuring an environment’s freedom from pests may require setting critical thresholds (such as number of incursions per year), beyond which policy is deemed to be failing. Whether this constitutes one snake found in a container, or some percentage of organisms per inspected container, is a matter for debate. The level of activity in ensuring the environment’s freedom from pests varies with a community’s willingness-to-pay for inspection and other measures.

3.2 Other decision support tools

Because it is difficult to enumerate all the components of a cost-benefit analysis, it is sometimes necessary (or sufficient) to subject choices to a different type of analysis. Below is a brief description of other methods available to assist decision-making.

3.2.1 Cost-effectiveness analysis

Cost-effectiveness analysis (CEA) simply compares the discounted costs of alternative projects that yield a single, common output. Discounted analysis indicates which method has the lowest present value cost over a defined period. The benefits are not valued because they are taken as given. Implicit questions in biosecurity suited to CEA are "What is the least cost way of detecting incursions?" or "What is the least cost way of achieving a unit reduction in risk of incursion?", e.g. screening passengers who are numerous but relatively contained on arrival, or screening freight which is exposed to the environment on board ships and wharves? The overarching aim of border control is reducing the risk of incursions. With surveillance at points of entry, the focus could be containers or people, arriving by sea or air.

3.2.2 Cost-utility analysis

Cost-utility analysis (CUA) produces a measure of "value for money" by dividing a "score" based on components of merit, by the cost of the project. The merit components are similar to the benefits in a CBA, but may be broader to include other things that contribute to the project's utility, such as the efficacy, urgency and feasibility of the project. This method assumes a degree of commensurability in that there are equivalent levels of different components, which are of equal importance. Weights applied to the contribution of each component reflects the analysts' perceptions of their relative importance.

In the case of biosecurity, a utility score for a particular measure might comprise such elements as:

- its effectiveness in detecting organisms;
- the seriousness of the threat posed by the organisms likely to be affected; and
- the clarity of line responsibilities (chain of command) in implementing the measure which affects the chance of it being misapplied.

3.2.3 Multiple-criteria analysis

Multi-criteria analysis (MCA) is not a single methodology, but rather a suite of techniques for assessing different levels of weighting for project options that deliver a varying mix of outcomes. Some multi-criteria analyses take a form very similar to CBA, except that instead of reducing all the diverse outputs to a common currency, they are assigned weights or scores on criteria which are not explicitly economic. Their efficiency implications are therefore cast in terms of maximising "weight-scores" per unit expenditure, rather than an economic return, and can be similar to a cost utility analysis. Other forms of MCA subsume a financial analysis within a broader set of criteria relating to desirable project outcomes, such as distributional impacts, timeliness and effects on the physical environment.

3.2.4 Precautionary principle

The precautionary principle states that paucity of proof about potential risk of damage should not deter taking action against the threat of irreversible changes. In the case of biosecurity the precautionary principle is most likely to be invoked to take measures against establishment of unwanted organisms whose long term effects on the environment are uncertain. This may be applied in a perceived "zero-infinity" scenario, where the probability of damage from an activity is very low, but the potential magnitude is significant or catastrophic. In such a case, the precautionary principle would support taking measures against such activity from going ahead. This principle assumes a degree of risk-aversion on the part of decision makers, and may prove expensive in terms of benefits foregone. New information which significantly alters this outlook is required in order to revise a decision under this criterion.

3.2.5 Safe minimum standards (SMSs)

In a similar vein to the precautionary principle, the adoption of a safe minimum standard involves adherence to a standard, unless the costs of so doing become excessively high. What exactly constitutes “excessively high” is open to interpretation, and usually relies on political judgement, assisted by expert technical advice. An example in biosecurity would be maintaining a level and standard of surveillance activity disproportionate to the apparent risk if the cost of so doing is low and the possible effects of incursion undesirable.

4. APPLICATIONS OF TECHNIQUES

Applying the principles of CBA is not straightforward. There is often considerable uncertainty surrounding the probability and magnitude of outcomes. Risks regarding a biosecurity breach include:

- the likelihood of an incursion. This will include aspects such as the volume of trade and tourism from particular risk countries, and the mode of transport (air, sea etc);
- the likelihood of the unwanted organism surviving the trip, and subsequently establishing a breeding population;
- in the case of disease vectors, the probability of their being / becoming infected, and transmitting infection;
- the speed of spread / distribution of organism / disease;
- the likely scale of spread (geographical area) of organism / disease;
- the ecosystem response to the unwanted organism;
- the irreversibility of outcomes.

Risk factors in treatment responses include:

- response of organism;
- ecosystem response;
- irreversibility.

In practice, approximations of effects are likely to be the best one can expect. There are a number of techniques available to assist decision-making under a CBA framework.

4.1 Standard cost-benefit approaches

4.1.1 Expected values

A common way of assessing uncertain future outcomes in CBA is to use expected values, which assign probabilities to the costs and benefits associated with the outcome of a given activity. The expected value is the product of the probability of a particular event and the magnitude of its cost or benefit. Expected values are appropriate for assessing some types of biosecurity risk – such as damage of trade disruption from an outbreak of farm animal disease, which can be restored in the medium to long term – but alone are insufficient for considering other types of biosecurity risk, such as those implying potentially catastrophic health impacts. For instance, a chance of one in a million that there will be one million deaths has an expected value of 1, identical to a risk of one person being killed with certainty. But many people would not agree that these two risks are equivalent, and expressed public concern about low probability catastrophic events suggest they weight such risks more heavily than expected values suggest. Since economic values serve as expressions of public preferences, and these reflect dimensions of anxiety, dread, familiarity and control which are not correlated with objective probabilities, biosecurity assessments need to distinguish different treatments for valuing the different types of risk.

4.1.2 Expected utility

Estimating expected utilities involves weighting the factors in an expected value calculation, to reflect such risk aversion. It acknowledges that the outcome of a less risky event may hold higher utility for society. The determination of these weights is necessarily arbitrary. The results can be compared with the direct costs associated with undertaking the activity.

4.1.3 Sensitivity analysis

Testing the sensitivity of results to changes in estimations of costs, benefits and other key assumptions gives some idea of the upper and lower bounds of the probability ranges around biosecurity risks and values which are inherently uncertain.

4.2 Specific changes for dealing with uncertainty

4.2.1 Delaying a decision

A decision may be delayed if there is the likelihood of risk being reduced by further relevant information coming to light during the delay. However, there are costs as well as benefits associated with delay, such as the opportunities foregone over the delay period. In the case of biosecurity, this is most likely to apply to decisions on relaxation of current controls, because of the inherent irreversibility of potential impacts of organisms slipping into the country.

4.2.2 Changing the discount rate

If the range of greatest and lowest future outcomes diverges over time at a constant rate, it may be appropriate to raise the discount rate, diminishing the apparent magnitude of long-term impacts, and discouraging hastily-conceived biosecurity interventions. But such divergence between future outcomes may be unlikely in a biological scenario.

4.2.3 Changing the cut-off benefit:cost ratio

Raising the benefit:cost ratio will increase the beneficial return necessary from a project, in order to secure its approval. Its effect is to discourage hasty response measures with uncertain outcome.

4.2.4 Pay-off matrices

A pay-off matrix shows the outcomes of various combinations of actions and states of nature, which may be derived from a CBA comparison of options. This tool does not determine which option to proceed with, but presents the information in an easily comprehensible format, showing the trade-offs between various strategies, including the “do nothing” option.

Table 1 (below) is an example of how such a matrix may be used, illustrating the various options available in the event of a biosecurity incursion by a creature such as the white-spotted tussock moth (as occurred in Auckland in 1997). It allows for the possibility that there may be no moths at large in the country at present, and that, if they are present, they may not be successfully eradicated by the various spray options. The benefits derived from particular actions comprise the avoided damage of moth establishment, less any costs incurred in achieving those benefits. Doing nothing maximises the potential benefits in the event that no moths are present, but also minimises the maximum loss in the event that they are present and eradication is unsuccessful. The lower “regret matrix” highlights the opportunity loss under different states of the world, or the difference between a particular strategy and the most beneficial strategy under each state of the world.

Table 1: Pay-off matrix for tussock moth eradication

Strategy / Outcome	No Moths Present	Extant Moth Population: Eradication Successful	Extant Moth Population: Eradication Failure
Do Nothing	0	-	-$D
Monitor only	-4.2M	-	-($D+4.2M)
Monitor & groundspray	-	-4.6M	-($D+4.6M)
Monitor & aerialspray	-	-5.5M	-($D+5.5M)

REGRET MATRIX

Strategy / Outcome	No Moths Present	Extant Moth Population: Eradication Successful	Extant Moth Population: Eradication Failure
Do Nothing	0	-	0
Monitor only	-$4.2M	-	-$4.2M
Monitor & groundspray	-	0	-$4.6M
Monitor & aerialspray	-	-$0.9M	-$5.5M

Notes: (1) $D is cost of damage from moth establishment

Source: NZIER

The table shows that even if there are no moths present, there can still be substantial cost involved in monitoring to establish that fact. If they are present and eradication is successful, the cost incurred is that related to the different eradication options, raising a subsidiary question of whether the more expensive option confers a greater likelihood of successful eradication. If eradication is unsuccessful, the cost incurred is the cost of the activity plus the long term cost of damage from the organism over time. The value of damage, $D, may vary between the do nothing and the spraying options, since even an unsuccessful eradication attempt may defer the organism's impact, lowering its cost in present value terms. However, this does not change the general principle that if there is a significant likelihood of eradication being unsuccessful, there will be long term costs of future damage incurred in addition to costs of the eradication attempt.

The regret matrix illustrates how much worse off the community will be following each option under each state of the world. If the community undertakes monitoring and finds there are no moths present, it will be worse off by the $4.2 million cost of monitoring, although this spending may have bought it some peace of mind. If moths are present and successfully eradicated, the community may regret spending $0.9 million more on aerial spraying than it needed to spend to achieve the same result by ground spraying – but this raises the question of whether there is additional likelihood of success from aerial spraying which justifies additional costs of that magnitude. If moths cannot be eradicated, the community is worse off by the full cost of whichever action it adopts to establish that fact – monitoring, ground spraying or aerial spraying.

Such a matrix approach does not provide simple decision rules. But it does highlight critical questions for decisions, such as the likelihood of establishment, the scale of potential damages and the feasibility and likelihood of successful eradication.

5. ALLOCATING COSTS AND BENEFITS

The Biosecurity Act is implemented through Votes Biosecurity, and involves a series of fiscally neutral transfers to various responsible government agencies. In the Government's estimates for the 1999/2000 fiscal year, $91.5 million was appropriated to Votes Biosecurity, the shares administered by separate agencies being Ministry of Agriculture 95%, Department of Conservation 3%, and 1% each for Ministry of Health and Ministry of Fisheries. Of the combined total, the allocations to departmental output areas were 41% to border operations, 21% to surveillance and control programmes, 11% to disease and pest response capability, 2% to specific disease and pest responses, 17% to regulation and standard setting, and 8% to policy advice. There are also non-governmental contributors to biosecurity activities such as pest management strategies.

The Act provides for cost allocation between beneficiaries of a measure and exacerbators of the problem being addressed, but provides no specific guidelines as to how this may be done. Section 61 requires a proposal for a specific measure to contain a rationale for the proposed allocation of costs, identifying the extent to which any persons are likely to benefit from the strategy, and the extent to which any persons contribute to the creation, continuance or exacerbation of the problems proposed to be resolved by the strategy.

Examples of beneficiaries and exacerbators of biosecurity are outlined in the table below.

Table 2: Users of biosecurity

Beneficiaries and risk exacerbators

Use beneficiaries	Non-use beneficiaries	Risk exacerbators
Commercial farming	Public health	Importers
Horticulture industry	Ecosystem biodiversity	Tourists
Forestry industry	Indigenous species	Primary industries
Fishing industry	Future generations	
Commercial animal breeders		
Future generations in these industries		

Source: NZIER

5.1 Economic principles of cost allocation

Cost allocation questions arise because of the joint production of benefits serving different end user groups. If all biosecurity measures were clearly attributable to specific groups of users, and their costs increased in strict proportion to the amount of use made of the measures, it would be easy to identify the marginal cost imposed by each additional user of each different type, and charge accordingly by the most cost effective means available. But where there are joint costs of production, and/or significant fixed cost components in supplying the measures, a portion of costs are incurred regardless of use and, being shared between users, are unattributable to individual users or groups of users.

Economics provides no precise guide as to how such shared costs should be allocated to different types of user. At the least each user or user group should pay the marginal cost of their use, i.e. the additional costs their use imposes on the system. At most each user could pay up to what it would cost them to obtain the same service on a stand-alone basis. A funding mechanism requiring any one user group to pay more towards a service than it would need to under a stand-alone scheme implies cross-subsidy and inefficient incentives.

These principles set the boundaries within which individual contributions can efficiently be set, but in practice the difference between these boundaries can be wide, and it can be difficult to identify the relevant marginal costs or stand-alone service equivalent. Full cost distribution formulae exist for allocating unattributable joint costs to various types of user in proportion to their share of attributable costs or outputs consumed, but these can be inefficient by loading joint costs disproportionately onto groups least able to bear them. An alternative is to apply Ramsey pricing principles which allocate costs in inverse proportion to users' price sensitivity. This is efficient in minimising disincentives to use the service, but generally impractical in requiring knowledge of respective price elasticities of demand which is difficult to come by. Joint costs for services with public good characteristics are likely to be allocated according to political assessment of what are "fair shares", often "equal" shares which are not necessarily the most efficient or equitable from an economic perspective.

As previously discussed, there are limits to how far biosecurity can be regarded as a public good: some groups clearly benefit more than others, and some precipitate more biosecurity measures than others. There is a case, then, for considering user-pays (at least in part) for biosecurity, if it is worthwhile to do so (ie. the costs of collecting user charges is less than the revenue received).

However, the amount by which individuals or groups benefit or contribute to risk may not be readily quantifiable. For example, trade volume/worth is more easily measurable than public health benefits from the absence of incursions. Groups who can be feasibly charged include importers and relevant primary industries. Areas where the risk is greater (such as ports with high proportion of cargo from high-risk countries) could be assigned a greater proportion of the cost.

In setting and assigning charges, it is useful to know the degree of private biosecurity measures that would occur in the absence of government intervention. This would provide some estimate of willingness to pay for biosecurity, by those on whom such activity has a direct effect.

Setting user charges can aid the internalisation of risk, and reduce the "free-rider" problem inherent in public goods. Free riding in biosecurity includes those affected failing to take account of the costs they generate, or benefits they reap, in their decision-making. For example, horticulturalists can influence the degree of biosecurity risk they pose in their selection of plant varieties (susceptibility to disease, pests) or inviting tourists to their farms. A recurring risk for a biosecurity system is the advocacy of collectively funded measures (such as eradication of a farm pest) by organised interest groups, when there are individual measures they could take to lower risk at higher private costs to themselves (e.g. pest resistant species) but lower social cost to public agencies and the community at large.

5.2 Cost recovery

There can be a trade-off in cost-recovery between raising revenue (e.g. to relieve fiscal needs) and setting charges for efficient price signalling. Revenue is often best raised by low charges across a broad base of contributors, so as to minimise distortions to resource use choices. Price signalling, by definition, aims to change behaviour at the margin, and requires high charges imposed on targeted activities. The objectives of cost recovery are identified in the guidelines for setting charges in the public sector (The Treasury, 1998):

- encouraging decisions on the volume and standards of services demanded that are consistent with the outcomes sought and the efficient allocation of resources generally;
- minimising the cost of supply both over the short term, and the long term when capital costs are significant;
- keeping transactions costs low, and evasion at acceptable levels;
- reducing reliance on funding from general taxation (with its associated costs);
- dealing equitably with the taxpayer, those who benefit from the output, and / or those whose actions give rise to it;
- looking for new ways to lower costs and find appropriate providers.

These objectives address efficiency, equity and fiscal concerns. Where there is a clear individual purchaser of a biosecurity service, charging the purchaser a transaction fee that recovers the marginal cost of providing those services ensures that the objective of allocative efficiency is met. Selecting between this and other charging options will come down to considerations of equity, fiscal imperatives and practicalities.

6. SUMMARY AND CONCLUSIONS

Economic approaches to biosecurity

Economics is primarily the study of resource use choices, and what is to be obtained from different resource allocations. As such it is concerned with the ways social preferences get expressed, through markets or other allocative mechanisms, and also with how inputs are combined in production processes to achieve particular mixes of desired outputs.

Biosecurity can be regarded as a production process, like other aspects of security - protection against foreign adversaries, environmental catastrophes or the internal security breaches represented by criminal behaviour. It requires diverting inputs from other potential uses to achieve a desired goal, which in the case of biosecurity is normally some measure of reduction in risk of potentially damaging incursion by alien organisms.

Since the risk in biosecurity is that damaging organisms will arrive accidentally, or that a deliberately introduced organism will have unforeseen effects in its new environment, the same economic principles apply to biosecurity as to other accident prevention. The choices in biosecurity are broadly between:

- regulating for precautions that reduce the chance of accidental damage, or lessen its severity;
- detecting breaches of biosecurity controls, and monitoring for incursions;
- prescribing response procedures to be taken once an accidental incursion has occurred.

Although these measures could be seen as a package of complementary actions, choices are still required in determining both the selection of components (what goes into the package), and the relative emphasis given to the elements. Ideally, such resource allocation decisions will be made on the basis of equating marginal benefit with marginal cost.

An initial step in economic analysis of biosecurity policy and systems, therefore, is to identify the inputs required, the outcomes sought, and the transformation processes that will need to be applied. Viewed in this light, biosecurity can be considered against a range of criteria:

- effectiveness in achieving the desired end, since not all processes or methods will be equal in this respect;
- efficiency in achieving the desired end in the sense of minimising the input cost per unit of risk reduction achieved;
- equity in process and in achieving the desired end, recognising that the costs and benefits are likely for all unevenly across the community.

Another characteristic of the economic approach to biosecurity is that it is focused on marginal analysis, comparing the increment of inputs (costs) with the increment of outputs (benefits) gained. Economics provides a simple but powerful rule for determining how much to spend on accident abatement: provide abatement to the point where the marginal benefit obtained just equals the marginal cost. Allocating inputs across activities to the point where marginal costs just equal marginal benefits will ensure an efficient allocation to each activity. The margin of interest may vary from a single production unit to a project to an entire programme, but the principle of looking at each increment's costs and benefits remains as a discipline for economic allocation. It provides distinct allocations from some other procedures that distribute new resources in proportion to total size of affected sector.

A corollary of this focus on the margin is that the economic optimum for biosecurity risk or residual pollution is unlikely to be zero: rather, equating marginal costs and benefits will likely show some residual level of risk which it is simply too costly to eliminate. Economic analysis usually involves weighing up gains and losses on some commensurable basis. Only rarely does it employ an "imperative standard" which *must* be met, and even when it does, in practice these standards are still constrained by affordability, the recognition of other resource use opportunities forgone, and the need to obtain value for money.

How economic analysis can assist biosecurity decisions

Apart from providing an approach or framework within which to view biosecurity issues economics also provides a number of specific tools to examining particular choices. Techniques like cost benefit analysis and cost effectiveness analysis can establish whether a particular proposal is worthwhile and how it compares with other options. They also provide a means for assessing who in the community is likely to benefit from a proposal and who is likely to bear the burden. Further, the process of going through the exercise of an economic analysis provides a means of identifying incentives to act in support of or against the proposal, what enforcement is likely to be needed and what its success is likely to be.

Principles for cost allocation

The Biosecurity Act refers to both beneficiaries and exacerbators of biosecurity risk having responsibility to contribute, but provides no clear guidance as to how this should be put into effect. Although economics has no clear-cut answers beyond suggesting that each contributor to collective biosecurity should pay at least their marginal cost but not more than they would pay for stand-alone measures delivering similar benefits, it offers some useful principles.

One is to ask how the incentives align within the biosecurity system, since there will be less monitoring and enforcement required if self-interest coincides with public outcomes. Another is to examine who is in the best position to influence desired outcomes, since transaction costs are likely to rise the further away are the operatives from the things they are trying to achieve. In this respect collectively funded schemes are often at a disadvantage, having weak inherent monitoring characteristics which allow wastage and the threat of moral hazard to creep in. Setting up partnership arrangements in which partners have incentive to monitor each other’s actions may provide one way around this risk.

Incentives and barriers for biosecurity

A country’s biosecurity can be regarded as a common pool resource, in which the possibility of some individual’s free-riding off others efforts provides a disincentive for worthwhile private initiatives. While this provides a case for judicious intervention, there is also a risk that shielding individuals from the full cost of their activities, or compensating them for their losses, may prompt them to expose themselves to added risk and increase the costs of protection services shared by all.

Market structure, pricing and costs

Biosecurity systems currently have a mix of responsible parties, including industry bodies, regional councils, and central government. Even within central government responsibility is shared between agencies with different focus, a situation in which it is easy for problems and responsibilities to become blurred, undermining effectiveness of proposed solutions.

Comparison between biosecurity and other public spending

Biosecurity has similarities to other government expenditures, such as military capability and civil defence, in that it is dealing with potentially large impacts which have a very low probability of occurring. As with these other activities, the scale of potential impact and its probability of occurrence are practically indeterminate.

Unlike these other activities biosecurity has some distinguishing features. One is that some biosecurity breaches are practically irreversible unless nipped in the bud, and the consequence of inaction is a transformation of some aspect of New Zealand existence in perpetuity. Another distinctive feature is that there are some clearly identifiable prime beneficiaries of biosecurity, and who may be organised enough to pursue an interest in securing collective funding for things of primarily private benefit. Biosecurity systems may be susceptible to interest group capture and any review needs to be alert to the incentives of those who make representations on the risks and potential solutions.

In the absence of commensurable measures of output across different expenditure areas, allocations to biosecurity and other activities are largely determined by political processes. But these can still be informed by economic analysis, so as to improve the efficiency within allocations.

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