Ministry for Primary Industries
Manatū Ahu Matua

Foot-and-Mouth Disease Economic Impact Assessment:

What it means for New Zealand

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Growing and Protecting New Zealand

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Executive summary

In 2013, New Zealand's Ministry for Primary Industries (MPI), in partnership with primary industry organisations, began new work on New Zealand's preparedness for an outbreak of foot-and-mouth disease (FMD). This report is part of that project and explores the potential economic impacts of FMD under several scenarios.

New Zealand's heavy reliance on exports of animal products makes us uniquely vulnerable to FMD. While the risk of an incursion is considered low, the impact would be severe. Understanding the potential economic cost is an important element in ensuring that we are prepared if an outbreak were to occur.

There are four main analytical stages to this work:

- Epidemiological models are used to simulate the way FMD might spread throughout the country from an initial outbreak;
- Scenarios were selected from the epidemiological modelling to represent a range of potential disease spread patterns;
- Production models were used to estimate the cash impacts on producers and export receipts under each scenario; and
- A whole economy macroeconomic model was used to trace the ripple effects of these cash impacts through the economy.

Epidemiology and Scenarios

A FMD incursion was assumed to occur on a lifestyle property in Taranaki. Random variation in the Interspread Plus (ISP) model was used simulate 100 possible spread patterns from this same introduction.

Three scenarios were selected from these 100 possibilities. There was only one infected property (IP) in the "small" scenario; 52 IPs in the medium scenario and 508 IPs in the large scenario. In none of these cases did the disease infect South Island properties – this was intentional to allow for an assessment of disease free zoning for the South Island which assumed that earlier resumption of South Island exports could be negotiated.

Vaccination can help reduce the spread of FMD and vaccination was also modelled. From this, two economic options were modelled: vaccination-to-die (VTD) means animals are vaccinated to stop the disease spreading but are then destroyed; vaccination-to-live (VTL) does not involve destroying the vaccinated animals. Under existing trade rules, FMD-free status takes twice as long to restore (six months after the last case, rather than three months) if VTL is used rather than VTD.

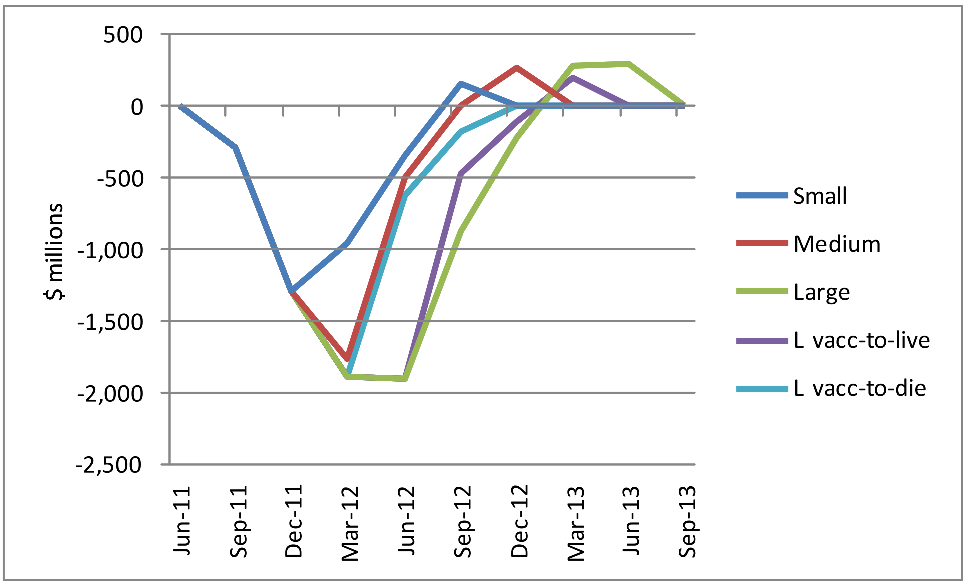
Production and export impacts

The modelled FMD incursion was assumed to have taken place on 30 September 2011, and impacts were assessed relative to actual exports from that date. Expert advice was used to develop assumptions regarding the response of processing industries in New Zealand and export partner countries. For example, in the large scenario it was assumed that

- Export meat slaughter would cease for 10 months;
- Dairy production closed down for the remainder of the season in the North Island while South Island milk was double pasteurised; and

- Trading partners varied in the time they re-opened export markets to New Zealand.

The production modelling indicated that most of the impact occurred in the year to June 2012, followed by a recovery period when earnings were actually higher, reflecting the build-up of saleable product after the disease was stamped out but before export markets re-opened. The following chart shows this time pattern for the meat sector; dairy follows a similar pattern.



Lost export earnings under different scenarios are shown in Table 1.

Table 1: Lost Export Earnings to June 2012 ($bn)

Scenario	Dairy sector	Meat sector
Small	2.00	2.73
Medium	3.20	3.55
Large	8.84	5.87
VTD	3.96	4.25
Earlier FMD free recognition for the South Island[1]	8.84	4.94

[1]This scenario is a modification of the large scenario whereby the South Island is declared FMD free enabling an earlier start to export trade.

In addition, for the large scenario eradication costs of $1,169m and compensation costs of $31m were incurred.

With export meat processing closed until trading partners opened up again, livestock that would otherwise have been slaughtered remained on farms and would have had to be destroyed for animal welfare purposes by their owners – 16.5 million lambs, 3.1 million adult sheep, 3.1 million adult cattle and calves and 356,000 deer in the reference case. A further culling of 10,775 sheep, 19,661 cattle and 331 deer was required for disease control purposes.

Macroeconomic impacts

The New Zealand Institute of Economic Research (NZIER) was contracted to estimate the macroeconomic impacts of FMD incursion scenarios both nationally and by industry using their Computable General Equilibrium Model (CGEM). The model outputs are annual values comparing each scenario to a baseline of no FMD outbreak. Table 2 shows the GDP impacts for the large scenario over the first two years following a hypothetical FMD outbreak on 30 September 2011.

Table 2: Real and Nominal GDP for Large Scenario for June Years

	Year to June 2012	Year to June 2013
Real GDP	-7.8%	0.5%
Nominal GDP (billion dollars)	-$13.8	$1.2

The CGEM provided distributional impacts across 106 industries. Farm level and processing industries were the worst hit, followed by industries that supplied goods and services, and household expenditure industries because of lower incomes. However, there were industries that benefited from exchange rate depreciation and lower prices from reduced competition for intermediate goods and services, labour and capital. Tourism industries benefited as the depreciated exchange rate increased spending in New Zealand dollars by tourists. Government expenditure on FMD eradication provided a short-term boost to GDP, but it was assumed to be funded by government borrowing overseas and paid back by 2020. The net present value (NPV) loss in real GDP over June years 2012 to 2020 was estimated at $16.2bn for the large scenario.

The VTL option reduced the FMD eradication and livestock compensation costs, but increased the World Organisation for Animal Health (OIE) current FMD freedom recognition time from three to six months (after the last FMD case). Based on the assumptions used, the VTD option reduced NPV real GDP loss by 46 percent to $8.7 billion compared to $10.5 billion for the VTL option. Further work is required to assess an optimal vaccination strategy.

The South Island free option explored an earlier recognition of FMD freedom for the large scenario. Based on the assumptions used, the NPV real GDP loss was reduced from $16.2bn to $15.6bn, a three percent reduction.

Discussion

The broad pattern of these results is considered reliable. In particular, it is likely that an outbreak of FMD would cause:

- a large loss of national income with most of the impact falling on the primary sector and agricultural processors;
- an increase in world prices for agricultural commodities;
- a depreciation in New Zealand's exchange rate; and
- recovery timing (after eradication) that depends on our trading partners.

The main statistical uncertainties are over the scale of an outbreak (and therefore the cost of eradication and compensation) and the timing of markets re-opening. These matters could result in materially higher economic costs than those estimated in this work.

In addition, even using the scale and timing assumptions adopted here, costs would be higher as a result of slaughter and compensation costs for animals destroyed on suspicion, from movement controls and from any recovery package adopted by the government of the day.

This economic impact assessment reaffirms the value of investment in FMD prevention and preparedness, and provides useful guidance on areas of mitigation where efforts should be focused.

Introduction

In 2013, New Zealand's Ministry for Primary Industries (MPI), in partnership with primary industry organisations, began new work on New Zealand's preparedness for an outbreak of foot-and-mouth disease (FMD). This report is part of that project and explores the potential economic impacts of FMD under several scenarios.

New Zealand's heavy reliance on exports of animal products makes us uniquely vulnerable to FMD. While the risk of an incursion is considered low, the impact would be severe. Understanding the economic cost of an outbreak is an important component of being prudently prepared and can help to:

- inform decision-making to determine an optimal "New Zealand Incorporated" strategy for responding to an incursion of FMD
- analyse different disease mitigation measures;
- identify useful trade intervention measures;
- target interventions in the most cost-effective way; and
- develop reasonable cost sharing strategies between government and industry.

Existing information on the cost of a FMD incursion dates back to a 2003 assessment which was undertaken for a different purpose.[1] Since then there have been material changes in the destination of New Zealand's exports and in trading agreements that include terms aimed at continuing trade in the event of an outbreak. It is therefore timely and prudent to investigate the likely economic costs.

This report is structured as follows.

Section 1 presents relevant background information on FMD, including the options for responding to an outbreak and the way these choices are likely to affect exports.

Section 2 describes the modelling work undertaken to explore the economic costs of an outbreak of FMD in New Zealand.

Section 3 presents and discusses the results of the modelling.

Section 4 outlines the next steps.

[1] This was joint work by Reserve Bank of New Zealand and The Treasury assessment aimed at testing the robustness of the New Zealand banking systems.

Section 1: Foot-and-mouth disease

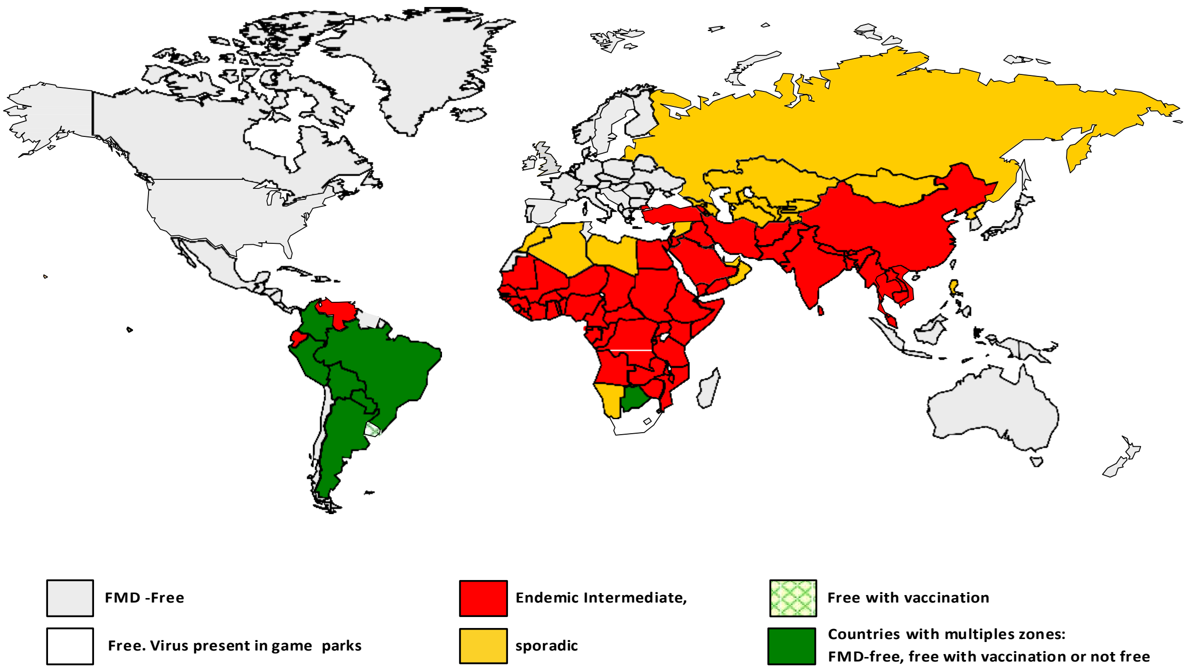
1.1 Background primer

FMD is a highly contagious viral disease that can infect all species of cloven-hoofed animals. It is rarely fatal to adult animals, but high mortality is common in young animals. Symptoms include fever and blister-like sores on the tongue and lips, in the mouth, on the teats and between the hooves. The disease causes severe production losses and while many affected animals recover, the disease often leaves them weakened and debilitated.

Key points to note are:

- FMD does not affect humans, and there is no food safety risk associated with consuming products from animals infected with FMD.
- The organism which causes FMD is a virus from the family *Picornaviridae.* Seven strains of the virus are known.[2]
- The current World Organisation for Animal Health (OIE)[3] [4] official list of free countries and zones with or without vaccination is shown in Figure 1.[5]

Figure 1: Current world situation of FMD



Source: OIE.

[2] A, O, C, SAT1, SAT2, SAT3, Asia1

[3] http://www.oie.int

[4] OIE is recognized by the World Trade Organisation (WTO) as having responsibility for animal health issues.

[5] OIE. http://www.oie.int/fileadmin/Home/eng/Media_Center/docs/pdf/Disease_cards/FMD-EN.pdf. Accessed 22 June 2014.

1.2 Responding to FMD

Countries that are free of FMD have traditionally responded to outbreaks of FMD through so-called "stamping out", a policy that is defined by the OIE and referenced in trade agreements.

The OIE defines a stamping-out policy[6] as requiring:

> *…the killing of the animals which are affected and those suspected of being affected in the herd and, where appropriate, those in other herds which have been exposed to infection by direct animal to animal contact, or by indirect contact of a kind likely to cause the transmission of the causal pathogen. All susceptible animals, vaccinated or unvaccinated, on an infected premises should be killed and their carcasses destroyed by burning or burial, or by any other method which will eliminate the spread of infection through the carcasses or products of the animals killed.*

Stamping out involves the rapid destruction and disposal of large numbers of livestock. This can be highly resource intensive and can also lead to criticism within the community of the method of disposal (Buetre et al, 2013).

The Food and Agriculture Organization of the United Nations (FAO) also endorses stamping out and defines its crucial elements as:[7]

- *designation of infected zones;*
- *intensive disease surveillance to identify infected premises and dangerous-contact premises or villages within these zones;*
- *imposition of quarantine and livestock movement restrictions;*
- *immediate slaughter of all susceptible animals either on the infected and dangerous-contact premises or in the whole infected area;*
- *safe disposal of their carcasses and other potentially infected materials;*
- *disinfection and cleaning of infected premises; and*
- *maintaining these premises depopulated of susceptible animals for a suitable period.*

Stamping out is the cornerstone of New Zealand's current FMD policy.[8] MPI would lead the response using powers under the Biosecurity Act 1993. The aim would be to regain FMD-free country status with minimum delay.

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[6] OIE. http://www.oie.int/index.php?id=169&L=0&htmfile=glossaire.htm. Accessed 22 June 2014.

[7] FAO. http://www.fao.org/docrep/004/y0660e/y0660e00.htm. Accessed 22 June 2014.

[8] MPI Response Plan for Foot-and-Mouth Disease, version 11, 2011.

1.3 Vaccination

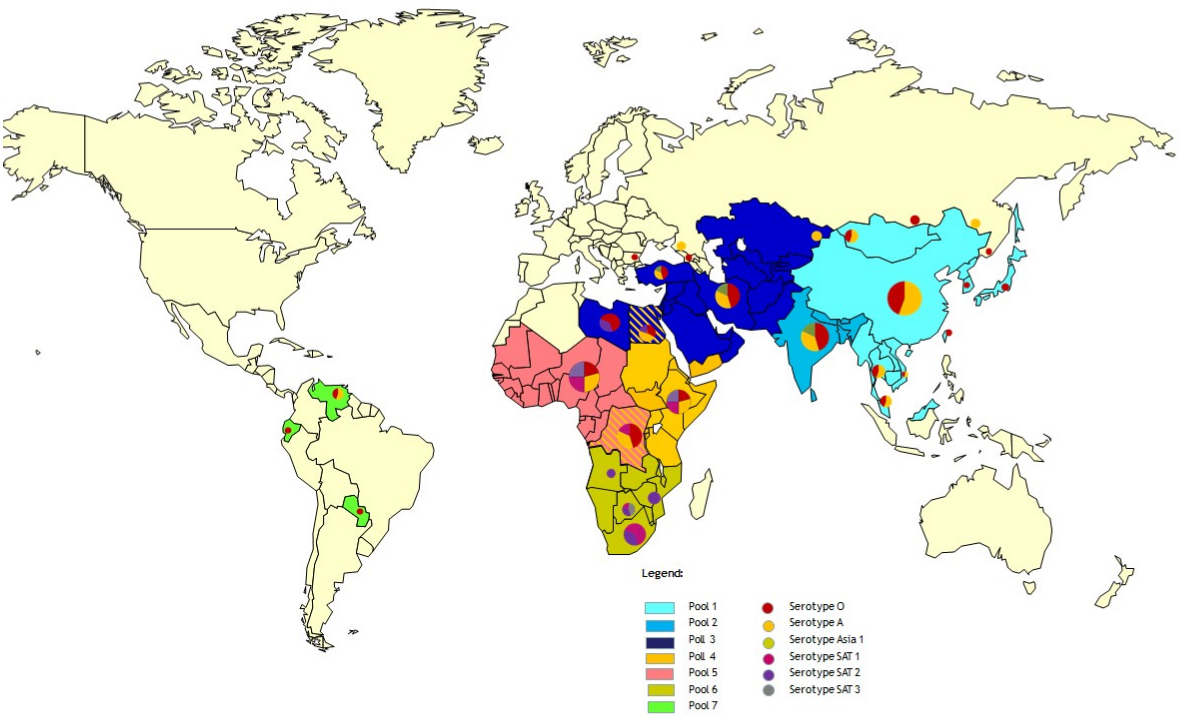
New Zealand is recognised by the OIE and by our trading partners as a *FMD-free country where vaccination is not practised*. To retain this status, FMD vaccine cannot be used pre-emptively before an outbreak occurs.

During an outbreak, there are two vaccination strategies that could be run concurrently with stamping out. Vaccinate-to-live (VTL) and vaccinate-to-die (VTD) both involve identifying the virus strain, procuring and administering the vaccine. They differ in that under VTD, the animal is slaughtered once killing capacity becomes available, whereas under VTL it lives a normal life.

Under the current OIE rules the time required from the end of an outbreak to the resumption of FMD-free status is six months if a VTL process is used, but only three months if VTD is used. Thus, while VTL requires fewer animals to be destroyed, it also involves a longer disruption to normal trade. The OIE trade rules are currently under review.

There are seven strains of the virus, and even within these strains there are differences (see Figure 2). This means that in an outbreak the strain of virus needs to be determined first, so that it can be matched against available vaccines to determine which one is likely to be most effective. New Zealand maintains a bank of antigens (the raw materials used to produce the vaccine) in the United Kingdom (UK) that allows for emergency vaccine to be produced rapidly in the event of an outbreak. This emergency vaccine is the so-called high-potency vaccine. Immunity to FMD can occur as soon as four to five days after vaccination (Geale et al, 2013). However, it may not prevent the animals becoming infected and spreading the virus (Cox and Barnett 2009; Halasa et al, 2012). However, vaccination reduces the level of spreading and therefore reduces the risk of viral spread (Cox and Barnett, 2013).

Figure 2: FMD virus pools 2011–2013



Source: FAO.

Section 2: The modelling

2.1 Methods

This study was designed by a panel with expertise in the fields of economics, epidemiology, disease control and trade. It used epidemiological modelling to specify the geographic reach and impact of different FMD outbreaks, followed by economic modelling to estimate the resulting costs.

2.2 The epidemiological modelling

Epidemiological modelling was undertaken by AsureQuality using Interspread Plus (ISP), a stochastic simulation model.[9] It is a state transition model with the farm (and not individual animals) as the epidemiological unit of interest. As a FMD outbreak progresses, affected farms can transition from being "susceptible" to "infected", and then "recovered/immune or depopulated".

Three possible set-ups of the model have previously been outlined by experts:

- minimal, which assumes reduced movements associated with the "quiet" farming season only, so there is no airborne spread and no dairy tanker movements are involved;
- standard, which uses an average number of movements and includes the possibility of disease spread by dairy tankers but no airborne spread; and
- maximal, which uses the maximum number of movements which are expected during the "busy" farming season, and provides for spread by dairy tankers and for airborne spread.

The standard option was used for this study and it was assumed that the FMD outbreak began on a lifestyle block with swill-fed pigs surrounded by dairy farms in Taranaki. For the three baseline scenarios, the control strategy assumes a stamping-out policy, with successful destruction and disposal on infected properties (IP) and movement controls preventing spread of FDM across New Zealand. Each time the model runs, it predicts a different pattern of disease spread. The model was run 100 times, and three baseline scenarios were chosen from these 100 runs so as to represent the range of possible outcomes.[10]

- **Small scenario**
  This scenario lasts one day and has only one IP. It represents a case where passive surveillance detects the disease prior to the infection moving off the property. Detection happens on day 21 post infection. This scenario resulted in nine sheep and two pigs being depopulated on this IP.

[9] Comparison studies between ISP and other international simulation models have been an effective process of verification and validation of ISP, and it is the modelling platform currently contracted by MPI for use in the event of an actual outbreak of FMD (Dube et al, 2006).

[10] Appendix 1 provides further detail on the parameterisation of the model.

- **Medium scenario (iteration 88)**
  This scenario contains the average number of IPs across all 100 iterations. This outbreak lasts 50 days and has 52 IPs. This resulted in the depopulation of 443 beef cattle, 5048 dairy cattle, 153 sheep, 34 pigs and 7 goats on these IP. These exclude any possible slaughter on suspicion of FMD infection. The first case is detected on day 18 post infection and the index case (i.e. the original source) identified 3 days later by tracing activity. This scenario is limited to the Taranaki region.

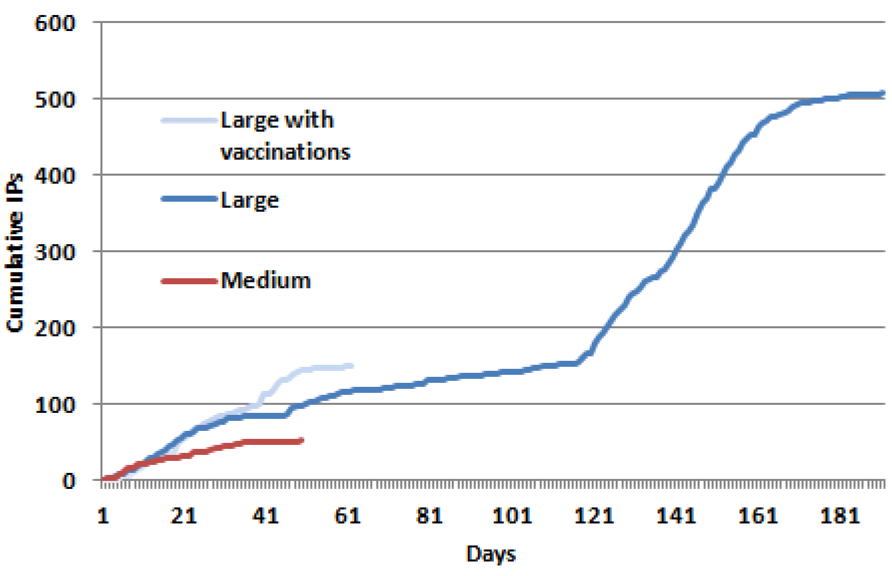
- **Large scenario (iteration 96)**
  The large scenario lasts 191 days and has 508 IPs. This resulted in the depopulation of 8780 beef cattle, 10 881 dairy cattle, 331 deer, 10 775 sheep, 93 pigs and 407 goats on these IPs. These exclude any possible slaughter on suspicion of FMD infection. This scenario affects the North Island only. The first case is detected on day 20 post infection and the index case is identified promptly following tracing activity on the following day.

Vaccination strategies were also modelled. It was assumed that only cattle would be vaccinated, that vaccination would start on day 17 of the outbreak and that it would cover all known infected properties detected from day 12 of the outbreak.[11] Again, the model was run 100 times and the average (mean) and the largest outbreaks with vaccination were taken as representing the range of outcomes with vaccination.

It should be noted that all of the modelled scenarios stemmed from the same introduction of the virus in Taranaki and that the South Island intentionally remained disease free. Infected properties were randomly generated in the model. An outbreak can occur at any location and both Islands may be affected. It needs to be noted that the selection of sites was randomly generated and does not imply an actual heightened risk of an introduction at these sites.

Figure 3 shows the cumulative distributions of IP for the medium and large scenarios.

Figure 3: Cumulative distributions of IPs for medium, large and large with vaccination scenarios



Source: AsureQuality and MPI.

[11] These are regarded as realistic estimates of the time needed to type the virus, produce a matching vaccine in the UK, acquire and deploy a vaccine in New Zealand.

Table 3 presents summary data on the incursion scenarios that were modelled.

Table 3: Data on FMD incursion scenarios

Scenarios	Small	Medium	Large	Large with vaccination-to-live	Large with vaccination-to-die
No of infected properties (IP)	1	52	508	153	153
Duration of incursion (days)	1	50	191	61	61
IP depopulation					
Beef	0	443	8 780	2 083	49 405
Dairy	0	5 048	10 881	15 938	205 228
Deer	0	0	331	121	121
Sheep	9	153	10 775	4 181	4 181
Pigs	2	34	93	801	801
Goats	0	7	407	578	578
Farms in surveillance zones (10-km radius)	2 101	2 277	12 478	7 726	7 726
Coverage	Taranaki	Taranaki	North Island	Taranaki and Auckland	Taranaki and Auckland

Sources: AsureQuality and MPI.

In addition, animals will need to be destroyed on dangerous contact premises, on suspect properties, or those animals that need to be destroyed for animal welfare reasons. Animal welfare cull numbers are shown in Table 4.

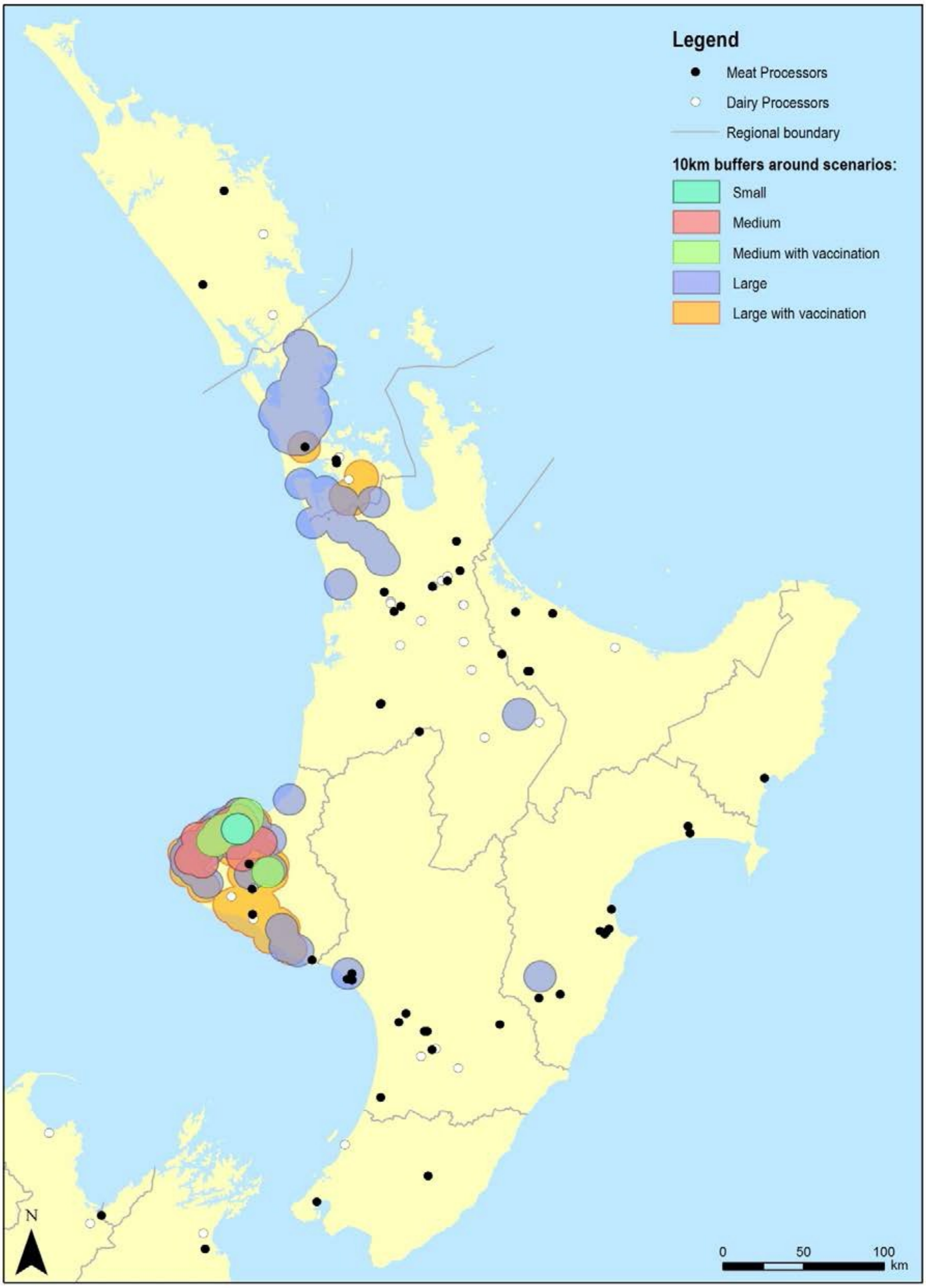
Table 4: Livestock to be destroyed for welfare purposes

	Small scenario	Medium scenario	Large scenario
Lambs	7 550 000	10 900 000	16 500 000
Adult sheep	1 750 000	2 270 000	3 080 000
Cattle and calves	1 090 000	1 790 000	3 070 000
Deer	115 000	239 000	356 000

Source: MPI.

Figure 4 shows the geographical distribution of surveillance zones which are areas within a ten-kilometre radius of each IP.

Figure 4: Distribution of infected premises within 10-kilometre radius surveillance zones



2.3 The economic modelling

The economic modelling is based on the scenarios defined above. It proceeded in two ways. The initial impacts on production, export losses and government expenditure on eradication and compensation were modelled using spreadsheets. Then these initial results were fed into a larger model of the whole economy, operated by the NZIER.

The actual economic cost of a FMD incursion will depend on many unknown factors including the location, timing and scale of the outbreak, the reaction of processors and other parties in New Zealand, and the reactions of export partner countries. Economic modelling requires assumptions to be made in order to estimate the potential scale of economic cost.

2.3.1 How processors might respond

The hypothetical FMD incursion modelled here was assumed to have taken place on 30 September 2011, which is relatively early in the main dairy season.

The dairy processing industry told us their response would depend on the location and time of year. FMD would disrupt milk tanker movements and strategic drying-off of herds may be considered, along with other interventions. The following drying-off assumptions were used in the modelling:

- Small scenario: all dairy farms within a 10-kilometre surveillance zone.
- Medium scenario: all dairy farms in Taranaki.
- Large scenario without vaccination: all dairying in the whole North Island.
- Large scenario with vaccination: all dairying in the Taranaki and Auckland regions.

It was also assumed that double pasteurisation would be required (depending on milk pH) for milk collected from remaining areas of New Zealand.[12] Based on dairy processing industry advice, a double pasteurisation capacity of 65 percent of peak season milk production was assumed.

Meat processors indicated that they would close down processing for exports until after the OIE granted New Zealand FMD freedom and premium overseas meat markets reopened up again, with only some production for domestic consumption. This was largely due to uncertainty around financial margins from processing and marketing, and the risk status to processing facilities being compromised.

2.3.2 How importing countries might respond

The response of importing countries is summarised by the time required for markets to re-open after FMD-free status is regained. Official FMD freedom is three months after the last infected animals have been killed. From that date, market re-openings were grouped into three sets by MPI trade specialists (see Table 5).

[12] Double pasteurisation is an OIE and EU requirement for trade. Future amendments may allow first-stage processing to be equivalent to a second pasteurisation.

Table 5: Dates from incursion to restoration of exports

Scenarios	Small	Medium	Large	Large with vaccination-to-live	Large with vaccination-to-die
First detection	30/9/2011	30/9/2011	30/9/2011	30/9/2011	30/9/2011
Last detection	30/9/2011	19/11/2011	9/4/2012	30/11/2011	30/11/2011
OIE FMD freedom	31/12/2011	19/2/2012	9/7/2012	31/05/2012	29/02/2012
Number of days until trade start from last detection:					
Early trade start[1]	123 days	121 days	122 days	213 days	122 days
Middle trade start[2]	152 days	152 days	152 days	244 days	152 days
Late trade start[3]	274 days	274 days	275 days	366 days	274 days

Source: MPI.

Notes:

[1]Early trade start countries for meat exports to resume. Dairy exports start in the month following the last IP.
[2]Middle trade start countries for meat exports to resume. Dairy exports start when OIE declare FMD freedom.
[3]Late trade start countries for meat exports to resume. Dairy exports start six months after the last IP.

There are a number of uncertainties over the decisions by overseas countries to resume New Zealand imports after a successful eradication of FMD. Notwithstanding New Zealand's generally strong reputation and its importance as a supplier, current health certificates of many trading partners have a clause saying that FMD "does not occur in New Zealand" and in a few cases that New Zealand has been free of FMD for the previous 12 months. Industry representatives also raised the possibility of further delays by market participants to reactivate supply chains and of variation in country recognition of FMD freedom depending on the scale of FMD incursion and time to eradicate. The modelling work assumed the New Zealand government could negotiate access consistent with the dates in Table 2, but further delays (and hence higher costs) could occur in practice.

2.3.3 Production and export modelling

Models were developed of FMD scenarios on monthly production and monthly exports for dairy, and for meat and other animal products. The FMD scenarios were each compared with actual data over the same time period (July 2011 to June 2013) on the following variables:

- Meat production: slaughter numbers and weights and average carcass weights for lambs, adult sheep, total cattle and deer.
- Dairy production: milk solids collected for Taranaki, Auckland, the rest of the North Island and the South Island.

- Exports: volume, value and price and disaggregated by early start, middle start and late start country destinations.

Exports volumes were assumed to be available in the same month as production.

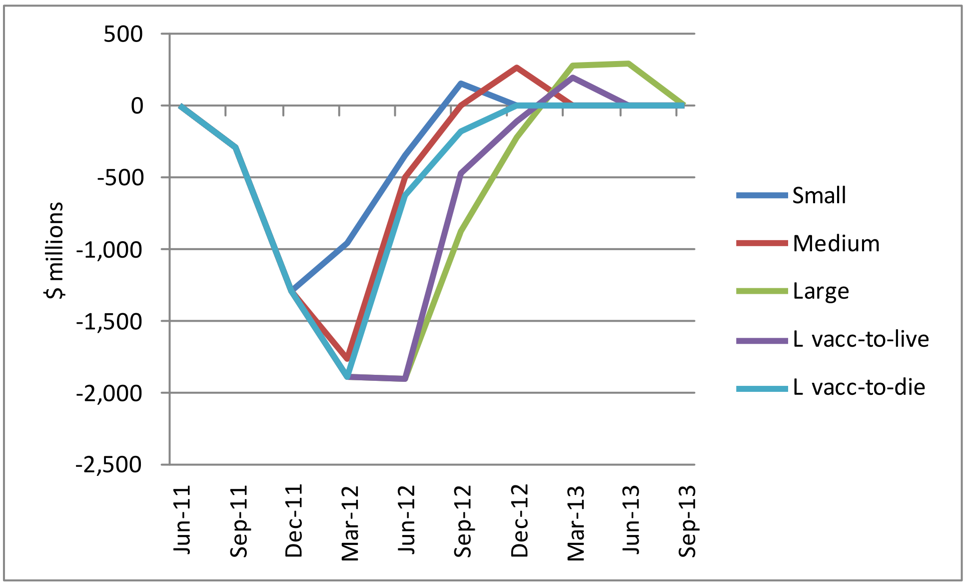
Domestic consumption of meat was assumed to increase by 15% due to lower prices during a FMD incursion. FMD presents no food safety risks. It does not pose a risk to human health and anyway normal meat inspection procedures will ensure that no diseased animals enter the human food supply.

Other assumptions incorporated into the models include:

- September 2011 export rejection losses (75 percent for meat and 50 percent for dairy) due to products having been produced in the risk period before the disease was detected and confirmed;
- A price elasticity of demand for dairy at consumer level in developing countries to derive the price decline required to clear end of season dairy stocks after meeting baseline dairy export volumes;
- Potential increases in export availability from inventories created after the last IP is identified;
- Changed profile of monthly exchange rates during the period from FMD incursion to the restoration of exports (sharp depreciation and slower recovery); and
- No allowance was made for changes in the world price of the relevant products or for the possibility that New Zealand might lose its premium status for dairy and meat exports.

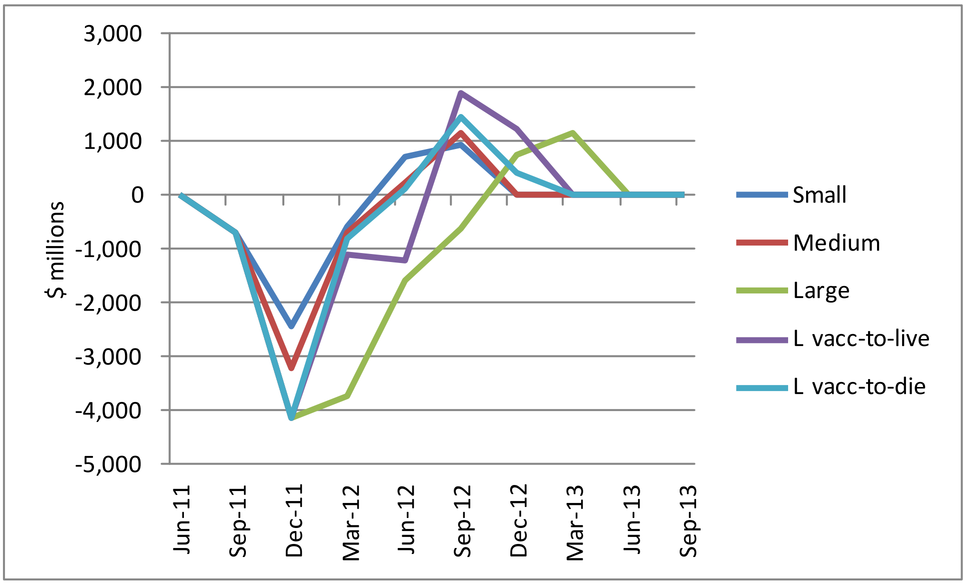
The time path of export value losses are shown in Figures 5 and 6 for meat and dairy products respectively. In all scenarios losses are negative (i.e. export sales are larger than without FMD) in the months immediately following market re-opening; this reflects the build-up of saleable product prior to markets re-opening.

Figure 5: Meat and other products export value losses for FMD scenarios



Sources: Statistics New Zealand and MPI.

Figure 6: Dairy export values for FMD scenarios



Sources: Statistics New Zealand and MPI.

2.3.4 FMD eradication and livestock compensation expenditure

The assumed costs of eradication and compensation are shown in Table 6. Compensation figures are based on the Inland Revenue Department's livestock values for March year 2012.

Table 6: Eradication and livestock compensation

	Eradication expenditure	Livestock compensation
Small scenario	$24.2 million	$1,710
Medium scenario	$122 million	$10.3 million
Large scenario	$1,169 million	$30.8 million
Large with vaccination-to-live	$172 million	$21.0 million
Large with vaccination-to-die	$249 million	$230 million

Sources: AsureQuality, Inland Revenue Department and MPI.

These are minimum estimates and only reflect compensation for destruction of animals for disease control purposes. Compensation claims would also apply to cases of slaughter on suspicion of FMD infection, from imposed movement controls and from any damage to chattels or property during eradication.[13] The modelling also omits any recovery package introduced by the government of the day as would be expected from extreme adverse events such as the medium and large FMD scenarios.

[13] See Appendix 2 for details on compensation under the Biosecurity Act.

2.3.5 The Broader Economic Modelling

The above modelling work results in estimates cash costs reflecting lost export earnings and payments for eradication and compensation. These cash costs and the associated changes in prices (eg meat prices, exchange rates) create ripple effects throughout the economy, affecting a wide range of activities, sectoral income levels, and major aggregates such as GDP. The total effect after all of these ripples have occurred can be represented using a computable general equilibrium (CGE) model, in this case, the NZIER's CGEM. In addition, a macroeconomic model by the New Zealand Treasury was run with the same inputs for the large scenario (see Appendix 3). All CGE models require a large number of assumptions, for example about how labour, goods and currency markets will respond to shocks.

Section 3: Results and Discussion

3.1 NZIER modelling results

Table 7 shows the CGEM estimations for GDP changes in the 2012 year for the whole economy and the subset of industries directly affected, and total real GDP effects over a longer time horizon to 2020.

Table 7: GDP results for FMD incursion scenarios

$ Billion

	Total economy, nominal, 2012	Direct industries, nominal, 2012	Total economy, real, NPV, 2012 to 2020
Small	-$5.8	-$1.6	-$6.1
Medium	-$8.0	-$2.5	-$8.2
Large	-$13.8	-$5.8	-$16.2
Vaccination-to-live	-$11.3	-$4.3	-$10.5
Vaccination-to-die	-$9.1	-$3.3	-$8.7
Earlier FMD free recognition for the South Island[1]	-$13.1	-$5.3	-$15.6

[1]This scenario is a modification of the large scenario whereby the South Island is declared FMD free enabling an earlier start to export trade.

Sources: NZIER and MPI.

CGEM also estimated the impact on other macroeconomic variables, as shown in Table 8.

Table 8: Macroeconomic results for year ended June 2012

Percentage change relative to baseline

	Small	Medium	Large	Vaccination-to-live	Vaccination-to-die	South Island free
Private consumption	-4.7	-6.7	-12.2	-9.6	-7.7	-11.5
Investment	-2.4	-3.2	-4.6	-4.1	-3.6	-4.4
Government consumption	0.1	0.3	3.1	0.5	0.7	3.1
Exports (volumes)	-4.4	-6.3	-12.6	-8.8	-7.3	-12.1
Imports (volumes)	-3.6	-5.1	-9.5	-7.4	-5.9	-9.0
GDP (volumes)	-3.0	-4.3	-7.8	-6.1	-4.9	-7.3
Real exchange rate	-8.5	-11.9	-20.2	-16.4	-13.4	-19.3
Terms of trade	-1.7	-2.4	-4.0	-3.3	-2.7	-3.9
Employment	-2.4	-3.3	-5.0	-4.3	-3.6	-4.8

Source: NZIER.

Notable findings here include a real exchange rate depreciation of 20 percent in the large scenario, a 4 percent reduction in terms of trade and a 5 percent fall in employment. All of these effects were temporary.

The structure of CGEM permitted further investigation at the level of industries. Table 9 shows the predicted effect of the large scenario on GDP for industries (i.e. value added) arranged into several groups. Four of the five directly affected industries were expected to suffer large contractions of around 70 percent in the year to June 2012.

Table 9: Industry impacts – value added and employment impacts in the year to June 2012

Selected industries, percentage change of large scenario relative to baseline

	Value added	**Employment**
Directly affected industries		
Sheep, beef and grain farming	-70.2	-20.5
Dairy cattle farming	-75.8	-23.4
Poultry, deer and other livestock farming*	-21.3	-6.4
Meat and meat product manufacturing	-69.0	-79.1
Dairy product manufacturing	-77.5	-86.8
Supplying industries		
Agricultural services	-26.4	-39.5
Fertiliser and pesticides	-1.4	-3.1
Fuel retailing	-22.0	-27.1
Electricity	-3.0	-13.5
Banking financing and investing	-5.3	-14.5
Competing industries		
Horticulture	1.0	6.5
Fishing	1.0	5.7
Clothing	12.8	20.6
Wood product manufacturing	12.2	20.1
Machinery and equip manufacturing	11.6	18.0
Tourism industries		
Accommodation	4.7	7.9
Travel services	10.2	15.1
Restaurant and bars	-2.2	-3.1
Household expenditure industries		
Supermarkets	-10.4	-16.3
Grocery wholesaling	-9.2	-12.5
Sport and recreation	-6.5	-8.6
Real estate	-2.7	-7.3

Source: NZIER.

Note:

*Other livestock farming includes pig farming.

Employment losses at the farm level were limited because of the high proportion of self-employment, but incomes were lower. Deer and pig farming cannot be separated out. MPI estimated that value added for deer farming would fall about 75 percent. Pig farming might not be impacted much other than by lower prices as little pig meat was exported and over 40 percent of domestic consumption came from imports. Processing for domestic consumption was assumed to continue with little interruption. Domestic meat prices would have decreased due to abundant supply of red meats. Lower competitive meat prices together with depreciated exchange rates would have reduced the demand for and supply of pig meat imports and domestic pig meat prices might have increased relative to other meats.

Much larger drops in employment at meat and dairy processors occurred because of the higher ratio of employees to owners. The drops of around 80 percent shown in Table 8 for these processors convert to 23,400 (meat) and 10,000 (dairy) short-term job losses.

In aggregate, value added from these five directly impacted industries decreased by $5.8 billion, 41 percent of the total fall of $13.8 billion, and employment decreased by around 50,400 jobs in the first year.

A range of upstream industries supply goods and services to the directly impacted industries and incurred losses as a consequence of a FMD incursion. Significant value added losses were estimated for agricultural services (down 26.4 percent) and fuel retailing (down 22 percent), but less so for electricity (down 3 percent) and fertiliser and pesticides (down 1.4 percent). The latter were lower than first expected because a lower exchange rate encouraged a shift from imported to local manufacturing and the industry definition included other chemical products.

Value added for the banking industry was estimated to contract 5.3 percent. The CGEM does not include debt levels or loan defaults and their ramifications on the banking industry and wider economy. However, MPI has supplied input data to the ANZ Bank who are testing the robustness of their financial systems to a FMD incursion.

There were other export industries that were not affected by FMD incursion, but would benefit from exchange rate depreciation and lower prices that arose from reduced competition for intermediate goods and services, labour and capital. The short-term nature of the FMD incursion means that expansion in some industries was constrained. For example, fishing was constrained by quotas and horticulture by the current planting and harvest. On MPI advice, the CGEM output was constrained accordingly. By contrast, manufacturing industries such as clothing, wood product manufacturing, and machinery and equipment manufacturing were better able to respond to favourable exchange rates and cheaper primary and intermediate inputs and expanded their value added by 12.8 percent, 12.2 percent and 9.4 percent, respectively.

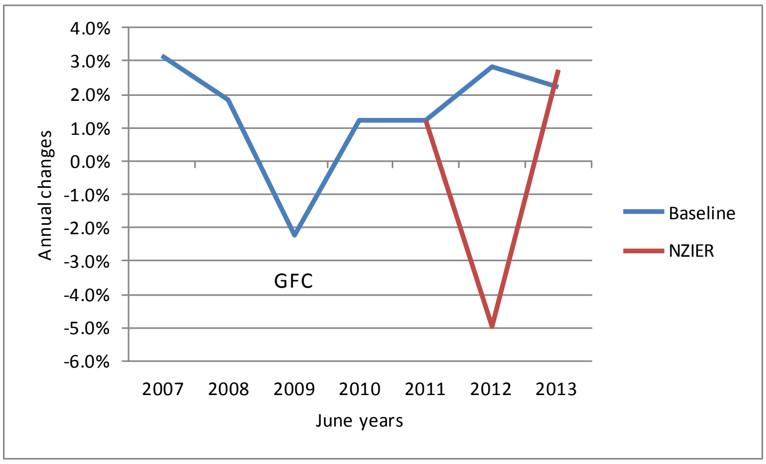
Tourism industries such as accommodation and travel services were estimated to expand value added by 10.2 percent and 4.7 percent, with employment up 15.1 percent and 7.9 percent, respectively. However, restaurants and bars contract because the fall in domestic household spending was greater than the increase in tourism spending. Value added was down 2.2 percent and employment was down 3.1 percent.

A FMD incursion caused household expenditure industries to suffer in the year to June 2012. Lower incomes in farm, processing and supplying industries left households with lower disposable incomes to spend.

3.2 Discussion

Figure 7 compares real GDP growth against what happened to New Zealand during the global financial crisis in 2008-09. The CGEM estimated that the large FMD scenario would put the New Zealand economy into recession. Real GDP would have decreased 5 percent from June years 2011 to 2012 and increased 2.7 percent in the next year. This exceeds the 2.2% fall in real GDP New Zealand experienced during the global financial crisis.

Figure 7: Real GDP annual percent change baseline and FMD large scenario impacts



Sources: Statistics New Zealand, NZIER, and MPI.

The broad pattern of economic impact estimated by these models is considered reliable. There is likely to be a substantial loss of income, with most of the effect falling on the primary sector and agricultural processors. World prices of affected commodities are likely to increase, and domestic prices to fall. New Zealand's exchange rate would fall.

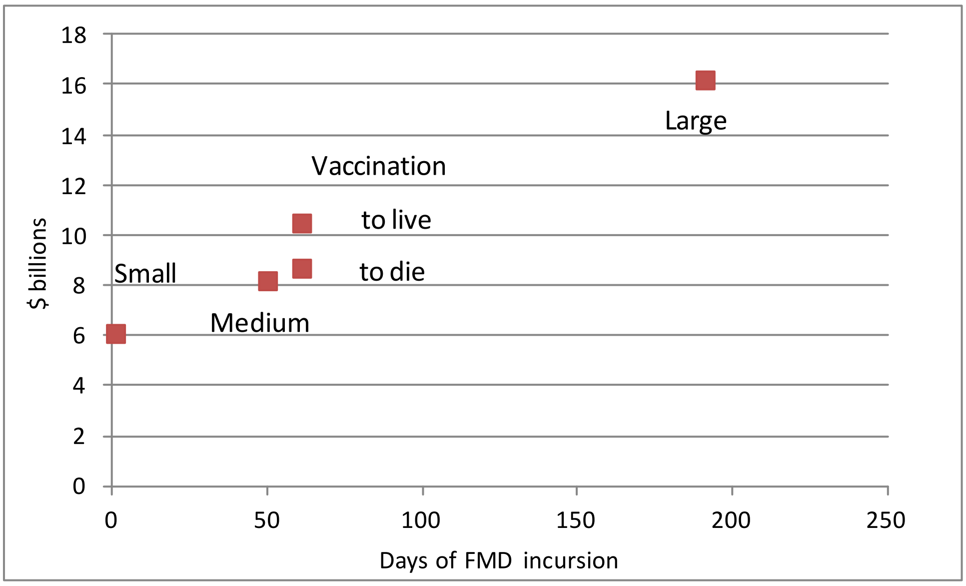
It is also clear that the estimates above understate costs because no estimates were available for the cost of destroying animals on suspicion, for movement controls, or for any recovery package announced by the government of the day.

Uncertainties

The primary uncertainties over the economic impacts arise from the scale of the outbreak, which affects the cost of stamping out, and the time before export markets re-open. Some insight into these uncertainties can be gained by plotting the estimated losses against the duration of each scenario (i.e. the time from outbreak to eradication).

Figure 8 shows this relationship using real GDP predictions (NPV of real GDP effects to June 2020) from the CGEM. It suggests a broadly linear relationship which could be extrapolated to estimate the cost of outbreaks of longer duration.

Figure 8: NPV of real GDP 2012 to 2020 by days of FMD incursion for scenarios



Sources: NZIER and MPI.

Whatever the scale of a FMD outbreak, there will be uncertainty over the timing of export markets re-opening.

On the positive side of this issue:

- New Zealand export industries and MPI have a good international reputation for biosecurity, animal health and welfare, and food safety;
- We are also recognised as strong advocates for reducing trade barriers and leading by example;
- The temporary cessation of dairy and meat exports from New Zealand is expected to drive up global prices and create pressure for re-opening; and
- In some countries it might be possible to sell some product at lower prices before FMD status is regained.

However there are also negative possibilities including:

- Countries could take longer than assumed to recognise New Zealand as FMD free;
- The time taken to accept New Zealand’s FMD free status may vary with the size of outbreak; and
- It may take longer than assumed to re-establish supply and value chains after FMD recognition.

The results of this economic impact assessment must also be viewed within the constraints of the modelling. As outlined by Schley, reviews and critiques of disease models appear regularly in the scientific literature (Morris et al, 2001; Green and Medley, 2002; Kao, 2002; Moutou and Durand, 2002; Kostova, 2004; Perez et al, 2004; Bronsvoort, 2005; Keeling, 2005; Taylor, 2005). Keeling (2005) notes that models are neither infallible nor a panacea and it is therefore important that decision-makers who use the results of model outcomes and those affected by the decisions, understand both the uses and limitations of the particular model.

Factors that influence economic costs

The epidemiological impact of FMD depends on the following factors that could influence the size of an outbreak:

- the point of entry of the virus into New Zealand;
- the strain of virus involved;
- the species of animal(s) affected;
- climatic conditions;
- how rapidly it is detected;
- the animal movements that have occurred before its detection;
- the time of year at which the outbreak occurs;
- the animal populations and farming systems in the area where the disease is introduced;
- the speed at which disease controls are implemented;
- the compliance with disease control measures; and
- the efficacy of the disease control measures.

In terms of response to an outbreak, the economic costs will depend on:

- how many livestock need to be destroyed on farms for animal welfare reasons;
- whether meat processors would be paid to slaughter livestock and render down to tallow and meat meal;
- how extensive the drying off of milking herds would be; and
- whether double pasteurisation would be required.

Importance of preparedness work

The large economic costs associated with a FMD outbreak reaffirm the benefits of prevention efforts. These include pre-border measures, stringent controls at the border, regulations governing the feeding of waste food to pigs, and surveillance with the aim of rapid detection in the event of an incursion of the virus. The modelling also outlines the value in preparing to deal with an outbreak – the higher the level of preparedness, the greater the likelihood of mounting an effective response, which will help limit the size of the outbreak.

It would be critically important to resume trade as quickly as possible after FMD has been eradicated and therefore necessary for MPI to negotiate with trading partners over their acceptance of New Zealand's restored FMD-free status by the OIE.

Section 4: Next steps

4.1 Development of a New Zealand FMD Response Strategy

The significant costs of a FMD incursion to New Zealand are not unexpected. This modelling has highlighted the wide impacts of the disease on a broad range of sectors, as well as its potential social impacts across the whole of New Zealand. It has provided information on the scale of disruption to the primary processing industries, and gives an idea of the large scale of stock numbers that will need to be managed as animals can no longer be processed for export.

The review has highlighted the need for a reassessment of our current FMD response strategy, and a consideration of alternative or complementary strategies to our current approach. This includes the consideration of alternative or complementary disease management strategies such as vaccination, and the use of impact mitigation measures such as disease-free zoning in the event of an outbreak to reduce the economic impacts of the disease.

4.2 New Zealand's current FMD vaccination policy and consideration of alternative strategies

New Zealand is recognised by the OIE and by our trading partners as a *FMD-free country where vaccination is not practised*. FMD vaccine cannot be used pre-emptively before an outbreak occurs.

MPI's current FMD policy affirms that vaccine against FMD will not be used preventatively in an outbreak, but that vaccine may be used in an outbreak as a means to "buy time" where animal culling and disposal resources are overwhelmed by the number of properties that have become infected. Vaccination helps slow the spread of the disease and therefore allows culling to catch up to reduce the risk of further spread. The benefits of "buying time" need to be weighed up against the number of vaccinated animals that need to be culled. All susceptible animals on infected properties will still need to be culled in accordance with the stamping-out disease control policy.

The OIE FMD Code currently does not encourage the use of a vaccinate-to-live policy (Geale et al, 2013). A vaccinate-to-live policy is a policy where animals that have been vaccinated against FMD in an outbreak are not culled, but are allowed to live to the end of their productive lives. The minimum time before which an official OIE return to freedom can be applied for is three months after the last FMD case or vaccinated animal has been culled where a vaccinate-to-die policy has been applied, as opposed to six months after the last case and animal was vaccinated for a vaccinate-to-live policy. This is after surveillance in accordance with OIE requirements has been undertaken, to provide a high level of certainty that the disease has been eradicated.

For an agricultural product exporting country like New Zealand, this prolonged period before official freedom can be requested represents a significant disincentive to implementing a vaccinate-to-live policy. However, since the images of mass animal culling in the 2001 UK FMD outbreak were seen around the world, there has been a groundswell of public and scientific opinion against the mass culling of animals to control FMD and the need to consider complementary strategies (Anderson 2002; Bergevoet and van Asseldonk 2012; Geale et al, 2013). Concerns have been expressed about animal welfare considerations, as well as the wastage of clinically healthy animals. Advances in vaccine and diagnostic technology have provided further momentum to a reconsideration of the FMD Code. The OIE is currently reviewing the specifications around country freedom after the use of FMD vaccine, with the purpose of removing this disincentive.

As part of the FMD preparedness programme, MPI is reconsidering its current FMD vaccination policy. It must be considered whether the benefits of vaccination (economic as well as social) are sufficient to outweigh potential additional costs (including further trade restrictions that may be imposed due to the implementation of vaccination), and logistical constraints. As outlined by Porphyre et al (2013), the use of vaccination in FMD control is a potentially valuable tool but its implementation remains a contentious issue. Despite the relatively large scientific literature on the potential benefits of vaccination, little consensus exists on when vaccination is most beneficial, and hence what factors might trigger its implementation as part of a FMD control strategy. This lack of consensus and clarity means control managers remain unclear on when vaccination should be used. This may cause delays in decision making, which could in itself, potentially affect the efficiency of the strategy (Porphyre et al, 2013).

The vaccination modelling scenario suggests that the probability of a large FMD outbreak is reduced where vaccination is used. This result needs to be seen in the context of the assumptions around the vaccination and the constraints of using a single scenario in which to determine the effects of vaccination. This finding is in accordance with other modelling studies done elsewhere (Hadorn et al, 2012; Garner et al, 2012; Backer et al, 2012). Further vaccination epidemiological modelling will be undertaken as part of the FMD vaccination policy review.

This modelling study reaffirms the value of investment in FMD prevention and preparedness and future management options, provides useful guidance on areas of mitigation where efforts should be focused, and informs the ongoing work of the FMD preparedness programme.

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Glossary

AHL – Animals Health Laboratory (part of the Investigation and Diagnostic Centre)

CGEM – Computable general equilibrium model at NZIER

Compensation – The Biosecurity Act 1993 compensation provisions provide for losses arising from actions of the exercise of powers under the Act. Compensation under the Biosecurity Act is related only to the use of statutory powers under the Act and not to the presence of, or losses due to, pests and diseases. Losses must result from damage to, or destruction of property, or from restrictions placed on the movement or disposal of goods. See Appendix 2 for details.

FAO – Food and Agriculture Organization of the United Nations

FMD – Foot-and-mouth disease

GDP – Gross domestic product

IDC – Investigation and Diagnostic Centre

IP – Infected property or place or premises

ISP – Interspread Plus (the epidemiological model)

MPI – Ministry for Primary Industries

NPV – Net present value

NZIER – New Zealand Institute of Economic Research

NZTM – New Zealand Treasury Model

OIE – Office Internationale des Epizooties, the original name of the World Organisation for Animal Health for which the acronym has been retained

Value added for industries – the equivalent of industry GDP

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Appendix 1 – Parameterisation of Interspread Plus for the epidemiological modelling

a. Index case

North Island introduction:

Introduction was through a swill-feeding pig farm surrounded by dairy farms in Taranaki and in all cases diagnosed as positive 21 days later initiating a response.

b. Silent spread period

Across all iterations the silent spread period was 21 days. This is the period from infection of the primary case until diagnosis of the index case. This period depends upon the incubation period of FMD which is usually 2 to 14 days, the likelihood that the first case in New Zealand would have a long incubation period due to a small initial infecting dose (Donaldson et al, 1987), and following this the period until notification through the passive surveillance system via the MPI 0800 disease and pest freephone. Diagnosis post-notification would be based on clinical and epidemiological signs with laboratory confirmation at the Investigation and Diagnostic Centre (IDC) in Wallaceville and subsequent typing of virus at Pirbright, UK.

Spread mechanisms:

Long distance spread: Defined as spread of virus by known conveyor over longer distances to another property. The conveyor could be by animal or people movements or milk tankers or other vehicles. Movements could occur directly from farm to farm or indirectly via saleyards or secondary contact on vehicles. In the standard scenario here a long distance movement seeds the infection from the Taranaki into the Waikato creating a second major disease cluster.

Localised spread: Defined as the short distance spread of disease between locations where there is no clear linkage other than geographical proximity.

Airborne spread: Spread under specific environmental conditions by wind usually from farms with pigs.

c. Response measures

i. Movement controls

1. National standstill

Immediately upon diagnosis of infection the whole of New Zealand would be subject to national livestock standstill (through a controlled area notice in accordance with section 131(2) of the Biosecurity Act 1993). The national standstill applies to all susceptible species and their genetic materials. The national standstill should remain in place until all long-distance movements and therefore all clusters of infection and outlier properties have been defined. In the standard model scenario the national standstill was lifted after 14 days, and retracted down to a control zone (50-kilometre radius). All markets were closed for standstill, and then kept closed in 50-kilometre control zones.

2. Controlled region (controlled area or high risk area)

A 50-kilometre radius area around all known clusters of infected places would be described as the controlled region. Movements of risk goods (live animals, semen and embryos of susceptible species, animal products of susceptible species and vehicles and equipment used with susceptible animal species would be brought under MPI control using movement permitting procedures.

3. Surveillance zone (or very high risk area)

The surveillance zone will be described as a dynamic spatial zone 10-kilometre radius around all infected premises. Movements of risk goods within this area are severely restricted during the outbreak. The surveillance zones will remain in place until at least 14 days following the decontamination of the last associated infected place and laboratory surveillance for freedom is complete.

4. Protection zone

The protection zone will be described as a dynamic spatial zone three-kilometre radius around all infected premises (for movement control purposes the same conditions apply within the 10-kilometre surveillance zone and within the three-kilometre protection zone).

ii. Organism management

1. Infected place management

All infected places are designated as restricted places and restrictions imposed on movements of all risk goods.

All susceptible stock on infected premises are slaughtered and disposed of (either on site, on neighbouring farms or at a mass disposal location – for example a rendering plant, a landfill, a designated burial area selected in consultation with regional council staff – potential sites have been mapped in advance by some regions).

Decontamination (cleaning and disinfection) of all in contact and at risk equipment and materials takes place following disposal of animals.

Restocking is unlikely to be allowed less than one month following disinfection.

iii. Surveillance

1. Response

Surveillance visits by patrol veterinarians would take place to all properties within the protection zone every two days. Visits will continue until not less than 14 days after completion of decontamination on associated infected places.

Any farm within New Zealand where signs of FMD are reported will receive a surveillance visit by a patrol veterinarian.

Each IP is subject to an epidemiological investigation to determine the likely time and means of infection (through collection of tracing information on risk good movements). This will result in a list of Dangerous Contact Premises (DCPs) all of which will receive surveillance visits every two days from a patrol veterinarian.

All movements of livestock from the North Island to the South Island in the 30 days prior to the implementation of the standstill notice will be traced and each property will receive a surveillance visit by a patrol veterinarian.

Each surveillance visit will involve veterinary inspection of a representative sample of susceptible species and possibly sampling of any suspect animals, as well as serological sampling of stock on the property.

All surveillance activities contribute evidence to zoning decisions made over time.

2. Proof of freedom

Proof of freedom surveys supported by movement control actions, epidemiological, and laboratory information, will be undertaken in the unaffected island allowing this island to be declared a disease free zone as soon as possible.

Three months after completion of decontamination on all infected premises the controlled area notice will be lifted and the affected island will also assume disease free status. This will be a significant exercise requiring thousands of samples to be taken and processed by the IDC, Animals Health Laboratory (AHL). The AHL may need to coordinate and manage several laboratories to achieve the capacity required. Sampling would be designed to be 95 percent confident of detecting an infected farm at a between farm prevalence of one percent. Additionally sampling would be undertaken on farms to allow 95 percent confidence that disease was not present at a within farm prevalence of five percent.

iv. Interventions

1. Contiguous culling

Should contiguous culling intervention be used this will be a significant cost. Decisions on contiguous culling will however be made based on sound epidemiological rationale and a case-by-case basis in the initial response period. This is not a pre-programmed decision and will not be considered further in this paper.

2. Vaccination costs

Immediately upon diagnosis, MPI will notify the supplier of the New Zealand vaccine bank. Virus samples would be sent to the world reference laboratory at Pirbright for virus typing. In consultation with the vaccine supplier it would be determined whether the bank holds a vaccine with suitable efficacy against the outbreak type. MPI would then consider placing a vaccine order – a minimum of 250 000 doses but up to 500 000 if needed. At that point in the outbreak it would already be clear whether vaccination needs to be considered, but vaccine activation may be undertaken as a precautionary measure. Delivery is contractually specified to be within seven working days of receipt of the order. Vaccination is an intervention used in the vaccination modelling scenarios and costs associated with ordering the vaccine would be incurred at activation of the order. Vaccination will be a resource intensive exercise.

Appendix 2 – Compensation under the Biosecurity Act 1993

The provisions for the payment of compensation are set out in Section 162A of the Biosecurity Act 1993, amended in 1998.

The compensation provisions provide for losses arising from actions of the exercise of powers under the Biosecurity Act. The key features of the compensation provisions are:

- losses must be caused by the exercise of powers under the Biosecurity Act for the purpose of managing or controlling any pest or disease and not from the effects of the pest or disease itself;
- losses must be verifiable;
- losses must result from damage to, or destruction of property, or from restrictions placed on the movement or disposal of goods;
- claimants receiving compensation must be placed in no better and no worse position than any person whose property or goods are not directly affected by the exercise of the powers;
- compensation must not be paid:
  - for a loss related to unauthorised or goods that have not been cleared for import;
  - for a loss suffered before the time the exercise of the powers commenced; or
  - to any person who has failed to comply with the Biosecurity Act or regulations made under the Act; where the failure is serious or significant; or contributed to the presence or spread of the pest or disease being managed or eradicated; and
- in the event of dispute, the compensation claim must be submitted to arbitration.

Compensation under the Biosecurity Act is related only to the use of statutory powers under the Act and not to the presence of, or losses due to, pests and diseases.

All reasonable steps must be taken by affected parties to mitigate losses. Compensation is calculated so that those affected are no better or worse off than any person whose property or goods are not directly affected by the exercise of the powers. It is the responsibility of the individual or organisation incurring the loss to present a claim, which must be verified by evidence. MPI will consider all claims for compensation, and offer settlement where this is consistent with section 162A of the Biosecurity Act.

Appendix 3 – The Treasury's macroeconomic model

The New Zealand Treasury Model (NZTM) was also run for the large scenario using the same export losses and costs of eradication and compensation as for the CGEM. Nominal GDP was estimated to fall $12.0bn in the first year and $6.5bn in the second year, while real GDP was estimated to decrease 3.0 percent and 2.4 percent, respectively. All these values are relative to what actually happened without FMD. If such an outbreak of FMD occurred in September 2011, real GDP growth would have recorded negative 0.2 percent in both years ended June 2012 and 2013.

The NZTM is calibrated differently to the CGEM and this reflects differences in the results, particularly in the second year. This was due to a decrease in wages and consumption in the NZTM while the CGEM had most of the recovery in household spending in the second year. The NZTM is better at accommodating monetary policy.