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Value of defensive R&D investments

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Abstract

Meat and Livestock engaged The CIE and ACIL Allen Consulting to develop a framework for assessing 'defensive' R&D investments by identifying information requirements and practical methods to describe and quantify risks associated with this class of investment. Defensive investments insure against uncertain adverse events in the future that could potentially impact on the value of the industry.

These investments can either influence the probability of occurrence for the adverse event or mitigate the impacts once the event has occurred. Three case studies were used to explore these characteristics including investments in improving FMD preparedness, a non-surgical approach to spaying and the National Pasture Genetic Resources Centre.

The project found that a common attribute of this class of investment, in the context of the LPI portfolio, was that benefit streams were particularly difficult to quantify because of lack of information around the probability and timing of the adverse event and more generally, how benefits flow to industry and the wider community.

More generally, availability of information rather than economic approach or technique was the major constraint. It was therefore not possible to identify one single framework to enable MLA staff to quantify defensive style investments, benefit –cost analysis and the development of a plausible 'without-MLA' investment case will continue to be crucial. Therefore, a pragmatic approach is required based on availability of data and resources. These findings have direct implications on how to approach evaluation of this style of project including the combination of ex ante and ex post review and collection of critical data.

A major conclusion was that the primary beneficiaries are levy payers in industry, and as such, defensive style investments should be compared directly with other productivity-based investments in the LPI portfolio. This comparison should be made initially using the tool developed in the companion project B.COM.1084 supported by strategic detailed quantification of economic benefits and cost.

Table of Contents

1 Executive summary

1.1 Purpose

Defensive investments are a particular class of project, accounting for nearly half MLA's Livestock Production Innovation expenditure. Defensive investments are insurance orientated in that they seek to avoid or mitigate the losses from uncertain adverse events. These characteristics make defensive investments harder to assess and difficult compare against other projects in order to balance the LPI portfolio.

This project developed a framework for assessing and evaluating LPI's defensive investments. The framework was created through reviewing previous approaches to identify key principles which were applied to three case studies on current LPI projects

1.2 What characterises a defensive investment?

Defensive investments are usually thought of in the context of the management of financial portfolios and insurance against the risk of adverse events, where the probability of occurrence is uncertain. Defensive investments manage this risk by either reducing the probability of an adverse event happening or increasing the capability to minimise losses once the event has occurred.

In practice, investments can have a defensive or both a defensive and offensive orientation. For example the improving FMD preparedness case study covers defensively oriented projects addressing a constant technical risk and subsequent market and political risks.

The non-surgical spaying and National Pasture Genetics Resource Centre case studies have a defensive (evolving technical and compliance failure risks) and offensive (potential productivity benefits) orientation.

1.3 Evaluating individual defensive investments

Benefit-cost analysis (BCA) is the foundation technique required by both the MLA Evaluation framework and CRRDCC evaluation guidelines to develop a comprehensive value of the net benefit of a project or project cluster.

In the majority of cases it will only be possible to evaluate defensive investments on an ex ante basis given the adverse event is unlikely to occur. The evaluation is dependent on a number of factors including:

- the probability of the adverse event occurring
- the value of the asset being defended (some component of the red meat industry)
- time delays in activating the defensive investment or mitigation response
- the cost of developing the defensive investment in the first place which accounts for considerations such as the cost of information
- the investor's (i.e. levy payers) aversion to the adverse event (risk preference)

As a result traditional BCA can be too structured to account for the uncertainties and complexities posed by the option of making the investment or leaving it idle at the time of decision.
It is important to note that it is the uncertainty and lack of information at the time of decision making, rather than the investment being defensively oriented that makes evaluation challenging.

The project has identified four alternative techniques which have been used to evaluate defensive investments: decision trees, sensitivity testing, Monte Carlo simulations and real option methodologies. These could be used to evaluate defensive LPI investments. However each technique requires additional resources, in terms of time, data and capability to develop them.

They are also subject to the same limitations as BCA. That is relevance to all LPI investments and lack of quality ex-ante data. As such these tools may not necessarily improve the efficiency and effectiveness of the MLA's defensive investment decision making.

A practical response is for MLA to retain BCA as the foundation evaluation technique and to augment defensive investment evaluations with the additional techniques to address the associated uncertainties and complexities. This indicates that such techniques should be used strategically, not as matter of course, to improve MLAs knowledge base and decision making. A further point is evaluations of defensive investments should only be updated if there are changes to the value of the asset being defended changes or the probability of an adverse event occurring.

1.4 Case study findings

1.4.1 Improving FMD preparedness

To quantify the costs of an FMD outbreak requires a range of data inputs and assumptions to be made. This is a resource intensive process but information, rather than available techniques, is the major limitation. The update of the potential costs of an outbreak should be conducted on an ex ante and irregular basis. The trigger would be the emergence of new information on the probability of an outbreak, changes in the time taken for Australian response or structural changes in key markets. This would provide the new baseline for calculating the benefits of MLA funded projects in this space. That said, we have identified that for a project designed to improve FMD preparedness and response, the marginal benefit will be determined primarily by the reduction in time of exclusion from key export markets. As such, in the planning and evaluation process, this variable should be identified as a key project outcome with some attempt made to quantify and discuss it. Another benefit of such an analysis would be that it would inform how the benefits of such a program are shared between the respective livestock industries. This is an example where a defensive project delivers primarily industry benefits with limited spillovers to the wider community.

1.4.2 Non-surgical spaying procedure

This cluster of projects represents a long- term investment by MLA to develop a replacement for a practice that would have both productivity and animal welfare benefits. This case study does not neatly fit into the defensive investment mould as defined by this report. The adverse event, which is being insured against, is reasonably certain and known, hence the high priority given to it by industry. The objective is to find a step change improvement in technology rather than incremental knowledge. The somewhat uncertain technical probability of success of the project should have given it a priority for on-going evaluation and monitoring. If successful, then adoption will be critical to establish the benefits on an ex post basis. If the objective of the project is primarily animal welfare, then this project(s) should be compared against other projects that also identify animal welfare. The majority of the potential benefits, are expected to be industry (private) benefits. Animal welfare benefits remain impractical to quantify.

1.4.3 National Pasture Genetic Resource Centre

This case study is another example where the approach taken to obtain estimates of benefits from this investment is a pragmatic solution to the lack of data and knowledge, rather than a deficiency in approach or tools. The approach taken in the ex ante evaluation provides an indication of the magnitude of the benefits, but also some guidance on how the benefits could be shared between beneficiaries (in this case, the distribution of benefits is similar to that on a GVP basis).

In contrast to the FMD case study, there is an opportunity to better inform MLA decision making and reporting by the collection of information that would, support ex post evaluation. This

additional data should provide information around the pathways, and the extent, to which stored genetic resources result in new pasture cultivars that would be adopted by industry.

1.5 Evaluating defensive investments within the LPI portfolio

In terms of the overall LPI portfolio, MLA needs to invest in a mix of defensive and offensive projects that provide the greatest potential value against its priorities. The related B.COM.1084 project found that BCA or other quantitative techniques are not a feasible or cost effective way for LPI to measure the value of its investments.

This finding is confirmed by this review which has found that defensive investments require strategic and deeper evaluations in order to develop quantified assessments. These evaluations should be part of the broader detailed evaluation program but would not be cost effective in LPI's project selection process. Over time, lessons from detailed quantitative assessment could be fed back into the LPI decision making process and also used in reporting to levy payers and other stakeholders.

The review also found that defensive investments can have both industry and private benefits. In many cases the rationale for investment stems from MLA's remit, or obligations, as the red meat industry services organisation as much as the scale of any potential impact.

These findings reinforce the need for MLA to utilise a qualitative multi-criteria analysis to assess all projects. The B.COM.1084 project provides a tool for measuring the value of all projects based on impact and remit. The tool also includes a confidence rating so that the uncertainties of each assessment are transparent. This will provide the basis for balancing the project mix in the portfolio against risk, priorities etc., irrespective of whether they are defensive, offensive or have any other particular characteristics.

1.6 Recommendations

- Projects and clusters that have characteristics of defensive investments should be assessed against *all other projects* in the LPI portfolio on the basis of their impact (benefit to industry) and the remit for MLA to fund the investment.
- Use the qualitative multi-criteria analysis, as developed in the B.COM.1084 project, to cost-effectively assess all projects providing the basis for balancing the project mix across the LPI portfolio.
- Conduct and update BCAs *strategically* to address associated uncertainties and complexities as part of the wider MLA evaluation process to improve MLAs knowledge base and decision making.

2 Introduction

MLA, like the other 13 rural research and development corporations is a service provider to industry. The principle functions of MLA are to:

- collect and account for the levy and public contributions
- prioritise, in conjunction with levy payers and the Government, the investment of the funds collected in the areas of research, development, extension and marketing
- enter the science, development and extension market to procure the required services
- develop a path to market for the results of the research and development investments and promote adoption of them
- evaluate the performance of the investments, not only in terms of effectiveness and efficiency, but also in terms of payoffs to investors
- oversee and ensure that the investments made are in the best interest of those contributing.

Therefore, a central function of MLA is to allocate investments across a portfolio where the distribution of these investments has the highest probability of optimising the expected returns for contributors.

MLA's Livestock Production Innovation (LPI) allocates considerable funds to defensive investments designed to avoid or mitigate potential losses. For example in the area of biosecurity, to prevent entry of diseases with consequent productivity, welfare and market losses; and environmental management, to prevent loss of markets arising from negative consumer perceptions while still maintaining productivity advantages and ensuring sustainability. An estimated 46 per cent of the current LPI portfolio has a 'defensive' character, aimed at avoiding or reducing loses in the face of uncertain future events.

Defensive R&D projects that ensure producers' social license to operate and prevent loss of market access are not readily amenable to traditional BCA methods, because of the high future uncertainty. Alternative approaches to assess risk and associated payoffs are available to value such investments. The information generated by this project will help MLA determine the appropriate level of investment in these areas within the broader LPI portfolio, and provide tools or methods to assist in decision-making regarding such investments in the future.

Objectives of this project are to:

1. Undertake a literature review of previous approaches to assessing 'defensive' R&D investments and the risk insurance field relevant to agricultural R&D including the application of frameworks and economic/risk modelling to evaluate R&D investments.
2. Define and detail the context for Australian agriculture and MLA activities including:
    - identifying the main types of risks in Australian agriculture and meat and livestock industries more specifically;
    - roles and responsibilities of MLA as an industry service provider, in terms of what areas it should and should not be involved in (industry considerations of defensive investments compared to MLA considerations);
    - types of defensive investments and options for MLA
    - how does MLA's prescribed discount rate for R&D evaluation impact on the evaluation of such investments.
3. Develop a framework for evaluation and assessment for defensive investments
    a. identifying the potential risks to be addressed by the investment;
    b. agreement on a probability matrix outlining possible outcomes/success rates under different conditions;
    c. inclusion of dynamic considerations, that is, which elements are likely to change over time;
    d. assessment of the modelling options available (real options, decision trees); and
    e. value calculations and use of confidence intervals

4. Apply the framework to four case studies, in consultation with MLA, for each of the following themes:
    - biosecurity or animal health
    - animal welfare,
    - environmental management, and
    - productivity focussed research where there are potential trade-offs between
    - productivity and eating quality and hence consumer perceptions of the product.
5. Report on the tested framework for application by MLA in assessing 'defensive' R&D investments outlining information requirements to apply the framework, practical methods to describe and quantify risks and associated investment choices; and capacity building requirements in terms of data collections and staff skills.
6. Assist LPI staff in understanding and applying the framework by conducting at least one workshop, and up to two workshops, with MLA R&D managers.

To achieve these goals, a case study approach was taken not only to answer these questions but also to provide MLA with useful and relevant information on current projects that would be useful in their day-to-day decision making. The three case studies of MLA investments were:

- continued investments in foot and mouth disease (FMD) preparedness
- development of a non-surgical techniques to spay heifers and cows (spaying)
- funding the National Pasture Genetic Resources Centre.

The primary audience for this work will be the MLA board and program managers. This group are already making a range of decisions concerning investment in defensive activities. This report aims to provide a framework and a better understanding of the key decision variables that underlie the investments rather treating them as an 'article of faith' or simply a requirement to comply with mutual obligations that are set out in various agreements between stakeholders in industry and government.

- It is these perspectives that drive funding levels that are based on historical allocation shares rather than information of expected benefits in terms of avoided costs.

A reasonable starting point is to review previous analysis to establish the underlying logic and overall approach to quantification. There are a number of components to this analysis:

- the characteristics of the proposal and how this aligns to the concept of a 'defensive' investment' such as the key uncertainties including identification of an appropriate baseline or 'without investment' case
- how you would go about capturing information about these uncertainties as part of an overall approach to quantify the potential benefits that would flow from the investment.

3 What are defensive investments?

Defensive investments are most often thought of in terms of a financial portfolio. They are strategies established to limit the risks or uncertainties of losing the principal of the investment. While they allow for upside and growth possibilities in the market, their primary consideration is to remove or limit the chances of the final investment position being worse than the initial investment position (often allowing for a small rate of return). A defensive strategy is usually one of the approaches to optimising or balancing a financial portfolio.

The importance of defensive strategies in the total portfolio would be expected to vary from investor to investor reflecting their attitudes to risk and the prevailing state of the market in terms of expected returns. For example, investors close to retirement are likely to pursue a more defensive strategy of lower, but more certain returns. Additionally, defensive investments may be predominant when financial markets are falling or becoming unpredictable.

In the context of allocation within a portfolio of research, development and extension (RD&E) and marketing by a research development corporation (RDC), what is being 'defended' through the defensive investment is not the initial investment position, but the capacity to earn income and maintain market position. The RDC and industry does this by collectively taking actions to mitigate risks of uncertain future events that would have an adverse impact on industry income.
By design, defensive investments are likely to take a relatively conservative approach to earning returns. In contrast, offensive investment strategies target higher growth opportunities at a cost of a higher risk of losing the initial principal investment. The definition of a defensive investment compared to an offensive investment is generally related to its insurance type protection of market position or its drive for growth.

The method of valuing defensive investments is likely to be different to that of valuing offensive, or growth, investments. In general, the approach will be similar to the approach taken when valuing the return on an insurance policy. That is, it is not necessarily correct to require a monetary return, or financial payout from an insurance policy. The implicit value of the policy is

based on the mitigation of the risk of losses. Just because no loss eventuated and there is no payout on the insurance policy does not mean the policy is of no value.

Once a decision is made to proceed with a defensive investment strategy, there are a number of factors to consider in determining the most appropriate and effective investment type to follow, including:

- the type of risk being faced
- the means through which losses should be mitigated (reducing the chances of an event occurring or reducing the damage once an event occurs)
- whether new information is likely to come to light after the initial investment decision but before completion, and how this may be capitalised upon.

3.1 Approach to risk

A defensive investment may target risk within a market through two main avenues:

- reduction of the risk that an adverse event will occur; and/or
- increasing the ability to adapt to and address an adverse event once it occurs.

That is, the first option is to alter the risk profile of the event, reducing the likelihood that it will occur and result in losses. Examples of such defensive investments may include vaccination schemes reducing the risk of a disease outbreak. The second option possible for a defensive investment is not to alter the probability of the event, but to reduce the costs associated with an event occurring — for example, improved procedures and protocols to fast track treatment and vaccination in the case of a disease outbreak.

The choice of defensive investment will depend heavily on the type of risk being faced, and whether or not the risk parameter (chance of an event occurring) or the response parameter (effect of an even occurring) is more efficiently targeted.

3.1.1 Insurance policy

The obvious comparison is between defensive investments and an insurance policy, say for house and contents. There are a number of similarities:

- up-front and ongoing expenditure (the insurance premium) is required to insure or protect the value of the asset should an adverse event occur (the house burns down)
- the probability of this event is not known with certainty and, the insurance policy may never be claimed against
- generally, if the value of the asset protected changes (the market value of the house appreciates) or the chance of the adverse event changes (the house becomes a rental property) then the premium will change
- the true benefit of the defensive expenditure may only be assessed ex post after the occurrence of the adverse event.

3.1.2 Types of risks being faced

Four main categories of risk faced across the Australian meat and livestock industry are of interest when developing defensive investment portfolio:

- constant technical risk
- evolving technical risk
- compliance failure risk
- market access and political risk.

These categories are delineated based on whether the risk parameter may be altered as well as which portion of the market is most affected by the risk.

3.1.2.1 Constant technical risk

Many agricultural, environmental and even commercial risks are considered to be fixed. In the context of agriculture and MLA's activities, a constant technical risk is one that it is not possible, or it is prohibitively costly, to attempt to alter. A constant technical risk may remain fixed over time through natural factors or maintained action by farmers, politicians or veterinary scientists for example.

An example is that the consensus view of risk of foot and mouth disease entering Australia is considered more or less fixed. This probability is a joint product of ongoing quarantine measures committed to by government and a range industry and geographic factors such as the probability of industry of including risk materials in feedstuffs for bovine and ovines.

Where there are technical risks and the risk value is unaffected by actions taken by MLA, the most effective and efficient defensive investment strategy is likely to be directed at mitigation of an event, rather than prevention of an event. For example, the investment's objective is likely to be along the lines of minimising the time taken to return to market after an outbreak.

3.1.2.2 Evolving technical risk

Evolving technical risks are not constant over time and have the ability to be altered through actions. These risks may either be affected by human actions, therefore may be reduced, or they may be altering over time in a manner that must be accounted for in valuations but may not be affected by human actions. Two examples are climate change and research into productivity improvements:

- climate change and greater seasonal variation are considered evolving technical risks that are largely external to the actions of producers and industry stakeholders — while the risk factor changes over time, there is little action that can be taken to alleviate this
- the impact on eating quality from productivity improvements and larger carcass weights is considered an evolving technical risk that changes over time in direct response to actions taken by producers and the industry.

3.1.2.3 Compliance failure risk

Compliance failure risk refers to the risk that industry participants may act inappropriately and jeopardise the social, community and market standing of the industry. An example is a failure to comply with animal welfare codes of practice or environmental standards and community perceptions of sustainable practice.

In general, the probability that an adverse compliance failure event may occur can be affected by defensive investment choices. These risks are likely to benefit most from mitigation based defensive investments, that minimise the chances of stakeholders not following industry based codes of conduct and meeting community expectations of production protocols.

3.1.2.4 Market and political risk

Beyond the actions of producers and industry, market risk refers to changes in consumer perceptions and demand for a product. An example of market risk may include a change in perception of Australian meat overseas. Political risk, a broader concept of sovereign risk, refers to changes in domestic or international policy that affects the market access.

The obvious example of political risk includes the decision by the Australian Government to suspend of live trade to Indonesia due to animal welfare concerns. Another example is governments, or their agencies, imposing more stringent compliance requirements or barriers that also restrict market access. An example would be the imposition of country of origin labelling

or requirements for inspection of individual cartons of product. While not as dramatic as closure of a market, these requirements pose a considerable risk to industry over time in increasing the costs of doing business.

3.1.3 Defensive investments by risk type

While there are likely to be many risks that cover one or more of the above categories, they provide a starting point for consideration of how defensive investments may be developed and applied. Table 3.1 provides a cross reference of the high level risk types and the form of defensive investment that may or may not be feasible.

For example, in the case of a constant technical risk, it is not possible to reduce the probability of the event occurring and so the only effective defensive investments will focus on adaptation to and mitigation of the consequences of an event should it occur.

Both evolving technical risks and market and political risks may be addressed either through actions to directly affect the risk parameter, or to consider means of adapting to or mitigating the effects of the event should it occur.

Table 3.1 Types of risk and appropriate defensive investment

Risk type	Example of risk	Defensive investment type	
		Reduction of risk of adverse event	Adaptation and mitigation
Constant technical risk	Biosecurity outbreak	No	Yes
Evolving technical risk	Impact of productivity or other production practices	Yes	Yes
Compliance failure risk	Wide spread non-compliance with animal welfare requirements	Yes	No
Market and political risk	Changed consumer perceptions and government response to live animal trade	Yes	Yes

In general, when considering compliance failure risk, once an event has occurred it can be difficult to mitigate and adapt due to the likelihood of strong consumer and government responses. In these cases, it is likely to be more effective to target investments at defending against the non-compliance event occurring in the first place.

3.2 Valuing the benefit from defensive investment

Estimating an ex ante value (anticipated value beforehand) of a defensive investment is not necessarily straightforward. The ultimate aim of a defensive investment is to maintain a market position through either reducing the probability that an event will occur or reducing the costs associated with an event.

Obviously, the decision to make the investment must be taken before the event occurs. There are three possible scenarios following a defensive investment to alter the probability of an event. That is, the investment may have:

- stopped the event from otherwise occurring
- had no visible effect as the event was not going to occur irrespective of action taken; or
- had no visible effect as the event still occurred.

All three cases must be evaluated jointly as, in ex ante terms, it is not clear which situation we are likely to face. Indeed, if this information were known with certainty, investment would only proceed in the first scenario.

Further, when the defensive investment is targeting mitigation of the impact of an event, there are also three alternative scenarios:

- the event did not occur and so the defensive investment was not initiated
- the event occurred and it is clear the effect the defensive investment had on industry recovery (perhaps based on historical comparisons of similar events)
- the event occurred and it is not clear whether or to what extent the investment had on industry recovery.

Again, the ex ante evaluation of the value of a defensive investment will not be able to distinguish between these scenarios. However, increasing the amount of information held at the evaluation stage, including a strong theoretical understanding of the risks and the market involved will assist in reducing the amount of uncertainty in an evaluation.

This all points to the possibility that the evaluation of a defensive investment may only be possible in an ex ante context. Instead of cycle of review through an ex post evaluation, the ex ante analysis is updated with latest information regarding the probability of the adverse and the changing market (the size of what is being defended).

3.2.1 Elements of a valuation

There are three main components of a defensive investment evaluation, as follows.

- Risk — a situation of risk occurs where there is uncertainty around what events may occur in the future, however, there is sufficient information to assign probabilities to each possible event, even if these probabilities are in the form of distributions and are not concrete.
- Value at risk — refers to the amount of money, for example through direct income, market position or future growth opportunities, that may be lost should an adverse event occur.
- Risk preferences — refers to the level of risk aversion investors hold over their value at risk, being represented by the amount they are willing to invest to protect against a decline in value.
    - A risk adverse investor would look to fully protect the value at stake limiting the potential for any losses, and would therefore be willing to pay a higher premium.
    - A risk neutral investor would take a more conservative approach, looking to ensure that the premium for the investment did not exceed the expected loss of value should an event occur.

Just like decision making for other investments, the provision of credible information to decision makers is critical to each of these components of defensive investments. The industry investing on behalf of levy payers could take, what appears, to be an incorrect position. However, such positions could be the result of rational decisions made with incomplete or poorly articulated information.

Determining the risk profile of an industry position, combined with a determination of the value at risk and the risk preferences provides much of the information required to determine how much to invest in defensive activities.

3.2.1.1 Acceptance of uncertainty in variables

When conducting evaluations, it is critical to accept that there will generally remain uncertainty around the variables and the modelling. This is unavoidable, but it is important to firstly understand the source of the uncertainty — environmental, commercial, political — how much effort and resources would be required to reduce this uncertainty, and what level of uncertainty is considered to be acceptable in the final analysis. The results may then be reported in terms of confidence intervals or other statistical functions that will both allow for the uncertainty as well as providing context around the robustness of the results.

3.2.1.2 Attribution of effects

Attributing a change in market outcomes to a particular action, investment or underlying factor is an important but complicated element of any evaluation. If there is an observed change in productivity or environmental outcomes, risk profiles or investment strategies, it is important to consider to what extent these changes may be attributed to previous defensive investment strategies of MLA, or to joint ventures between MLA and other industry stakeholders.

An extension of these attribution considerations is to allow for changes in industry or political perceptions and actions that may have taken place irrespective of MLA's defensive investment program.

Solving attribution issues is the converse of addressing the 'no change' complications in valuation. When there is an observed change in the market, is it possible to attribute the change to any particular actions?

3.2.2 Adjusting to new information

One of the most important factors to understand in developing and implementing defensive investments is the role that research and development activities as well as new market information play in the efficiency and adaptability of defensive investments over time. Defensive investments are made to specifically counter an event that may or may not occur, whether or not the probability of that event occurring is known. Therefore, it is crucial to the efficiency of the strategy that the investments are flexible enough to take into account emerging information and changing market conditions, both domestically and internationally.

Following the household insurance example before, the expenditure made on the defence investment (the insurance premium) should be reviewed if either:

- the value of what you are protecting changes
- the probability of the adverse event changes.

4 Tools for evaluating defensive investments

The quantification of the value of benefits from MLAs investments are crucial in terms of:

- informing decision making in the prioritisation of investments in individual projects or more likely clusters of related projects
- reporting to stakeholders in both industry and government on the expected and realised value of benefits from those investments.

4.1 MLA's current selection and evaluation process

While LPI projects have a spectrum of expected outcomes and associated attributes, which all have different weights in the planning and decision stages, the potential value of the benefit stream less costs of a project or project cluster is the single most important factor. Currently, the LPI program uses a combination of quantitative and qualitative methods in assessing value and other attributes against its strategic goals.

In 2005, MLA engaged the CIE to conduct an independent review, and to develop an effective evaluation framework to assess the industry impact of its programs and their compliance with government priorities. The framework provides independent estimates of the net industry benefits of MLA programs — including achievements relative to targets and the net present value relative to a 'no investment' situation. Since then, MLA has invested considerable resources into this process and has made public 11 ex post evaluations of its major programs.

In addition, the Council of Rural Research and Development Corporations Chairs (CRRDCC) has developed the standard assessment guidelines based on benefit cost analysis (BCA) to which MLA contributes to overall reporting for the RDCs. The following are general guidelines for the conduct of the BCAs including:

- BCAs should be on clusters of investments where outcomes can be reasonably estimated taking into account the likelihood of adoption or implementation
- all projections and calculations should be in real terms (without escalating benefits and costs for inflation)
- all BCAs should report present values (NPVs) of net benefits (benefits minus costs); internal rates of return (IRRs); and benefit-to-cost ratios (BCRs) calculated using the present value of benefits and costs
- The Commonwealth Guidelines for benefit cost analysis should be followed in calculation of the net benefits (Handbook of Cost-Benefit Analysis 2006)[1]

As identified, defensive investments are typically aimed at reducing the risk, or mitigating the impact, of an adverse event occurring in the future. The value of a defensive investment, assessed at the time that the investment is made, is dependent on a number of factors, including:

- the probability of an adverse event occurring
- time delays in activating the defensive investment or mitigation response
- the cost of developing the defensive investment in the first place which accounts for considerations such as the cost of information.

As a result, traditional cost benefit analyses can be too structured to account for uncertainties and complexities posed by options to activate an investment or to leave it idle. More commonly, valuation techniques such as decision trees, sensitivity testing, Monte Carlo simulations and real options methodologies are tools that have been identified for valuing defensive investment strategies. These tools and techniques are able to account for uncertainty and risk at different stages in the investment cycle, as well as including considerations and responses to issues such as threshold events.[2]

In practice, the type of valuation technique applied will depend on the type of defensive investment that is proposed. For example, defensive investments that are a type of holding pattern, requiring a relatively small upfront investment to buy the option to activate a larger investment in the future will utilise a real options valuation approach — these will typically be adaptation- based defensive investments.

In contrast, a defensive investment that is implemented from the outset without a guarantee of an adverse event occurring will be more suited to the use of a Monte Carlo type analysis — these will typically be mitigation-based defensive investments. Decision trees may be used for either mitigation or adaptation based defensive investments.

These tools are inherently sensitive to methodology used and the assumptions made. As a result, in addition to gaining skills in using these tools and techniques it is also important to ensure that issues of standardisation and quality assurance are considered.

This chapter now provides an overview of these tools and techniques and considers issues of standardisation and quality assurance that are necessary to ensure that the tools are implemented effectively across different project teams and departments.

[1] http://www.finance.gov.au/FinFramework/fc_2006_01.html

[2] That said, a key advantage of benefit cost analysis is that it allows decision makers to compare between alternative defence initiatives and between defensive and other initiatives that do not have a risk mitigation focus. This trade-off between internally appropriate evaluation techniques and externally comparable results is managed within the analysis.

Decision trees essentially provide a schematic overview of possible future scenarios, including assessments of the probability of occurrence, to value a defensive investment under these alternate scenarios.

- A concrete example of the use of a decision tree in the context of assessing a defensive investment to mitigate the impact of foot-and-mouth disease is provided in this report as a case study.
- Decision trees should be flexible enough to provide a valuation framework for both mitigation and adaptation based defensive investments.

While not necessarily producing an actual tree diagram, the concept and thought processes behind decision trees are typically employed whenever a project considers future possibilities and events and the 'without investment' case. Tree diagrams produced more formally can be a useful framework for a number of tasks:

- identifying and discussing possible future scenarios and events
- identifying and discussing the likelihood of future scenarios and events
- estimating the expected or most likely outcomes.

4.2 Alternatives to traditional BCA

We now identify how traditional BCA can be augmented to account for uncertainty based on the following approaches:

- decision trees
- structured sensitivity analysis
- monte carlo analysis and
- real options.

4.2.1 Decision trees

Decision trees essentially provide a schematic overview of possible future scenarios, including probability assessments, to value a defensive investment under these alternate scenarios.

- A concrete example of the use of a decision tree in the context of assessing a defensive investment to mitigate the impact of foot-and-mouth disease is provided in this report as a case study.
- Decision trees should be flexible enough to provide a valuation framework for both mitigation and adaptation based defensive investments.

While not necessarily producing an actual tree diagram, the concept and thought processes behind decision trees are typically employed whenever a project considers future possibilities and events and the 'without investment' case. Tree diagrams produced more formally can be a useful framework for a number of tasks:

- identifying and discussing possible future scenarios and events
- identifying and discussing the likelihood of future scenarios and events
- estimating the expected or most likely outcomes.

As the simplest of the valuation methodologies, decision trees are essentially reduced to a model that uses the weighted average probability of a sequence of events occurring. The decision tree is built up around possible changes in scenarios over time, with branches expanding out of decision nodes, or timing nodes where for example, a new technology or information is attained.

- Each branch requires a probability and a valuation calculation to be included.
- Uncertainty is incorporated through the probabilities associated with different scenarios, but uncertainty associated with the determination of these scenario probabilities is not as easily incorporated.

That is, *more* error may be introduced by choosing an incorrect or implausible decision tree approach rather than getting the underlying probabilities wrong.

Decision trees are more likely to be a foundation for answering more sophisticated questions such as the sensitivity of the final estimates to assumptions made and assessing the probability of achieving a pay-off level, for example, what is required for an investment to break even or achieve a threshold rate of return.

4.2.2 Structured sensitivity testing

The magnitude or likelihood of scenarios identified on a decision tree are often highly uncertain and based on a large number of assumptions. Structured sensitivity testing can be used to assess:

- the value of an input needed to achieve a particular investment value
- the impact on the investment value of changing the assumption regarding an input.

For example, in the evaluation of the benefits of an alternative spaying option below, the sensitivity to the value of an alternative is tested with regard to final market prices. Alternatively, another question that could have been addressed is what price would the alternative option need to be to ensure that the expected value of the alternative solution is in excess of $300 million?

4.2.3 Monte Carlo method

Monte Carlo simulations are essentially a generalisation of sensitivity testing. That is, instead of testing how the value of an investment varies depending on two or three alternative values of an input, a large number of possible values of an input are simulated based on an assumed probability distribution. The outcome is therefore a distribution of possible values for the defensive investment depending on a number of possible values of inputs that have been identified as being important.

Monte Carlo analysis is a relatively straight forward technique that allows for uncertainty in input variables to be specifically accounted for in the evaluation. Similar to a reduced decision tree analysis (weighted average probability model) the Monte Carlo simulation estimates the probability distribution function of an investment generating a positive net return based on probability distributions of select input variables (for example, market conditions or successful research programs).

A defensive investment that is implemented from the outset without a guarantee of an adverse event occurring will be more suited to the use of a Monte Carlo type analysis — these will typically be mitigation-based defensive investments.

Questions that are answered by the use of Monte Carlo simulations typically include:

- what is the probability that x is below a target or critical level?
- the probability of breaking even is?
- the probability that revenue if between x and y is?

Simulation typically starts with an excel model which determines how inputs map to outputs. Microsoft excel is probably an adequate software package to perform Monte Carlo simulation. Practically speaking, in order to perform Monte Carlo simulations, an excel add-in will need to be downloaded.

Table 4.1 shows that Monte Carlo analysis can potentially utilise a large number of assumed distributions.

- This choice is practically restricted by knowledge of underlying distribution of the factors that are critical to the investment and data to inform their plausible ranges.
- Data availability tends to be a critical constraint, in many cases, the average or median value of variables is not well known let alone the likely distribution around the average.

Table Error! No text of specified style in document.**.1** Examples of probability distributions[a]

Distribution	Characteristics
Bivariate normal	Two factors are determined by normal distributions
Cumulative	Probability of being less than a specified value
Discrete	Finite number of possible outcomes, probabilities sum to 1
Normal	Bell shape curve — often appropriate natural occurring processes
Triangular	Triangle based on most likely value, upper and lower bounds
TruncBiVarNormal	BiVarNormal distribution that has an upper or lower bound
TruncNormal	Normal distribution that has an upper or lower bound
Uniform	All outcomes have the same probability of occurring

[a] Other distributions include Binomial, Exponential, Integer, Lognormal,Poisson and Sample.

Box 4.2 shows some practical questions that require answering to implement standard Monte Carlo analysis. Apart from restrictions on data, these techniques require a high level of specialisation and may not readily accessible to most people in industry who would want to use these techniques on a casual basis.

Error! No text of specified style in document..2 Checklist for selecting probability distributions

Can the variable have a continuous or discrete range of outcomes?

The answer will help to determine if a continuous or discrete distribution is more appropriate

Are some outcomes more likely than others?

The answer will help to determine if a uniform or non-uniform distribution is more appropriate

Are there any lower or upper bounds?

The answer will help to determine the starting point and end point of the distribution

Is there any data to help infer the distribution?

The answer may help to determine the precise probability distribution

Is the process naturally occurring?

If the answer is yes, a normal distribution is likely to be appropriate

4.2.4 Real options

Real options valuation techniques provide an estimate of the value of having the option to choose to implement a defensive investment in the future in response to an observed event. They are more suited to valuation of adaptation-based strategies where an initial investment is made, purchasing the right to invest more or change the composition of the investment in the future in response to an event.

For a real options analysis to be undertaken, the investment strategy must have at least two decision points, the initial decision to invest in the option, and the secondary decision to activate the investment or not. Further decision nodes may also be incorporated.

- Further, to be distinct from a simple decision tree analysis, a real options analysis requires additional information (or the potential for additional information) to become known between the two investment decision points, allowing a more informed choice to be made on activating the investment.
- This may be very relevant for LPI managers who, in the majority of cases, gain a better understanding of the potential and limitations of a project once it is underway.

Real options analysis allows for an ex ante evaluation of how investment/research managers will respond to good and bad news through the project, for example, limiting losses in response to poor performance or negative information and increase in investment in response to good results or positive information. In this way, real options analysis presents a reduced form of decision tree analysis, limiting the weighted average probability model to incorporate only those investment decision paths that limit investment losses.

4.3 Sources of information and quality assurance

In essence, the four approaches identified have a number of common features or attributes. They all require:

- being more explicit about thinking around key assumptions used in the underlying BCA especially around those concerning the 'without investment' case and uncertainties that affect the outcome of the investment
- additional data to support that thinking and analysis.

In practice, this will involve accessing a range of potential information sources to gauge the likely scenarios and their associated probabilities:

- similar episodes or events in the past
- academic literature
- historical patterns of bio-physical and economic variables
- evidence gathered from surveys on potential responses of industry and market players
- informed judgment from market participants and industry observers.

The logic behind the use of decision trees should be implicit in the development of the 'without investment' case for the establishment of the benefit stream. Given the fact that decision trees are likely to be the foundation for asking more sophisticated questions about characteristics of a defensive investment, it may be important to ensure that an appropriate range of future scenarios have been identified and that the probabilities that are associated with the scenarios are reasonable and can be justified. In practice, this would require:

- obtaining additional information on possible pathways between the investment and outcomes — from sources of information that were identified above
- a transparent review process which could vary in terms of scale and scope depending on the significance of the defensive investments being examined.

Structured sensitivity analysis is logically an extension of decision tree analysis. In practice, judgments will need to be made about the range of values of key variables that will add value to the decision making process in terms of establishing confidence around benefits or identification of project risks. Therefore sensitivity testing requires a model that specifies how key inputs and parameters will affect the value of the investment. Inputs are then adjusted either side of the estimated value in order to assess the impact on the expected value of the investment. This requires that the correlations between input variables are understood as a movement in one key input or parameter is likely to be associated with changes in other inputs.

For example, evaluating a new product that is being introduced, the market price and penetration rate over time are highly uncertain. Testing the sensitivity of the value of product with regard to the price will need to consider the relationship between price and market penetration (or adoption by users).

This judgment should in part be guided by the assumed probability distribution of the input. For example, if an input is assumed to have a probability distribution with a maximum value of 80, then using a value of 120 in sensitivity testing is unlikely to be of use. The same range of information sources identified above can be used to gauge sensible adjustments to the expected values of inputs in the underlying BCA.

Similar to sensitivity testing, Monte Carlo simulations requires a model that specifies how key inputs and parameters will affect the value of the investment. Inputs are then adjusted on either side of the estimated value in order to assess the impact on the expected value of the investment. This requires that the correlations between input variables are understood as a movement in one key input or parameter is likely to be associated with changes in other inputs.

5 Improving FMD preparedness

Foot and mouth disease (FMD) is recognised by both the red meat industry and Australian governments as the most significant threat to industry profitability with catastrophic consequences. Australia's FMD free status provides a significant competitive advantage in global markets in providing access to key Pacific Rim markets for both beef and sheepmeat. This is particularly the case when compared to key South American and other competitors who, under the World Organisation for Animal Health:

- have endemic status
- can export from approved FMD free zones
- vaccinate against FMD.

MLA investments in FMD related projects and clusters are widely supported at all levels of industry as being appropriate defensive investments, or insurance policy, decisions reflecting the value of the industry as being at stake. That is, there is an implicit judgement that the benefits (avoided costs from and FMD event) are significantly greater than the costs of the programs designed to mitigate the impact of an outbreak.

5.1 Investment decision by MLA

Table 5.1 shows the investment made by MLA in this program area between 2010 and 2015. Originally, the project application was for $5.266 million but rather than introducing a stop-go point, the MDC board opted for a two phase project.
To better prepare Australia's livestock industries for the potential catastrophe of an FMD incursion, this two-phase project is aimed at:

- characterising strains of the FMD virus present in the south-east Asian region
- ensuring that Australia's vaccine bank contains vaccines specific to these strains
- ascertaining how these vaccines will perform under Australian conditions
- improving Australia's diagnostic capabilities to ensure swift response to an incursion and minimal delay in returning to a disease-free status.

Table 5.1 MLA investments to improve FMD preparedness

Investments	Project	Investment partner	Start Completion	Investment by MLA	Investment by partners
				$	%
FMD preparedness program Phase 1[a]	P.PSH.0558	AHA industry members CSIRO	Jan 2010 Dec 2011	1 048 842	1 048 842
FMD preparedness program Phase 2[a]	P.PSH.0652	AHA industry members CSIRO	Jul 2013 Jul 2015	1 687 396	1 687 396
Total MLA investment				**2 736 238**	**2 736 238**

[a] Funded through the MLA Donor Company (MDC).

Source: MLA.

It is clear that this project is marginal to the significant investments already made by Australian livestock industries for preparedness for FMD and exotic disease incursions more generally.
This MDC project is co-funded by Animal Health Australia, utilising beef (grass and grainfed), sheep (meat and wool), dairy, pig and goat reserve funds and is supervised by a project oversight committee, with representation from all these industries. Therefore, this project has multiple stakeholders, investors and beneficiaries.
The output of this research is expected to be:

- a better understanding of FMD viruses in our region
- improvement in Australia's technical skills base in FMD diagnostics
- better understanding of the action of the vaccines in Australia's FMD antigen bank
- the development of tests and diagnostic capability to differentiate vaccinated animals from post-infection recovered animals to expedite a return to disease-free status.

Rather than preventing the adverse event (FMD outbreak), the investment has the ultimate objective of improving the effectiveness and speed of the response. This mitigates impacts through a vaccination program for uninfected stock (which would be used in conjunction with zoning and destruction of infected animals).

- In addition, there will be investment in capacity building in the SEA region, both in Vietnam and at the Regional Reference Laboratory in Thailand.

5.1.1 Rationale for LPI involvement

This project is consistent with the overall industry imperative of maintain and increasing productivity in the supply chain through the two digit project cluster 3.4 *Support industry to improve animal health and biosecurity* and more specifically the four digit 3.4.1.1 *Deliver improved diagnostic methods, enhanced understanding and/or improved control methods for external threats such as FMD, bluetongue capripox and screw worm fly*.

In terms of the categorisation within the LPI portfolio, this project is clearly a defensive investment that falls within the remit of the LPI and MLA strategic objectives. There is also an obvious role for MLA from a number of perspectives:

- in the 'without' MLA investment case, this research would not be funded
  - Due to the nature of such an investment, an individual or company would have little incentive to invest.
  - Another question is if there is a role for government in this investment
  - They would not have the capacity to fund, bear the risk and to access required scientific capability for such a project
- this investment also represents the opportunity to achieve leverage off the existing investments in responses to FMD and exotic disease incursions (infrastructure already in place) and from funds from the other livestock industries

- the organisation and funding of such a project requires co-ordination across the livestock industries and governments
  - This is already facilitated by the existence of memorandum of understandings between the livestock industry, service providers and government.
  - As an example, Emergency Animal Disease Response Agreement (EADRA) is a contractual arrangement between the Commonwealth, state and territory governments, livestock industry groups and Animal Health Australia (AHA) to collectively and significantly increase Australia's capacity to prepare for and respond to emergency animal disease incursions.

On this basis, the project is consistent the remit of wider industry and MLA strategic imperatives that directly addresses an 'industry failure'. That is, the industry is better off collectively investing in this project than acting as individuals. Given this, how do you go about establishing the size of this benefit?

5.2 Approach to estimating costs of an FMD outbreak

As a result of the wide recognition of the potential significant costs of an outbreak, there have been a number of studies that have estimated the potential costs of an FMD outbreak in Australia. They also have identified the critical factors that influence the outcomes and impacts of a simulated an FMD outbreak. These are:

- Productivity Commission (2002) which was subsequently updated by Buetre et al (2013)
- the development of the NLIS (sheep and goats) Business Plan by CIE (2010)
  - This study not only quantified the potential costs on an outbreak but examined the impact of improved traceability for the sheep and goat industries on the reduction on overall costs.

Following these studies, estimates of the potential losses of FMD have been made across the following dimensions:

- across, cattle, sheep and other susceptible livestock industries excluding dairy and without considering economy-wide flow-on effects
- for two scenarios: a contained and an extensive disease outbreak
- across three export market types: those that are sensitive to FMD status (discerning) and those who are less sensitive (less discerning) and those who are not sensitive.

There are three broad cost components included for an FMD outbreak:

- losses from international market exclusion
- losses from the domestic market
- costs of control and eradication of the disease which include
  - Control costs: flock appraisals, surveillance, and suspect flocks visits.
  - Eradication costs: quarantine, slaughter, disposal, decontamination, movement restrictions.
  - Compensation costs correspond to payment by government to famers for all slaughtered animals due to disease eradication activities.

Details of the assumptions and approach from CIE (2010) study are included in appendix A of this report. Common findings of previous studies was that the magnitude of losses from a potential FMD outbreak are determined by a number of factors:

- the probability, size and duration of an FMD outbreak
- the sensitivity of key markets to the outbreak
- the timeframe over which key export markets permit re-entry of Australian product.

There is considerable uncertainty about all of these factors especially given that Australia has been FMD free for a long time and that to conduct the analysis we must rely on a range of information sources including:

- expert opinion
- experiences from other countries.

In terms of the categorisation identified in chapter 2, the MLA FMD Preparedness project addresses two types of risks:

- constant technical risk — the probability of an FMD outbreak
- market access and political risk — timeframe and condition of re-entry back into key export markets.

Following the approaches taken by CIE (2010) and Buetre et al (2013), table 5.2 sets out the factors that would need to establish the value of losses from such a FMD outbreak.

- The probability of an outbreak is very low, in the order of one or two events every 100 years, although for Australia, this estimate reflects a more subjective approach by industry experts than science because of the large number of environmental and other factors at play.
- Potential losses also depend on time taken by authorities to respond to the outbreak, the effectiveness of this response and the confidence that major industry customers have in this response. These in turn, depend on the traceability system and the capability of authorities who manage the outbreak to use that system.

The CIE analysis showed that in the event of a large FMD outbreak, future costs due to losses in market access represented around 98 per cent of total losses and that on-farm and compensation costs were relatively minor.

- Strategically, this implies that small improvements in regaining access to export markets have substantial payoffs.
- Similar results provide the underling logic for MLA continued investment.

Table 5.2 Summary of assumptions for calculating the losses of an FMD outbreak

Assumption		Outbreak size scenarios	
		Contained	Extensive
Duration		6 months	1 year
Degree of export market closure in the first year			
Discerning markets	%	50	100
Less discerning markets	%	25	50
Exports recovery period	years	2	4
Total animals requiring destruction			
Total	no.	417 000	762 000
Beef cattle[a]	no.	19 000	73 000
Sheep and goats	no.	393 000	669 000
Pigs	no.	5 000	20 000
Eradication and compensation costs			
Eradication costs	$ per head	$770	
Compensation costs	$ per head.	$859 for cattle, $65 for sheep and $226 for pigs	

[a] Impacts on dairy cattle have not been evaluated.

Source: CIE (2010).

5.3 Approaches to quantification of project benefits

The approaches used in all of previous studies have been based on standard BCA analysis that estimated costs of outbreak. In fact, in July 2010 the National Biosecurity Committee endorsed an initiative to apply the National Framework for Biosecurity Benefit Cost Analysis to all BCAs that evaluate future biosecurity investments.

- This was the rationale for the commissioning of the study by Buetre et al (2013).
- This is because the BCA framework is the only approach available to express the future costs in present value terms to enable comparison between investments.

5.3.1 The with and without MLA investment scenario

To this point, all of these approaches have focused on developing the present value of the potential future costs of an FMD outbreak. That is, comparing the with FMD scenario to a baseline without an outbreak.

The next step, in the majority of cases is to establish the 'with FMD' case as the 'without investment' case and then develop how these expected costs may change in response to the outputs and outcomes that are expected under the 'with investment' case.

For example, CIE (2010) estimated how the expected costs of an FMD outbreak were expected to fall (relative to the 'without' case) in response to the investment in an improved traceability system for sheep and goats that achieved the National Livestock Traceability Performance Standards.

- For this study, it was assumed that the period of complete market exclusion under an extensive outbreak[3] , and in consequence, the losses are reduced by 50 per cent if zoning is backed-up by full Electronic identifications (without exemptions).
- This means that an extensive outbreak will have the implications of a contained outbreak because after detection of the last infected individual — zoning is rapidly accepted in international markets facilitating the continuation of exports by some regions

Similarly, to evaluate the expected benefits of the FMD preparedness program, we would need to identify how the variables, identified in table 5.2, would change as a result of the project.

- As identified in the project specification, the benefits would be faster recognition of the particular FMD virus and identification of the appropriate vaccine.
- This would be expected to provide quicker access back into key export markets and possibly restrict the spread of the outbreak (in combination with appropriate movement control and zoning around the infected area).
- The 'benefit' of the FMD preparedness program would be to reduce the exclusion period of key markets by months, reducing the overall size of losses to industry. This benefit would be a marginal improvement as a result of strengthening the FMD response mechanisms that are already in place.

In fact, we would expect that in the future, that further revisions of the potential impact of FMD would take these 'improvements' in responsiveness into account.

5.3.2 Alternative approaches to standard BCA

In terms of the other quantitative tools and approaches identified in chapter 3, structured sensitivity/Monte Carlo analysis is probably the most appropriate bolt-on for standard BCA.

- This is because of the high degree of uncertainty around many of the variables present in table 5.2, not only in terms of the most likely or average value but also what the distribution would look like over time.

[3] Our estimation of an extensive outbreak assumes a reduction of 100 per cent in exports to discerning markets and 50 per cent in exports to less discerning markets in the first year.

- For example, there is currently little or no evidence to support an 'average' probability of an FMD outbreak in Australia, let alone how this may change in the future with changes in risk factors such as feeding infected materials.

The practical approach taken by previous studies is that structured sensitivity testing is limited due to the lack of knowledge around what would be suitable alternative values and the resources required to do the testing.

However, what sensitivity testing been done has provided the insight that changes in the period of exclusion from export markets is the single most important factor for the difference between the with and without investment scenarios.

5.4 The approach to valuing public (spillover) benefits

The core analysis focused on the industry (livestock industry) costs and avoided costs from an FMD outbreak. Both the Productivity Commission (2002) and Buetre et al (2013) examined the economic and social impacts of an outbreak. The impact on the livestock industries was classified as the direct impact, while other industry and regional impacts along with social impacts where identified as spillovers.

Buetre et al (2013) found that other industries could be positively or negatively impacted depending on their relationship with livestock industries. Input providers to FMD-susceptible livestock production (for example, transport, trade and feedstock suppliers) could see reductions in the present value of production. Some industries that are competitors in production — such as grain and horticulture and their downstream processors—are likely to benefit, with an estimated increase in the present net value of production of $15 billion over 10 years, compared with no FMD outbreak. These increases are the result of resources, such as land, being diverted from livestock to other agricultural uses.

- It was found that the large multi-state outbreak scenario would reduce Australia's gross domestic product by an estimated 0.16 per cent ($23.6 billion in present value terms) over 10 years, while the small Victorian outbreak would result in a reduction of 0.03 per cent ($4.6 billion).
- This compares to total direct costs for livestock producers of $52 billion in present value terms over 10 years. This reflects the fact that some industries, and consumers, benefit from a smaller livestock industries.

Social impacts from the loss of income were also identified — such as mental health issues, changed gender roles and reduced welfare. Other impacts may result from the control measures used to manage and eradicate FMD. While these factors were identified, there was no attempt made to quantify them in dollar terms.

- The social costs are notoriously difficult to quantify and even beyond the resources of both the Productivity Commission (2002) and Buetre et al (2013).

For this case study, we would be primarily interested in how the MLA project, at the margin, may reduce these flow-on economic and social costs. We have already identified that the project would result primarily in industry benefits, therefore we would expect that, at a maximum, that the economic and social costs avoided (benefits) would fall proportionately to the industry costs of an outbreak.

5.5 Recommended approach in an LPI portfolio context

The major factor that distinguishes this defensive investment from productivity-based projects is the difficulty in the estimation of value — the future benefit stream from the investment.

- This is because of the uncertainty (or risk) around a large number of variables that need to be considered to establish the value of the project. This chapter has shown the complexities involved in quantification of value.
- This factor is not a game changer in terms of budget allocation and priority, but suggests that the approach to evaluation and transparency of decision making should be different to other projects in the LPI portfolio.
- Quantification of benefits is not amenable to tools used to assess productivity benefits.

Is there a higher level of industry or market failure than for other LPI projects?

- In a triple bottom line framework, previous studies have demonstrated that the vast majority of the potential benefits are private industry benefits with spillovers to the wider community primarily through the flow-on economic impacts of a smaller red meat (livestock) industry.
- This investment is therefore a classic 'industry good' where the red meat industry is better off as a result of its collective investment. The role of MLA on behalf of the red meat industry is strengthened by the requirement to work collaboratively with other livestock industries and government. That is, individuals or businesses are not well positioned to achieve the same outcomes as the industry body.
- On this basis, similar projects should not be treated any differently to those that are productivity-based as the majority of benefits accrue to the industry. The difference is that these benefits involve uncertainties that make them more difficult to quantify.

5.6 Recommended approach in an evaluation context

The evaluation of future projects similar to the current project FMD preparedness, should be approached strategically from a number of perspectives:

- it is likely that such a project type will only be evaluated on an ex ante basis, because of the low probability of the adverse event you are insuring against
- the evaluations are resource intensive to conduct and rely on information, much of which is subjective or judgemental
- because of these factors, not only do the key insights need to communicated to decision makers within MLA and the wider industry but also the reliability and precision of the results
- in the absence of new or better information, the total estimated cost of an FMD outbreak should not change significantly from year-to-year due to the structural nature of the configuration of production and key markets, but also because of the static nature around the knowledge about the underlying assumptions.

To improve decision making, resources could be put towards better understanding how marginal changes in FMD preparedness and response reduce the exclusion time from key export markets, or at least, identify this as a key variable when comparing between alternative projects.
What then would be the pre-conditions to update the BCA and even reposition the project? There would be two cases:

- when new information becomes available as a result of targeted research (for example, better information on the probability of an outbreak or knowledge of how fast it spreads) or as a result of change in the operational environment (customer attitudes to FMD)
- when there is significant structural change in the industry or change in the value of the asset that is being protected. For example, significant change in export composition between FMD sensitive and insensitive markets. Recently negotiated FTAs with Japan and Korea and the re-emergence of the United States as an export market will increase Australia's overall exposure to FMD sensitive markets.

6 Non-surgical spaying procedure

The management of fertility of female cattle continues to be an important driver of herd management in Australia. This is especially true in northern beef systems where cattle are run in extensive pastoral environments and where bull control is problematic. Spaying is seen as an important husbandry and on-farm management tool. The rationale for spaying is well understood in the beef industry and includes:[4]

- prevention of unwanted mating and pregnancies to maximise the survival of females, particularly with the risk of dystocia in maiden heifers
- reduction in mounting behaviour resulting in less bruising and injuries to themselves and other cattle (particularly feedlots)
- allows flexibility to finish (fatten) females under variable seasonal conditions for turn off which allows for better management of stocking rates and overall herd welfare outcomes.
- some live export markets require non-pregnant females which can be achieved via spaying or pregnancy testing prior to departure.

Producers have a number of alternatives to spaying that can be used to prevent unwanted pregnancies including separation of bulls from heifers and cows in a secure paddock and sell or transfer their sale/cull females to another property.

In the extensive or pastoral context where these solutions are not physically possible or not financially sustainable, cattle producers are forced to focus directly on the reproductive system of their cattle. Many properties in northern Australia span vast areas, making it near impossible to segregate different groups of cattle and often have unwanted pregnancies.

In the absence of a vaccine or chemical implant, some cattle producers need to perform husbandry surgery on cattle. This can take the form of two methods of removal of the ovaries including Willis Dropped Ovary and Flank spaying methods. The Cattle Standards and Guidelines Writing Group concluded: 'All methods are associated with a degree of pain and, from this point of view; no one method is markedly superior to others. On the basis of limited scientific evidence Dropped Ovary Technique has apparent advantages over flank spaying. Appropriate pain relief should be used and the writing group believe that this is necessary for flank incisions but the regime for a reasonable level of pain relief is yet to be determined'.

At the same time the Writing Group make the observation that while requirement for pain relief for the flank approach will lead to an improvement in cattle welfare, the exact meaning of 'pain relief' and the regimes of treatment to be applied have to be determined in the context of what is reasonable for the veterinary profession to deliver to cattle.
These concerns have led MLA to invest in a range of R&D initiatives aimed at developing an alternative to current spaying techniques and procedures.

6.1 Investment decision by MLA

Changes in both industry and community expectations of livestock management practices have led to the search for non-surgical alternatives to spaying:

- The MLA welfare plan identifies finding replacements for painful and bloody husbandry procedures as a strategic priority.
- A non-surgical and cost effective alternative to spaying would not only address animal welfare concerns could potentially improve productivity.

Table 6.1 shows the current cluster of four projects funded by MLA in pursuit of these goals. The majority of these projects have been or will be funded in partnership with established companies in the veterinary pharmaceutical industry.

[4] Cattle standards and Guidelines — Spaying, Prepared by the Cattle Standards and Guidelines Writing Group February 2013.

Table 6.1 MLA investments to find a non-surgical spaying procedure

Investments	Project	Investment partner	Start Completion	Investment by MLA	Investment by partner
				$	
GonoCon trial in Heifers and bull calves[a]	B.AWW.0194	University of Queensland	May 2010 Jul 2014	101 630	101 630
Chemical sterilisation as an alternative to spaying heifers	B.AWW.0219	James Cook University	Jun 2013 Dec 2015	65 495	125 625
Development of single dose treatments	MDC funded program	University and Corporates	Dec 2010 Sep 2019	1 793 300	1 793 300
Total MLA investment				**1 963 425**	**2 023 555**

[a] Includes Phase study with bulls.[b] Funded through the MLA Donor Company (MDC). Details are confidential.

Source: MLA.

6.1.1 GonoCon trial

The USDA developed an anti-sex hormone vaccine for use specifically for wildlife to control reproduction, including bison and elk. Data from the United States on the efficacy of the vaccine was promising and showed that testing of the efficacy of the GonaCon vaccine on cattle in Australia should be a priority.

- At the time of approval by MLA, this project was identified as having a low likelihood of technical success and very high adoption risk by producers in Northern Australia
- That said, if a single dose vaccine was developed at a competitive price point, compared to surgical spaying, then the new product would be expected to have a strong uptake.

The research project found that a single dose of the vaccine GonaCon did not provide the response required to make it an effective contraception option for northern heifers. The research:

- investigated the application of the immuno-contraceptive drug for its potential to reduce the need for surgical spaying of heifers in the northern cattle industry
- tested a single dose and two doses given 60 days apart in heifers and monitored the ovarian function of the animals to test efficacy.

Animals that received a single dose of the drug showed that it was not an effective option as only 10 per cent of the animals showed suppressed ovarian function. The results from the group that received a double dose of the vaccine showed long-term suppressed ovarian function in five out of nine treated animals.

While response to the double dosage treatment were more promising, administering two treatments was found not to be practical in the northern industry when considered with its effectiveness rate.

- The use of the vaccine is not gender specific and other research was conducted to test if GonaCon given at higher dosages to young bulls can deliver desired outcomes (that is, non-surgical castration).

6.1.2 Chemical sterilisation

This project offered a potential practical alternative to spaying and was deemed worth a modest investment in a proof of concept study. Table 6.1 shows that MLA achieved a significant amount of leverage from its research partner.

The project was initiated by a recommendation given to the project proponents by an expert panel convened by MLA to assess alternatives to surgical practices in the northern beef industry. The expected outcomes are a potentially inexpensive, practical alternative to spaying. The key project outs puts to be delivered between 2014 and 2015 are to:

- determine effectiveness of chemical sterilisation treatments on reproductive physiology, fertility and liveweights of female Bos indicus cattle.
- complete an evaluation of histopathology and hormonal changes in female cattle.

6.1.3 Development of a medical approach

This Program had the objective of delivering one-treatment and affordable alternative to surgical spaying in female cattle maintained under extensive management.

- Similar to the other projects, at the time of MLA approval, there was a need to develop new technologies that replace current practices targeting northern Australia.
- These projects at the outset had a moderate likelihood of technical success because similar treatments using these active ingredients have been effective – the challenge was to reduce the dose and make it economically viable.
- Furthermore if the price is right it has a reasonable chance of adoption – as producers are familiar with applying these treatments in northern Australia (the target audience) and the economics of reducing mortality and saving spay costs are clear.
- Subsequent to commencement proof of concept has been achieved – so technical risk of failure is now low.

The primary outcome of the program is expected to be the development of a treatment along with an adoption strategy involving:

- working with key opinion leaders throughout development, registration, launch and post launch phase work with Key Opinion Leaders
- present data and obtain feedback on trials
- demonstrate welfare advantages
- create high level of awareness surrounding product
- co-develop identification method (branding/tagging) acceptable to graziers.

The program is being delivered through a collaborative partnership between MLA, research providers and companies with significant experience in this field.

The MDC program is promising but entails considerable risk before successful marketing of a product. This is why MDC has been approached.
The company considers the economic return likely to justify the investment and they will manage the risk around registration.

6.1.4 Rationale for LPI involvement

The development of non-surgical spaying has been an industry priority, particularly in Northern Australia, since the early 1990s. The rationale for these MLA investment decisions were based on the potential benefits of the development of new technologies that replace current practices, that is, a targeted response to a problem that is most prevalent in North Australia. A reliable, cost effective and potentially reversible female fertility control from a single treatment would deliver significant improvements in:

- animal welfare for cows that otherwise would be spayed
- productivity from lower costs and the wider adoption of spaying as a management tool in the rangeland industry.

As identified earlier, the potential benefits are significant by managing key risks in the industry:

- pain from surgery and subsequent mortality would be eliminated
- producers would have the incentive to fatten and sell cull stock rather than have them die in the paddock
- there would be more management options for producers in Northern systems with regard to heifer retention and turnoff especially in targeting the live trade or feedlots who now require females to be spayed or pregnancy tested empty (PTE).

The first two factors would have a distinct benefit in terms of safeguarding the reputation of industry in the eyes of customers and consumers, and avoiding the possibility of direct regulation

by governments or customer groups in terms of whether spaying could be used and under what restrictions.

For these reasons, there is a clear remit for MLA to be involved given endorsement by the Cattle Council of Australia (CCA), the alignment with the MISP, beef strategy and the MLA welfare plan. This project is consistent with the 2-digit AOP node *4.3 Support industry to make continued improvement in animal welfare without reducing productivity levels*, and more particular the 4 digit AOP node 4.3.1.4 *Develop replacements for aversive procedures*.

Two risks were identified at the planning stage for this cluster of projects:

- probability of technical success (from the experience of the 1990s)
- adoption risk (the target producer group are cautious).

Previous research showed that price was the barrier. The focus of the recent projects was to reduce price by making the treatment more efficient and therefore save money of the cost of the product. Adoption risk would be reduced by a single treatment at the correct price point.

- In terms of the categorisation against types of risks identified in chapter 2, the risk of compliance failure is the most appropriate especially in a market environment where the expectations of customers and consumers are evolving to incorporate more stringent requirements on production systems and animal welfare.

Following the project logic with the emphasis on animal welfare, it could be interpreted that the focus of this cluster of projects is the improvement in animal welfare — which would indicate significant public benefits. However, a major component of the defensive investment is to provide industry with a cost-effective technique (competitively priced with surgical spaying) that would provide productivity benefits and avoid additional regulations — which indicates potential industry or private benefits.
In summary, this project cluster shows a multifaceted approach to achieving the objective of replacing spaying with an alternative practice. If successful, they would:

- develop an replacement for an existing practise
- represent a significant (step) change instead of an incremental improvement
- yield non-market animal welfare benefits.

6.2 Approach to quantification of project benefits

As a result of the importance of the focus on industry on-farm practices, there is a significant body of data and information accessible. In summary:

- the practice of spaying cows and heifers is primarily used as a productivity tool with the benefit of being able to spay heifers and cull cows was estimated to be around $145/head and $205/head respectively
-
- the practice is more prevalent and important for the Northern industry where bull control is more difficult.

Key market drivers include the requirement for the Indonesian trade and the Australian Standards for Export of Livestock (ASEL) is that all female livestock exported for feeder and slaughter purposes are either: spayed (desexed by removal of the ovaries), or pregnancy tested within 30 days of export and found to be not detectably pregnant.

- While the MLA survey found that the average cost of spaying was $79 per head, because of difficulties with shared costs with other operations, a more representative cost was found to be between $30 and $45 per head.
- post-procedure mortalities occur.

Before exploring the benefits and costs of the MLA investment, the first step is to understand the drivers of the spaying procedure itself.

These gains were dependent on the capability of preventing pregnancy. An analysis of all the results demonstrated a relationship between the improvement in the net value of the female sales from spaying and the fall in number turned off. This study identified the following decision rule:

- If the percentage improvement in net value of the female sales is greater than the percentage difference in total turnoff by more than 2.45, then spaying females would appear to have a positive cost benefit for the enterprise.
- That is, if the percentage increase in average female sales value is greater than the expected fall in total stock numbers by 2.45, there should be an increase in gross margin.

Table 5.2 provides a summary of the cost-benefit of spaying as an on-farm practice. Based on an average cost of around $5 per head for the spaying operation, the average payoffs across northern properties was around $100 per female spayed.

- A critical component of the BCA was the assumed per head cost of spaying which is unclear across the properties from the report.
- It would be expected that the BCA would be highly sensitive to the spaying cost on a per head basis and its treatment with other shared costs particularly those for labour and mustering.

Given this information, the next step is to establish how these benefits and costs would change at the margin if the MLA investment were to be successful.

Table 6.2 Summary of the net benefit of spaying

	Cows spayed	Change in gross margin		Change in female value	
	No	%	$ per cow spayed	%	$ per head
Pilbara	1 145	1.7	40	25.4	76
Kimberley	483	1.7	48	15.7	61
VRD	792	0.9	35	11.2	55
Barkly	781	5.1	293	12.5	51
NWQ/Gulf	707	6.0	307	13.2	52
Alice Springs	304	-3.4	-219	3.0	15
Total	**4 212**	**2.8**	**113**	**13.2**	**53**

Source: Niethe and Holmes (2008).

6.2.1 The with and without investment scenarios

Fundamental to the BCA approach is the development of the 'with' and 'without' MLA investment scenarios that will underlie the net benefit stream. In this analysis we consider three outcomes:

- baseline or business as usual: where Australian beef producers continue to have access to spaying (assumed to be the preferred Dropped Ovary Technique) and that use of this technique follows current adoption levels
- the without MLA investment case: due to pressure from governments or customers, producers lose access to the practice and suffer a loss in productivity — including a loss of the net benefits of spaying identified above on a $ per head basis (and an unknown impact on animal welfare due to unwanted pregnancies)
  - It could be imagined where this scenario is escalated where the Australian beef industry suffered a negative demand shift from these impacts as consumers move away from production systems that use spaying.
  - What is more likely is that producers and customers will align themselves to higher welfare standards through the use of accreditation as a point of differentiation such as that used by 'sow stall' and 'cage free' products.

- (alternative) without MLA investment case: producers still have access to spaying but with additional regulatory requirements such as the mandatory use of an accredited veterinarian, the use of anaesthesia and analgesia and possibly the supervision of an third part auditory.
    - Similar to the option above, this imposes additional costs that would result in a loss in productivity.
- the with MLA investment case: a cost-effective medical treatment is developed that permits continued access to the productivity benefits or spaying without compromising animal welfare. The productivity benefit will come through two mechanisms:
    - maintenance or reduction in costs for those producers who already use the technique
    - adoption of the new product, and access to productivity benefits, by producers who previously didn't use spaying due to cost or welfare considerations.

Chart 6.3 illustrates the overall approach to quantifying the difference between the 'with' and 'without' MLA investment scenarios.

6.3 The approach to valuing industry (private) benefits

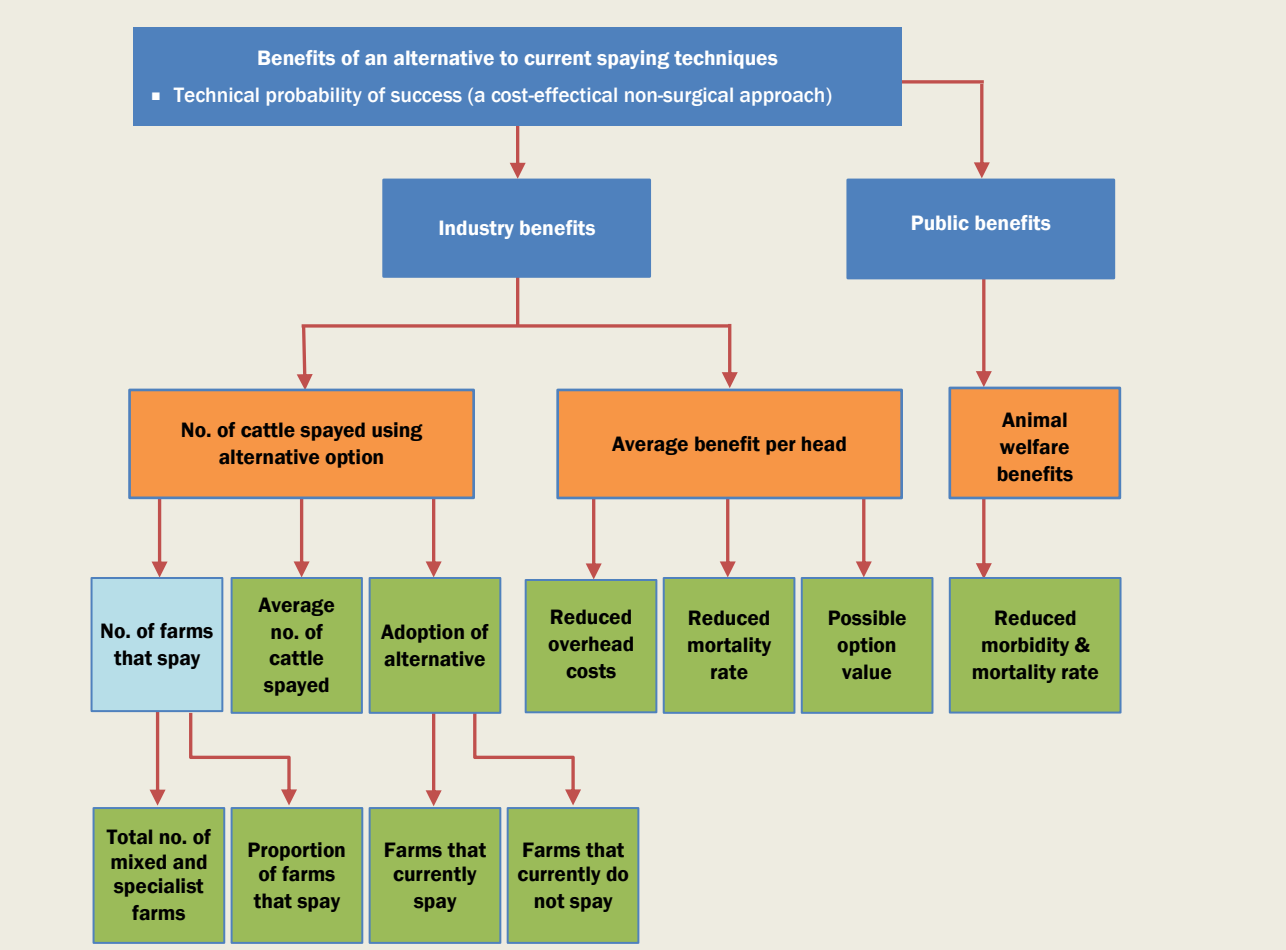
The first component is to estimate the productivity or industry benefits of the MLA investment. The expected benefits depend on four critical parameters:

- the probability of technical success of the project [5]
- the potential change in net cost of the spaying procedure (cost of the new technology less costs involved in the surgical procedure)
- adoption of the new technology and
- (more widely) spaying as a manage management tool by producers who previously didn't use the practice.

6.3.1 Changes in the cost of spaying

[5] Or more accurately the probability of success at the output level recognises that there is always uncertainty about whether the outputs of a project will be achieved. The MLA Questionnaire allows the probability of success to be recorded at three stages – before the project has started, during the project and at the end of the project. Once a project has been completed, outputs can be assessed relative to expectations. This may mean that the project achieved the expected output (100%), achieved no output (0%) or achieved an output of an inferior or superior quality to that expected (less than 100% and greater than 100% respectively).

Chart 6.3 Expected productivity improvements from non-surgical spaying



As MLA's projects are still in a relatively early stage of development, the likelihood of successfully developing a marketable alternative to current spaying techniques and the characteristics of any alternative are unknown. The uncertainty surrounding the characteristics of the final product is accounted for in the analysis below through the use of sensitivity analysis. More specifically, three price points were considered: $2.50, $7.50 and $15 per head

6.3.2 Technical success of the investment

Defensive investments are about uncertainty and risk. An obvious risk going forward is that producers will lose access to the practice or face higher costs as a result of compliance with more onerous requirements around spaying that are higher cost, or if too high a cost, will make the practical uneconomic.

- Given the common use of the ovary drop technique, the additional costs of providing pain relief would be the obvious risk.
- However, there is little or no uncertainty about these changes, as reflected by the high priority given to it by industry. What is more uncertain is the timing of these requirements and how long it takes to achieve technical success of the investment.

The ultimate objective of the series of MLA investments is an intervention that replaces the surgical procedure and is reversible.

- As noted, previous treatments have been technically successful but are uneconomic because of the cost of the proprietary drug at higher concentrations, or the requirement for multiple treatment at lower (more cost effective) concentrations.

- In its investment decisions, it was noted that the probability of technical success was uncertain and up until now based on subjective judgement. It would be logical that this would be a key parameter in a systematic sensitivity test in any analysis.

Variation in the final price would result in different levels of adoption, and in turn, different levels of economic benefits for cattle producers and the country more broadly. The choice of $15 per head as the upper bound price point is consistent with previous survey findings from MLA that showed that the vast majority of cattle producers would not adopt a chemical alternative if it were priced above $20 (see table 6.4 below).

Table 6.4 Survey findings on potential adoption of a non-surgical alternatives[a]

Response	Price per head ($)		
	Under $10	$10 -20	Over $20
Definitely use it	48	11	1
Use it	21	15	4
Can' say	15	14	9
Would not use it	1	15	9
Definitely would not use it	16	45	77
Total	**100**	**100**	**100**

[a] The base was all beef cattle respondents who spay cull / surplus cows.

Source: MLA.

In terms of permanency, both temporary and permanent solutions are considered based on information about current investments. In the analysis that follows, it is assumed that a permanent solution is developed, while the additional option value associated with a temporary solution is considered through the use of option value techniques.
This temporary option solution may take the form of implant technology proposed is as next-generation and would provide long-term contraception (12-24 months), with the option of restoration of normal fertility.

All of the alternative options that MLA have so far invested in would allow cattle producers to administer treatment without the services of a veterinarian or contractor. This will in turn remove the associated fees and expenses. It is also assumed that the alternative options, if successful, would remove the need for cattle producers to use pain management as well as any monitoring costs. These changes would result in a reduction in the cost of spaying per head of up to $20 per head.
One of the industry benefits of a cheaper and safer alternative to current spaying techniques will be a reduction in overhead costs paid by cattle producers that practice spaying. In order to quantify this saving it is necessary to estimate the current overhead costs associated with spaying and the expected costs in the event that a cheaper alternative is developed.

Table 6.5 presents our estimates of the main cost components of spaying for cattle producers that hire a vet or a qualified contractor. The costs of spaying were assessed through consultation with cattle producers and survey evidence. On average, spaying is estimated to cost $27 per head, with over 50 per cent of these costs due to the labour required to muster and process cattle. The labour costs associated with mustering and processing cattle were estimated based on the assumption that cattle would not be mustered for the sole purpose of spaying, and hence only a proportion of the mustering costs could be allocated to spaying.

Table 6.5 Costs of spaying with and without the MLA investment

Cost components	Current practices	Alternative
	($ per head)	($ per head)
Vet/contractor fee	6.00	
Vaccine/implant		7.50
Vet travel costs	4.00	
Labour (mustering, processing etc.)	15.00	15.00
Monitoring costs	1.00	
Other (pain killers, maintenance costs)	1.00	
Total	**27.00**	**22.50**

Given the central assumption that a spaying alternative would cost $7.5 per head, the overall cost of spaying is estimated to reduce by $4.5 per head.

6.3.3 Potential adoption rates

In the event of an alternative to current spaying techniques coming onto the market, there would be expected to be an increase in spaying by properties that previously did not spay. For example, properties that previously found it was not cost effective to spay or were concerned about the animal welfare implications may now start to spay some proportion of their female cattle.

The 2008 survey conducted by MLA included a question regarding the reasons why cattle producers do not spay. Reasons given included:

- no need (54%), ability to segregate bulls from heifers and cull cows (22%), no perceived economic benefit (11%)
- the expense of spaying (9%), animal welfare issues (7%), not appropriate for my operation (8%), unacceptable stock losses due to procedure (7%) ,successfully fatten otherwise (6%), skilled staff availability issues (5%), increased opportunity to sell breeding cattle (5%).

This indicated that rationale for 13 per cent of producers who did not use spaying, would be addressed by the new technology (given producers current understanding of the cost of spaying and potential benefits).

Table 6.4 shows that 70 per cent of cattle producers surveyed that currently spay reported that at a price point of $10 or lower they would ‘definitely use’ or ‘use’ a chemical alternative. Assuming that some proportion of cattle producers that reported that they ‘couldn’t say’ would eventually end up adopting a chemical alternative, suggests that close to 75 per cent of cattle producers who currently use the practice would adopt a chemical non-surgical non –invasive alternative to current spaying practices at a price point of $10 per head.

6.3.4 Other factors

As mentioned previously, there is a large range of procedures and personnel used by cattle producers to spay their cattle. While the majority of spaying procedures are performed ethically and humanly, some spaying processes in Australia may not be consistent with current welfare codes.

In the event that information about these procedures is made public, there is a risk of a greater degree of government regulation surrounding husbandry practices. A number of animal welfare groups are advocating for greater regulation of spaying practices across Australia. For example, in late 2012 the RSPCA released new guidelines for the Australian beef cattle industry. These guidelines covered all stages of the beef supply chain from on-farm to the point of slaughter.

In relation to spaying, the RSPCA guideline specified that the spaying of female cattle should not be performed unless it is:

- carried out by a veterinarian for therapeutic reasons
- was accompanied by pre-and post-procedure pain relief.[6]

A safer alternative to current spaying techniques would help to reduce the risk of increased government/regulatory intervention. An estimate of the costs to cattle producers of the regulation outlined in the RSPCA's new guidelines for the Australian beef industry is shown in table 6.6 below.

Table 6.6 Estimated annual costs of increased government regulation

Regulation	Additional costs
	$m
Compulsory use of a VET	1.8
Compulsory use of anaesthetic and/or pain killers	1.2
Total cost increase of regulation	3.0

6.4 Estimating the benefits of the MLA investment

This section develops a central estimate of the public and private benefits of a permanent alternative to current spaying techniques:

- on in a net present value terms over a 20-year period from 2015-16
- at a state, regional and national level
- by benefit type (reduced overheads, reduced mortality rate, public benefits etc.).

Because the costs and benefits of an alternative spaying solution will have different time paths, the net present value of cost and benefits streams need to be calculated. In the results presented below, a real discount rate of 7 per cent was used.

The costs and benefits of an alternative option to current spaying practices must be assessed against a plausible baseline, that is, what would have happened without the introduction of an alternative. Estimating the number of cattle spayed under a baseline scenario involved three steps:

- analyse MLA survey data on the prevalence of spaying
- estimate number of cattle spayed in 2015-16 (based on end dates of R&D programs)
- forecast the number of cattle spayed over the next 20 years.

6.4.1 Baseline number of cattle spayed 2015-16 onwards

In terms of ex ante, we estimate that 75% of the cattle subject to spaying are in Northern Australia. The next step would be to project the baseline numbers going forward out to, say, 2035, or the 20 year time horizon over which benefits would be expected to flow. The establishment of the baseline, or the without MLA investment case, is difficult to assess as there are two factors at play:

- herd dynamics especially in Northern Australian regions where the practice of spaying is prevalent which in turn depends critically on demand in, and access to, the Indonesian market and naturally seasonal conditions
  - market access to Indonesian has been variable since 2008 with a range of quantitative and weight restrictions in place. However, this is likely to determine the scope for premiums for female cattle for live export over alternative sales channels in the domestic market

[6] RSPCA, Australia Animal Welfare Guidelines Beef Cattle, 2012

  - dry seasonal conditions and tough market conditions during 2013 and 2014 have meant that northern cattle numbers are currently at a 10 year low and not an appropriate base from which to conduct an analysis of the benefits
- the intensity of use of the spaying among that herd. We know that this is a farm by farm business decision that also depends on both the policy and regulatory environment but also market configuration.

Overall, a conservative approach should be taken to the baseline using MLA forecasts of projected herd by the northern and southern region out to 2020. These forecasts show eventual recovery of the northern herd back to near to pre-2013 levels. Over the longer term, the trend growth in the northern herd could be expected to be similar observed between 2000 and 2012.

6.4.2 Better understanding responses by producers

The demand for spaying is assumed to be relatively inelastic with respect to price for the majority of cattle producers in the short term, that is, changes in the cost of spaying are assumed to lead to only a modest change in the number of female cattle spayed. This is consistent with reports that spaying was a necessary practice in order to prepare heifers for sale to the live export trade or feedlots and to prevent older cows falling pregnant and prepare them for sale.

The impact of a new cheaper and safer alternative to current spaying techniques is assumed to affect spaying practices in two stages:

- the reduction in the cost of spaying is assumed to result in only a small increase in the number of cattle spayed due to the assumed inelasticity of demand.
  - In this case, the main benefit for cattle producers that currently spay is a reduction in overhead costs on a per head basis or put another way, a productivity improvement.
- the greater efficiency and safety of the new alternative is assumed to result in a proportion of farms start to spay female cattle.
  - This will again reflect a productivity improvement for these cattle producers who were either focussed on managing fertility rates through other means or focussed on managing the financial costs of unwanted pregnancies.
  - Due to improved animal welfare and more efficient administration, an alternative solution is expected to increase the number of cattle producers that spay in the range of 5 to 10 per cent.

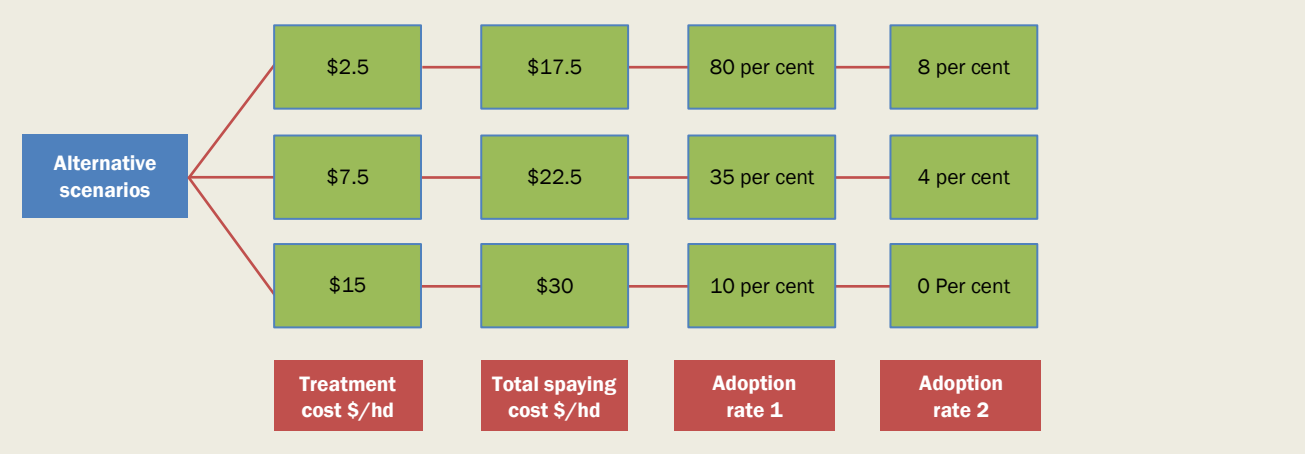
In the short-term, the majority of these benefits are assumed to stem from a reduction in overhead costs associated with the spaying procedure and a reduction in the mortality rate, that is, a productivity improvement.

Over a longer period of say 3 to 5 years, cattle producers are assumed to have a greater degree of flexibility with regard to the scale and composition of their outputs. Work by Niethe and Holmes (2008) indicate that these benefits over the longer term, given no changes in the carrying capacity in adult equivalent terms, the wider adoption of spaying would most likely be a small reduction in the turnoff of cattle from northern properties, but and a change in the composition of the turnoff resulting in higher value sales (see table 6.2).

6.4.3 Alternatives approaches to standard BCA

The obvious technique to be used in conjunction with standard BCA is a structured sensitivity analysis particularly around the relationship between the expected price per head treatment cost of the new technology and the adoption profile — which may be crucial for producers who currently do no spay due to cost and/or the nature of the procedure. Table 6.10 shows how the sensitivity testing would be conducted around the price points identified above.

Table 6.10 Relationships between key input parameters



In addition to sensitivity testing, the real options framework would be suited to this analysis. In fact, the analysis by Niethe and Holmes (2008) reflects many of these principles of real options to better manage their herd and market female cattle by looking at alternative culling strategies based on the use of spaying. However, real options is probably more useful on examining the impacts on individual farms, based on their profitability analysis.

- That is, the decision to use non-surgical spaying as a management tool is more appropriate at an individual farm, rather than industry level. The real option analysis would be able to assist with answering which operational conditions, would non-surgical spaying be used.
- This information could be then used to infer adoption by the wider industry (or subset of the industry) based on case studies and their representativeness of the wider industry.
- As noted in chapter 2, real options approach provides another way of handling the 'with' and 'without' MLA scenario.

6.5 The approach to valuing public (spillover) benefits

MLA's investment decision and to allocate the project's allocation to animal welfare in the LPI portfolio indicates the importance of these outcomes.

6.5.1 Reduction in morbidity and mortality

In the event of an alternative to current spaying techniques coming onto the market, it would be reasonable to expect there would be a number of complementary animal welfare benefits.
The spaying practice itself is considered to improve animal welfare as a result of fewer animals dying in the paddock. In terms of the spaying procedure itself, there is strong scientific evidence that current practices does cause animals pain and suffering. For example, an article published in the Journal of Animal Science in 2012 made the following conclusions:

- FL and DOT spaying should not be conducted without measures to manage the associated pain and stress
- electroimmobilization causes pain and stress and should not be routinely used as a method of restraint. [7]

An alternative to current spaying techniques in the form of a vaccine or slow release implant would effectively eliminate pain and suffering during and after the procedure and a reduction in the mortality rate associated with the procedure.

[7] Evaluation of the impacts of spaying by either the dropped ovary technique or ovariectomy via flank laparotomy on the welfare of Bos indicus beef heifers and cows.

6.5.2 Estimating benefits from improved animal welfare outcomes

The valuation of benefits from improved animal welfare are notoriously difficult to quantify. This is why, in nearly all cases, the vast majority of effort goes into quantification of more tangible benefits.
This requires a two-step approach:

- determine a system to objectively measure welfare or wellbeing in animals and, once developed, observed how this measure changes with alternative management and procedures
- how societies or consumers' willingness-to-pay (or some other mechanism) change in response to the changes in welfare outcome.

The vast majority of the literature with respect to the first point, is in reference to housing arrangements for intensive industries (pigs and poultry) rather than for individual management practices or changes in mortality and morbidity. The majority of work completed in this area has been around objectively measuring the so-called 5 freedoms:

- from hunger and thirst
- from discomfort: by providing an appropriate environment including shelter and a comfortable resting area.
- from pain, injury or disease: by prevention through rapid diagnosis and treatment.
- to express normal behaviour: by providing sufficient space, proper facilities and company of the animal's own kind
- from fear and distress: by ensuring conditions and treatment which avoid mental suffering.

While various stakeholders agree on the definition of the freedoms, and in some cases how to measure them, there remains significant and vigorous debate about the weights assigned to each freedom to obtain a measure of an overall improvement in welfare.

Petherick and Edge (no date) note that measuring animal welfare in extensive livestock production systems is challenging as few existing few animal-based measures can be applied. Some of these include measures of productivity (live weight gain and fertility) health records, numbers of mortalities, culls and injuries, and body condition score (to reflect nutritional status). These tend to be observed after the event, and so are best handled through the use of appropriately structured (scientific) experiments.

One relevant example is the preliminary work conducted by Paton et al (no date) who developed a simplistic semi-quantitative framework to compare two different issues affecting the welfare of pigs and the welfare impacts associated with the issues of flystrike and mulesing, using the epidemiologically-based risk assessment approach. This study did not propose to assign absolute welfare values to the management scenarios or make any absolute findings on the comparative welfare effects.

The second step would be to establish what consumers and society would be willing to pay (WTP). There are a number of possible approaches through which this can be achieved but relies on exploring how people would make choices for, and tradeoff improvements in, animal welfare against other benefits that they could 'consume'. For example, Bennet et al (2012) proposes a simple single measure scoring system, based on a welfare quality index, together with a choice experiment economic valuation method to place a value of improvements in animal welfare across species measured on a scale from 1 to 100. They note that these approaches can rank, but not reliably value, alternative changes in animal welfare.

In summary, approaches to quantify improvements in animal welfare, especially for the extensive industries, are poorly developed and expensive to conduct even in an ex-post analysis. A simple scoring assessment is likely the most cost effective method of assessing benefit at this stage.

6.6 Recommended approach in an LPI portfolio context

One of the objectives of this report was to distinguish the difference in characteristics of, and approach to quantification, of defensive investments and 'standard' productivity projects. The spaying case study contained aspects of both of types of projects types: its ultimate classification depends the relative weight put on the productivity (industry) benefits and those from improved animal welfare (public benefits).

- These weights depend on how the 'with and without' MLA investment scenarios have been constructed and the associated probability of the 'adverse events'.

In terms of the categories of adverse events risk identified in chapter 2, this project seeks to address either a compliance failure or a market political risk, that is, the loss of spaying technique or increased costs in terms of those associated with aesthetic or other regulatory requirements.

In the event of a technically successful output from the research — that being the development of a cost-effective non-surgical alternative to spaying — there should be productivity benefits that result from higher herd returns and/or lower costs.

- If the projects are successful against their stated objectives (in terms of cost effectiveness) a high level of adoption can be expected as a result of productivity benefits.
- The assessment of the technical probability of success, even without consideration the animal welfare implications, should be the main criteria against which MLA should evaluate this project cluster because of the industry (private) benefits.

On this basis, this cluster of investments should be compared directly to other LPI investments in the portfolio as this cluster of investment addresses primarily industry failure (private benefits), or where industry is better off by acting collectively.

6.7 Recommended approach in an evaluation context

Given the arguments identified in this chapter, the ongoing evaluation of this cluster of 'defensive' projects should use a similar approach to other (largely) productivity based projects in the portfolio.

- Unlike the FMD case study, there will be an opportunity to examine these projects on an ex post basis.
- We have identified that the critical factor to be monitored over the remainder of project timeframe is any indication of the technical success of the project changing in relation to achieving its stated objective (a cost-effective spaying treatment).
- In essence, this success will determine if the project produces an incremental improvement in knowledge or a step change in technology that can be applied across the industry.
- In contrast to the other case studies, there is (comparatively) a lot of information available from a previous BCA analysis, a somewhat dated survey of spaying practices and recent situation analysis for northern beef producers.
- The initial (baseline) survey data on prevalence of spaying has also been questioned. If the project is successful, then monitoring the extent of adoption of the new technology will also be crucial in determining the benefits of project on an ex post basis.

7 National Pasture Genetic Resources Centre

In April 2006 the Primary industries Ministerial Council took the decision to establish a National Genetic Resources Centre (NGRC) for the purpose of conserving plant genetic resources for food and agriculture.

At present, there are five separate major centres for plant genetic resources in Australia, located in New South Wales, Queensland, Victoria, South Australia and Western Australia. The five plant genetic resources centres are custodians of approximately 184 000 accessions (documented samples), including grain crop, field crop, pasture, forage, feed and perennial germplasm.

- The conserved material serves as a bank of seeds and genes that can potentially be used by plant breeders to develop new crop, pasture, and forage cultivars (perennial-based farming systems) and plants for other uses, such as land rehabilitation purposes.
- The material could also potentially be used in biotechnology, genomics, phenomics and other research.

7.1 Background to NGRC and the NPGRC

Most of the centres contain a significant proportion of material that is unique to the collection[8] . While the centres differ in the proportion of accessions classified as relevant to feed and non-feed end uses, across the total collection held in all centres there is approximately a 50:50 split between feed-relevant and non-feed-relevant germplasm [9].

The proposal to establish an NGRC arose from the identified need to reform the operations of the five separate centres, improve economies of scale, reduce duplication, establish a comprehensive information management system, strategically manage and conserve the collections, and place collections on a more secure financial footing.

The NGRC steering committee recommended a two-node model as the preferred option for the centre. The crops collections would be consolidated at a 'crops' node at Horsham, Victoria, and the pastures collections at the 'pasture' node at Adelaide, South Australia.

7.1.1 Australian Grains Gene Bank

The crops node has become the Australian Grains Genebank consolidating including the Australian Temperate Field Crops Collection of oilseeds and pulses at Horsham, plus tropical and temperate cereal collections respectively at Biloela, Queensland, and Tamworth, New South Wales.

- In 2013, the Grains Research and Development Corporation (GRDC) took responsibility on behalf of industry. The GRDC contributed $2.85 million out of the $ 5.7 million cost of the new facility, matched by funds from the Victorian Government.
- The GRDC and Victorian Government are also providing up to $600 000 a year for operating costs over five years.[10]

GRDC on behalf of the grains industry funded the crops node because of the strong linkages between the investment in, and maintenance of, the facility and potential benefits that would flow to grain growers. This linkage is through the operation of the Genebank as an important component of GRDC's pre-breeding program.

7.1.2 National Pastures Genetic Resource Centre (NPGRC)

The funding of the so-called pastures node was partially resolved in a meeting in 2011. [11] Australia houses the world's largest pasture collections, with at least 25 000 annex 1 accessions

[8] Meaning that it is not principally conserved in overseas seed banks.
[9] Feed end use refers to the use of improved plants for animal feed, including grains, pastures and forages. Non-feed use refers to the use of improved plants for any purpose other than animal feed and includes crops for human consumption, plants for fibre, vegetable oils, biofuels and 'industrials'.
[10] http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-105-July-August-2013/Industry-snapshot
[11] National Pasture Genetic Meeting, 22 February 2011 at the Plant Research Centre SARDI

and with 95 per cent of the germplasm could be unique to these centres. The extent of the collections are summarised in table 7.1.

The meeting discussed the transition process for consolidating the 5 facilities towards a fully integrated collection at the end of the 5 year operation plan.

Table 7.1 National pastures plant genetic resource centres

Centre	State	Specialisation	Number of accessions	Average distribution of seed samples
			no	no per year
Medicago Centre	▪ South Australia	▪ Annual and perennial temperate legumes, grasses and natives	45 500	3 000
Trifolium Centre	▪ Western Australia	▪ Legumes for acidic soils	20 000	600
Tropical Crops and Forages Centre	▪ Queensland	▪ Tropical legumes and grasses	13 500	2 000
Winter Cereals Collection	▪ New South Wales	▪ Informal collection of pasture legumes	na	0
Temperate Field Crops Collection	▪ Victoria	▪ Informal collection of temperate grasses	na	0

Source: The Allen Consulting Group (2007) and National Pasture Genetic Resources (2011).

7.2 Investment decision by MLA

Funding of the NPGRC was also discussed at the 2011 meeting:

- 92 per cent of the centres costs are attributable to the maintenance of the centre or $700 000 of the total $750 000 each year
- that a user-pays approach should be taken with provision for free access for researchers in developing countries and to students
- cost recovery would make a small contribution between 5 and 10 per cent of total costs each year.

A key action at that meeting was that MLA would be the lead agency for investment in the NPGRC and would initiate further discussions with Department of Forestry and Fishing, Australian Wool Innovation, Dairy Australia and Grains Research and Development Corporation to determine investment contributions for each agency for the initial 5 year term.

A further meeting took place on 17 April 2012 for South Australian Research and Development Institute (SARDI) and the RDCs to discuss the investment in the pastures centre. The main outcomes of that meeting were:

- SARDI committed to providing in-kind funding with facilities. SARDI advised that the pasture node required $760 000 contribution in addition to in-kind contributions from South Australia, Tasmania, Western Australia and Queensland.
- all RDCs agreed in-principle to invest in the centre and agreed to bring investment proposals before their boards before 1 July 2012
- these discussions were on the basis of cost-sharing scenario of expected gains to respective industries.

A funding agreement has been finalised between MLA and its investment partners involving annual expenditures in the order of $400, 000 (see table 7.2).

Table 7.2 MLA investments for the Australian Pastures Genebank[a]

Investments	Project	Investment partner	Start Completion	Investment by MLA	Investment by partners
				$	%
National Pasture Genetic Resource Centre	B.PBE.0039	AWI, DA, GRDC RIRDC	July 2013 Jun 2018	390 922	398 819
Total MLA investment				**390 922**	**398 819**

[a] Annual expenditure over 5 years

Source: MLA.

7.2.1 Rationale for LPI involvement

The nature of the APG, in that potential benefits span the livestock industries, and the timeline of events suggests that MLA had little discretion in funding this investment. Logically, the project fits under the 2 digit AOP node 3.1 *Create opportunities to increase on-farm productivity* and more particularly, the 4 digit AOP node 3.1.1.2 *Accelerate both discovery and delivery of new breeding methods to improve pasture and forage crop productivity, quality and persistence*. Although this project is not representative of the core activities of this node as it is not applied R&D, it provides fundamental infrastructure that could potentially feed into public and private sector R&D including that funded by MLA.

The way this project has been defined, it is clearly a defensive investment. That is, the investment provides for benefits, the probability of which are highly uncertain, that would not be possible without action by MLA and its investment partners.

- Because of the substantial investment and operational costs and the difficulties in capturing the value of the centre's outputs, there is a strong argument for concerted action given positive net benefits.

At the end of the day, MLA was required to invest on behalf of the red meat industry in partnership with government and other pasture-based industries. This obligation larely removed any discretion

The next key question is: should MLA be involved? This should be answered by the calculation of the net benefit stream or payoff to red meat producers. There could also be public benefits that flow from the investment which would further justify MLAs involvement.

7.3 Approach to quantification of project benefits

In 2007, The Allen Consulting Group (ACG) were engaged by the NGRC Steering Committee to undertake a social benefit cost analysis of the proposed options for the NGRC.

7.3.1 The with and without MLA investment scenario

The study's terms of reference required all benefits and costs to be evaluated against a baseline (or without investment case) where no plant material is conserved in Australia.

- Therefore, the purpose of the evaluation was not to examine the net benefits of consolidating the five centres to one national centre.
- Instead, the aim was to assess the net benefits of conserving plant genetic resources within Australia, as proposed by the NGRC, as opposed to conservation outside of Australia.
- This makes this study particularly relevant to the MLA investment decision.

The underlying logic for the investment in plant resource centres has not changed significantly since the Allen Consulting Group (2007), and is based around the capability of industry and government to address the future needs to identify and access plant genetic material that could potentially contribute traits to the development of superior or better performing pasture varieties.

- A large part of the rationale going forward is that ongoing productivity improvements and adaptation to climate change will require the development of new cultivars with attributes such as tolerance to hotter and dryer conditions, or most likely, faster growth through narrower seasonal growing windows.

The value proposition for the NPGRC, however, is significantly more complex than for cropping. The 2011meeting identified some key factors:

- pastures can have a productive life from 4 to 30 years — this means that the pathways between the resource centre, plant breeding are unclear and involve significant lags to adoption by farmers
- importing perennial ryegrass from New Zealand for use in the dairy industry is viable — and recognises that there are other sources of new cultivars available which could be adapted to the Australia. (This also recognises that the benefits will be different for each of the grazing industries.)
- although royalties are collected on pasture seed sales, low returns in the sector result in a low commercial sector participation — this is an important component of the demand drivers for the NPGRC
- a number of state agencies are not investing in improvement and others in a minor way — an outcome that is also a function of final demand level for pasture seeds.

The analysis conducted by ACG (2007) identified categories of benefits and costs in table 7.3. Obviously, to update the analysis for this report we would need to examine those components that are directly relevant to pastures.

Table 7.3 Benefits and costs identified by the ACG report

Benefits	Costs
Private	**Private**
▪ Enhanced *productivity gains* in animal and cropping industries attributable to the NGRC ▪ Grains *price premiums* derived from genetic quality improvements ▪ Containment of the spread of dryland salinity on private land as a consequence of new perennial cultivars and the contribution of the NGRC towards this outcome.	▪ It was assumed that in absence of the centre, all costs currently incurred in the local conservation of plant genetic material would be incurred, plus additional costs, in obtaining the equivalent material from other sources. ▪ This cost would be borne by plant breeders and researchers
Public	
▪ Water quality benefits attributable to new perennial cultivars and the contribution of the NGRC ▪ Public health benefits from the development of new crop and pasture varieties with nutriceutical benefits	▪ Cost savings from efficiency gains in the operation of the NGRC

The study did not attempt to value the plant genetic resources themselves but:

- identified the users and beneficiaries of the conserved plant genetic material and evaluate the market failures associated with its supply for use by plant breeders for food and agriculture
- identified and value the private and public benefits of maintaining a national collection of plant genetic material in Australia (the NGRC) net of the costs of establishing and operating this centre
- estimated the private benefits accruing to animal industries and cropping industries, to help inform sectoral benefits
- estimated the public benefits of the conserved genetic resources to help inform decisions about appropriate levels of public investment in the NGRC.

The report identified that such a resource centre provides a number of challenges for economic valuation:

- plant genetic resources are an input to a production process that involves breeding of a new plant cultivar . This 'value' depends on:
  - the contribution of the genetic resources to the final attributes of the cultivar that is market ready
  - its level of adoption by industry
  - the relative contribution of the pre-breeding and breeding stages (or the value added of the intermediate steps)
- accessions are usually provided to users at no cost, so the observed demand would be different to that under a cost recovery model
- a range of public good values arise from the use of plant genetic material which is not valued by markets or where this value is limited.

This last challenges brings in the concept of market failure. The report identifies why there should be limited or 'thin' markets in the value chain:

- the collection has natural monopoly characteristics with large maintenance costs and very small distribution costs — economies of scale makes it inefficient for several firms to participate
- there is limited information along the chain about the nature of the good or service being provided including the uncertainties about how the 'inputs' or the genetic material are to be used in producing the 'output', the
- the resource has public good characteristics, of — that is, it is difficult to restrict access to the genetic material (non-excludability) and one individuals' use will not significantly reduce the amount available to others.

The report then outlines the rationale for industry and public investment. In summary:

- new plant varieties will have targeted and untargeted public good outcomes such as those that result in environmental and health benefits
- option values — where option value is defined as the value of keeping a diverse array of genetic material available for future use, even though no immediate use exists today
- information and scientific knowledge — about these resources and how to manage them can be public goods
- equity considerations — if some market segments do not end up having access to the resource, or the outputs of the resource, who are disadvantaged because of their economic or regional characteristics.

In terms of service they provide, genetic resources centres' catalogue, store, preserve resource material. They reduce research costs for plant breeders enabling the materials to be located and test quicker at lower cost than the 'without centre' case by making material more accessible through information management systems and maintaining collaborative arrangements with other providers such as international seed banks, plant breeders and plant research institutions.

7.4 The approach to valuing private (productivity) benefits

The approach to the valuation of the productivity benefits, and their distribution between the respective pasture-based industries, will is of most interest to LPI, as this is where the majority of benefits would be expected to be derived. Therefore, there are two sources of benefits from such an investment:

- the direct use value — the potential value that the PGR can contribute to ongoing plant and pasture improvement in the future
- the insurance or option value — which is related to the first but has a greater emphasis on the risk management option, that is, the potential contribution of the PGR in the future given challenges from adverse events.

An example of the option value often cited is in the case of climate change, new pasture varieties will need to be developed that are not simply incremental improvements on previous varieties, rather a step change. As noted the option value also depends on the laternative means of obtaining the same outcome including:

- accessing genetic material from their own collections, collections overseas and from the Australian landscape
- adaptation or moving varieties/species suited to an environmental window as the climate changes, for example, plants growing in south east Queensland may be needed in southern NSW and Victoria (meaning there is no need to breed completely new varieties).

The ideal approach to establishing these benefits would be to better understand what exactly the outputs of the resources centre would be and how these translate into outcomes that could be adopted by the red meat and other livestock industries. This is not a straightforward activity and requires high levels of speculation and a large number of assumptions around the following parameters:

- the probability that genetic material from the resource centre (as opposed to material from other sources in Australia and from overseas) being used in the development of new pasture cultivars to incremental genetic improvement and to step change adaptation if required
- the contribution of the original genetic material to the final value of new cultivars recognising that pre-breeding and breeding stages are also critical to the development of attributes required by the market
- the potential extent of adoption of any new pasture cultivars by each of the pasture based industries and how this would translate through to increases in productivity (relative to the without investment case).

Each of these steps, at best, requires a significant amount of industry knowledge and data. The key problem is that providers of genetic material have little knowledge of how their outputs translate through to market ready products, let alone how these products could potentially contribute to productivity the pasture based industries.

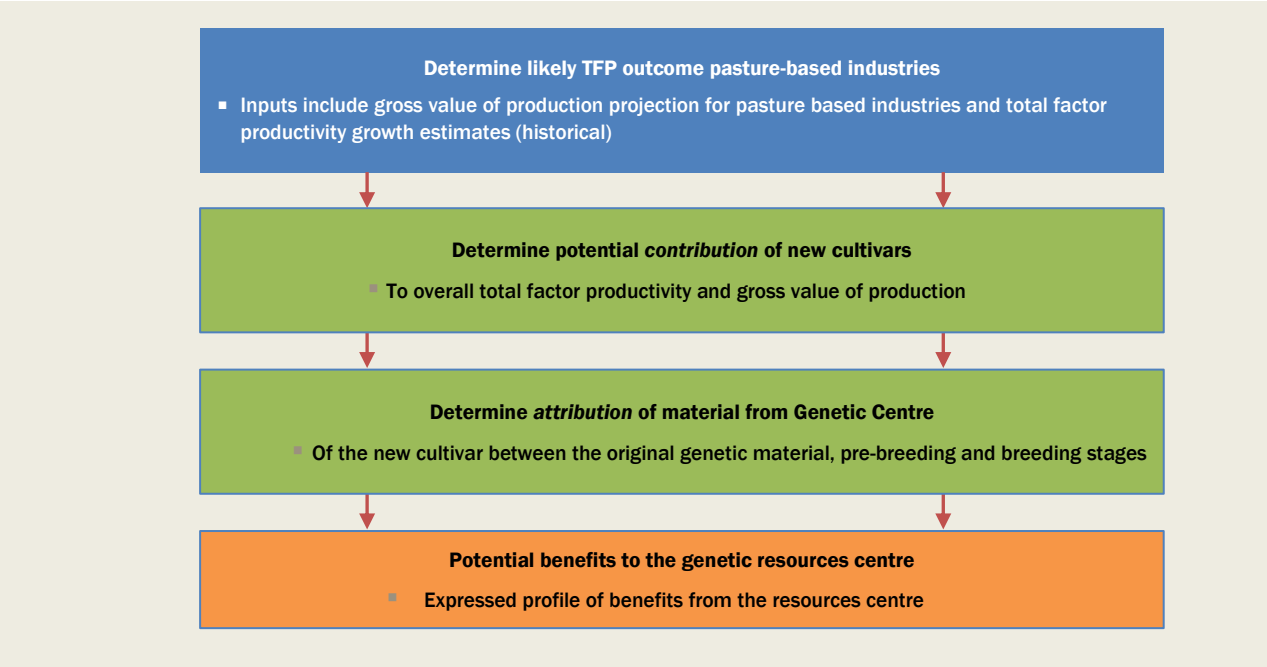
- To suggest how in principle, new cultivars could be developed in response to climate change is possible, but putting a value on this is quite different.
- It would be quite likely, that to develop a ball park estimate of the value of benefits, more resources (funding) would be required than the original MLA investment.

The conclusion is that without knowing the type, or timing, of the outputs (cultivars) and which industries it will be used, it is not possible to estimate a benefit value directly.

7.4.1 Method used to establish benefits

To solve this problem, economists take a so-called ‘tops-down approach’ as summarised in chart 7.4, which reflects that taken by ACG (2007). This approach reflects what was possible with the existing information base but without any additional information concerning the link between genetic material stored, the new cultivars developed and the benefits to agriculture (that is, ‘bottoms-up’ approach).

Chart 7.4 Overview of the 'tops-down' assessment of potential contribution



The type of analysis assumes that the continued availability of conserved plant material in Australia (the with investment scenario) will enable historic trends in farm productivity to be maintained into the future.

- This scenario however, precludes the possibility of a significant one-off discovery (step changes) but these are rare occurrences and very difficult to predict before the fact.

In the absence of conserved genetic resources in Australia (the without investment scenario), it was assumed that industry productivity would continue but at a slower rate. The difference in the gross value of production (GVP) between the 'with' and 'without' scenario, is the measure of the economic benefit of conserving genetic resources. Table 7.5 shows the data and assumptions that were required in the ACG (2007) assessment.

- This type of analysis is relevant to LPI primarily through the identification of specialist and mixed livestock enterprises identified in table 7.5.
- Given that the existing analysis covers both crops and pasture, the key points are that the expected payoffs to the livestock industry are expected to be significantly lower than for cropping specialists.

Table 7.5 Assumptions underlying ACG productivity assessment

	Annual GVP for2004-05	Annual average TFP growth	Share of productivity due to new cultivars	Share of gain due to NGRC
	$m	%	%	%
Sheep specialists	2 176	0.9	5	30
Sheep-beef	2 295	1.0	10	30
Beef specialists	10 205	1.8	10	30
Mixed livestock-crops	5 057	2.4	20	30
Crop specialists	7 740	3.3	30	30
Dairy	4 479	1.7	10	30

Source: Allen Consulting Group (2007).

To better understand the degree of this approach to LPI and the wider red meat industry, table 7.6 makes an assessment of the data and assumptions used in the 'tops-down' approach around

availability and reliability. It would be easy to conclude that such an approach would be capable of producing results that are indicative only.

Table 7.6 Data sources for 'tops-down' approach for productivity benefits

Key	Easy/difficult	Sources	Reliability
Base GVP estimates	▪ Easy	▪ Published ABS/ABARES data	▪ High
Forecasts of GVP going forward (including commodity prices)	▪ Difficult	▪ Commodity prices were assumed to remain constant in real terms	▪ Moderate
Total factor productivity	▪ Easy	▪ Published ABARES data. ▪ Productivity in future was assumed to look like past.	▪ Moderate[a]
Productivity due to new cultivars	▪ Difficult	▪ Requires assumption that future will look like the past.	▪ Mow to moderate
Attribution back to PGRC	▪ Difficult	▪ None. Subjective judgement and assumption. ▪ No account was made of the contribution of pre-breeding and breeding stages.	▪ Low
Improved performance of the centre and of plant breeders.	▪ Difficult	▪ None. Subjective judgement and assumption ▪ No account was taken of the changes in size, composition or effectiveness of the centre over time	▪ Low
Timing and dynamics of key variables (primarily productivity and attribution)	▪ Difficult	▪ Informed by historical performance ▪ Largely subjective and by assumption	▪ Low

[a] Care need to be taken with 'official' TFP estimates, a good understanding is required of limitations due to data inaccuracies and estimation methods.

Source: ACIL Allen Consulting and the CIE.

- Many of the assumptions required, such as the share of productivity due to new cultivars is are almost impossible to establish quantitatively — what is probably more important is the judgement around the relativities between industries.
- A key source of such information is generally judgements made by the proponents. This puts decision makers within MLA in a difficult position because they cannot verify or cross-check the information.

The most obvious activity for this analysis would be to update the ACG analysis with most recent data. This is a classic example where there are not significant payoffs to updating the base GVP data and TFP estimates. There is probably more to be gained from refining the estimates of:

- the contribution of cultivars to TFP
- the attribution of the NPGRS to this outcome.

In fact, one of the better outcomes from this approach, is to provide guidance on how benefits are shared between industries (see table 6.7) which in turn are determined by the relative contribution of gross value of production from each industry going forward. In this way, this outcome is similar to the calculation for cost sharing arrangements across industries for a range of plant and animal health initiatives that span industries.

Table 6.7 Value of productivity benefits from the NGRS

	Net present value over 30 years	Annuity benefit
	$m	$m
Sheep specialists	30	2
Sheep-beef	71	5
Beef specialists	626	45
Mixed livestock-crops	889	65
Crop specialists	3 132	228
Dairy	256	19
Total benefit	**5 044**	**364**

Source: Allen Consulting Group (2007).

Excluding the benefits to the cropping sector, the red meat industry would be a significant benefactor simply on a GVP basis.

7.4.2 Alternative approaches to standard BCA

Intuitively, because of the large number of assumptions involved (tables 7.5 and 7.6), structured sensitivity analysis and Monte Carlo analysis are the most obvious option. However, the time and resources involved for such an analysis, given the potential payoffs from additional insights, would need to be carefully considered first.

While analysis with real options may also be appealing — because of the option nature of the expected benefits — the lack of knowledge on timing and nature of the discovery which may originate from the Centre's genetic material is unknown in an ex ante basis. Real options would be more suitable when there is more information and certainty around how the Centre's outputs will be used so that decision nodes (where you have the option of restructuring the investment or the operation of the activity) can be identified and the probability at each decision node is better understood. Therefore, this approach may be practical where there is more information available. Where this is the case, if this level of detail were available, a 'bottoms-up' analysis may be possible for the headline analysis.

7.5 The approach to valuing public (spillover) benefits

The work in ACG (2007) confirmed the challenge of quantifying the range of other 'public benefits', as identified in table 7.8. The most significant of these in value terms was associated with public health benefits from associated with improved food products developed from plant breeding.

- A number of the benefits are not applicable when considering the pasture component only, and it would be safe to consider that the public benefits would be significantly lower than for both the cropping and pasture components.
- An example of public benefits applicable to the pastures node would most likely be water quality benefits.

Table 7.8 Value of other benefits

Benefit	Net present value over 30 years	Annuity benefit
	$m	$m
Quality premiums	207	15.0
Salinity benefits to farmers	130	9.4
Efficiency cost savings	9	0.6
Water quality benefits	784	57.0
Public health benefits	37	2.7
Total	**1 167**	**84.7**

Source: Allen Consulting Group (2007).

Water quality and salinity, especially in the Murray Darling Basin (MDB), imposes large costs on water users through lost production and treatment costs. The proposition was that wide adoption of perennial-based farming systems in the MDB will avoid some of these costs. This required a number of assumptions:

- Perennials reduce the rate of annual increases in river salinity by 30 per cent to $6.7 million each year over a 30 year period (recognising that wide scale plantings are not likely to restrict salt discharge).
- In absence of conserved germplasm in Australia, there would be a further 8 year delay until the new perennial species become available, and so there would be a delay in the benefit (reduction in costs) stream.

Such an analysis of non-industry benefits is not straight-forward, it also requires a range of assumptions and skills that would not be readily available in the red meat industry. It is likely that the most effective way of dealing with these types of benefits is through qualification and a simple scoring system.

7.5.1 Bottom line for total benefits

The estimated benefits of the NGRC to be $6.2 billion over 30 years, with a present value of establishing and operating the centre of $52 million. This resulted in:

- a benefit cost ratio of 119:1 for both crops and pastures
- a benefit cost ratio of 44:1 the Pastures Centre component
- private to public benefits was 87 and 13 per cent respectively ($5.35 billion to $0.82 billion).

The magnitude of these estimates are not uncommon with the ‘tops-down’ approach, but are difficult to verify given the nature of the key assumptions involved. Generally, payoffs of these magnitudes are not consistent with real world experiences, they are usually met with some scepticism. For the pastures node, we would expect that the vast majority of the benefits are industry benefits.

7.6 Recommended approach in an LPI portfolio context

One of the key issues is that the benefits from such an investment are likely to be lumpy (from one large discovery rather than incremental improvements) and so, very difficult to predict.

- That is why there is potentially a large option value involved, but that value is difficult to establish.
- It is also why this investment should be classified as a defensive investment or industry good with industry benefits.

Therefore, the investment falls within MLA’s remit but determination of value, certainly in an ex ante sense, remains elusive. This is an example where the use of scoring against other priorities may be just as effective as an evaluation based on standard BCA.

7.7 Recommended approach in an evaluation context

The evaluation of projects with similar characteristics to the MLA investment in the NPGRC can be regarded in two ways:

- that MLA has little discretion as a result of its commitments to investment partners, and so this investment is treated as an overhead or sunk cost
- MLA attempts to better establish an estimate of the value its investment through the collection of information that will better inform how the investment outputs convert through to outcomes and impacts for the red meat industry.

For the second option, because of the timeframes involves, this information may not be sufficient for a definitive ex post evaluation, rather provide the basis of an updated ex ante assessment.

- A significant factor to be considered is the cost and the accuracy of the information collected.
- It is quite possible that the additional investment in collection of this information, or to refine the BCA using a 'bottoms-up' approach, may not yield that anything that is useful to decision makers in MLA or in industry.

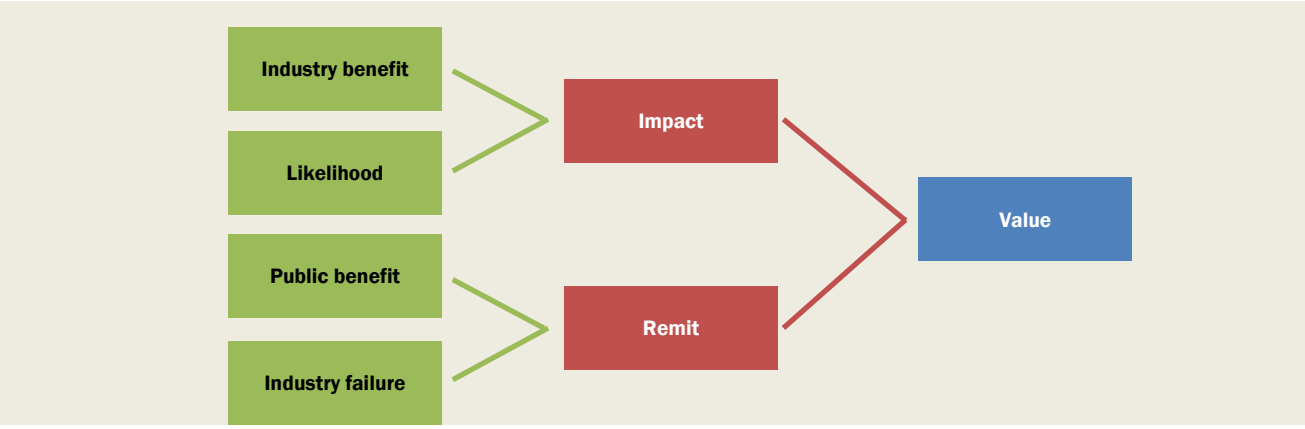
8 Defensive investments in the LPI portfolio

The related project B.COM.1084 also reviewed the range of tools available to evaluate defensive and other types of investments in the LPI portfolio. The review found frustration around how to consistently and cost-effectively measure the value of LPI investments, particularly in economic and quantitative terms. This has led to a large number of additional criteria (for example, RD&E continuum, defensive-offensive) being considered in various and often inconsistent ways.

8.1 Recommendations on defensive investment

The project recommends that LPI move away from seeking to quantitatively measure and balance balancing so many criteria to focus on consistently using impact and remit as the key discriminator of value for all projects — irrespective of size, type or duration (see chart 8.1).

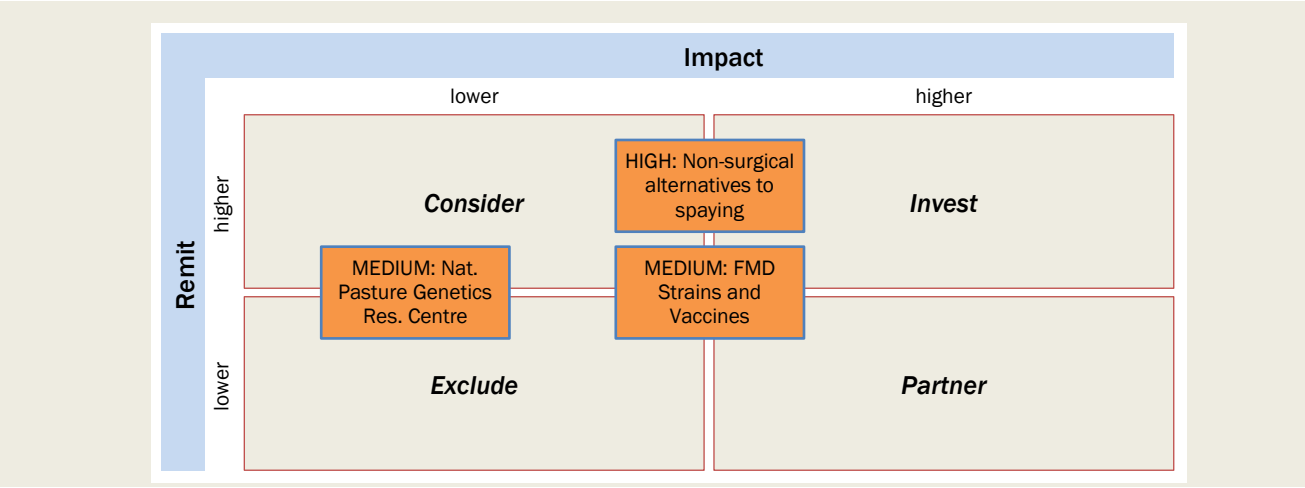
Chart 8.1 Value assessment of LPI portfolio investments



The reason for considering impact and remit discretely is to provide a transparent framework for MLA-LPI to compare projects on the basis of and relative difference in value between projects to assess and report on its investment.

The assessment tool was applied to the three case studies identified in this report: Overall spaying has a higher value than the FMD or NPGRC case studies due to the difference in impact and remit ratings and quality of available evidence (see chart 8.2).

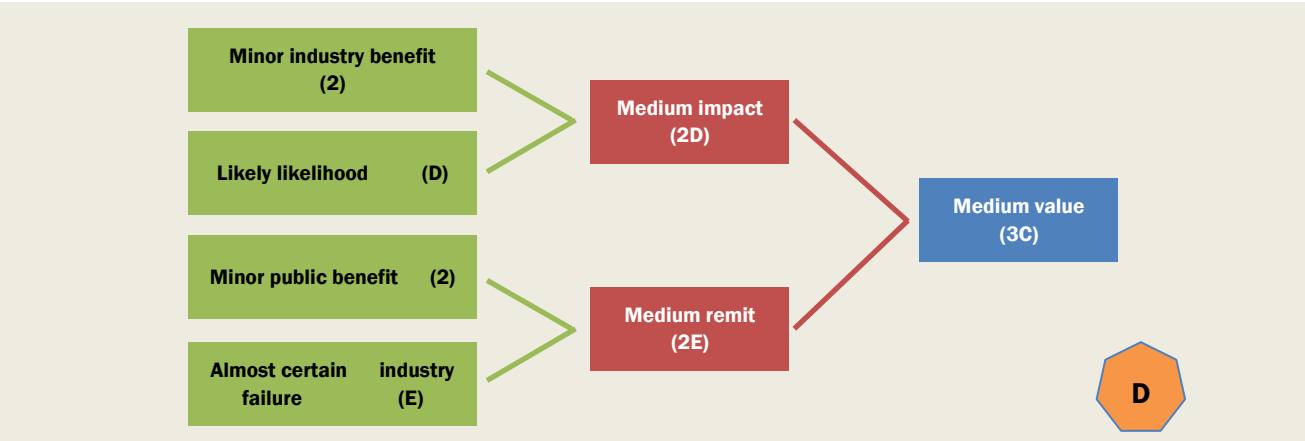
Chart 8.2 Value assessment of LPI portfolio investments



The FMD Preparedness case study has a medium impact and remit rating for a medium overall value to MLA (chart 8.3).

There is a low confidence to the assessment (D in the bottom right corner of the figure below) since while the value of FMD is well evaluated, the benefit of this specific project is less understood.
The medium impact stems from the R&D being additional to existing FMD defences. So given any benefits are likely to be marginal which along with the low likelihood of an FMD outbreak means the project scores a medium impact. In terms of remit there is clear industry failure in terms or pursuing this type of R&D but very little public benefit.

Chart 8.3 Improving FMD Preparedness project assessment

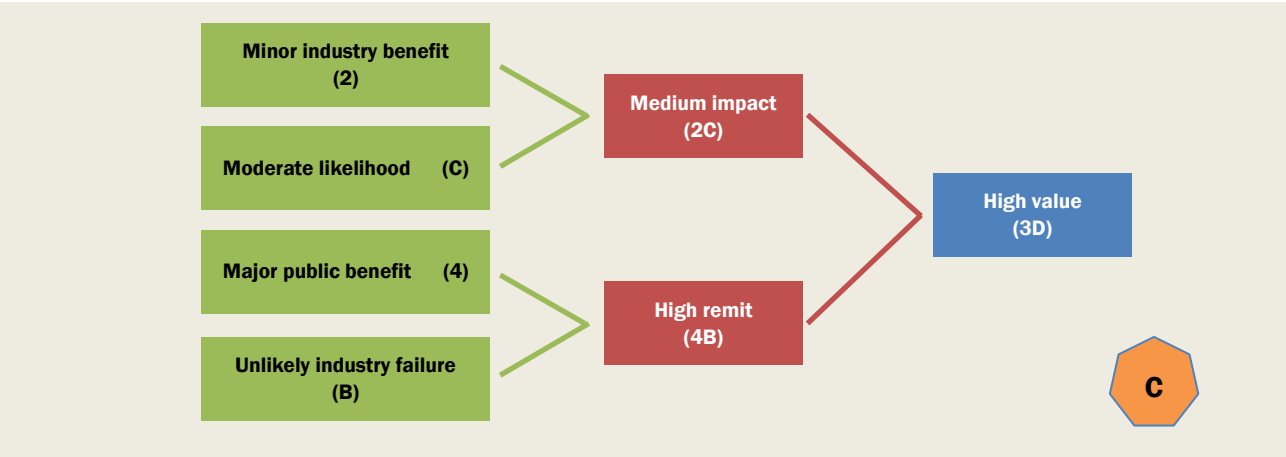


The high value rating for the spaying case study (chart 8.4) stems from improved animal welfare which strengthens the remit for MLA to invest on the basis of public benefits. Failure in the red meat industry's ability to organise R&D to is not that high given that private providers and substitute technologies are present. On the impact side the benefit to industry will be minor given that alternatives are likely to be cost neutral or more expensive and the practice is not applicable to the whole industry.

The assessment reflects that spaying alternatives is a valuable investment for MLA because it contributes to improved animal welfare, which has public value. This does not mean that the cost of this research should be totally publically funded.

The assessment is sensitive to the assumption that adoption of alternatives will lead to increased animal welfare that is recognised by consumers and society. If this assumed scenario does not occur then it would have an even lower assessment. On the impact side there is considerable information on the costs and benefits of alternatives to spaying. As such there is a moderate degree of confidence (C rating) around this assessment (shown in the bottom right hand corner of chart 8.4).

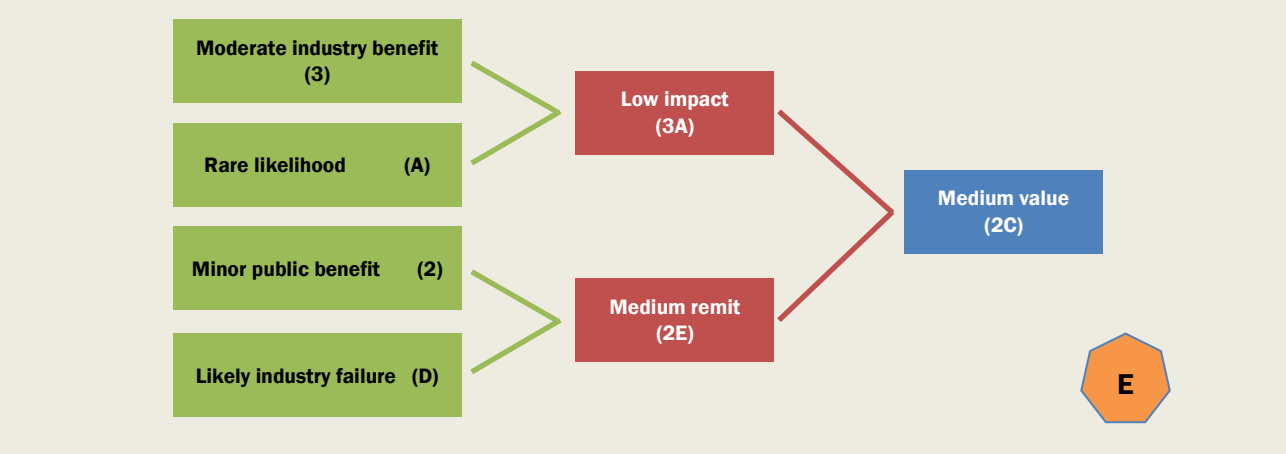
Chart 8.4 Non-surgical spaying procedure project assessment



The NPGRC case study shares a similar remit profile to FMD in that there is strong industry failure (that is, MLA has little choice to be involved) but limited public benefit. On the impact side, the project is unlikely to lead to a benefit that will be even of a modest level unless there is a significant breakthrough in which case the centre would only be one of many contributions. This creates an overall medium rating (chart 8.5).

Applying the LPI portfolio assessment tool to the three case studies indicates that the tool can be readily applied to defensive type investments. This provides LPI a sound basis for confidently comparing the value of all investments across the portfolio, whether they are offensive or defensive.
The confidence rating feature in the tool also indicates how sensitive the value score is to the underlying assumptions. None of the case studies scored more than a low confidence, indicating that assessment is limited by data availability or highly sensitive to an underlying assumption(s). This provides the basis for further investigation or acknowledgement of other constraints.

Chart 8.5 NPGRC project assessment



For example the spaying alternatives case study value is dependent on animal welfare (that is, public) benefits being realised. Further investigations on whether replacement with alternatives

will improve animal welfare in a manner that is recognised by consumers and society will assist in determining whether the project is of high overall value. Similarly investigating the marginal benefit of the FMD strains and vaccine may improve the overall value score. In both cases simple economic assessment tools such the RM model have limited application. This indicates any further investigation will require the use of targeted and tailored evaluation techniques rather than generic tools.

The NPGRC project assessment has the lowest confidence rating of all the case studies because the benefits are extremely lagged and dependent on in determinant subsequent actions. The confidence rating for this case study (and all investments) can be improved by having more people with differing perspective applying the assessment tool.

8.2 Appropriate discount rates

Appropriate discount rates across the LPI portfolio is considered in the companion project B.COM.1084. The primary conclusion was that investing in activities that required a commercial rate of return was not consistent with the role of MLA or the Corporations more widely. Therefore, LPI projects should be assessed against lower rates of return where there are industry benefits from collective investments.

A relevant question is the extent to which different discount rates are appropriate for different classes of projects within the LPI portfolio? Further, do defensive investment warrant different (lower) discount rates to other productivity based projects?

The lessons provided by the case studies was that industry were the primary (or potential) beneficiaries from this class of investment and in some cases there was a mix of defensive and productivity components in the same project cluster (see non-surgical spaying).
When comparing between projects and clusters, the objective should remain to maximise expected benefits to levy payers. While it may be appealing to use different discount rates for projects with different attributes (say those with animal welfare or environmental benefits), distinguishing between the categories could become somewhat subjective and arbitrary. Especially if there is no clear logic behind the decision to support one project with a lower discount rate over another project.

A Potential losses from a FMD outbreak

This appendix provides more details to those in chapter 4, on the approach taken to the calculation of the benefits (or avoided losses) outbreak such as foot and mouth disease.
A first step for the estimation of the benefits consisted of assessing the costs of an FMD outbreak that would potentially represent the worst- case scenario. From this starting point, the rest of the scenarios were modelled.
As Australia has not experienced a disease outbreak in recent history, a number of scenarios were established to reflect the possible intensity and duration of an outbreak. We now present a description of the exercise conducted and the results.

A.1 The scenarios

The duration and intensity of the outbreak are key variables for the magnitude of the losses. The duration of the outbreak is a key variable for export market impact, while the intensity, as per rate of spread and total animal population infected, is fundamental for the escalation in control and eradication costs.

A.1.1 An extensive outbreak scenario

For this scenario we used ABARE data on number of farms and animals per region for cattle, sheep and pigs. The key assumption was that an event of considerable magnitude is one that would affect all susceptible species. A second assumption was that an extensive event could happen if the affected or at-risk regions are those where there is a large population of those species and there is frequent movement of animals.

As with the Productivity Commission report, the region for this scenario comprised central New South Wales and central Victoria. [12] It was considered that an outbreak occurring in this area represents has a high probability of affecting cattle, sheep and pigs and that there is a high risk of spread given the extremely high number of animal movements within the area. A critical element for the choice of this region is also the composition of the population for each susceptible species.
Table A.1 presents the region, the number of farms and animals at risk for this and the other scenario.

Table A.1 Farms and animals in selected regions and size of disease outbreak

Outbreak size	Number of farms at risk				Number of animals at risk			
	Cattle	Sheep	Pigs	Total	Cattle	Sheep	Pigs	Total
	no.	no.	No.	No.	000’	000’	000’	000’
Contained								
Southern WA	1 808	4 565	137	6 509	866	17 459	201	18 526
Extensive								
Central NSW and VIC	7 997	11 502	607	20 106	3 023	27 874	847	31 744

Source: ABARE, ABS

The total population at risk in the large scenario is around 32 million animals, 88 per cent of which are sheep.

[12] Specifically these regions are Central, Riverina and Tablelands regions in NSW and Central North Victoria.

A.1.2 A contained outbreak scenario

This scenario refers to an outbreak affecting Southern Western Australia. Here, cattle, sheep and pigs are also at risk, but cattle to a lesser extent than in the large scenario.

In this way, the scenario is less devastating in terms of aggregated losses for the overall meat industry because of the lower exposure to export markets.

- The population of cattle in the selected region represents around 5 per cent of total animals at risk.
- But the sheep population in this scenario is over 17 million animals, or around 94 per cent of the total population at risk.

A.2 Exclusion from international markets

In the event of an FMD outbreak in Australia, importing countries would ban Australian livestock products until there was evidence of the outbreak being contained. The reactions will vary depending on the sensitivity of each market to food safety issues and their FMD status.

- In certain countries, especially in the Pacific Rim, demand for meat is very sensitive to food safety issues while in other countries it is responsive to price variation. Recent examples of sensitive countries are Japan and Korea in response to the 2003 BSE outbreak in the United States.
- Disease-free countries will not accept contaminated product as FMD is highly contagious especially if there is a risk of infected material entering the food chain for livestock. Countries where FMD is endemic may also restrict imports from Australia but to a lesser extent.

In our estimates, we have segmented the markets into discerning, less discerning and non-discerning. We have applied individual demand shocks (impacts) to each group to account for the different responses that can be expected as a result of an event. This allows for a more accurate estimation of the losses from market exclusion than if a uniform shock was applied to exports across all markets.

The total losses from market exclusion have two dimensions.

- In first instance, they refer to overall lower export quantities of Australian meat in the international market. In the event of a disease outbreak, in the second round, meat products can be diverted, to some extent, from discerning to less or non-discerning markets.
- In second instance, the losses relate to lower international prices of meat received by countries where imports are not disrupted and are being diverted to. The closure of markets includes losses of price premiums are currently observed in these markets — which reflects the composition of the exports that are sent and the so-called FMD-free premium over equivalent prices paid to other exporters.

The total losses to the industry therefore relate to the net reduction on meat exports quantities and the price differential between the three groups of countries.

A.2.1 Discerning markets

Discerning markets refer to countries that are FMD-free, are very sensitive to food safety issues and where imports from Australia may be substantially affected until the disease is eradicated and a disease-free status is achieved. Also, regaining of market access in these countries could take several years, depending on the size of the outbreak, and the time to achieve disease-free status.

Discerning markets, in most cases, correspond to high value markets due to price premiums. This group comprises the European Union , the United States, Canada, Japan and Korea. [13] Reactions by these markets are expected to be 'severe' (total closure until FMD-free status is achieved) in any outbreak size.
The less discerning markets group is comprised by the Middle East. [14] The reaction by this group to a FMD outbreak in Australia is expected to be less severe than that by the sensitive markets. The Middle East is an important destination of sheep meat, live cattle and live sheep but not so for Australian beef exports.

A.2.2 Non-discerning markets

All other countries are grouped as non-discerning markets. No adverse reaction is expected from them in terms of market closure; rather, their demand for Australian meat is likely to increase in response to changes in relative prices. This is the result of a highly elastic (responsive) demand to changes in prices and the fact that they are not as sensitive to food safety issues.

A.2.3 Impact on the domestic market

There is little experience on domestic disease outbreaks that could help predicting Australian consumers' behaviour in this situation. In the past, we have observed that Australian consumers were not sensitive to disease outbreaks overseas. However, this relates to the fact that Australia does not consume any meat products from affected regions. We believe that a conservative approach is to model the domestic market as a less discerning market rather than a non-discerning market.

Losses from the domestic market are the result of potential decrease in consumption, combined with lower prices. The reaction to a disease outbreak would be small and have a shorter duration when compared to discerning markets. Furthermore, domestic consumption of meat should increase, as a second round effect from reduced prices. This allows for aggregate losses to be offset somewhat.

For the beef and sheep meat industries the export market are substantial; double and ten times bigger than the domestic market respectively on the basis of 2009 quantity figures. In terms of value the difference is even larger.

- To the extent that profits for these industries rely significantly on the export markets, increases in domestic consumption are insufficient to completely offset the losses from international market closures.
- In comparison, for the pig industry, the domestic market faces significant competition from international markets through import pressure rather than from exports.

In the situation of an FMD outbreak, producers in affected industries will reduce slaughtering in order to mitigate the fall in prices. This is an additional effect that will contribute to the total outcome for domestic prices.

A.3 Control and eradication costs

The accurate estimation of these costs requires a very large exercise, using information from expert opinion and the agencies that would be responsible for the disease response. For this exercise, we have used estimates and assumptions from other studies.
In an FMD outbreak, control and eradication costs depend mainly on the spread rate of the disease and the resulting number of animals infected and slaughtered. Control and eradication

[13] GMI model considers EU15 which includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden and United Kingdom.
[14] In the GMI model the group includes Abu Dhabi, Al Fujairah, Bahrain, Dubai, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Ras Al Kahibah, Saudi Arabia, Syria and the Republic of Yemen

costs in this report include the actions taken to stamp out the disease; quarantine, slaughter, disposal, decontamination, movement restriction and compensation. Vaccination costs are excluded.

- We have used the cost per animal estimates from Productivity Commission (2002) for estimating the eradication costs.
- Prices of cattle, sheep and pigs projected by GMI model for 2009 were used for estimating the costs of compensation to producers.
- Costs estimates for surveillance, flock appraisals and visits were based on Carpenter et al. (2010).

A.4 Key model assumptions

A summary of the main assumptions made for the estimates are listed in table 5.2.

A.4.1 Duration and intensity of the outbreak

Using GMI projections of export quantities and prices for 2010-2020 we simulated an FMD outbreak in 2013. Based on the scenarios of the Productivity Commission (2002), the duration of an extensive disease outbreak is estimated at one year until it is totally controlled and eradicated. A contained outbreak is likely to take six months.

Discerning markets would impose a ban on Australian livestock products during the outbreak; this means:

- 100 per cent reduction on Australia's exports of livestock products to those markets for the first year in the event of a large outbreak;
- 50 per cent reduction on Australia's exports of livestock products to those markets for the first year in the event of a medium outbreak; and
- 30 per cent reduction on Australia's exports of livestock products to those markets for the first year in the event of a small outbreak.

The impact on exports (shocks) applied to Australian exports to less discerning markets were half of those to discerning markets. There were no shocks imposed onto the other countries group.

- Reductions in exports to discerning and less discerning markets will result in diversion to non-discerning markets. The resulting impact on exports to these countries is determined by the model as a function of overall changes in prices in prices that result from the simulation.

In addition to market exclusion during the outbreak, additional effects were modelled to account for:

- regaining FMD-free status — which can take up to three months from the last reported case of the disease; and
- re-building confidence of consumers and importing authorities, particularly in sensitive markets, which can take a considerable time if the outbreak escalates to a large size.

We estimate that exports will recover progressively from the second year of the FMD event until reaching the projected level that would have occurred without the outbreak.

- For an extensive outbreak, the recovery period is four years, for a medium size outbreak is two years and for a small is one year.
- The reductions applied to domestic consumption in the first year of the FMD outbreak are the same as those for less discerning market.

A.4.2 Control and eradications costs assumptions

Eradication cost estimates were based on those of Productivity Commission (2002), which are in turn based on the FMD experience of United Kingdom in 2001.

- The Productivity Commission report estimated average costs of quarantine, slaughter, disposal, decontamination and movement restrictions per animal to be around A$600.

We have used this cost in its equivalent to 2010 prices for our estimate; which is $770 per animal. This is a conservative approach as this amount will be higher in 2013, the year when we have simulated the FMD outbreak occurs.

- Compensation costs were based on expected prices per animal of cattle, sheep and pigs for 2013. This is $859 for cattle, $65 for sheep and $226 for pigs.
- Control costs were based on the estimates by Carpenter et al. 2010 where appraisal, surveillance and visits of affected farms at risk are of $364 per farm, $273 per farm and $118 per visit respectively. [15]

The number of animals to be destroyed was extrapolated from estimates in the Productivity Commission report. Between 2 and 3 per cent of animals at risk are slaughtered to eradicate the disease and achieve FMD-free status.

A.5 Results

A.5.1 Aggregate potential losses and the main component

The results show that under a large disease outbreak with the current traceability, total losses to the affected livestock industry can potentially be around $18 billion. For a medium outbreak, the industry could have as much as $9 billion in losses.

- In any outbreak scenario, the losses from international market exclusion are the largest contributor to total losses experienced by industry.
- In comparison, losses from the domestic market and from control and eradication of the disease are minimal.

The most important factors that influence this outcome are:

- the meat industries are highly export oriented, especially the beef and mutton industries;
- the primary destinations are high value export markets that are the most sensitive to events such as FMD; and
- the domestic market consumption for sheep meat and beef falls in the short term reaction (an adverse reaction to the FMD outbreak) but is mitigated to some degree due to lower meat prices.
- Around 90 per cent of the total losses are the result of losses in market access. Control and eradication costs represent around 5 per cent of the total losses in any outbreak scenario.

A.5.2 Who are the main losers?

In contained or extensive FMD outbreaks, the beef industry is likely to be the major loser. Losses to beef industry are of around $15 billion, significantly higher than those of sheep at $2.5 billion, and for the pig industry of $400 million.

Losses to the beef industry represent around 33 per cent of gross value of production over the period of the FMD outbreak. Losses to the sheep and pigs industry are 11 and 7 per cent of GVP respectively.

[15] Costs in Carpenter et al. correspond to 2010 prices in US dollars. The exchange rate used for conversion of these values to Australian dollars was the average exchange rate between the two currencies for the period January — April 2010; at an exchange rate of US 0.91 cents.

In all scenarios, it was estimated that an FMD outbreak would impact on the sheep industry to a greater or equal extent than the other species in terms of numbers of animals affected.

- However, the higher average value and greater export exposure are the primary reasons for the beef industry bearing greater losses than the sheep industry. – Sheep meat exports represent between 25 and 30 per cent of those of beef (in value and quantity terms).
- Any reaction from sensitive markets to species affected by FMD would impact more on the beef industry than to sheep due to the size and value of the exports.
- A fall of 30 per cent in the value of beef exports would represent a greater loss than a 100 per cent loss in the value to sheep meat exports.

Due to the characteristics of exports destinations, industries other than beef would likely recover more quickly from the FMD outbreak. Around fifty per cent of lamb exports and 90 per cent of mutton exports are supplied to less sensitive markets such as the Middle East and other markets. In contrast, around 80 per cent of beef exports are supplied to sensitive markets.

A.5.3 Expected present value of the losses

The losses, regardless of their magnitude, need to be discounted by the fact that the probability of an FMD outbreak will only occur once or twice in a 100 year period. This probability is assumed to be the same for each and every year for the period simulated.
The average annualised expected loss equals to 1.5 per cent of the totals presented above.
To make these estimates comparable with the stream of costs (of achieving full compliance with the standards), these losses need to be expressed in real present value terms.

- This is because costs and benefits of improvements in traceability will have different time paths — calculation of present value brings the two streams into the same terms in today's terms.
- Investments required to improve traceability by 2013 will need to occur in the next few years while additional resources to improve verification and compliance will be ongoing annual costs.
- Benefits, as avoided losses, have a similar profile each year because of the assumptions about the probability of an outbreak.

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