Quantifying the economic impacts of a Brown Marmorated Stink Bug incursion in New Zealand

A dynamic Computable General Equilibrium modelling assessment

NZIER report to Horticulture NZ
July 2017
About NZIER

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NZIER is also known for its long-established Quarterly Survey of Business Opinion and Quarterly Predictions.

Our aim is to be the premier centre of applied economic research in New Zealand. We pride ourselves on our reputation for independence and delivering quality analysis in the right form, and at the right time, for our clients. We ensure quality through teamwork on individual projects, critical review at internal seminars, and by peer review at various stages through a project by a senior staff member otherwise not involved in the project.

Each year NZIER devotes resources to undertake and make freely available economic research and thinking aimed at promoting a better understanding of New Zealand’s important economic challenges.

NZIER was established in 1958.

Authorship

This paper was prepared at NZIER by John Ballingall and Dr Daniel Pambudi.

It was quality approved by Peter Clough.

The assistance of the Samurai Wasp Steering Group is gratefully acknowledged.
Key points

Horticulture New Zealand has asked NZIER to estimate the potential impacts of an incursion of the Brown Marmorated Stink Bug (BMSB) on the New Zealand economy.

We use NZIER’s computable general equilibrium (CGE) model of the New Zealand economy to estimate these economic impacts.

BMSB will significantly reduce horticultural yields and impose surveillance and treatment costs on orchard owners

Based on discussions with industry stakeholders, MPI officials and scientific experts, we consider four modelling scenarios.

1. **Do nothing** – BMSB is left untreated
2. **Do minimum** – minor additional spraying is used to reduce yield losses
3. **Precautionary chemical treatment** – more intensive application of chemicals to further reduce yield losses
4. **Precautionary BCA** – introduction of an EPA-approved imported Biological Control Agent (namely the Samurai Wasp).

We designed scenarios in close consultation with industry and officials

Since there is no scientific evidence available on how BMSB would fare in New Zealand conditions, we rely on international experience and the professional judgement of industry experts to shape our scenarios.

We assume BMSB arrives in 2018 and that infestation occurs in an S-shaped curve – slowly to begin with, then accelerating as a critical mass is reached.

**Table 1 Summary of modelling scenarios**

<table>
<thead>
<tr>
<th></th>
<th>Do nothing</th>
<th>Do minimum</th>
<th>Precautionary chemical treatment</th>
<th>Precautionary BCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average yield loss</td>
<td>26%</td>
<td>22%</td>
<td>13%</td>
<td>8%</td>
</tr>
<tr>
<td>Additional pesticide costs</td>
<td>-</td>
<td>10%</td>
<td>30%</td>
<td>5%</td>
</tr>
<tr>
<td>Additional labour costs, hours p/w</td>
<td>-</td>
<td>1.5</td>
<td>4.5</td>
<td>3</td>
</tr>
<tr>
<td>Higher capital costs</td>
<td>-</td>
<td>5%</td>
<td>7.5%</td>
<td>-</td>
</tr>
<tr>
<td>Cost of sacrificial crops</td>
<td>-</td>
<td>-</td>
<td>2%</td>
<td>-</td>
</tr>
<tr>
<td>Additional netting costs, % of opex</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5%</td>
</tr>
</tbody>
</table>

Source: NZIER

Real GDP could fall by up to $3.6 billion by 2038

The initial GDP impacts are relatively minor, reflecting the S-shaped incursion curve. By 2020, real GDP is between $50 million (BCA scenario) and $127 million (do minimum) lower than BAU.
As BMSB takes hold more firmly, the GDP impacts become more significant. After 10 years, real GDP is lower than BAU by between $1.4 billion (BCA) and $3.1 billion (do minimum).

By 2038, the GDP losses grow to between $1.8 billion and $3.6 billion.

Total export volumes (i.e. excluding price changes) fall by between $291 million and $602 million by 2028; and by between $312 million and $554 million by 2038.

**Figure 1 GDP, welfare and export volume impacts of BMSB**
Change in levels from BAU; real GDP, equivalent variation, volume of exports
Living standards could fall by up to $2.8 billion by 2038 as employment and real wages decrease

While we do see some reallocation of resources into other sectors over time, the overall level of demand for labour in the New Zealand economy falls after BMSB occurs. Economywide employment falls by between 0.07% and 0.14% by 2028, and real wages drop by between 0.5% and 1.1%.

By the end of the projection period (2038) employment returns to its long run level, and the impacts of BMSB on the labour market are felt primarily through continued real wage falls of between 0.45% and 1.0% below BAU.

Because of these decreases in household income, and the broader slowdown in economy, equivalent variation – our preferred measure of living standards or ‘welfare’ – falls by between $1.4 billion (BCA) and $2.8 billion (do minimum).

The horticulture sector suffers considerably from BMSB

Focusing on the horticulture sector, total horticultural export values (i.e. considering both volume and price impacts) fall by between $1.4 billion and $3.0 billion in 2028; and by between $2.0 billion and $4.2 billion in 2038 (see Table 2 below).

These drops are from a BAU of horticultural export values of $7.6 billion in 2028 and $10.8 billion in 2038, as a point of reference.

Table 2 Horticulture sector export value impacts

<table>
<thead>
<tr>
<th>Sector</th>
<th>2028</th>
<th>2038</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do minimum</td>
<td>Precautionary chemical</td>
</tr>
<tr>
<td>Seeds</td>
<td>-53</td>
<td>-25</td>
</tr>
<tr>
<td>Vegetables</td>
<td>-322</td>
<td>-149</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>-1,340</td>
<td>-632</td>
</tr>
<tr>
<td>Apples &amp; pears</td>
<td>-738</td>
<td>-345</td>
</tr>
<tr>
<td>Other fruit</td>
<td>-266</td>
<td>-122</td>
</tr>
<tr>
<td>Wine</td>
<td>-293</td>
<td>-118</td>
</tr>
<tr>
<td>Total horticulture</td>
<td>-3,012</td>
<td>-1,392</td>
</tr>
</tbody>
</table>

Source: NZIER

Introducing a BCA could reduce the costs of BMSB by 50%

Our modelling demonstrates that the economic costs of BMSB would be much lower if a BCA were approved and introduced into New Zealand to manage the spread of BMSB. The mitigating effects of a BCA are far greater than simply using more chemicals.

In the precautionary chemical treatment scenario (i.e. more spraying), the economic costs (either GDP or welfare) fall by around 20% compared to the do minimum
scenario. If a BCA were introduced, these negative economic impacts decrease by around 50%.

A note of caution

Estimating the precise economic impacts of BMSB on New Zealand is subject to numerous assumptions, all of which have a high degree of uncertainty attached to them. As more information and data becomes available on the likely spread of BMSB and the on-orchard costs associated with its treatment, we will be able to carry out further economic modelling as required.

We do not attempt to estimate the nuisance impacts of BMSB on households, domestic gardens, or on biodiversity. These effects are discussed in a separate NZIER report that provides a risk assessment of introducing a BCA into New Zealand.
Contents

Key points .......................................................................................................................................................... i
1. Context and objectives .................................................................................................................................... 1
   1.1. What is BMSB? ...................................................................................................................................... 1
   1.2. How might BMSB affect the New Zealand economy? ...................................................................... 2
   1.3. Scope and caveats ................................................................................................................................. 2
2. Modelling approach ...................................................................................................................................... 4
3. BMSB scenario design ................................................................................................................................. 7
   3.1. Process .................................................................................................................................................. 7
   3.2. Range of scenarios ................................................................................................................................. 7
   3.3. Assumptions for all scenarios .............................................................................................................. 8
   3.4. Parameterising the BMSB scenarios ..................................................................................................... 9
4. Results .......................................................................................................................................................... 10
   4.1. What would we expect to see? ............................................................................................................. 10
   4.2. Macroeconomic results ....................................................................................................................... 10
   4.3. Horticulture sector results ................................................................................................................ 12
5. Conclusion .................................................................................................................................................. 13

Appendices

Appendix A References .................................................................................................................................. 14
Appendix B Yield loss assumptions by crop type ........................................................................................ 15

Figures

Figure 1 GDP, welfare and export volume impacts of BMSB ....................................................................... ii
Figure 2 The Brown Marmorated Stink Bug and its impact on crops ............................................................. 1
Figure 3 Structure of CGE model to examine BMSB impacts ........................................................................ 4
Figure 4 GDP, welfare and export volume impacts of BMSB ....................................................................... 11

Tables

Table 1 Summary of modelling scenarios ...................................................................................................... i
Table 2 Horticulture sector export value impacts ......................................................................................... iii
Table 3 Crops at risk from BMSB .................................................................................................................. 8
Table 4 Summary of modelling assumptions ............................................................................................... 9
Table 5 Horticulture sector export impacts .................................................................................................. 12
Table 6 Yield losses by crop type ................................................................................................................ 15
1. Context and objectives

Horticulture NZ, in conjunction with the Samurai Wasp Steering Group, has asked us to estimate the macroeconomic impacts of the incursion and spread of the Brown Marmorated Stink Bug (BMSB) in New Zealand’s horticultural sector.

1.1. What is BMSB?

BMSB is an agricultural pest largely found in Asia, Europe and the US. It has not yet found its way to New Zealand’s shores, but could potentially arrive in imported loaded containers or travellers’ personal effects. The bug feeds on fruit trees, field crops and woody ornamentals.

Figure 2 The Brown Marmorated Stink Bug and its impact on crops

Source: Dreamtime; Rutgers University; University of Maryland; Good Fruit Grower

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This section draws on MPI’s BMSB factsheet at https://www.mpi.govt.nz/document-vault/10784
When BMSB feeds on fruit and crops, the major impact is discolouration, which can make products unsuitable for sale to consumers.

While BMSB is not a threat to human health, it does emit an unpleasant odour when crushed or disturbed, so is regarded as a public nuisance. This nuisance effect is amplified because BMSB can infest domestic gardens, damaging fruit and crops there; and because they tend to gather in homes in cold weather and are difficult – and smelly – to remove.

1.2. How might BMSB affect the New Zealand economy?

Based on discussions with industry stakeholders, scientific experts and MPI officials, we consider that the most likely channels of impacts will include:

- Yield losses for affected crops
- Additional pesticide costs
- Reduced on-orchard labour productivity due to time spent monitoring for BMSB and more time managing an infestation (or additional contractor costs if the orchardist chooses to outsource this work)
- Likely decrease in per unit export prices due to changes in consumer perceptions about quality
- Costs to install new machinery for more vigilant sorting of fruit
- Costs of planting ‘sacrificial crops’ to draw BMSB away from priority crops
- Additional netting costs, if a BCA is introduced.

We use our dynamic computable general equilibrium (CGE) model of the New Zealand economy to explore various scenarios that incorporate these channels of impact.

1.3. Scope and caveats

We focus in this report on the macroeconomic or ‘NZ Inc’ impacts of BMSB incursion. Regional analysis was out of scope for this project.

There is considerable uncertainty about the severity of the potential impacts, both in terms of the science and economics. We attempt to explore some of these uncertainties through the design of modelling scenarios. However, it is important to note that our estimates can only ever be indicative of direction and magnitude, rather than precise forecasts.

Our model of the New Zealand economy is not a farm-level model. CGE models’ strengths lie in their robust theoretical frameworks and detailed databases of how industries respond to changes in an economy. However, the model itself cannot determine (say) the spread rate of BMSB, netting costs or how much time orchardists or rural contractors will need to spend on mitigating the risks of spread.

These parameters need to be determined outside of the model, and then translated into CGE modelling scenarios that proxy their effects.
Despite these caveats we are confident that, based on the assumptions we have made after extensive discussions with scientific experts and industry stakeholders, our estimates provide a reasonable indication of the macroeconomic impacts of BMSB incursion. These impacts can then be used in our separate report that provides a cost-benefit analysis and risk assessment of the potential introduction of a BCA to manage BMSB.

The modelling can be updated in the future as additional data and information becomes available that might provide a stronger evidential base for our assumptions and scenarios.
2. Modelling approach

We use our dynamic CGE model of the New Zealand economy to estimate the potential macroeconomic impacts of BMSB incursion. We have also used this model to examine the potential impacts of foot and mouth disease and velvetleaf in New Zealand.2

The model represents the entire New Zealand economy

The MONASH-NZ dynamic CGE model is a representation of the New Zealand economy that contains information on 106 industries and 201 commodities in its basic form. The model captures the various inter-linkages between these sectors, as well as their links to households (via the labour market), the government sector, capital markets and the global economy (via imports and exports).

Our model is based on the Australian version of the MONASH model, now known as ‘VU-National’. We summarise the key features of the model here. A technical description of the model is provided in Dixon and Rimmer (2002).

A visual representation is shown in Figure 2, highlighting the complex and multidirectional relationships between the various parts of an economy.

Figure 3 Structure of CGE model to examine BMSB impacts

Source: NZIER

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Key features of the model

- It is a large-scale macroeconomic model, designed for answering “what if?” questions. It is not a detailed farm-level spreadsheet model.
- It covers 106 sectors that produce 201 goods and services (or ‘commodities’). The model database is derived from Statistics New Zealand’s input-output tables, which show all the sales and purchases between these sectors, and from these sectors to the final consumer (i.e. Kiwi households or exports).
- Specific commodities of interest for the BMSB project are apples and pears, kiwifruit, wine, vegetables, seeds, and ‘Other’ fruit.
- Production inputs are intermediate inputs (domestic and imported) and primary factors (labour, land and capital).
- The demand for primary factors and the choice between imported and domestic commodities are determined by Constant Elasticity of Substitution (CES) production nests. This means an increase in price of one input shifts sourcing towards another input.
- Intermediate goods, primary factors and other costs are combined using a Leontief production function. This means the proportion of production inputs is held constant for all levels of output.
- The production mix of each industry is dependent on the relative prices of each commodity. The proportion of output exported or consumed domestically is also dependent on relative prices.
- The model assumes that the amount of resources (land, labour, capital) in the economy are fixed in any single year. Therefore, if one sector (e.g. pipfruit) needs less labour, more labour is available for use elsewhere (e.g. dairy).
- This means that there are always winners and losers from any imposed change to the economy. Some sectors shrink; others expand. The overall economic impact is the net effect of the wins and losses.

The model’s dynamic adjustment features

The model is dynamic, meaning that we can examine changes to the economy due to shocks such as BMSB incursion over time and see how key variables respond as the economy returns to its long run growth path.

MONASH-NZ is a recursive dynamic CGE model. It can be thought of as a series of static simulations linked by three dynamic adjustment procedures:

1. **Labour market adjustment**: We assume that wages are sticky (i.e. don’t change much) in the short run and gradually adjust over time. This means that labour market effects are initially seen through changes to employment. As employment returns to equilibrium over time, the labour market returns to equilibrium through changes in real wages.

2. **Capital formation**: An industry-specific capital accumulation mechanism allows industries to build their stock of capital over time. Capital is generated by investment, which in turn responds to rates of return in each industry.
3. **Balance of payments adjustment**: The model tracks changes in the current account and capital account over time. Changes in net foreign liabilities affect domestic consumption through the level of interest that must be paid to service the foreign debt.

**Core data is based on Statistics New Zealand’s input output tables**

The model is based on a large database containing the value flows of the economy. The database defines the initial structure of the economy, which is assumed to be in equilibrium in all markets.

The structure of the database is broadly similar to a traditional input-output table. For example, commodities may be used as intermediate inputs for further production, used in investment, exported or consumed by households and the government. Industry costs include the cost of intermediates, margins, taxes and primary factor costs for labour, land and capital.

The database is sourced initially from Statistics New Zealand’s 2013 Inter-Industry tables (Statistics New Zealand, 2016). To provide a baseline (or BAU) against which to compare the effects of a BMSB incursion, we project the model out to 2030 using NZIER’s *Quarterly Predictions* macroeconomic forecasts and longer term projections based on labour force growth and productivity assumptions. NZIER’s *Quarterly Predictions* forecasts include NZIER’s views on commodity prices, global economic growth, export growth, interest rates, exchange rates, etc.

Since the model solves in percentage changes from the baseline or BAU, the precise level of the baseline is not critical to our findings.

Once we have calibrated the model and developed a baseline, we then ‘shock’ key parameters to simulate the effects of BMSB incursion. The scenario development is discussed in section 3 below.
3. BMSB scenario design

3.1. Process
As noted in section 1.2, we have identified several potential channels through which a BMSB incursion could affect the New Zealand primary sector and wider economy:

- Reduced yields across a wide range of horticultural crops, reducing exports and domestic sales
- Increased pesticide costs
- Higher labour costs to monitor and treat BMSB
- Higher sorting costs to pick out damaged fruit and vegetables
- Lower horticultural export prices due to concerns over increased chemical use
- The cost of using ‘sacrificial crops’ to attract BMSB and keep it away from more valuable crops
- Additional netting costs (if a BCA is introduced).

To model these channels (or ‘shocks’ in the modelling jargon), we needed to determine their potential magnitude. This was challenging due to a dearth of New Zealand-relevant empirical estimates.

In lieu of empirical evidence, we developed the scenarios through an iterative process with industry stakeholders, scientists and researchers. We started with some ‘straw men’ impacts and refined them based on feedback from experts.

We recognise that any number of parameters could have been selected for this exercise. There was a range of views and where there was particular uncertainty, we have used alternative scenarios to try to take these views into account.

Should more evidence come to light, it is a simple task to re-design the scenarios and re-run the CGE modelling.

3.2. Range of scenarios
We then designed four scenarios to allow us to start exploring different potential severities of these impacts:

1. **Do nothing** – BMSB is left untreated.

2. **Do minimum** – farmers are reactive and deal with BMSB infestations as they occur, primarily through greater use of pesticides.

3. **Precautionary chemical treatment** – farmers are more proactive than in the do minimum scenario. They use broad-based pesticides and some ‘sacrificial crops’ to deal with BMSB. Higher chemical residues result from the additional pesticides, leading to greater export market concerns and hence lower prices. There is a risk of damage to IPMS and hence the potential for secondary pest outbreaks.
4. **Precautionary BCA** – introduction of an imported BCA, namely the Samurai Wasp. The BCA is successful in reducing yield loss. Pesticide application is lower than in the do minimum or precautionary chemical treatment scenarios, and export price impacts are reduced accordingly. No sacrificial crops are required, but additional netting costs are incurred to keep the wasp in proximity to crops.

3.3. **Assumptions for all scenarios**

- The period to be modelled is 2018 to 2038.
- BMSB arrives in early 2018.
- We consider a 10-year period for BMSB to reach a serious level of infestation. We assume BMSB infestation grows in an S-shape curve over this period (i.e. very rapidly at first, then easing off towards the end of the period).
- We exclude impacts on forests and ornamental trees and shrubs in the CGE modelling, though we discuss these impacts qualitatively in our accompanying cost-benefit analysis and risk analysis. We also exclude any potential risk of ‘wine taint’ for grape growers, because the literature is inconclusive on this effect.
- There is no change in MPI resources at the border or elsewhere to deal with any infestation, with any additional screening/monitoring costs to be funded through reprioritisation of baselines.
- Damaged crops are largely, but not entirely, discarded rather than being used for other purposes (e.g. for fruit processing or animal feed).
- The affected crops are shown in the table below. Their total export value is around $4.6 billion (including wine from grapes).

**Table 3 Crops at risk from BMSB**

<table>
<thead>
<tr>
<th>Apples</th>
<th>Grapes/wine</th>
<th>Berries</th>
<th>Sorghum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pears</td>
<td>Stonefruit</td>
<td>Peas</td>
<td>Seeds</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>Citrus</td>
<td>Beans</td>
<td>Hops</td>
</tr>
<tr>
<td>Field corn</td>
<td>Avocado</td>
<td>Brassicas</td>
<td>Pumpkins</td>
</tr>
<tr>
<td>Non-greenhouse tomatoes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: NZIER, based on MPI spreadsheet 'Additional hosts of BMSB v4.0'*
3.4. Parameterising the BMSB scenarios

Table 4 summarises our key assumptions for the four scenarios, based on the scientific literature and our discussions with industry experts. The complete set of yield loss assumptions by crop are shown in Appendix B.

Table 4 Summary of modelling assumptions
Compared to BAU

<table>
<thead>
<tr>
<th></th>
<th>Do nothing</th>
<th>Do minimum</th>
<th>Precautionary chemical treatment</th>
<th>Precautionary BCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average yield loss$^3$</td>
<td>26%</td>
<td>22%</td>
<td>13%</td>
<td>8%</td>
</tr>
<tr>
<td>Additional pesticide costs</td>
<td>-</td>
<td>10%</td>
<td>30%</td>
<td>5%</td>
</tr>
<tr>
<td>Additional labour costs, hrs per week$^4$</td>
<td>-</td>
<td>1.5</td>
<td>4.5</td>
<td>3</td>
</tr>
<tr>
<td>Higher capital costs$^5$</td>
<td>-</td>
<td>5%</td>
<td>7.5%</td>
<td>-</td>
</tr>
<tr>
<td>Cost of sacrificial crops$^6$</td>
<td>-</td>
<td>-</td>
<td>2%</td>
<td>-</td>
</tr>
<tr>
<td>Additional netting costs, % of opex</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5%</td>
</tr>
</tbody>
</table>

Source: NZIER, based on literature and industry views

We were unable to easily and robustly incorporate lower export prices into our scenarios. This is because our CGE model has the usual upward-sloping supply curves. When supply is reduced through yield losses, prices rise because produce is more scarce.

As such, the results presented below do not include the impacts of lower export prices. Export revenues still fall, but due entirely to lower volumes.

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3 This was calculated by using industry estimates of yield loss for each horticultural crop, and weighting them up into our sector classifications based on production values.

4 We use a reduction in labour productivity in the horticulture sector to proxy this – essentially saying that more labour is required for any given amount of output, or less output can be produced for a given amount of labour.

5 This is proxied by reducing the margin on capital used in horticulture, effectively meaning that orchards get lower returns from their capital spend.

6 We assume – arbitrarily – these costs are 2% of farm revenue across the board.
4. Results

4.1. What would we expect to see?

We would expect horticultural production to fall due to yield losses, higher costs of production, and farmers and rural contractors spending more time on monitoring and treating BMSB.

Sectors closely related to the horticulture sector (e.g. horticultural processing, agricultural services) will suffer from the horticultural sector slowdown. Horticultural exports will also fall, partly due to consumer preference shifts around the additional chemical treatment required to manage BMSB and partly due to the overall drop in horticultural production.

Both effects will reduce real GDP, employment and household incomes.

Other sectors (manufacturing, services, other parts of the primary sector) will benefit at the margin from the contraction in the horticulture sector, as more resources (labour, capital, land) become available for producing other goods and services.

4.2. Macroeconomic results

The chart below shows the headline macroeconomic results. These are all shown relative to the BAU projections for each year out to 2038.

They show the expected pattern – the economic impacts are less severe as we move from the do minimum and precautionary chemical treatment scenarios, through to precautionary BCA.\(^7\)

GDP and export volumes drop significantly once BMSB is established

As shown in Figure 4, the initial GDP impacts are relatively minor, reflecting the S-shaped incursion curve. By 2020, real GDP is between $50 million (BCA scenario) and $127 million (do minimum) lower than BAU.

As BMSB takes hold more firmly, the GDP impacts become more significant. After 10 years, real GDP is lower than BAU by between $1.4 billion (BCA) and $3.1 billion (do minimum). By 2038, the GDP losses grow to between $1.8 billion and $3.6 billion.

Total real exports (i.e. export volumes) fall by between $291 million and $602 million by 2028; and by between $312 million and $554 million by 2038.

BMSB would also lead to job losses and falling real wages

A BMSB incursion would also have impacts on total economywide employment and real wages. While we do see some reallocation of resources into other sectors over time, the overall level of demand for labour and capital in the New Zealand economy falls after BMSB occurs.

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\(^7\) We report results only for the three viable scenarios (do minimum, precautionary chemical treatment and precautionary BCA), as the do nothing scenario is only a straw man scenario that would never eventuate in reality.
This pushes economywide employment down by between 0.07% and 0.14% by 2028, and real wages down by between 0.5% and 1.1%.

By the end of the projection period (2038) employment returns to its long run level, and the impacts of BMSB on the labour market are felt primarily through continued real wage falls of between 0.45% and 1.0% below BAU.

Figure 4 GDP, welfare and export volume impacts of BMSB
Change in levels from BAU; real GDP, equivalent variation, volume of exports

Source: NZIER
Living standards take a dive as household incomes fall

Because of these decreases in household income, and the broader slowdown in economy, equivalent variation\(^8\) – our preferred measure of living standards or ‘welfare’ – falls by between $1.4 billion (BCA) and $2.8 billion (do minimum).

EV falls by slightly less than GDP because in the Monash-NZ model, households are not directly affected by the decrease in the rate of return on capital that we see after an incursion of BMSB. This lower rate of return does feed into the GDP fall, however.

4.3. Horticulture sector results

Focusing on the horticulture sector, total horticultural export values fall by between $1.4 billion and $3.0 billion in 2028; and by between $2.0 billion and $4.2 billion in 2038 (see Table 5 below).

These drops are from a BAU of horticultural export values of $7.6 billion in 2028 and $10.8 billion in 2038, as a point of reference.

The horticultural sector export losses are larger than the economywide export losses. This seems counterintuitive, but is a standard CGE modelling result. The resources that were previously employed in the horticultural sector before BMSB shift to other exporting sectors in the primary, manufacturing and services sectors, which allows those sectors to expand production and increase exports.

### Table 5 Horticulture sector export impacts

<table>
<thead>
<tr>
<th>Sector</th>
<th>2028</th>
<th>2038</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do minimum</td>
<td>Precautionary chemical</td>
</tr>
<tr>
<td>Seeds</td>
<td>-53</td>
<td>-42</td>
</tr>
<tr>
<td>Vegetables</td>
<td>-322</td>
<td>-251</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>-1,340</td>
<td>-1,053</td>
</tr>
<tr>
<td>Apples &amp; pears</td>
<td>-738</td>
<td>-575</td>
</tr>
<tr>
<td>Other fruit</td>
<td>-266</td>
<td>-207</td>
</tr>
<tr>
<td>Wine</td>
<td>-293</td>
<td>-206</td>
</tr>
<tr>
<td>Total horticulture</td>
<td>-3,012</td>
<td>-2,333</td>
</tr>
</tbody>
</table>

Source: NZIER

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\(^8\) Equivalent variation measures the amount of money that households would need to be compensated by for their living standards to be maintained at pre-BMSB levels.
5. Conclusion

Based on the assumptions agreed to by NZIER and the Samurai Wasp Steering Group, our CGE modelling of various scenarios indicates that the macroeconomic impacts of a potential BMSB incursion are significant.

By 2038:

- The level of real GDP could be between $1.8 billion and $3.6 billion lower than BAU.
- The level of total real exports (i.e. export volumes) could be between $312 million and $554 million lower than BAU.
- Living standards, as proxied by equivalent variation, could be between $1.4 billion and $2.8 billion lower than BAU.

The more severe ends of these ranges are for the do minimum scenario, where orchardists use a small amount of chemical treatment to try to manage BMSB.

When orchardists are more proactive and employ precautionary chemical treatments and sacrificial crops, the macroeconomic impacts fall by around 20%.

Introducing a BCA – the Samurai Wasp – reduces the macroeconomic costs by another 30%, so that the overall impacts are half those in the do minimum scenario.

In the horticulture sector, a BMSB could see export values fall by between $2.0 billion and $4.2 billion below BAU by 2038. These drops are from a BAU of horticultural export values of $7.6 billion in 2028 and $10.8 billion in 2038, as a point of reference.

The precautionary chemical treatment reduces these export value losses by 22%, and the precautionary BCA reduces them by 52%.

These results are driven primarily by changes in the yield loss assumptions between scenarios. While there is some uncertainty around the precise magnitude of these losses, overall, our modelling demonstrates that the economic costs of BMSB would be much lower if a BCA were approved and introduced into New Zealand to manage the spread of BMSB. The mitigating effects of a BCA are far greater than simply using more chemicals.
Appendix A References


Appendix B Yield loss assumptions by crop type

Table 6 Yield losses by crop type
Once BMSB fully established after 10 years

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Apples</th>
<th>Pears</th>
<th>Grapes</th>
<th>Kiwifruit</th>
<th>Stonefruit</th>
<th>Citrus</th>
<th>Berries</th>
<th>Peas</th>
<th>Beans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do nothing</td>
<td>47%</td>
<td>45%</td>
<td>10%</td>
<td>30%</td>
<td>45%</td>
<td>45%</td>
<td>30%</td>
<td>20%</td>
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<tr>
<td>Do minimum</td>
<td>40%</td>
<td>38%</td>
<td>9%</td>
<td>26%</td>
<td>38%</td>
<td>38%</td>
<td>26%</td>
<td>17%</td>
<td>26%</td>
</tr>
<tr>
<td>Precautionary chemical treatment</td>
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<td>23%</td>
<td>5%</td>
<td>15%</td>
<td>23%</td>
<td>23%</td>
<td>15%</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>Precautionary BCA</td>
<td>12%</td>
<td>11%</td>
<td>3%</td>
<td>8%</td>
<td>11%</td>
<td>11%</td>
<td>8%</td>
<td>5%</td>
<td>8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Field corn</th>
<th>Avocados</th>
<th>Brassicas</th>
<th>Tomatoes</th>
<th>Capsicums</th>
<th>Pumpkins</th>
<th>Sorghum</th>
<th>Seeds</th>
<th>Hops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do nothing</td>
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<tr>
<td>Do minimum</td>
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<td>4%</td>
<td>43%</td>
<td>43%</td>
<td>43%</td>
<td>43%</td>
<td>43%</td>
<td>43%</td>
<td>17%</td>
</tr>
<tr>
<td>Precautionary chemical treatment</td>
<td>25%</td>
<td>3%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>10%</td>
</tr>
<tr>
<td>Precautionary BCA</td>
<td>13%</td>
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<td>13%</td>
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<td>13%</td>
<td>13%</td>
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<td>5%</td>
</tr>
</tbody>
</table>

Source: NZIER, based on scientific literature and industry consultation