RESILIENCE TO NATURE'S CHALLENGES | Kia manawaroa – Ngā Ākina o Te Ao Tūroa | National SCIENCE Challenges

# Economic impact of the 2016 Kaikoura earthquake

A report prepared for the Ministry of Transport

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ECONOMICS of RESILIENT INFRASTRUCTURE

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# Contents

# Executive Summary

This report provides an assessment of the economic impact of the 2016 Kaikoura earthquake via disruption to horizontal infrastructure, household and government consumption and industry sectors, including tourism. This assessment provides direct impacts (changes in expenditure, business operability and employment) and flow-on impacts caused by these direct impacts (known as indirect impacts). These indirect impacts are estimated using 'MERIT' (Modelling the Economics of Resilient Infrastructure Tool), a multi-sectoral, multi-regional and fully dynamic economic model intentionally designed to imitate the core features of a Computable General Equilibrium (CGE) model.

In this report a scenarios analysis is carried out on scenarios differentiated according to transport route reopenings and estimated rebuilding timelines and costings. These can be summarised as:

| | |
|---|---|
| Scenario 1. | Moderate-scale damage and quick rebuild |
| Scenario 2. | Large-scale damage and quick rebuild |
| Scenario 3. | Large-scale damage and slow rebuild |

This assessment covers sectoral and spatial impacts for the period 14 November to 25 November 2016 (2 weeks following the event). A number of additional time periods are included (where relevant) at different intervals from 7 weeks to 4 years following the earthquake.

The 2016 Kaikoura earthquake directly impacted transport margins, business operability and tourism expenditure. Key results include:

- Increases in domestic and international transport margins to/from Canterbury were slightly higher under the slow rebuild at high cost scenario (Scenario 3) than Scenarios 1 and 2.
- Tourism expenditure (domestic and international) in the Kaikoura District decreased the most compared to other regions (down $\$_{2016}$NZ 21 million for November and December), with international spend dropping to zero for the first 5 weeks.
- The international tourism spend has moved between regions due to the earthquake. The biggest gains have been in the Nelson Tasman region, and the 'Rest of the North Island'. North Canterbury, Marlborough and Wellington RTO experienced losses.
- However, international tourism spend was up approximately 5% ($\$_{2016}$NZ 113 million for November and December) on forecasted expenditure at a national level. There are difficulties in isolating higher than forecast existing tourism growth from the earthquake impacts, but the evidence from the first two weeks of November (pre-earthquake) suggest that much of this increase is due to existing tourism growth. Thus the direct impact estimates could understate the losses in the affected regions and overstate the gains in other regions, and the estimated tourism impacts in Section 4.3.2 should be treated with caution.
- Domestic tourism spend was down 7% ($\$_{2016}$NZ 202 million for November and December) on forecast expenditure. Although it is difficult to separate existing tourism trends from earthquake impacts, a decrease this large was not seen in the first two weeks of November (pre-earthquake), and thus a portion of this decrease is thought to be related to the Kaikoura earthquake. The direct impact estimates could overstate the losses in the affected regions and undeerstate the gains in other regions, and the estimated tourism impacts in Section 4.3.3 should be treated with caution.

The direct impacts have flow-on effects across the economy, including:

- The estimated loss to the New Zealand economy over two years for the 'quick rebuild' scenarios (Scenarios 1 and 2) is $\$_{2016}$NZ465 million of GDP, of which $\$_{2016}$NZ 117 million is in Canterbury and $2016NZ 348 million is in the rest of New Zealand.
- The loss in total GDP is $\$_{2016}$NZ 48 million larger in the slow rebuild scenario (Scenario 3).The largest total losses in value added occur within manufacturing, where the loss in value-added is $\$_{2016}$NZ 48 million larger in the slow rebuild scenario (Scenario 3).
- However, the loss in value added in the service sectors is $\$_{2016}$NZ 100 million smaller in the slow rebuild scenario (Scenario 3).
- Approximately 45-51% of the total impact on GDP over 2 years is attributed to transportation cost increases as NZ consumers can afford to spend less on other goods, and goods produced in NZ become less competitive with overseas goods.
- Approximately 54-60% of the total impact on GDP over 2 years is attributed to lost business operability from disruptions in infrastructure and other factors.
- The tourism module in MERIT is still in development. There are difficulties in isolating higher than forecast existing tourism growth from the earthquake impacts, but to calculate the flow-on effects of tourism impacts in MERIT a correction (of 3-4%) was made to estimate the earthquake-specific impacts. It was estimated that the Kaikoura earthquake had a short-term (2-3 week) impact that slightly increased international tourism spend at a national level, but that longer-term tourism effects were a regional displacement of spending that did not change the total national spend.

In terms of rebuild workforce requirement, there is only a small difference between Scenarios 2 and 3, which vary in the pace of the rebuild. In contrast, the rebuild scenario costing $2016NZ 5b less in total (Scenario 1), requires approximately 63% (45,137 MEC years) less in workforce requirements.

A number of key insights into the usefulness of the modelling work were identified along with several opportunities for further research to better understand the impacts of the Kaikoura event and New Zealand's economic vulnerability to natural hazards and disruption events. These opportunities include the economic impacts of displaced Wellington workers, coastal shipping dynamics in rerouting goods, risk to stockpiled goods, and tourism impacts.

# Glossary

**ANZCO:** Australia and New Zealand Standard Classification of Occupations.

**ANZSIC:** Australia and New Zealand Standard Industrial Classification.

**CBD:** Central Business District.

**Census Area Unit** (CAU): A geographic unit from Statistics New Zealand Census Area Unit Boundaries. The CAU is constructed by combining meshblocks and generally coincide with main or secondary urban areas. On average, CAUs within urban and rural areas normally contain a population of 3,000 to 5,000 and 500 to 2,000 respectively.

**Computable General Equilibrium** (CGE): A class of applied economic models typically used to illustrate an economy's responses to changes in policy, technology or other external shocks. Typically CGE models recognise a number of different types of economic agents (usually different types of industries, households and government), conceptualised as either profit or utility maximisers. Optimisation algorithms are employed to determine the set of prices for all commodities and factors of production that would prevail subject to selected constraints (e.g. all commodity and factor markets clear, and total income equals total expenditure for all agents).

**GDP:** Gross Domestic Product.

**Households**: New Zealand resident individuals and families, and Private Non-Profit Organisation (PNPO) serving households.

**Input-Output Model**: A quantitative economic technique that represents the interdependencies between different branches (industries or sectors) of a national economy or different regional economies. The technique depends on a matrix of raw economic data collected by companies and governments to study the relationship between suppliers and producers within an economy. Of particular interest is the extent that the outputs of one industry become the inputs to another.

**Industry Value Added**: Value added summed according to industry groups.

**Meshblock**: The smallest geographic unit for which statistical data is collected by SNZ. These vary in size depending on population. Rural meshblocks generally having a population of around 60 people, while urban meshblocks are roughly the size of a city block with approximately 110 people.

**Modified Employment Counts** (MECs): Statistics New Zealand typically reports employment data according to the Employee Count (EC) measure. ECs are a head count of all salary and wage earners for a reference period. This includes most employees but does not capture all working proprietors – individuals who pay themselves a salary or wage. The modified employment count or MEC measure is based on ECs but includes an adjustment to incorporate an estimate of the number of working proprietors.

**SAM:** Social Accounting Matrices.

**SH:** State Highway.

**System Dynamics**: A methodology for understanding certain kinds of dynamic systems. The methodology concentrates on mapping the feedback relationships between different components or relationships within a system, and simulating changes in systems over time.

**TA**: Territorial Local Authority.

**Transport margin for imported commodities:** For each region, this is the net additional road transportation costs for moving physical goods from the port of import to New Zealand, to the locations of consumption within that region. The additional margins are measured in $NZ$_{2007}$ per $NZ$_{2007}$000 of the relevant commodity or good transported, excluding GST and other taxes on products.

**Transport margin for exported commodities:** For each region, this is the net additional road transportation costs for moving physical goods from the place of production, to the port of export from New Zealand. The additional margins are measured in $NZ$_{2007}$ per $NZ$_{2007}$000 of the relevant commodity or good transported, excluding GST and other taxes on products.

**Transport margin for domestically traded commodities:** This is the net additional road transportation costs incurred in the trade of physical goods within and between regions. The additional margins are measured in $NZ$_{2007}$ per $NZ$_{2007}$000 of the relevant commodity or good transported, excluding GST and other taxes on products.

**Value Added**: The value added to goods and services by the contributions of capital and labour, i.e. the value of output after the cost of bought-in materials and services has been deducted. It includes the national accounts categories 'gross operating surplus', 'compensation of employees', 'other taxes on productions' and 'subsidies'. The sum of all value added is equal to gross domestic product (GDP), excluding taxes on products and import taxes net of subsidies. Thus in New Zealand, total value added is equal to approximately 88% of GDP.

# 1 Introduction

The 2016 Kaikoura earthquake was a magnitude 7.8 (Mw) earthquake in the South Island of New Zealand that occurred at 12:02 am (NZDT) on 14 November 2016. The epicentre was approximately 15km north-east of Culverden and 60km south-west of Kaikoura; the hypocentre was at a depth of approximately 15km. The earthquake ruptured on multiple fault lines in a complex sequence that lasted for more than one minute.

State Highway 1 (SH1) between Seddon and Cheviot via Kaikoura and the Inland Kaikoura Road were closed immediately following the earthquake. In addition, the Main North Line railway was closed, effectively cutting off all land routes into Kaikoura. Hanmer Springs was temporarily cut off at the Waiau Ferry Bridge.

The impact of the Kaikoura earthquake extended beyond the transport network with damage to a number of buildings and facilities in the Wellington Region (Stuff, 2016). The Port of Wellington (Centreport) suspended shipping operations. Towns and farms in the upper South Island were also affected, in particular Waiau, Seddon and Ward.

The purpose of this project is to provide an assessment of the economic impact of the Kaikoura earthquake via disruption to horizontal infrastructure, household and government consumption and industry sectors, including tourism. This assessment provides direct impacts (changes in expenditure, business operability and employment) and flow-on impacts caused by these direct impacts (known as indirect impacts). These indirect impacts are estimated using 'MERIT' (Modelling the Economics of Resilient Infrastructure Tool), developed during the Economics of Resilient Infrastructure (ERI) Programme[1].

This assessment covers sectoral and spatial impacts for the period 14 November to 25 November 2016 (2 weeks following the event). In addition, the following scenarios are included (where relevant):

a. 7 weeks (to Christmas/New Year 2016)
b. 2 months (end January 2017)
c. 3 months (end February 2017)
d. 6 months (end May 2017)
e. 12 months (November 2017)
f. 18 months (May 2018)
g. 2 years (November 2018)
h. 3 years (November 2019)
i. 4 years (November 2020)

This report is structured as follows: Section 2 provides a brief description of the MERIT model, Section 3 describes the methodological steps and key assumptions applied in the analysis, Section 4 outlines the results including impacts to transport margins, business operability, tourism expenditure, total economic

[1] A $2.8 million MBIE Research Programme funded between 1 October 2012 and the 30 September 2016 (https://www.naturalhazards.org.nz/NHRP/Hazard-themes/Societal-Resilience/EoRI).

impacts and rebuild workforce requirements, and Section 5 discusses next steps to further this research and key challenges.

# 2 Modelling the Economics of Resilient Infrastructure Tool (MERIT)

MERIT is a new analytical tool enabling researchers and stakeholders to quantify the economic impacts of infrastructure failure, including organisation mitigations, adaptations and resilience-building responses. MERIT was developed under the Ministry of Business Innovation and Employment (MBIE) funded Economics of Resilient Infrastructure (ERI) programme (2012-2016) by ME Research, GNS Science and Resilient Organisations.

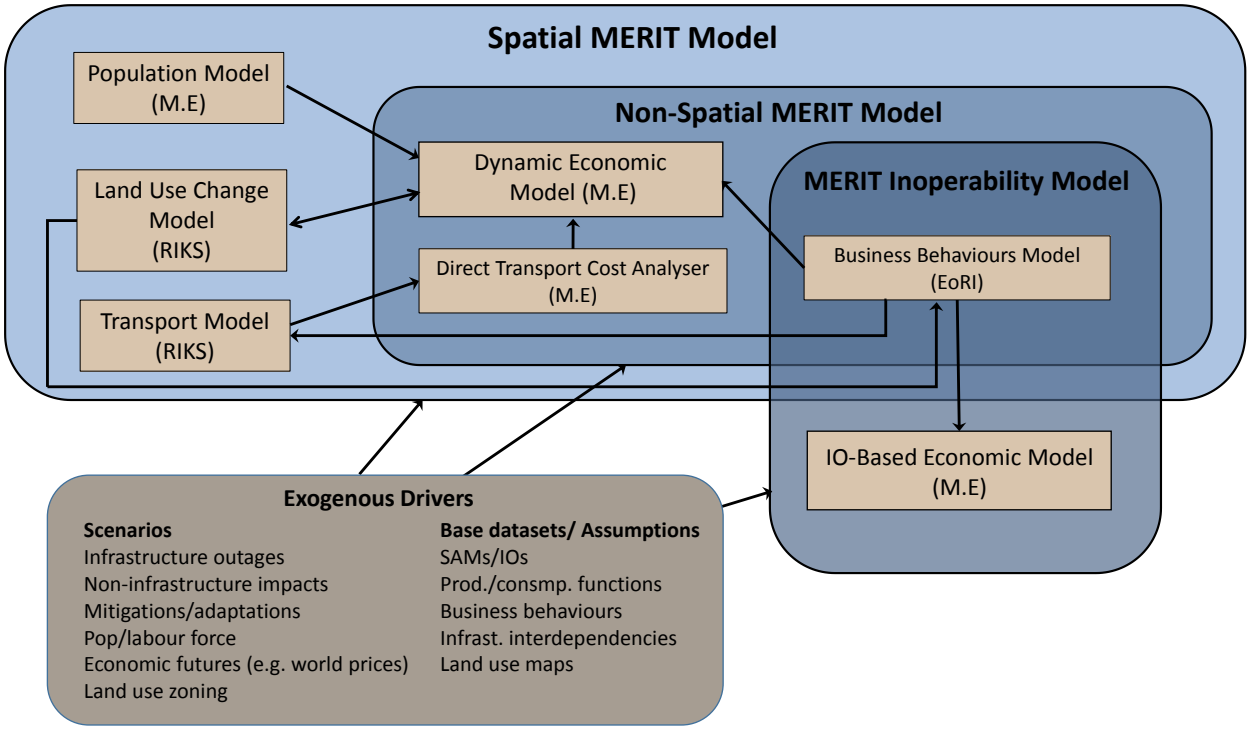
Although we often refer to the 'MERIT model', to respond to requests of users, we have developed a suite of economic modelling tools to address various infrastructure outages (Figure 2.1). Where infrastructure outages are low in complexity and of short duration, the 'MERIT Inoperability Model' is likely to be the most suitable tool for analysis. The advantages of this tool are that scenarios can be very quickly evaluated, and the tool itself is relatively simple and is formulated in Microsoft Excel, which is typically available to most end-users. By contrast, the 'MERIT Spatial Model' is a relatively complex model incorporating sub-models that capture dynamic relationships and feedbacks between land use, economics, demographics, transport, and business behaviours. It is better suited to the analysis of more complex scenarios, including infrastructure outages that may occur in the future when the spatial configuration of business activities may be different from that existing today. For this particular study we applied the 'Non-Spatial MERIT' model. In the remainder of the report any use of the MERIT acronym refers to this version of the model.

MERIT is a multi-sectoral, multi-regional and fully dynamic economic model intentionally designed to imitate the core features of a Computable General Equilibrium (CGE) model. CGE models tend to be the favoured approach and 'state-of-art' in modelling of regional and national-level economic impacts. Among the advantages of these types of models are the whole-of-economy coverage, the capture of not only indirect (i.e. so-called upstream and downstream multiplier effects generated through supply chains) and induced (i.e. as generated through household consumption) impacts, but also the 'general equilibrium' impacts (i.e. price changes, factor substitution and transformation).

Although MERIT incorporates the core features of a CGE model, it is important to note that it differs from a standard CGE model in that it is formulated as a System Dynamics model using finite difference equations. This is an innovative extension to economic modelling undertaken in part to improve our ability to capture the impacts of events over time. Standard economic models are 'equilibrium' models that describe conditions of demand for all commodities and factors when a set of pre-determined conditions are met i.e. supply equates to demand for commodities and factors, and income equates to expenditure for all economic agents. MERIT however is a simulation model acknowledging that in meeting these constraints there is a transition pathway through which the an economy must pass.

Once information is transformed into appropriate inputs and MERIT is run, it is able to produce a variety of indicators to help us assess economic impacts in aggregate and by industry of an infrastructure outage. The model can thus not only be used to assess the economic consequence of a natural hazard event resulting from infrastructure failure, but also to inform on resilience-building and investment initiatives.

Please refer to Smith *et al*. (2015) for further details on the MERIT model and its application.




Notes: M.E = Market Economics, RO = Resilient Organisations, GNS = GNS Science, RIKS = Research Institute for Knowledge Systems, EoRI = Economics of Resilient Infrastructure.

**Figure 2.1 System of MERIT Models.**

# 3 Method

## 3.1 Research investment

A key feature of the work presented in this study was the ability to use MERIT to provide a robust 'rapid assessment' of the economic impacts associated with the Kaikoura earthquake (initial cut of results was required within a 40-hour working week). Without government funded science investments made following the 2010-11 Christchurch earthquakes this would not have been possible, these included: the 2011 MBIE targeted research round (the Economics of Resilient Infrastructure (ERI) programme), Natural Hazard Platform contestable funding (the Faster Rebuilds through Multi-Regional Computable General Equilibrium Modelling (MRCGE) project), the Resilience of Nature's Challenges National Science Challenge (interfacing with established hazard and risk assessment tools) and the QuakeCoRE (tourism and rebuild extensions).

## 3.2 A note on modelling process

To enable the rapid assessment of impacts a clear process is required that sharpens our focus to key concerns. The well-coordinated whole-of-government information response to the Kaikoura earthquake through 'factsheets' provided a simple, but effective, means of communicating quickly the scale and extent of the impacts associated with the earthquake. The adoption of this process facilitated easy dovetailing of the economic impact assessment results into the response i.e. outputs of the MERIT modelling were directly aligned to factsheets. Specifically, this included coverage of: (1) business operation, (2) transport (road, rail, coastal shipping and port), (3) tourism (domestic and international), and (4) the flow-on and cascading (i.e. indirect) economic impacts through the rest of the New Zealand economy. Using MBIE's National Construction Occupations Model (NCOM) it was also possible to provide a crude breakdown of the workforce requirements for the ensuing rebuild. The work itself was completed in three iterations: (1) initial cut of the five economic impact summary sheets by the 12 December 2016, (2) update of the summary sheets by the 21 December 2016, (3) draft report by the 23rd December, and (4) full reporting by the 27th January 2017.

## 3.3 Scenario Analysis

An initial assessment of the Kaikoura earthquake was completed on the 12th December 2016 and a subsequent update on the 21st December 2016. These assessments were developed to compliment the whole-of-government information response being led by the Ministry of Transport, Ministry of Business, Innovation and Employment and others. ME Research was asked, in this initial assessment, to assess the following economic impacts associated with the event: (1) business operational losses (by 46 economic industries) resulting from infrastructure (all types) failure, (2) transport re-routing impacts (particularly freight) associated with road, rail and shipping, (3) international and domestic tourism impacts, and (4) wider flow-on and cascading economic impacts through the New Zealand economy (including general equilibrium impacts). ME Research was also asked to run MBIE's National Construction Occupations Model (NCOM) to provide initial estimates of the workforce rebuild requirements.

In this report the two initial assessments are extended to include an scenarios analysis differentiated according to transport route reopenings and estimated rebuilding timelines and costings. We have however still reported according to (1) business operation (business 'operability'), (2) transport, (3) tourism, (4) total economic impacts, and (5) workforce requirements for rebuild. Specifically, three scenarios were considered for further analysis (Ministry of Transport, 20th December 2016) and are explained below.

**Scenario 1: Moderate-scale damage and quick rebuild**

- *Transport routes:* Under this scenario the inland route to Kaikoura (Waiau to Kaikoura) was 'functionally open'[2] on the 19 December 2016 and fully open by the 28th February 2017, the route south of Kaikoura (Kaikoura to Parnassus) is functionally open on the 21 December 2016 and fully open by the 31 July 2017, and the route north of Kaikoura (Kaikoura to Ward) is functionally open on the 31 May 2017 and fully open on the 31 July 2017.
- *Rebuild schedule and cost:* The residential/commercial rebuild is scheduled to occur over two years, and the transport rebuild over nine months; with transport related infrastructure rebuild costs estimated at $\$_{2016}$NZ 2 billion, and residential/commercial building rebuild estimated at $\$_{2016}$NZ 1 billion.

**Scenario 2: Large-scale damage and quick rebuild**

- *Transport routes:* Same as per Scenario 1.
- *Rebuild schedule and cost.* The residential/commercial rebuild is scheduled to occur over two years, and the transport rebuild over nine months; with transport related infrastructure rebuild costs estimated at $\$_{2016}$NZ 3 billion, and residential/commercial building rebuild estimated at $\$_{2016}$NZ 5 billion.

**Scenario 3: Large-scale damage and slow rebuild**

- *Transport routes:* Under this scenario the inland route to Kaikoura (Waiau to Kaikoura) is functionally open on the 19th December 2016 and fully open by the 30th April 2017, the route south of Kaikoura (Kaikoura to Parnassus) was functionally opened on the 21st December 2016 and fully open by the 31st October 2018, and the route north of Kaikoura (Kaikoura to Ward) is functionally opened on the 31st July 2017 and fully open on the 31st October 2018.
- *Rebuild schedule and cost.* The residential/commercial rebuild is scheduled to occur over four years, and the transport rebuild over two years; with transport related infrastructure rebuild costs estimated at $\$_{2016}$NZ 3 billion, and residential/commercial building rebuild estimated at $\$_{2016}$NZ 5 billion.

## 3.4 Approach

To assess the economic impacts associated with the Kaikoura earthquake the direct costs associated with business operation, transport and tourism impacts must first be assessed. This requires running three sub-models of the MERIT system. Specifically, the Direct Transport Cost Module (which determines

[2] Functionally open routes have additional time delays when compared to fully open routes. There are: (1) inland route to Kaikoura – 5 to 10 minutes (10 minutes was used), south of Kaikoura route – 10 to 20 minutes (20 minutes was used), and north of Kaikoura route (20 to 40 minutes) (40 minutes was used).

changes in domestic, import and export margins associated with re-routing of commodities), Business Behaviours Module (which accounts for direct business operational losses including adaptations experienced following the 2010-11 Canterbury earthquake series), and Tourism Module (which assesses international tourist expenditure changes based on MarketView creditcard data). Figure 3.1 provides an overview of how these sub-modules link. Once the direct impacts have been determined, and compiled into a form suitable for MERIT, the MERIT model is then run to estimate the wider flow-on impacts through the New Zealand economy. Refer to Smith *et al*. (2015) for further details on MERIT and its set up. Finally, the rebuild workforce estimates are quantified using MBIE's National Construction Occupations Model (NCOM)[3]. These steps are described in detail below:

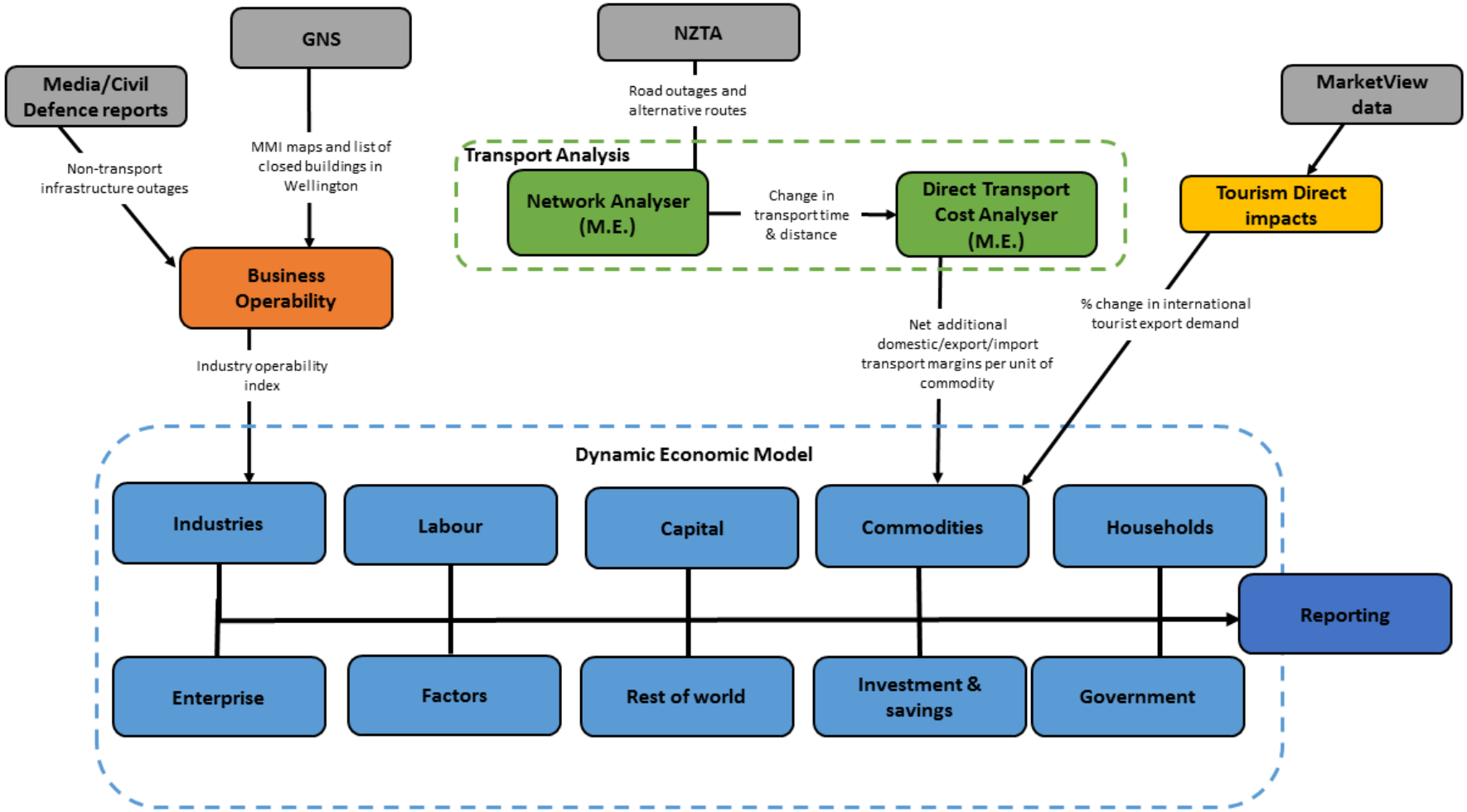
*Step 1: Generate description of Kaikoura earthquake* – A natural disaster event is spatially explicit and impacts can vary depending on geographical location. Specific aspects of the event were described by a series of Geographic Information System (GIS) maps that are 'time-stamped' so that it is possible to determine the period over which impacts last, changes in the condition or degree of impacts over time, and when the impacts dissipate and return to prevent conditions or stabilise. This information has been sourced from Civil Defence and media reports, the New Zealand Transport Agency, GNS Science and others.

*Step 2: Sub-module Analysis* – In the next stage of the analysis we employ sub-modules to calculate direct impacts relating to transport (Section 3.5), business operation and response (Section 3.6) and tourism (Section 3.7). These sub-modules essentially transform known or assumed information regarding the natural hazard event (e.g. locations of road closures, towns with interrupted water supply) into a set of parameters that directly input into MERIT e.g. increase in transport margins in dollars per kg of commodity, or 'operability' of a sector measured in percentage terms.

*Step 3: Compile Direct Impacts* – It is then necessary to gather outputs from each of the sub-models (direct impacts), and compile a single set of inputs for MERIT.

*Step 4: Run Dynamic Economic Model* – The final stage of the analysis is to run MERIT. An application generally involves running the model twice: once without the 'economic shock' (i.e. excluding the direct impacts calculated under Step 3), and once with the shock. The 'net change' in model outputs between the two model runs, represents the economic impact. Further information is provided in Section 3.8.

[3] Developed by ME Research for the Ministry of Business, Innovation and Employment (MBIE). NCOM forms part of the MBIE's National Construction Pipeline which provides 'forward view' forecasts of upcoming building and construction work.




Notes: M.E = Market Economics, GNS = GNS Science, NZTA = New Zealand Transport Agency.

**Figure 3.1 Economic Impact Assessment of Infrastructure Outages using MERIT.**

## 3.5 Transport Impact Analysis

The road networks were severely affected by the earthquake and this resulted in Kaikoura Township becoming completely disconnected from the network. Initial restoration efforts focused on gaining emergency vehicle access through the Inland Route (Route 70). The main north rail line was also cut between Christchurch and Blenheim.

The main impacts from road and rail outages, apart from tourism, are likely to be related to the transportation of goods/commodities. This study has concentrated on quantifying the increased travel costs for freight as a result of needing to transport goods via longer routes. Although loss and degradation of perishable products are additional indirectly-related freight impacts resulting from transport network outage, these types of impacts have not been incorporated into the study. Wine production losses which arguably relate in part to the ability to have contractors fix building structures etc., which requires road access, are included under the business operability impact analysis (Section 3.6).

Figure 3.2 provides an overview of the steps necessary to translate information on road outages into measures of economic impact.

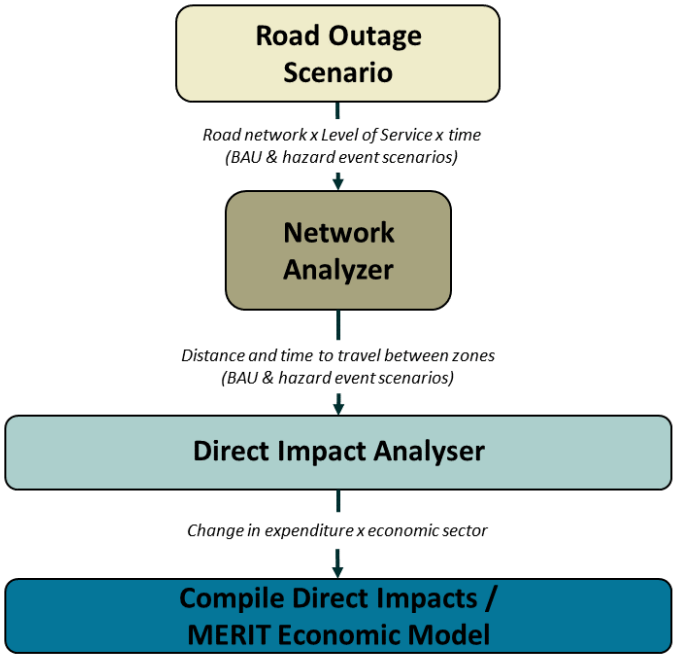



**Figure 3.2 Modelling Road Outages using MERIT.**

*Step 1: Generate description of road outages* – The following data sources and assumptions were used.

- State highway outage maps (covering the period 14 November to 20th December 2016) and re-instatement maps (covering the period 21st December 2016 to 31 October 2018), as per Table 3.1 and Table 3.2, were provided by the New Zealand Transport Agency on 23 January 2017.

Time-stamping reflects key changes in route status from 'closed', to 'functionally open', to 'fully open'. The key 'alternate route' from Picton to Christchurch is via SH63/SH6/SH65/SH7 which is approximately 143km longer than the disrupted SH1 route (NZTA, 2016; Edens, 2016).

- The inland route via Route 70 to Kaikoura was re-opened under tight controls on the 25th November, on the 5th December it was re-opened to milk tankers/essential freight services (NZTA, 2016b; Shaw, 2016), and functionally open on the 19th December 2016 to all other traffic. Under Scenario 1 and 2 the inland road will be fully open from 28th February 2017, and under Scenario 3 from the 30th April 2017.
- From mid-December 2016, there was controlled, single-lane access for residents and essential services on SH1 south of Kaikoura (New Zealand Transport Agency, 2016b), and from the 21st December 2016 the road was functionally open. Under Scenario 1 and 2 this route will be fully open from the 31st July 2017, and under Scenario 3 from the 31st October 2018.
- Our analysis only considers routes once they are functionally or fully open.

*Step 2: Transport Network Analysis* – The change in distance and time to travel between locations as a result of the road outages are calculated using discrete mathematics (using a node-to-node pairs implementation of the Floyd-Warshall algorithm, we refer to this as the Network Analyser in Figure 3.2 above) to assess alternatives routes following closure of a segment of the road network. Congestion resulting from the closures was incorporated for those commodities traversing alternatives routes based on estimates from the NZTA. The following data sources and assumptions were used:

- *Road freight transport*. Territorial-local-authority (TA) to TA road distance and travel time origin-destination matrices were generated, in alignment with the time-stamped outage/reinstatement maps. Alternate routes were determined for the final two periods using the NZTA-supplied maps (ArcMap GIS shapefiles) and through Google Maps. NZTA advised motorists to allow an extra 2.5 hours (for congestion (Hutching, 2016; Mainfreight, 2016) and rest stops) for the alternate route (New Zealand Transport Agency, 2016a).
- *Rail freight transport*. All rail freight ceases to operate over the entire assessment period and is instead freighted by road i.e. the net increase in transport margins are the same as for road freight. The main north line between Christchurch, Blenheim and Picton is estimated to carry 1.12 million tonnes of freight per year (Ministry of Transport, 2016b).
- *Coastal shipping*. KiwiRail has introduced a coastal shipping service 'NZ Connect' supported by Ports of Auckland, Lyttelton Port Company and ANL Shipping (KiwiRail, 2016b). MERIT requires updating to include a dedicated coastal shipping sector which is beyond the timeframes of this study. We instead assume coastal shipping margins are analogous to road freight transport margins.
- *CentrePort*. We assume the disruption to container shipping at CentrePort lasts for at least nine months under Scenario 1 and 2, and up to 2 years under Scenario 3. We re-route all containers through other New Zealand ports; particularly Napier Port and Port of Tauranga (Frykberg, 2016).

*Step 3: Analysis of Direct Impacts* – Changes in travel distance and time between TAs are then translated into a set of altered transport margins for domestically- and internationally-traded commodities. Refer to Smith *et al*. (2015) for further details. It is necessary to determine not only how much additional expenditure on transportation is required, but also the types of goods and services towards which the expenditure is allocated (e.g. petrol, road transportation services and so on), and the distribution of expenditure across different economic agents (i.e. different industry types). To do this, we apply a 'Direct

Impact Analyser' (refer to Figure 3.2 above) to estimate not only the number of trips generated between major locations, but also the purpose of those trips (e.g. travel to work, freight and so on).

Once the transport re-routing impacts are quantified these are, in turn, fed into MERIT where the total economic impacts associated with the Kaikoura earthquake are estimated (See Section 3.8 below).

Our analysis does not account for (1) road and rail passenger services, (2) changes in demand for freight as a result of road closures, (3) the spike in freight transport associated with resumption of roll-on roll-off Aratere ferry services (KiwiRail, 2016a) on the 29th November 2016, and (4) the build-up and slow-release of freight isolated in Kaikoura.

**Table 3.1 Route Status for Disrupted State Highway Network Segments at Selected Points in Time as Supplied by the New Zealand Transport Agency on the 23rd January 2017 – Scenario 1 and 2.**

| State Highway | Length (Km) | Status as at | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 14-Nov-16 | 15-Nov-16 | 16-Nov-16 | 21-Nov-16 | 19-Dec-16 | 21-Dec-16 | 28-Feb-17 | 31-May-17 | 31-Jul-17 |
| Waiau to Kaikoura | 79 | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open | Road Open | Road Open |
| Culverden to Waiau | 23 | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open | Road Open | Road Open |
| SH7a to Hanmer | 9 | Road Closed | Road Closed | Road Open - Functional | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Waipara to 7a Intersection | 67 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| SH7a to Springs Junction | 84 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Lewis Pass Detour Route | 244 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Blenheim to Picton | 28 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Seddon to Blenheim | 25 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Ward to Seddon | 21 | Road Closed | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Clarence to Ward | 42 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open |
| Okiwi Bay to Clarence | 10 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open |
| Mangamaunu to Okiwi Bay | 15 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open |
| Kaikoura to Mangamaunu | 16 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open |
| Peketa to Kaikoura | 9 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open - Functional | Road Open |
| Goose Bay to Peketa | 8 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open - Functional | Road Open |
| Oaro to Goose Bay | 5 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open - Functional | Road Open |
| Parnassus to Oaro | 31 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open - Functional | Road Open |
| Cheviot to Parnassus | 16 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Waipara to Cheviot | 54 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Christchurch to Waipara | 60 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |

**Table 3.2 Route Status for Disrupted State Highway Network Segments at Selected Points in Time as Supplied by the New Zealand Transport Agency on the 23rd January 2017 – Scenario 3.**

| State Highway | Length (Km) | Status as at | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 14-Nov-16 | 15-Nov-16 | 16-Nov-16 | 21-Nov-16 | 19-Dec-16 | 21-Dec-16 | 30-Apr-17 | 31-Jul-17 | 31-Oct-18 |
| Waiau to Kaikoura | 79 | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open | Road Open | Road Open |
| Culverden to Waiau | 23 | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open | Road Open | Road Open |
| SH7a to Hanmer | 9 | Road Closed | Road Closed | Road Open - Functional | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Waipara to 7a Intersection | 67 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| SH7a to Springs Junction | 84 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Lewis Pass Detour Route | 244 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Blenheim to Picton | 28 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Seddon to Blenheim | 25 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Ward to Seddon | 21 | Road Closed | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Clarence to Ward | 42 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open |
| Okiwi Bay to Clarence | 10 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open |
| Mangamaunu to Okiwi Bay | 15 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open |
| Kaikoura to Mangamaunu | 16 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open |
| Peketa to Kaikoura | 9 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open - Functional | Road Open |
| Goose Bay to Peketa | 8 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open - Functional | Road Open |
| Oaro to Goose Bay | 5 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open - Functional | Road Open |
| Parnassus to Oaro | 31 | Road Closed | Road Closed | Road Closed | Road Closed | Road Closed | Road Open - Functional | Road Open - Functional | Road Open - Functional | Road Open |
| Cheviot to Parnassus | 16 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Waipara to Cheviot | 54 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |
| Christchurch to Waipara | 60 | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open | Road Open |

## 3.6 Business Operability impact analysis

The Business Behaviours Module (BBM) is used to assess the direct impact on business operability. Business operability is defined as the proportion of demand for products and services that an organisation is able to meet at a given point in time (Brown, Giovinazzi, Seville, Stevenson, & Vargo, 2015).

The modelling framework is based on a statistical method and the main dataset used to calculate the parameters of the statistical model is sourced from a 2010-11 Canterbury earthquakes dataset (see Brown *et al*. (2015) for further details). In particular, the model takes into account multiple disruption sources from infrastructure (water, sewage, electricity, gas, phone data, road, rail, airport, port, and fuel) and non-infrastructure (damages to premises, local neighbourhood and effects on staff) and estimates the 'experienced disruption' for each of these sources. These disruptions are then used to calculate the 'overall' experienced disruptions for businesses, which in turn, is used in the calculation of the operability function for businesses. Operability is defined as the percentage of the normal or 'as planned' level of production that is able to be achieved. Figure 3.3 illustrates the methodological process of the BBM.

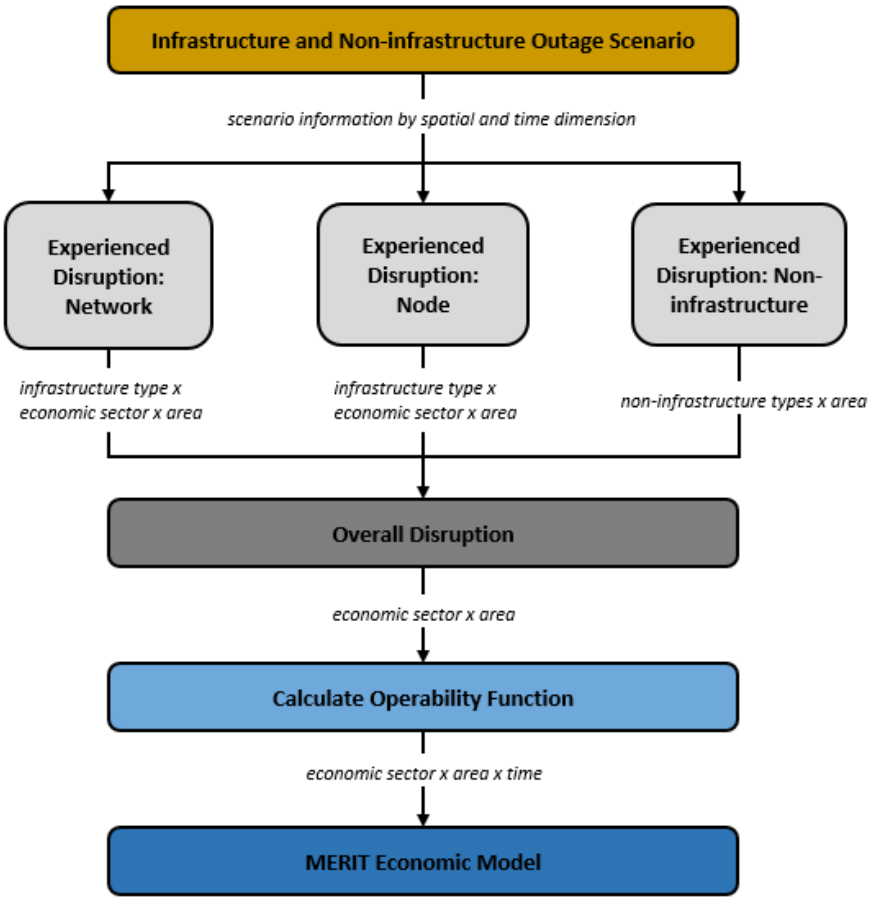



**Figure 3.3 The Business Behaviours Model**

Business operability is measured as a percentage reduction in operability, by industry group, at 1 week, 7 weeks, 3 months, 6 months and 12 months after the earthquake. The following sequence was followed in the estimation of business operability impacts:

- *Mapping impacted businesses*. Maps were derived for (1) building damage, and (2) infrastructure outage for electricity, water and sewerage (as per ***Table 3.3*** based on Civil Defence, District Council and media releases). In the Wellington CBD building damage maps were created by assuming all businesses were closed on the 14 Nov 2016 and thereafter using a list of damaged buildings (MBIE, 2016). In the Upper South Island ground-shaking maps (based on Modified Mercalli Intensity (MMI)) were used to identify areas with building damage.
- *Estimating business operability*. This was determined using the MERIT Business Behaviours Module (BBM).
- *Performing ad hoc adjustments for key businesses/industries*. Operation losses were estimated explicitly for:
    - Centerport - Operations at CentrePort for ferries, fuel/oil, logs, car and cruise ships were only temporarily affected (CentrePort Ltd, 2016). Container services are non-operational with no time given to when these will be reinstated (World Cargo News, 2016). Container revenue losses were estimated based on an analysis of the number containers handled averaged over 12 months (Ministry of Transport, 2016a) and by assuming (1) 30% of containers are empty, (2) 9.5 cargo t per container, (3) $\$_{2016}$NZ1,250 per cargo t i.e. $\$_{2016}$NZ \$11,500 to \$12,000 per container, and (4) no container handling for 9 months under Scenario 1 and 2, and 2 years under Scenario 3.
    - KiwiRail - Loss in revenue was estimated by assuming no freight being transported over the next 18 months on the Main North Line (Picton to/from Addington). This was estimated to account for 12% p.a. rail freight loss for the Canterbury region, and a 1% p.a. freight loss for the rest of New Zealand (Cardwell, McDonald, Smith, & Kim, 2016).
    - Whale watching - Marine-based tourism in Kaikoura is unable to operate until the marina is dredged which, based on data from other marina's (Half Moon Bay Marina, 2013) and the amount of material to be removed (Cropp, 2016), is estimated to require around 3 months of work. An emergency bill passed through Parliament on the 5th December 2016 has allowed dredging (New Zealand Parliament, 2016). We assume no marine-based tourism while dredging occurs then recovery as per the MERIT BBM curves.
    - Other Kaikoura tourism businesses - Losses to key tourism-dependent businesses in Kaikoura (accommodation, retail, food services, culture and recreation) were estimated by determining the proportion of output supplied by these industries to tourists. Half of this component was assumed to have very low operability (0-5%) until full road access was reinstated upon which business operability was as per the BBM. For the other half of this component, it was also assumed operability was very low (0-5%) – until access to Kaikoura is opened up from the South, upon which business operability was as per the BBM.
    - Wine manufacturing - Losses in wine production are estimated to be around 2% p.a. according to the New Zealand Winegrowers (New Zealand Winegrowers, 2016).[4] Recovery of the industry was assumed to occur over 200 days.

[4] Note that we have not considered losses to existing stockpiled wines that perished as a result of the earthquake.

**Table 3.3 Infrastructure Outages by Location (Excluding Road and Rail networks) at Two Weeks after the 14 November 2016 Kaikoura earthquake.**

| Area | Geospatial definition | Electricity (Days of Outage) | Water (Days of Outage) | Sewerage (Days of Outage) | Stormwater (Days of Outage) |
|---|---|---|---|---|---|
| Kaikoura | Urban Area | 8[4] | 5[2] | 11[3] | 11[1] |
| Hanmer Springs | Urban Area | 1[5] | 0[5] | 0 | 0 |
| Waiau | Area Unit | 2[6] | 1[5] | 0 | 0 |
| Waiau - Rural | Area Unit | 2[6] | 12[7] | 0 | 0 |
| Culverden | Area Unit | 1[6] | 0[5] | 0 | 0 |
| Cheviot | Area Unit | 1[6] | 0[5] | 0 | 0 |
| Ward | Area Unit | 5[9,4] | 14[8] | 14[8] | 14[1] |
| Seddon | Area Unit | 3[10] | 3[10] | 0 | 0 |
| Blenheim | Urban Area | 0 | 0 | 0 | 0 |
| Picton | Urban Area | 0 | 0 | 0 | 0 |
| Nelson | Urban Area | 0 | 0 | 0 | 0 |
| Wellington | Urban Area | 0 | 0 | 0 | 0 |
| Lower Hutt | Urban Area | 1[11] | 0 | 0 | 0 |

Table 3.1 notes: **1.** Stormwater outage was assumed to be the same duration as wastewater; **2.** https://www.facebook.com/CanterburyEM/posts/10154908674569674; **3.** Civil Defence Media Release 25/11/16 1330; **4.** Civil Defence Media Release 21/11/16 1300; **5.** http://www.hurunui.govt.nz/news-and-views/council-news/it-has-been-a-busy-24-hours-in-hurunui/; **6.** http://www.mainpower.co.nz/contact-us/latest-news/mainpower-emergency-response; **7.** http://www.civildefence.govt.nz/assets/Uploads/18-MCDEM-Media-release-23.11.16.docx; **8.** http://www.marlborough.govt.nz/Your-Council/News-Notices/Media-Releases-2016/Earthquake-Recovery-Update.aspx; **9.** http://www.marlborough.govt.nz/Your-Council/News-Notices/Media-Releases-2016/Civil-Defence-Update-12pm-18-November-2016.aspx; **10.** http://www.stuff.co.nz/national/nz-earthquake/86474496/Seddon-residents-back-to-square-one-after-earthquakes; **11.** http://www.radionz.co.nz/news/national/318005/earthquake-what-you-need-to-know.

## 3.7 Tourism impact analysis

The tourism sector is demand driven (i.e. depends on exogenous consumption decisions of consumers, in this case tourists) and it is difficult to model consumer demand behaviours of tourism in a natural disaster event. Direct impacts to domestic and international tourism expenditure were estimated using the methods described below. Direct changes to international tourism expenditure, thought to be attributable to the Kaikoura Quake were incorporated into MERIT to calculate indirect impacts (See Section 3.8).

International and domestic tourist debit (EFTPOS) and credit card transaction data[5] around the time of the earthquake in 2016 and in the three previous years (2013-2015) were supplied by Marketview Ltd. Specifically, data for the weekly spend and total number of transactions, by domestic and international tourists, in the 2 weeks before and 7 weeks after the the Kaikoura earthquake were obtained for 2014-2016. Data for the 2 weeks before and 2 weeks after for 2013 were also obtained. The data was produced for 10 tourism spend types (sectors) and for 11 spatial areas of interest. To isolate domestic tourism expenditure from local expenditure, Marketview applies a set of pre-defined filters that are regularly used

[5] The dataset does not cover cash or cheque purchases or payments via direct debit. Nationally, about 68% of all retail purchases are card based, with the balance mainly by cash, cheque and time payment (finance company, which are usually big ticket items).

by the company to identify transactions by identified domestic tourists (pers. communication). In addition, only sales and transaction information for tourism spend categories with more than three merchants in a selected spatial area is released, so as to protect the confidentiality of customers and the commercial sensitivity of merchants.

To estimate the impact of the quake, we require a prediction of the expenditure had the Kaikoura earthquake not occurred. We are not able to make this prediction reliably at weekly resolution for more than the first two weeks after the event, and instead will consider the impact at the time resolution of months, to obtain predictions of the expenditure for the months of November and December in 2016. We make this prediction based on Monthly Regional Tourism Expenditure (MRTE) data at Territorial Authority level from MBIE, which we obtained for April 2008 until October 2016. The MRTE data is aggregated up to 8 regions of interest, from April 2012 (to avoid Christchurch earthquake effects) until October 2016, and these total spend figures for 2013-2016 are shown with solid lines in Figure 4.2 and Figure 4.4, for international and domestic tourism respectively. A combination of forecasting methods was then used to forecast the monthly expenditure for the next 24 months (November 2016 – October 2018), with the choice of method based on the best estimates when cross-validating against past data. These monthly spend forecasts for the first 12 months are shown with dashed lines in Figure 4.2 and Figure 4.4, for international and domestic tourism respectively, with shading to indicate the upper and lower estimates.

For November 2016, MBIE have produced tourism spend estimates at RTO level. We use these figures with our November 2016 MRTE forecasts to estimate the impact on international and domestic tourism expenditure for that month.

For December 2016, we use the Marketview data to predict the actual total expenditure in each region of interest. To do this we must have an estimate of the proportion of the total (MRTE) spend that is captured in the Marketview data within each region and tourist type (domestic and international). By comparing the Marketview and MRTE data at a monthly resolution[6] we find that the proportion changes year to year, and that the best estimate for December 2016 is to be obtained from the November 2016 proportion (within each region and tourist type) with a correction term added based on the November to December change in previous years. This proportion can then be used to transform the December 2016 Marketview spend into an estimated total spend within each region.

For November 2016 MRTE data was provided at Regional Tourism Organisation (RTO) level, whereas Marketview data was at pre-defined regions of interest. These were consistent except for in Canterbury and Wellington, where the different spatial boundaries may have affected our estimates of the North Canterbury and Wellington RTO expenditure. For example, the MRTE data divides Canterbury into North Canterbury (including Kaikoura, Hurunui, and Waimakariri districts), South Canterbury, Christchurch, and Waitaki RTO, whereas the Marketview data regions were Kaikoura District, Hanmer Springs, Rest of Hurunui District, and Rest of Canterbury. Thus the smallest common boundary of the two is the whole of Canterbury. Similarly the MRTE data was provided for Wellington RTO (Wellington City, Porirua, Upper

[6] We sum up the first 4.5 weeks of Marketview data to approximate the November spend and the second 4.5 weeks to approximate the December spend. This will consistently overestimate the November spend and underestimate the December spend, but as we are only using this number to estimate the proportion of total (MRTE) spend that is captured in the Marketview data, we can correct for this.

and Lower Hutt), whereas the MarketView data was for Wellington City and Rest of the North Island. Thus the smallest common boundary of the two is the whole of the North Island.

This is an issue as we have found that the spend proportion captured in MarketView varies substantially between regions (especially for international tourism). So to assess the impact in the North Canterbury region and Wellington we made the assumption that the regional distribution of spend is similar in November and December 2016 i.e. that the proportion spent in North Canterbury captured by MarketView in Kaikoura and Hurunui in November 2016 (including 2 weeks pre-quake and 2.5 weeks post-quake) was representative of the proportion spent in December 2016 (2.5 – 7 weeks post-quake), and similarly that the proportion spent in Wellington RTO captured by MarketView in Wellington City in November 2016 was representative of the proportion spent in December 2016.

## 3.8 Total economic impact analysis (MERIT)

The total economic impacts associated with the Kaikoura earthquake incorporate not only the major direct transport, business operability and tourism impacts, but also the flow-on and general equilibrium (price change and substitution) impacts through the entire New Zealand economy. These impacts are assessed using MERIT.

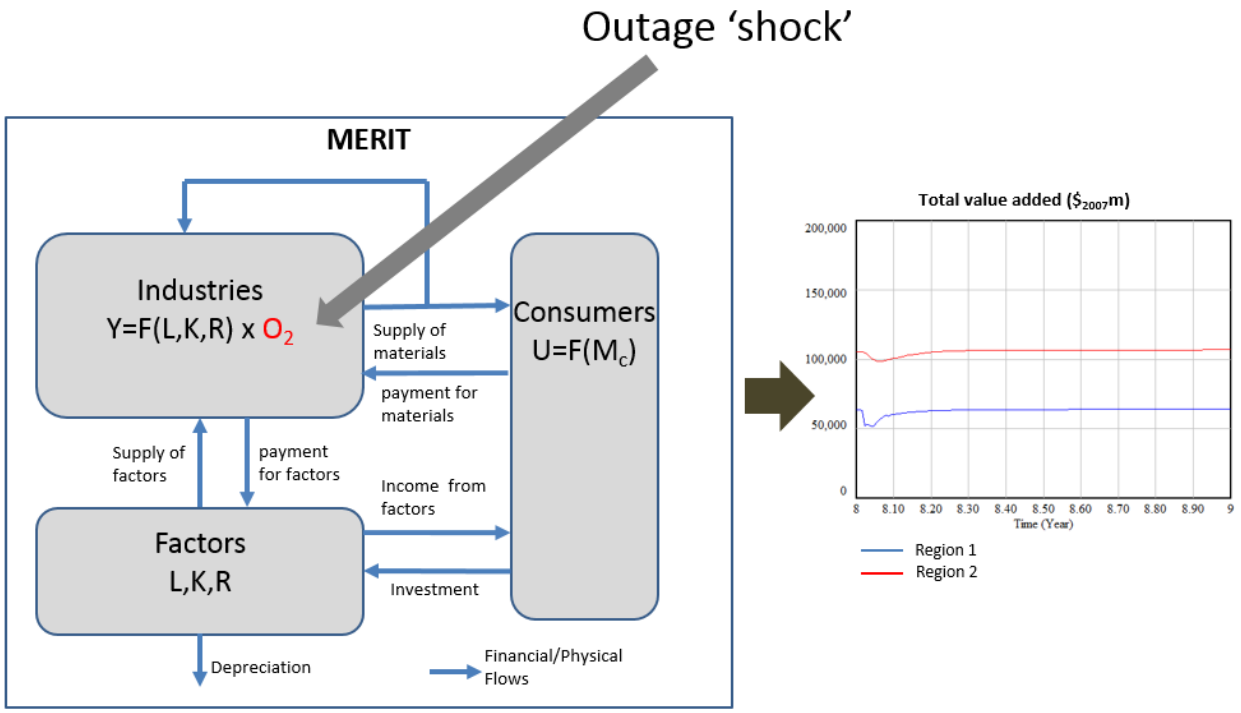
MERIT is a multi-regional and multi-sectoral economic model containing many of the core features of a Computable General Equilibrium (CGE) model. The model is set up according to regional council boundaries and always contains two regions e.g. Canterbury region and the rest of New Zealand. It simulates the behaviour of representative agents within the New Zealand economy include 46 industries, households, local and central government. Industries produce commodities for the local, rest of domestic, and international markets, based on the prices of those commodities relative to the costs of production and available capital and labour resources. Household and government agents receive income from a variety of sources (including from wages and salaries, business profits, dividends, taxes and transfers from other agents) and, in turn, allocate this income towards a variety of expenditure scenarios (purchases of goods and services, savings, taxes, transfers to other agents). Prices changes, financial flows between New Zealand and the rest of the world, and changes in economic resources are also accounted for.

The Dynamic Economic Model within MERIT (see Figure 2.1 and Figure 3.1) is described in a detailed technical report (Smith, McDonald, & Harvey, 2016), and thus only a concise summary is provided here. Figure 3.4 provides a schematic of the model. Among the important features of the model are:

- For each region, the model describes the behaviour of representative agents (46 industries, households, local government and central government). Each industry agent chooses the quantity and type of commodities to produce, based on the prices of those commodities relative to the costs of production. Household and government agents receive income from a variety of sources (including from wages and salaries, business profits, dividends, taxes and transfers from other agents), and then allocates this income towards a variety of expenditure scenarios (purchases of goods and services, savings, taxes, transfers to other agents).
- The model incorporates 'price' variables for all commodities and factors of production (i.e. types of labour and capital). 'Nested' production functions allow the economy to react to imbalances between supply and demand in commodities/factors through substitution of demands and/or

production. For example, the constant elasticity of substitution (CES) function describes the way in which demand for New Zealand-manufactured goods can be substituted for demand for goods produced overseas, if the price of domestic goods becomes too expensive relative to foreign goods. A separate CES function also describes the substitution between locally-manufactured goods (i.e. produced within the same region) and goods produced in the rest of New Zealand.

- The model also includes accounts that keep track of financial flows between New Zealand and the rest of the world (i.e. balance of payments). When the demand for New Zealand currency starts to outstrip supply this causes the exchange rate to rise. Changes in the exchange rate decrease/increase the price of New Zealand goods relative to overseas goods, thus influencing demand and supply relationships.
- The model incorporates the dynamics of economic growth by keeping track of stocks of capital held by each industry. Capital stocks accumulate via investments in new capital and are diminished via the ongoing process of depreciation.




Notes: Y = output, L = labour, K = capital, R = natural resources, U = Utility and Mc = materials/commodities. The 'F' represents "is a function of".

**Figure 3.4 MERIT Dynamic Economic Model**

It is important to note that while MERIT incorporates core features of a CGE model, it differs from a 'standard' CGE model in that it is formulated based on System Dynamics, which uses finite difference equations. This is an innovative extension to economic modelling undertaken to improve our ability to capture the impacts of infrastructure outages. Standard economic models are 'equilibrium' models that describe conditions existing in an economy when a set of pre-determined conditions are met (normally prices equilibrate when supply equals demand for all commodities and factors, and income equals expenditure for all economic agents). For the analysis of infrastructure outages, however, an equilibrium-based analysis may not be helpful, as the time to reach equilibrium will often be longer than the actual length of the infrastructure outage, and during the period of disruption the economy is likely to be exhibiting non-equilibrium behaviour e.g. industries may be operating at a loss. MERIT is a *simulation*

model that shows a *transition pathway* towards equilibrium. It is not necessary that an equilibrium is actually achieved, and indeed the equilibrium towards which the economic system is moving may continue to change over time.

To run MERIT for the Kaikoura earthquake, parameters in the model were altered ("shocked") to address three key topics:

- *Changes in transportation costs and modes* (refer to Section 3.5) – The net changes in transport margins on physical commodities ($ per $1000 of commodity transported) were estimated by modelling changes in freight flows. Margin increases are entered separately for each region for different types of physical commodities (10 in total) and different trade types (domestic, imported, exported).
- *Changes in business operability* (refer to Section 3.6) – Infrastructure disruptions, damages to premises/equipment, and staffing disruptions alter the ability of businesses to supply goods and services to the market. The model contains an operability parameter for each economic industry varying from 1 (normal operations and production) to 0 (no production). The operability parameters for each industry in each study region were obtained from the MERIT Business Behaviours Module.
- *Tourism* (refer to Section 3.7) – The supply-side impacts for tourism are covered by changes in business operability. We have available expenditure data for the first six weeks. Ongoing changes in tourism demands as a result of the quake are extremely uncertain and impossible to predict. Thus tourism impacts used in the model are just one scenario outcome (a best guess) of what might eventuate based on the data available for the first six weeks.
    a. For international tourism, we assume a loss of 11.5 – 12.7% for Canterbury until around the end of December. This reduces to a loss of 5% over the next 1.5 months and stays at this level until SH1 fully opens. For the rest of New Zealand there is evidence of quite a strong gain in expenditure. We assume around 9% gain in international expenditure for the first 1-2 weeks, and 3% during December. Without better information it is simply assumed for the remainder of the period that the loss in demands for Canterbury up until SH1 is opened are a displacement (i.e. gain) to the rest of New Zealand.
    b. For this study we have not attempted to alter domestic tourism demand parameters. Further work is necessary to develop a suitable domestic tourism module. Even if we were able to predict the percentage changes in domestic tourism expenditure for the two study regions, it is unclear how this would impact on other domestic expenditures (e.g. less tourism expenditure could be countered by more consumption, more savings, and so on).

This is only a first-cut estimate of the total economic impacts. While every attempt has been made to include key impacts there are nevertheless several streams of impacts that have not yet been evaluated. These include:

a. *Repair and rebuild* (refer to Section 3.9) – A significant amount of buildings, infrastructure, equipment and other capital was damaged by the quake. Significant funds and labour will be necessary over many months for repair and rebuild.
b. *Domestic tourism demand changes* ¬as explained above.
c. *Population relocation* – We have assumed that population growth for Canterbury and the rest of New Zealand are unaffected. The quake may however cause (or contribute) to the movement of people. This can influence the relative distributions of supply and demand of

labour, housing and other capital, with potential economic consequences at a local and even regional level.

d. *Cost of delays in delivery of goods* – Some goods (e.g. foods) clearly degrade over time. Even for other goods, consumers/businesses often pay more for faster delivery. No attempt has been made to incorporate the costs to the New Zealand economy of losses in the usefulness/attractiveness of goods with longer delivery times.
e. *Non-market and some intangible impacts* – MERIT is a market simulation tool and no attempt is made to value stress and inconvenience. Also less tangible and uncertain impacts, such as loss of confidence for potential investors in the New Zealand economy, are not considered.
f. *Impacts identified as 'not included' in Sections 3.5, 3.6, and 3.7.*

## 3.9 Rebuild Workforce Requirements

Workforce estimates are based on the National Construction Occupations Model (NCOM) which applies a multi-regional input-output model to estimate the direct, indirect (i.e. from supply chain linkages) and induced (i.e. from consumer spending in the wider economy) labour force requirements for the earthquake rebuild.

NCOM translates construction investment (both residential, non-residential, and heavy and civil engineering (predominantly infrastructure)) into regional estimates of employment by occupation (1022 ANZCO groupings) and industry (507 ANZSIC groupings) to provide a high level of detail, accuracy and precision for decision-making. The following steps were followed to estimate workforce requirements:

- Direct reinstatement costs for residential and non-residential construction ($\$_{2016}$NZ million) were extracted from the RiskScape model – a multi-hazard loss assessment tool developed by GNS Science and NIWA. RiskScape quantifies and maps building and infrastructure damage and loss to inform risk-based decision-making. These costs are scaled on a pro-rata basis to match rebuild cost estimates provided by the Ministry of Transport on the 20th December 2016 as per Scenarios 1, 2 and 3 outlined above. To the best of our knowledge these costs do not account for the rebuild of CentrePort.
- The above reinstatement costs for residential, non-residential and infrastructure were further disaggregated into industry workforce requirements based on NCOM profiles from the 2010/11 Christchurch quakes and occupation by industry breakdowns from the 2013 Census of Population and Dwellings.
- Indirect and induced workforce requirements were calculated by NCOM using input-output mathematics. Note that NCOM: (1) is based on Statistics New Zealand's 2007 Inter-industry Study of the New Zealand economy, (2) accounts for construction related productivity improvements and changes in labour utilisation capacity through time, and (3) is a demand side analysis of the workforce requirements i.e. it doesn't take account of any supply side constraints that restrict available labour supply.
- It is assumed that non-transport related reinstatement/rebuild occurs over 2 years for Scenario 1 and 2, and over 4 years for Scenario 3. Reinstatement/rebuild of transport infrastructure is assumed to occur at a quicker pace i.e. 9 months under Scenario 1 and 2, and 2 years under Scenario 3.

# 4 Results

## 4.1 Transport impacts

The direct impact of transport-related infrastructure disruptions caused by the Kaikoura earthquake on transport freight margins was measured as the average percentage increase in transport margins for domestic and international trade commodity freight after the earthquake for the Canterbury region and the rest of New Zealand. As outlined in Section 3.5, the road network analysis did not consider the tightly controlled inland route and thus changes in the use of this road for freight once access is resumed on SH1 to Kaikoura.

Table 4.1 and Table 4.2 show the percentage increase in domestic and international freight margins, averaged (by value) over all commodities for Scenarios 1 and 2, where SH1 is reinstated in 9 months. The average percentage increases in domestic transport margins were higher for commodities transported into and out of Canterbury from/to other NZ regions (Table 4.1). However average increases in international freight margins were similar across regions, ranging between 2-4% (Table 4.2). Average increases in freight margins transported internally in Canterbury or internally within the rest of New Zealand were minimal.

When SH1 is reinstated in 2 years (Scenario 3), the percentage increases in domestic and international freight margins show similar trends to Scenarios 1 and 2. The average percentage increases in domestic transport margins were higher for commodities transported into and out of Canterbury from/to other NZ regions (Table 4.3). Average increases in international freight margins were similar across regions, ranging between 2-6% (Table 4.4).

When extra time is taken to reinstate SH1 (Scenario 3), the average percentage increases in freight margins become slightly higher than Scenarios 1 and 2.

**Table 4.1 Average Percentage Increase in the Costs of Delivering Freight for Domestic (Canterbury Region and rest of New Zealand) Freight as a result of SH1 being reinstated by 31 July 2017, 9 months following the 2016 Kaikoura Earthquake (Scenario 1 & 2).**

| Origin \ Destination | Canterbury Region | Rest of New Zealand |
|---|---|---|
| Canterbury Region | <1% | 5% |
| Rest of New Zealand | 5% | 1% |

NB: This does not account for price changes due to any shortages in supply of freight services.

**Table 4.2 Average Percentage Increase in the Costs of Delivering Freight for International Import and Export Commodity Freight as a result of SH1 being reinstated by 31 July 2017, 9 months following the 2016 Kaikoura Earthquake (Scenario 1 & 2).**

| | Canterbury Region | Rest of New Zealand |
|---|---|---|
| Imports to | 4% | 3% |
| Exports from | 4% | 2% |

NB: This does not account for price changes due to any shortages in supply of freight services.

**Table 4.3 Average Percentage Increase in the Costs of Delivering Freight for Domestic (Canterbury Region and rest of New Zealand) Freight as a result of SH1 being reinstated by 31 Oct 2018, 2 years following the 2016 Kaikoura Earthquake (Scenario 3).**

| Origin \ Destination | Canterbury Region | Rest of New Zealand |
|---|---|---|
| Canterbury Region | <1% | 6% |
| Rest of New Zealand | 7% | 2% |

NB: This does not account for price changes due to any shortages in supply of freight services.

**Table 4.4 Average Percentage Increase in the Costs of Delivering Freight for International Import and Export Commodity Freight as a result of SH1 being reinstated by 31 Oct 2018, 2 years following the 2016 Kaikoura Earthquake (Scenario 3).**

| | Canterbury Region | Rest of New Zealand |
|---|---|---|
| Imports to | 6% | 3% |
| Exports from | 5% | 2% |

NB: This does not account for price changes due to any shortages in supply of freight services.

## 4.2 Business operability impacts

Table 4.5 and Table 4.6 show the percentage loss in business operability by selected industries. There is a clear localised impact to the Kaikoura, Hurunui and Marlborough districts up to 3 months following the earthquake. However the loss in operability generally decreases to zero by 6 months. This is based on the relationship between infrastructure outages and business recovery times, calculated using data from the Canterbury earthquakes (see Brown *et al*. (2015) for further details).

The largest percentage loss to business operability is in trade and hospitality in the Kaikoura District (75% loss in the first week, decreasing to 35% loss 6 months following the earthquake). This equates to an approximate loss in regional value added of $\$_{2016}$NZ 4.7 million at 6 months following the earthquake.

The utilities, construction and transport industry in the Kaikoura District was also impacted with a 34% loss in operability in the first week, decreasing to a 5% loss at 3 months following the earthquake.

In the Marlborough District, the largest percentage loss to business operability is in food manufacturing (17% loss in the first week, decreasing to 4% at 3 months) and wood and paper manufacturing (16% loss in the first week, decreasing to 3% at 3 months). The operability loss in food manufacturing equates to a loss in regional value added of approximately $\$_{2016}$NZ 18 million at 3 months following the earthquake.

In the Canterbury region, impacts are 0-1%. The 1% loss in trade and hospitality operability equates to a loss in regional value added of approximately $\$_{2016}$NZ 8.7 million at 3 months following the earthquake (Table 4.5).

While the loss in business operability in both finance, insurance, real estate, and professional services in the Wellington Region is only around 1% in the first week, this equates to a loss in value added for the industry of approximately $\$_{2016}$NZ 2.2 million over that first week, as the industry is a sizeable component of the economy (Table 4.6).

For New Zealand as a whole the loss in business operability was less than 1% in all industries from the first week to 12 months following the earthquake (Table 4.6).

**Table 4.5 Loss of Business Operability by Industry for Kaikoura District, Hurunui District and Canterbury Region at Selected Points in Time following the 14 November 2016 Kaikoura Earthquake.**

| | Industry | Kaikoura District | | | | | | Hurunui District | | | | | | Canterbury Region | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % Loss to Business Operability | | | | | Pre-quake Value Added ($2016NZmil) | % Loss to Business Operability | | | | | Pre-quake Value Added ($2016NZmil) | % Loss to Business Operability | | | | | Pre-quake Value Added ($2016NZmil) |
| | | 1 week | 7 weeks | 3 months | 6 months | 12 months | | 1 week | 7 weeks | 3 months | 6 months | 12 months | | 1 week | 7 weeks | 3 months | 6 months | 12 months | |
| 1 | Agriculture | 0% | 0% | 0% | 0% | 0% | 42 | 0% | 0% | 0% | 0% | 0% | 211 | 0% | 0% | 0% | 0% | 0% | 1,880 |
| 2 | Other primary | 0% | 0% | 0% | 0% | 0% | 2 | 1% | 1% | 0% | 0% | 0% | 25 | 0% | 0% | 0% | 0% | 0% | 262 |
| 3 | Food manufacturing | 19% | 8% | 4% | 0% | 0% | 0 | 19% | 8% | 4% | 0% | 0% | 59 | 0% | 0% | 0% | 0% | 0% | 1,360 |
| 4 | Wood and paper manufacturing | 23% | 9% | 5% | 0% | 0% | 2 | 11% | 5% | 2% | 0% | 0% | 1 | 0% | 0% | 0% | 0% | 0% | 180 |
| 5 | Other manufacturing | 19% | 8% | 4% | 0% | 0% | 2 | 15% | 6% | 3% | 0% | 0% | 8 | 0% | 0% | 0% | 0% | 0% | 2,094 |
| 6 | Utilities, construction & transport | 34% | 26% | 5% | 0% | 0% | 39 | 14% | 6% | 3% | 0% | 0% | 76 | 0% | 0% | 0% | 0% | 0% | 5,082 |
| 7 | Trade and hospitality | 75% | 37% | 36% | 35% | 0% | 27 | 14% | 6% | 3% | 0% | 0% | 46 | 1% | 1% | 1% | 0% | 0% | 3,495 |
| 8 | Finance, insurance, real estate & professional services | 26% | 11% | 6% | 0% | 0% | 19 | 16% | 6% | 3% | 0% | 0% | 110 | 0% | 0% | 0% | 0% | 0% | 6,975 |
| 9 | Government, education & health services | 20% | 8% | 4% | 0% | 0% | 9 | 12% | 5% | 2% | 0% | 0% | 29 | 0% | 0% | 0% | 0% | 0% | 4,097 |
| 10 | Other services | 37% | 17% | 14% | 11% | 0% | 7 | 18% | 7% | 4% | 0% | 0% | 44 | 1% | 0% | 0% | 0% | 0% | 1,105 |

**Table 4.6 Loss of Business Operability by Industry for Marlborough Region, Wellington Region and New Zealand at Selected Points in Time following the 14 November 2016 Kaikoura Earthquake.**

| | Industry | Marlborough District | | | | | | Wellington Region | | | | | | New Zealand | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % Loss to Business Operability | | | | | Pre-quake Value Added ($2016NZmil) | % Loss to Business Operability | | | | | Pre-quake Value Added ($2016NZmil) | % Loss to Business Operability | | | | | Pre-quake Value Added ($2016NZmil) |
| | | 1 week | 7 weeks | 3 months | 6 months | 12 months | | 1 week | 7 weeks | 3 months | 6 months | 12 months | | 1 week | 7 weeks | 3 months | 6 months | 12 months | |
| 1 | Agriculture | 0% | 0% | 0% | 0% | 0% | 196 | 0% | 0% | 0% | 0% | 0% | 221 | 0% | 0% | 0% | 0% | 0% | 10,194 |
| 2 | Other primary | 3% | 1% | 1% | 0% | 0% | 128 | 0% | 0% | 0% | 0% | 0% | 81 | 0% | 0% | 0% | 0% | 0% | 5,452 |
| 3 | Food manufacturing | 17% | 7% | 4% | 0% | 0% | 419 | 0% | 0% | 0% | 0% | 0% | 971 | 1% | 0% | 0% | 0% | 0% | 9,513 |
| 4 | Wood and paper manufacturing | 16% | 6% | 3% | 0% | 0% | 9 | 0% | 0% | 0% | 0% | 0% | 111 | 0% | 0% | 0% | 0% | 0% | 2,072 |
| 5 | Other manufacturing | 10% | 4% | 2% | 0% | 0% | 79 | 0% | 0% | 0% | 0% | 0% | 1,502 | 0% | 0% | 0% | 0% | 0% | 14,379 |
| 6 | Utilities, construction & transport | 11% | 5% | 3% | 1% | 1% | 252 | 1% | 0% | 0% | 0% | 0% | 4,030 | 0% | 0% | 0% | 0% | 0% | 31,903 |
| 7 | Trade and hospitality | 10% | 4% | 2% | 0% | 0% | 239 | 0% | 0% | 0% | 0% | 0% | 2,745 | 0% | 0% | 0% | 0% | 0% | 27,305 |
| 8 | Finance, insurance, real estate & professional services | 8% | 3% | 1% | 0% | 0% | 494 | 1% | 0% | 0% | 0% | 0% | 11,552 | 0% | 0% | 0% | 0% | 0% | 63,686 |
| 9 | Government, education & health services | 9% | 3% | 2% | 0% | 0% | 227 | 1% | 1% | 0% | 0% | 0% | 6,862 | 0% | 0% | 0% | 0% | 0% | 35,040 |
| 10 | Other services | 9% | 3% | 2% | 0% | 0% | 217 | 1% | 0% | 0% | 0% | 0% | 1,303 | 0% | 0% | 0% | 0% | 0% | 9,428 |

## 4.3 Tourism impacts

The tourism sector is a key sector in the New Zealand economy, bringing in an estimated $\$_{2016}$NZ 15 billion in domestic tourism spend and $\$_{2016}$NZ 10.7 billion in international spend annually for the year ending October 2016. Growth in both international and domestic tourism markets has been strong; up 15% and 6%, respectively, from the year ending October 2015.

The impact on international and domestic tourism sectors by selected regions for November and December 2016 have been estimated, as well as forecasts generated for the next 24 months to assist in the evaluation of potential ongoing impacts. The drivers of, and impacts on, international and domestic sectors are different, and we present the results separately.

### 4.3.1 Kaikoura Impact

With very limited road access to Kaikoura after the earthquake, tourism expenditure in the Kaikoura District decreased the most compared to other regions. International tourism spend dropped to zero for the first 5 weeks after the earthquake (Figure 4.1), and the domestic tourism dropped approximately 85% (Figure 4.3). In weeks 6 and 7, after road access from the south was partially restored, the tourism spend has started to increase, but is still well below the usual spend at this time of year. Based on the forecast MRTE data, conservative estimates put the estimated loss in tourism spend at $\$_{2016}$NZ 21 million (made up of $\$_{2016}$NZ 15 million international and $\$_{2016}$NZ 6 million domestic for the Kaikoura District for the 7 weeks after the earthquake. This contributes the bulk of the impact for North Canterbury shown in Table 4.7 and Table 4.9, with smaller impacts in the Hurunui District, and a slight increase in the Waimakariri District.

The Kaikoura District has a population of 3,730 people, with a quarter of jobs in the tourism sector (Edmunds 2016), and 34.1% of the district's GDP coming from international tourism spend (MBIE). Although Sounds Air have been flying to Kaikoura from Christchurch and Blenheim and Air Kaikoura from Hanmer Springs (Lewis 2016), re-establishing road access will be vital to get tourists back into the region. Additionally, marine-based tourism – a large contributor to the region's tourism spend, cannot operate until the marina is dredged (One News 2016). Whale Watch Kaikoura normally runs 16 tours a day from Dec to March, equating to 760 people each day (One News 2016).

### 4.3.2 International Tourism

Table 4.7 presents the predicted and actual estimated international tourism spend by region, and for the whole of New Zealand for the months of November and December 2016. International tourism spend in New Zealand was up approximately 5% ($\$_{2016}$NZ 113 million) on forecast expenditure, which is made up of to $\$_{2016}$NZ 62 million in November and $\$_{2016}$NZ 51 million in December. We do not believe this increase to be solely due to the Kaikoura earthquake. Our interpretation is that the growth-rate of international tourism in New Zealand is 3-4% higher than expected. Taking this into account we still find that the spend in November is higher than predictions, and conclude that the Kaikoura earthquake had a short-term (2-3 week) impact that increased international tourism spend at a national level. We find no effect at a national level in December, but strong regional differences due to spending displacement.

**Losses**

The regional impact on international tourism spend is strongest in North Canterbury, as the majority of this spend is usually in Kaikoura. Asuuming the first two weeks of November were the same as forecasted, tourism spend in North Canterbury decreased 80% for the second half of November and -63% for December (Table 4.7). Whilst we only have monthly impacts at the North Canterbury level, we predict from the Marketview data that there have been losses in Hurunui as well (Figure 4.1), and infer that there must have been increases in Waimakariri to add up to the observed monthly spends.

Other regions to experience a loss in international tourism expenditure are Marlborough (-12% for the second half of November and -11% for December (Table 4.7)) and Wellington RTO (-10% for the second half of November and -2% for December (Table 4.7)). We suspect that the impact in Wellington City itself will be the largest proportion of the loss for Wellington RTO. The Marketview data for the West Coast shows a marked increase in spending 3-4 weeks after the earthquake. However, the MRTE data for November, while higher than the year before, matches the forecasted spend i.e. the MRTE data does not reflect a marked increase in spending. Our explanation for this is a change in tourist travel dynamics that changed the proportion of expenditure that was captured in Marketview (cash/card ratio). This leads us to predict that there has been a slight decrease in West Coast expenditure over the months of November and December.

**Gains**

The international tourism spend has moved between regions due to the earthquake. The biggest gains have been in the Nelson Tasman region, with increases of 16% ($\$_{2016}$NZ 9 million) for the November and December period (Table 4.7). There has been a smaller increase of 10% ($\$_{2016}$NZ 117 million) in expenditure in the 'Rest of the North Island' (i.e. not in the Wellington RTO). There was also a $\$_{2016}$NZ 19 million increase in the 'Rest of South Island' region, especially in November.

**Ongoing impacts**

As described above, we suspect that the forecasts we have used under-estimate the growth rate by 3-4%. To interpret the reported impact, it is important to consider keep in mind that this 3-4% higher growth rate is not included in Table 4.7, and thus the losses will be underestimated and the gains overestimated. It is not possible to confirm this prediction without further longitudinal data.

To evaluate the potential impact on regions of the continued loss or gain of tourists, Table 4.8 shows forecasted spend for the 2, 3, 6, 12, and 24 months after the Kaikoura earthquake. For example, if the 9% decrease in expenditure in the Marlborough region continued for 6 months, this would produce a maximum loss of $\$_{2016}$NZ 11 million (9% of the upper estimate $\$_{2016}$NZ 112 million forecasted spend) over the 6 months.

**Table 4.7 International Tourism Expenditure and Estimated Impacts from Marketview and MRTE Data by Selected Regions of Interest. Numbers in BOLD are where there is a statistically significant effect.**

| Month (2016) | Expected spend ($$_{2016}$NZ million) | Actual spend ($$_{2016}$NZ million) | Impact ($$_{2016}$NZ million) | | Impact (%) |
|---|---|---|---|---|---|
| North Canterbury | | | | | |
| November | **13** | **8** | **-5** | **(-4.6,-5.9)** | **-40%** |
| December | **19** | **7** | **-12** | **(-11.4,-13.3)** | **-63%** |
| Total | **33** | **15** | **-18** | **(-16,-19.2)** | **-54%** |
| Rest of Canterbury | | | | | |
| November | 120 | 120 | 0 | (5.5,-5.2) | 0% |
| December | 160 | 157 | -2 | (5.5,-10.8) | -2% |
| Total | 279 | 277 | -2 | (11,-16) | -1% |
| Marlborough RTO | | | | | |
| November | 15 | 14 | -1 | (0.1,-1.9) | -6% |
| December | **20** | **18** | **-2** | **(-1,-3.5)** | **-11%** |
| Total | **35** | **32** | **-3** | **(-1,-5.4)** | **-9%** |
| Nelson Tasman RTO | | | | | |
| November | **20** | **24** | **4** | **(5.6,2.9)** | **21%** |
| December | **32** | **36** | **4** | **(6.4,2.1)** | **13%** |
| Total | **52** | **61** | **9** | **(11.9,5)** | **16%** |
| West Coast RTO | | | | | |
| November | 30 | 30 | -1 | (1.3,-2.5) | -2% |
| December | **39** | **35** | **-4** | **(-1.3,-6.1)** | **-9%** |
| Total | **69** | **65** | **-4** | **(0,-8.6)** | **-6%** |
| Rest of South Island | | | | | |
| November | **200** | **217** | **17** | **(29,4)** | **8%** |
| December | 274 | 276 | 2 | (22.4,-19.5) | 1% |
| Total | 474 | 493 | 19 | (51.4,-15.5) | 4% |
| Wellington RTO | | | | | |
| November | 69 | 66 | -3 | (1,-7.8) | -5% |
| December | 81 | 80 | -1 | (4.2,-6.9) | -2% |
| Total | 150 | 146 | -5 | (5.2,-14.7) | -3% |
| Rest of North Island | | | | | |
| November | **518** | **569** | **51** | **(80.2,20.5)** | **10%** |
| December | **657** | **723** | **66** | **(106.9,23.7)** | **10%** |
| Total | **1,174** | **1,292** | **117** | **(187.1,44.2)** | **10%** |
| Total New Zealand | | | | | |
| November | **985** | **1,047** | **62** | **(117.9,4.1)** | **6%** |
| December | 1,282 | 1,333 | 51 | (131.7,-34.4) | 4% |
| Total | 2,266 | 2,380 | 113 | (249.6,-30.2) | 5% |

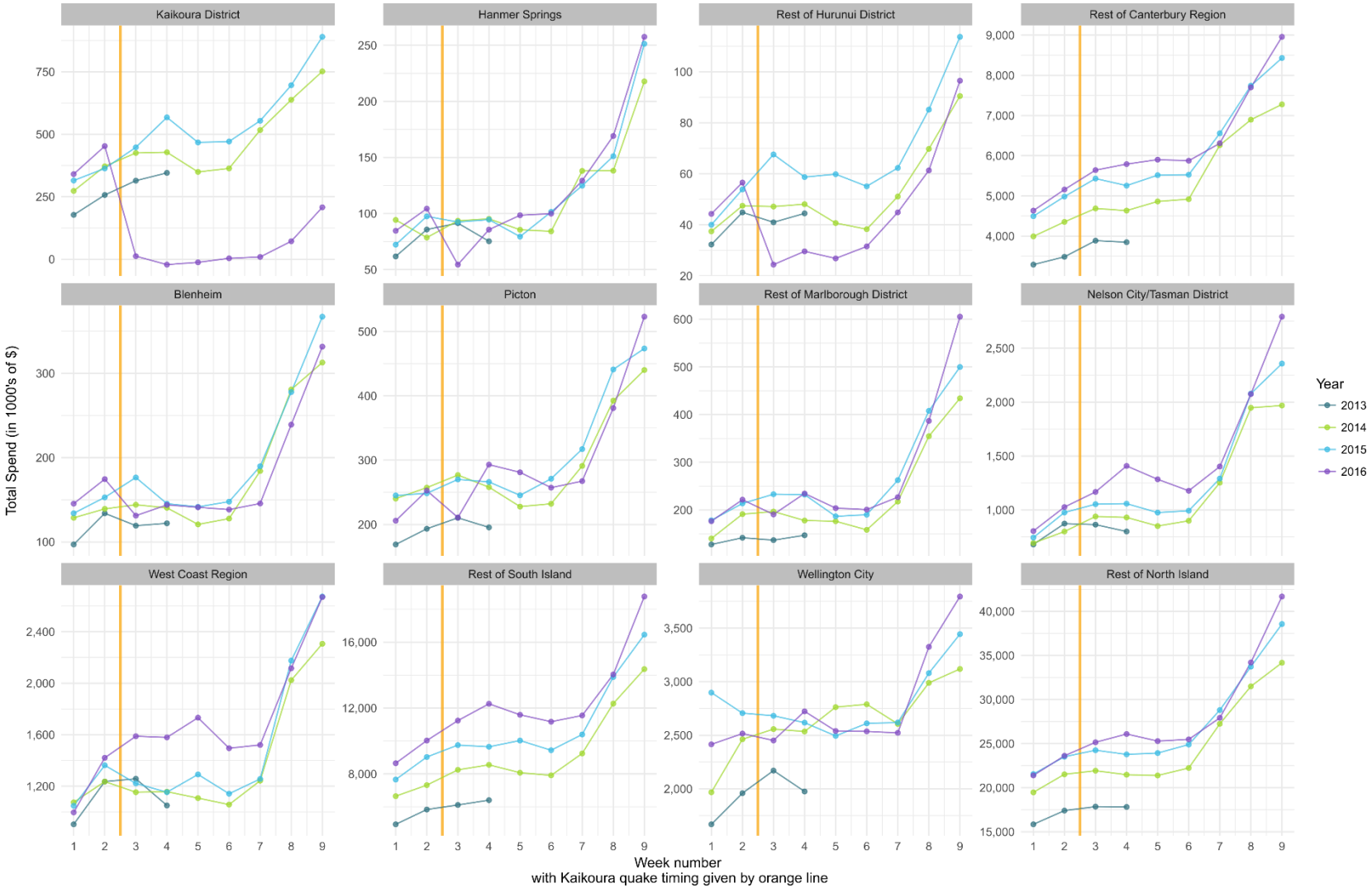



**Figure 4.1 International Tourism Spend from Marketview within each Region for the First Two Weeks of November (pre-Kaikoura quake in 2016) and the Seven Weeks after that, for 2013-2016. The orange vertical line indicates 2016 Kaikoura quake timing. Note: only weeks 1-4 are available from 2013.**

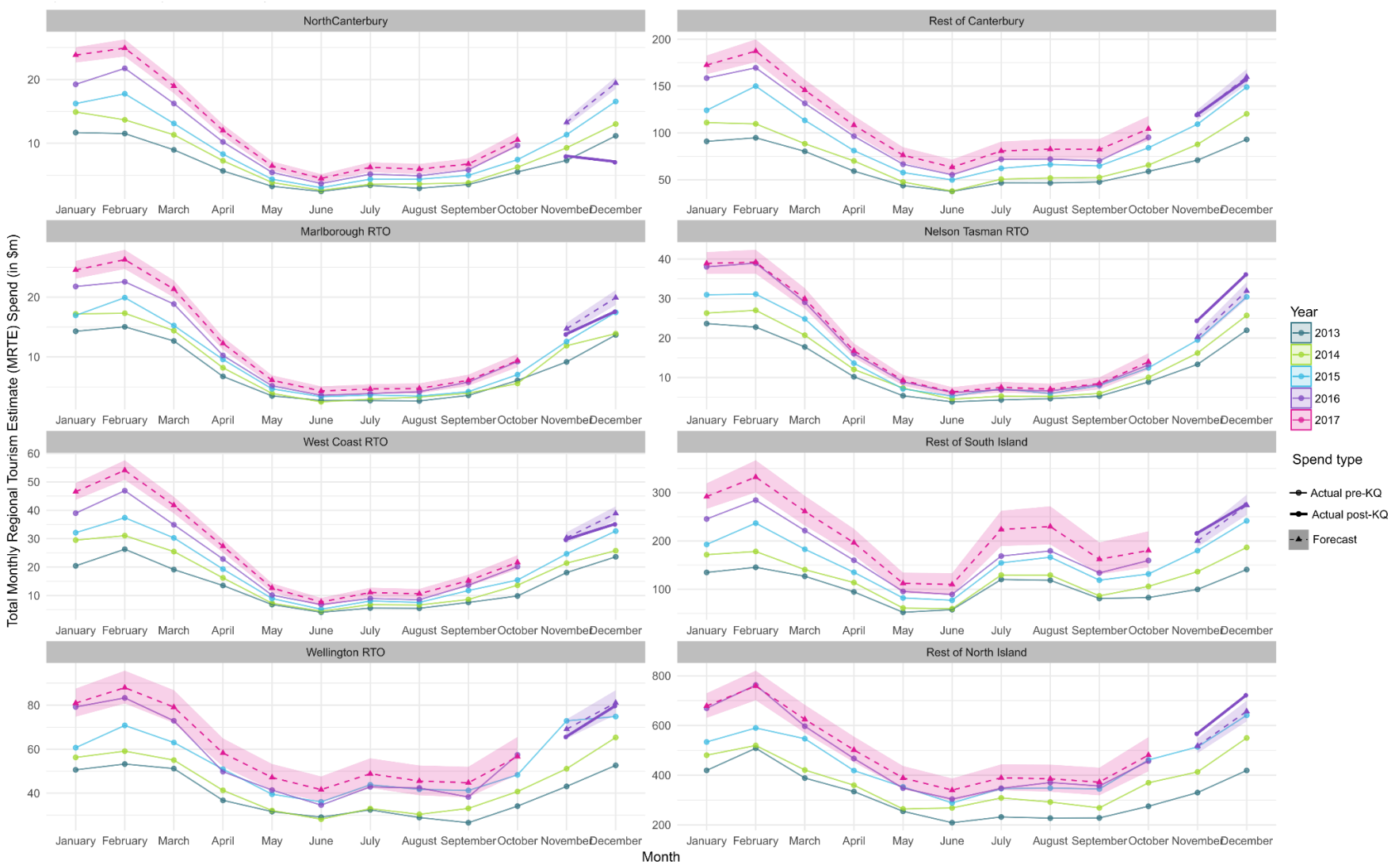



**Figure 4.2 International Monthly Regional Tourism Estimate (MRTE) Spend ($2016NZ mil) January 2013 to October 2016 (pre-Kaikoura Quake), Forecast Monthly Spends for November 2016 to October 2017, and actual November 2016 MRTE Spend and Estimated December 2016 Spend (post-Kaikoura Quake).**

**Table 4.8 International Tourism Forecasted spend ($_{2016NZ}$ mil) (with lower and upper bounds) by Selected Regions for 2, 3, 6, 12 and 24 Months following the event.**

| Forecast spend ($_{2016NZ}$ million) | 2 months | | 3 months | | 6 months | | 12 months | | 24 months | |
|---|---|---|---|---|---|---|---|---|---|---|
| North Canterbury | 33 | (31,34) | 57 | (54,59) | 112 | (106,119) | 153 | (142,164) | 325 | (296,356) |
| Rest of Canterbury | 279 | (266,293) | 452 | (429,476) | 893 | (838,951) | 1383 | (1269,1503) | 2922 | (2600,3274) |
| Marlborough RTO | 35 | (37,2) | 59 | (56,63) | 119 | (127,8) | 154 | (141,168) | 324 | (294,355) |
| Nelson Tasman RTO | 52 | (49,56) | 91 | (85,98) | 177 | (164,191) | 230 | (208,253) | 471 | (413,534) |
| West Coast RTO | 69 | (65,74) | 116 | (109,123) | 239 | (223,255) | 318 | (292,345) | 677 | (611,746) |
| Rest of South Island | 474 | (441,508) | 765 | (708,827) | 1,555 | (1410,1712) | 2,572 | (2248,2930) | 5,499 | (4559,6592) |
| Wellington RTO | 150 | (141,160) | 231 | (215,248) | 456 | (420,495) | 741 | (666,822) | 1,519 | (1319,1742) |
| Rest of North Island | 1,174 | (1105,1248) | 1,853 | (1735,1977) | 3,738 | (3459,4036) | 6,094 | (5506,6728) | 12,505 | (10918,14271) |

### 4.3.3 Domestic Tourism

Table 4.9 presents the predicted and actual domestic tourism spend by region, and for the whole of New Zealand for the months of November and December 2016. Domestic tourism spend in New Zealand is down approximately 7% ($\$_{2016}$NZ 202 million) on forecast expenditure (6% ($\$_{2016}$NZ 73 million) in November and 8% ($\$_{2016}$NZ 129 million) in December). We believe that the Kaikoura earthquake was a large contributing factor, as the Marketview data in the weeks before the earthquake was in line with forecasts. This decrease in domestic tourism spend is seen in every region of interest, and both the Marketview weekly data (Figure 4.3) and the MRTE monthly expenditures (Figure 4.4). We attribute this underlying decrease to indirect consequences of the earthquake, which are spatially diffuse. There are also some regional differences in the impact that are due to more direct effects, and we discuss these in the following paragraphs.

**Losses**

The regional impact on domestic tourism spend is strongest in North Canterbury, with a 28% ($\$_{2016}$NZ 11 million) decrease (Table 4.9). However, the impact is lower than for the international tourism spend, as the majority of the domestic tourism spend is in the Hurunui District which was less affected. The Wellington region was also affected, with much larger decreases in domestic tourism spend than international tourism spend. An estimated $\$_{2016}$NZ 36 million (15%) less was spent than expected in the Wellington RTO in November and December, with the largest impact in November (Table 4.9). There were smaller decreases in Marlborough, Nelson Tasman, and the South Island as a whole.

**Gains**

Whilst nationwide and regional expenditure was less than forecast, some regions were closer to the forecasted spend than others. We interpret this as a relative gain in the proportion of domestic tourism spend. These relative gains are seen in the West Coast region, the Rest of Canterbury, and the Rest of the North Island, and are attributable to displacement effects from North Canterbury (Table 4.9).

**Ongoing impacts**

As described at the beginning of this section, the overall domestic tourism spend was 7% lower than forecast. The Marketview data shows this clearly, with expenditure in most regions lower than in past years for the whole of December. To evaluate the potential longer term impact of the decrease in domestic tourism on the regions, Table 4.10 shows the forecasts for 2, 3, 6, 12, and 24 months after the Kaikoura earthquake. The increase in the last week of December may indicate a return to 'normal' spending levels, but data through January and February is required to determine this.

**Table 4.9 Domestic Tourism Expenditure and Estimated Impacts by Selected Regions of Interest. Numbers in BOLD are where there is a statistically significant effect.**

| Month (2016) | Expected spend ($$_{2016}$$NZ million) | Actual spend ($$_{2016}$$NZ million) | Impact ($$_{2016}$$NZ million) | | Impact (%) |
|---|---|---|---|---|---|
| North Canterbury | | | | | |
| November | **17** | **14** | **-3** | **(-2.1,-4.3)** | **-18%** |
| December | **22** | **14** | **-8** | **(-6.6,-9.1)** | **-35%** |
| Total | **40** | **29** | **-11** | **(-8.7,-13.4)** | **-28%** |
| Rest of Canterbury | | | | | |
| November | **147** | **141** | **-6** | **(-0.4,-10.7)** | **-4%** |
| December | **181** | **171** | **-10** | **(-4.3,-15.8)** | **-6%** |
| Total | **327** | **312** | **-16** | **(-4.7,-26.5)** | **-5%** |
| Marlborough RTO | | | | | |
| November | **19** | **17** | **-2** | **(-0.9,-3.3)** | **-11%** |
| December | **28** | **23** | **-4** | **(-2.9,-5.9)** | **-16%** |
| Total | **47** | **40** | **-6** | **(-3.8,-9.2)** | **-14%** |
| Nelson Tasman RTO | | | | | |
| November | **30** | **27** | **-2** | **(-0.2,-4.7)** | **-8%** |
| December | **48** | **42** | **-6** | **(-3.9,-9)** | **-13%** |
| Total | **78** | **69** | **-9** | **(-4.1,-13.7)** | **-11%** |
| West Coast RTO | | | | | |
| November | 15 | 14 | -1 | (0.3,-2.7) | -8% |
| December | 20 | 20 | -1 | (1.1,-2.6) | -3% |
| Total | 35 | 33 | -2 | (1.3,-5.3) | -5% |
| Rest of South Island | | | | | |
| November | **140** | **135** | **-5** | **(-0.4,-10.3)** | **-4%** |
| December | **190** | **173** | **-16** | **(-10.2,-22.3)** | **-9%** |
| Total | **330** | **308** | **-22** | **(-10.6,-32.6)** | **-7%** |
| Wellington RTO | | | | | |
| November | **118** | **95** | **-23** | **(-16.5,-29.1)** | **-19%** |
| December | **118** | **104** | **-14** | **(-7.2,-19.9)** | **-11%** |
| Total | **236** | **199** | **-36** | **(-23.8,-49)** | **-15%** |
| Rest of North Island | | | | | |
| November | **726** | **695** | **-31** | **(-9.6,-52.6)** | **-4%** |
| December | **951** | **881** | **-70** | **(-44.5,-95.5)** | **-7%** |
| Total | **1,677** | **1,576** | **-101** | **(-54.1,-148.1)** | **-6%** |
| Total New Zealand | | | | | |
| November | **1,212** | **1,138** | **-73** | **(-30,-117.6)** | **-6%** |
| December | **1,557** | **1,429** | **-129** | **(-78.5,-180.2)** | **-8%** |
| Total | **2,769** | **2,567** | **-202** | **(-108.5,-297.7)** | **-7%** |

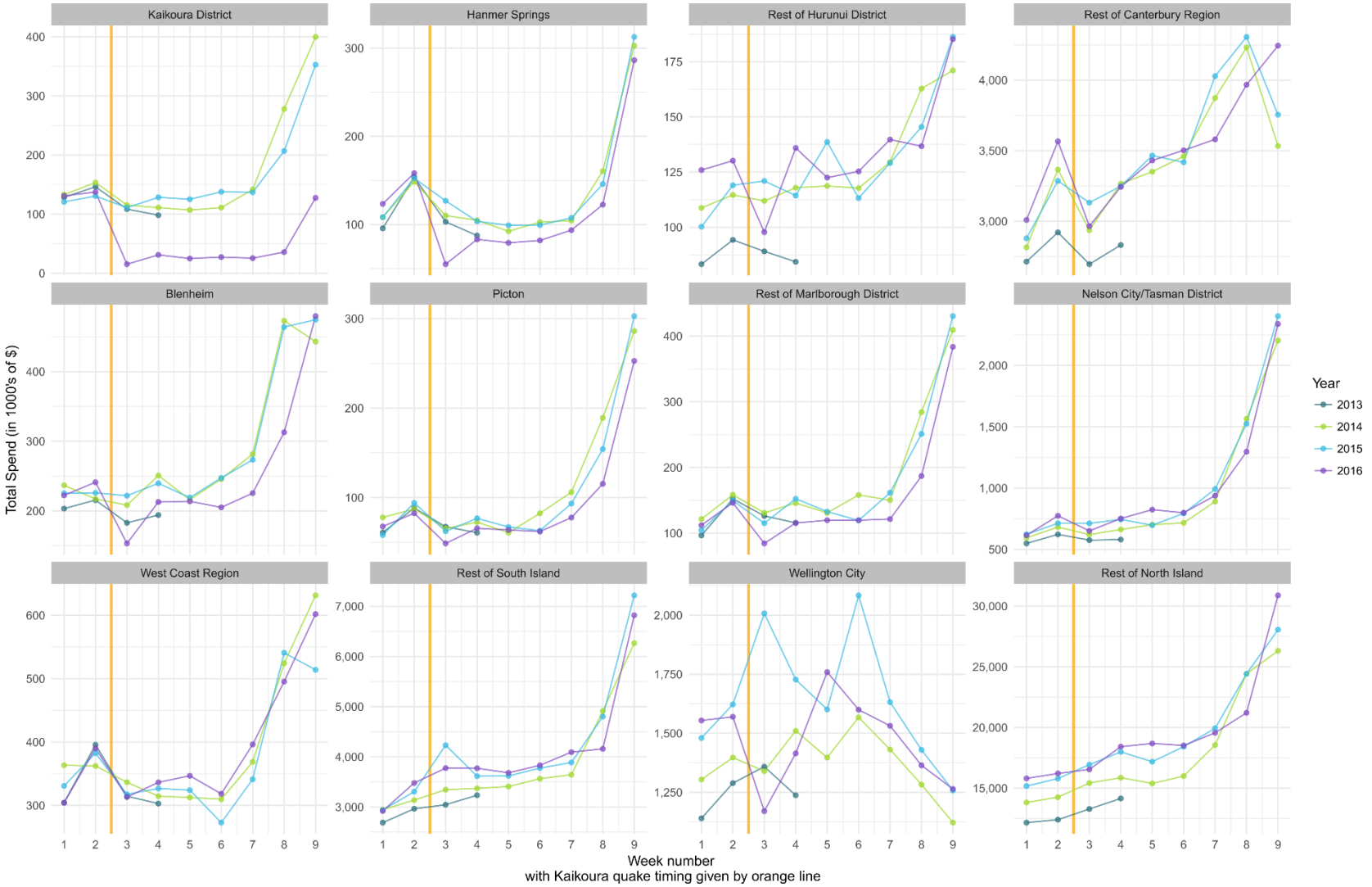



**Figure 4.3 Domestic Tourism Spend from Marketview within Each Region for the First Two Weeks of November (pre-Kaikoura quake in 2016) and the Seven Weeks after that, for 2013-2016. The orange vertical line indicates 2016 Kaikoura quake timing. Note: only weeks 1-4 are available from 2013.**

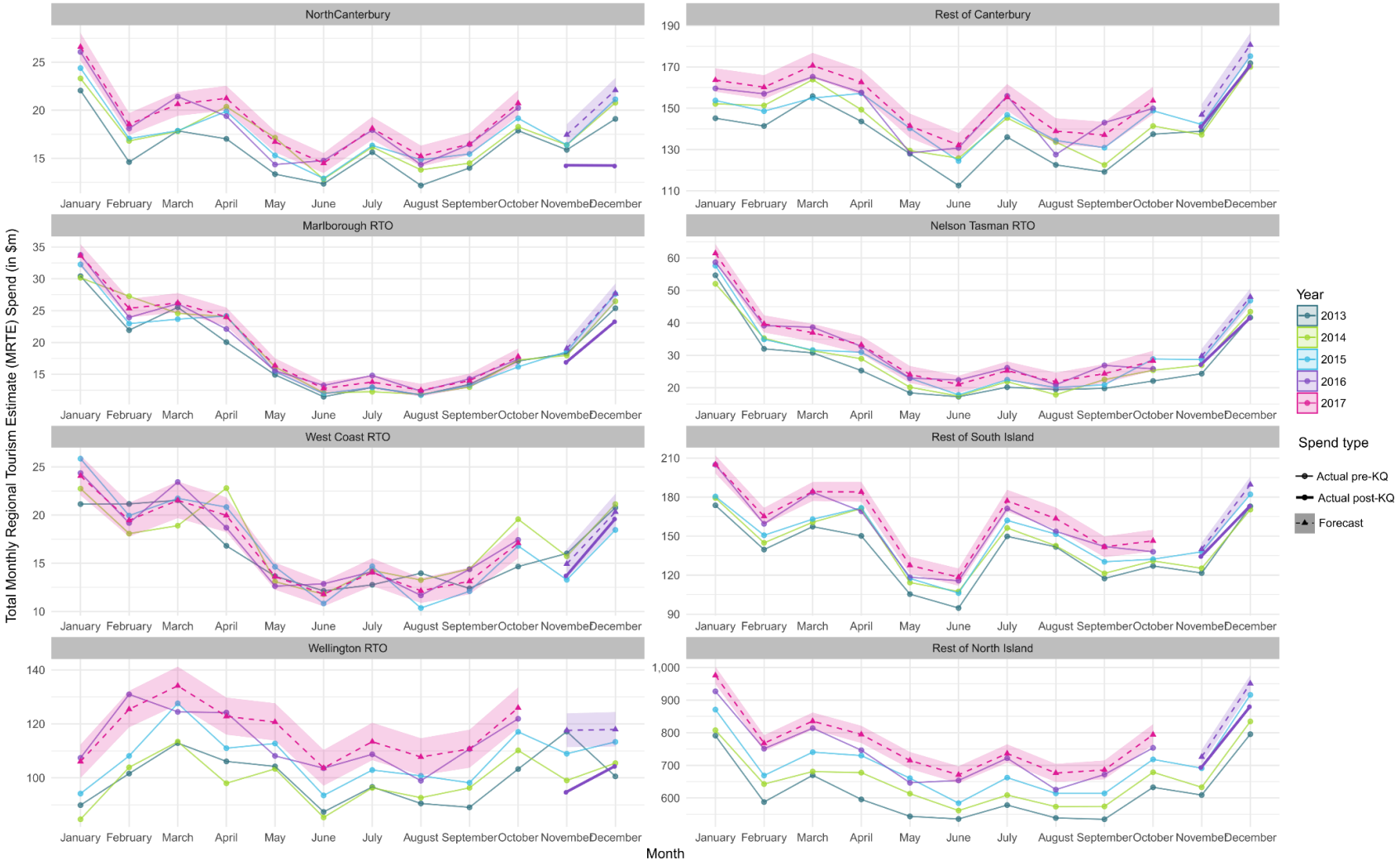



**Figure 4.4 Domestic Monthly Regional Tourism Estimate (MRTE) Spend ($$_{2016NZ}$ mil) January 2013 to October 2016 (pre-Kaikoura Quake), Forecast Monthly Spends for November 2016 to October 2017, actual November 2016 MRTE Spend and Estimated December 2016 spend (post-Kaikoura Quake).**

**Table 4.10 Domestic Tourism Forecast ed spend ($2016NZ mil) (with lower and upper bounds) by Selected Regions for 2, 3, 6, 12 and 24 Months following the event.**

| Forecast spend ($2016NZ million) | 2 months | | 3 months | | 6 months | | 12 months | | 24 months | |
|---|---|---|---|---|---|---|---|---|---|---|
| North Canterbury | 40 | (37,42) | 66 | (62,70) | 127 | (119,134) | 228 | (214,243) | 464 | (434,495) |
| Rest of Canterbury | 327 | (317,338) | 491 | (475,508) | 985 | (950,1019) | 1843 | (1771,1915) | 3725 | (3565,3888) |
| Marlborough RTO | 47 | (44,49) | 80 | (76,85) | 156 | (147,165) | 243 | (228,259) | 489 | (457,522) |
| Nelson Tasman RTO | 78 | (73,83) | 139 | (132,147) | 249 | (234,265) | 394 | (362,427) | 791 | (716,867) |
| West Coast RTO | 35 | (32,39) | 59 | (54,65) | 120 | (110,131) | 202 | (183,222) | 404 | (367,444) |
| Rest of South Island | 330 | (319,341) | 535 | (517,553) | 1,068 | (1029,1108) | 1,942 | (1858,2029) | 3,959 | (3752,4174) |
| Wellington RTO | 236 | (223,248) | 342 | (323,361) | 724 | (685,764) | 1,406 | (1326,1488) | 2,863 | (2688,3041) |
| Rest of North Island | 1,677 | (1630,1724) | 2,653 | (2580,2727) | 5,051 | (4901,5203) | 9,330 | (9013,9652) | 19,055 | (18274,19851) |

## 4.4 Total Economic Impacts

This section of the report presents outputs of MERIT model runs, i.e. the simulated economic impacts of the Kaikoura earthquake in aggregate and by industry. Economic impacts are presented using the economic indicators of Gross Domestic Product (GDP) and value added.[7]

The three different scenarios for rebuild provided were incorporated in the MERIT modelling. It is important to note, however, that currently there is no rebuild and recovery module within MERIT, and thus actual rebuild activities are excluded from the modelling. The timing under which different infrastructure comes back on line, specifically when SH1 north of Kaikoura and Centreport are opened, and the length of time over which delays are experienced on the disrupted road network have been incorporated for each scenario. This timing of infrastructure reinstatement in turn impacts on the assumed future disruptions to tourism, and the period over which increased freight costs are experienced. Given that the timing for infrastructure reinstatement is the same for Scenarios 1 and 2,[8] the MERIT modelling results are identical for these two scenarios. Thus we present two sets of results in this section, one for Scenarios 1 and 2, and one for Scenario 3.

In order to undertake the modelling, we use the MERIT dynamic economic model to simulate the Canterbury and rest of New Zealand economies under a baseline scenario (i.e. without a quake). We then alter the model to reflect changes brought about by the Kaikoura quake, and re-simulate. The economic impacts reported are the differences between the quake simulation and the baseline simulation.

### 4.4.1 Summary of MERIT outputs

Table 4.11 and Table 4.12 provide a summary of the economic impacts for the Kaikoura quake, with the two alternative sets of scenarios for infrastructure reinstatement.

Over the entire two years of the model simulation the estimated loss to the New Zealand economy assuming Scenario 1 or 2 for infrastructure reinstatement is $\$_{2016}$NZ465 million of GDP, of which $\$_{2016}$NZ 117 million is in Canterbury and $\$_{2016}$NZ 348 million is in the rest of New Zealand. The results are about 10% higher under Scenario 3, with a total GDP loss of $\$_{2016}$NZ 513 million, of which $\$_{2016}$NZ 137 million is in Canterbury and $\$_{2016}$NZ 376 million is in the rest of New Zealand.

[7] 'Value added' is the value added to goods and services by the contributions of capital and labour, i.e. the value of output after the cost of brought-in materials and services has been deducted. It includes the national accounts categories of 'gross operating surplus', 'compensation of employees', 'other taxes on production' and 'subsidies'. The sum of all value added is equal to Gross Domestic Product (GDP), excluding taxes on products and import taxes net of subsidies. GDP is frequently used to measure economic impacts at a national level. In my work, which considers specifically impacts occurring at a regional level, value added is selected as a more appropriate indicator than GDP or its regional equivalent (Gross Regional Product). This is because the value added indicator can be broken down into contributions by individual industries, while the components missing from the value added indicator compared to GDP/GRP (i.e. taxes on products and import taxes net of subsidies) are not easily assigned to regions or industries.

[8] Scenarios 1 and 2 differ only by the quantum of costs necessary to undertake rebuild and recovery. These differences are not able to be captured without development of the rebuild and recovery module for MERIT.

**Table 4.11 Summary of MERIT Results for Kaikoura Quake and Infrastructure Reinstatement Scenarios 1&2.**

| Options 1 & 2<br>Size of the rebuild (not included in MERIT)<br>Transport Rebuild Timeframe = 9 months | Baseline GDP ($2016m) | Time Period After Event | | | | | Time Period After Event | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0-6 months | 6-12 months | 12-18 months | 18-24 months | Total (0-24 months) | 0-6 months | 6-12 months | 12-18 months | 18-24 months | Total (0-24 months) |
| **Regional Results** | | **Estimated change in GDP ($2016m)** | | | | | **% change from YE March 2016 GDP ($2016m)** | | | | |
| Total New Zealand | 241,200 | -275 | -127 | -49 | -13 | **-465** | -0.2% | -0.1% | 0.0% | 0.0% | **-0.1%** |
| Canterbury | 32,900 | -86 | -21 | -7 | -3 | **-117** | -0.5% | -0.1% | 0.0% | 0.0% | **-0.2%** |
| Rest of New Zealand | 208,300 | -189 | -106 | -42 | -10 | **-348** | -0.2% | -0.1% | 0.0% | 0.0% | **-0.1%** |
| **Industry Results** | | **Estimated change in Value Added ($2016m)** | | | | | **% contribution to GDP loss** | | | | |
| All industries | | -257 | -126 | -46 | -11 | **-439** | 93% | 99% | 92% | 84% | **94%** |
| Agriculture | 10,500 | -15 | -6 | -5 | -5 | **-31** | 6% | 5% | 9% | 36% | **7%** |
| Other primary | 5,200 | -30 | -5 | -3 | -4 | **-43** | 11% | 4% | 7% | 31% | **9%** |
| Food manufacturing | 9,500 | -96 | -19 | -3 | -1 | **-119** | 35% | 15% | 6% | 9% | **26%** |
| Wood and paper manufacturing | 2,100 | -35 | -2 | -1 | -1 | **-39** | 13% | 2% | 2% | 6% | **8%** |
| Other manufacturing | 14,400 | -72 | -14 | 0 | 2 | **-84** | 26% | 11% | 0% | -14% | **18%** |
| Utilities, construction & transport | 31,900 | 223 | -49 | -52 | -23 | **98** | -81% | 38% | 106% | 176% | **-21%** |
| Trade and hospitality | 27,300 | -28 | -8 | 1 | 3 | **-32** | 10% | 6% | -2% | -23% | **7%** |
| Government, education & health services | 35,000 | -76 | -11 | 12 | 10 | **-65** | 28% | 8% | -24% | -79% | **14%** |
| Other services | 87,600 | -128 | -12 | 6 | 8 | **-126** | 47% | 9% | -12% | -58% | **27%** |
| **GDP impacts by component** | | **Estimated GDP impacts ($2016m)** | | | | | **Share of GDP impacts (%)** | | | | |
| Transport - all New Zealand | | -30 | -121 | -47 | -11 | **-209** | 11% | 95% | 95% | 84% | **45%** |
| Canterbury | | -20 | -19 | -8 | -3 | **-50** | 23% | 91% | 115% | 116% | **43%** |
| Rest of New Zealand | | -11 | -101 | -39 | -8 | **-159** | 6% | 96% | 92% | 76% | **46%** |
| Business operability[1] - all New Zealand | | -265 | -8 | -1 | -2 | **-277** | 96% | 7% | 3% | 12% | **60%** |
| Canterbury | | -50 | -1 | 1 | 0 | **-51** | 59% | 6% | -8% | -12% | **44%** |
| Rest of New Zealand | | -215 | -7 | -2 | -2 | **-226** | 113% | 7% | 5% | 18% | **65%** |
| Tourism - all New Zealand | | 21 | -2 | 0 | 0 | **19** | -7% | 1% | 0% | -3% | **-4%** |
| Canterbury | | -16 | -2 | 1 | 0 | **-16** | 18% | 7% | -15% | -10% | **14%** |
| Rest of New Zealand | | 36 | 0 | -1 | 0 | **35** | -19% | 0% | 2% | -2% | **-10%** |
| **Freight transport costs** | | **Estimated change from baseline ($2016m)** | | | | | | | | | |
| Total increase New Zealand | | 420 | 60 | 0 | 0 | **490** | | | | | |

Notes: 1. This includes supply-side impacts on tourism businesses

## Table 4.12 Summary of MERIT Results for Kaikoura Quake and Infrastructure Reinstatement Scenario 3.

| Option 3<br>Size of the rebuild (not included in MERIT)<br>Transport Rebuild Timeframe = 2 years | Baseline GDP ($_{2016}$m) | Time Period After Event | | | | | Time Period After Event | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0-6 months | 6-12 months | 12-18 months | 18-24 months | Total (0-24 months) | 0-6 months | 6-12 months | 12-18 months | 18-24 months | Total (0-24 months) |
| **Regional Results** | | **Estimated change in GDP ($_{2016}$m)** | | | | | **% change from YE March 2016 GDP ($_{2016}$m)** | | | | |
| Total New Zealand | 241,200 | -275 | -143 | -81 | -14 | **-513** | -0.2% | -0.1% | -0.1% | 0.0% | **-0.1%** |
| Canterbury | 32,900 | -86 | -32 | -15 | -5 | **-137** | -0.5% | -0.2% | -0.1% | 0.0% | **-0.2%** |
| Rest of New Zealand | 208,300 | -189 | -111 | -67 | -9 | **-376** | -0.2% | -0.1% | -0.1% | 0.0% | **-0.1%** |
| **Industry Results** | | **Estimated change in Value Added ($_{2016}$m)** | | | | | **% contribution to GDP loss** | | | | |
| All industries | | -257 | -140 | -77 | -14 | **-488** | 93% | 98% | 95% | 105% | **95%** |
| Agriculture | 10,500 | -15 | -12 | -8 | -7 | **-43** | 6% | 9% | 10% | 53% | **8%** |
| Other primary | 5,200 | -30 | -14 | -7 | -7 | **-57** | 11% | 9% | 8% | 51% | **11%** |
| Food manufacturing | 9,500 | -96 | -44 | -21 | -7 | **-168** | 35% | 31% | 26% | 54% | **33%** |
| Wood and paper manufacturing | 2,100 | -35 | -20 | -17 | 0 | **-72** | 13% | 14% | 21% | -2% | **14%** |
| Other manufacturing | 14,400 | -72 | -40 | -12 | 0 | **-124** | 26% | 28% | 14% | 0% | **24%** |
| Utilities, construction & transport | 31,900 | 223 | 63 | -2 | -31 | **253** | -81% | -44% | 2% | 227% | **-49%** |
| Trade and hospitality | 27,300 | -28 | -14 | -4 | 6 | **-41** | 10% | 10% | 5% | -43% | **8%** |
| Government, education & health services | 35,000 | -76 | -30 | 0 | 18 | **-88** | 28% | 21% | 0% | -130% | **17%** |
| Other services | 87,600 | -128 | -28 | -6 | 15 | **-148** | 47% | 20% | 7% | -107% | **29%** |
| **GDP impacts by component** | | **Estimated GDP impacts ($_{2016}$m)** | | | | | **Share of GDP impacts (%)** | | | | |
| Transport - all New Zealand | | -30 | -136 | -80 | -16 | **-263** | 11% | 95% | 99% | 120% | **51%** |
| Canterbury | | -20 | -26 | -16 | -6 | **-68** | 23% | 81% | 110% | 121% | **49%** |
| Rest of New Zealand | | -11 | -111 | -64 | -10 | **-196** | 6% | 100% | 96% | 119% | **52%** |
| Business operability[1] - all New Zealand | | -265 | -14 | -1 | 2 | **-278** | 96% | 10% | 1% | -13% | **54%** |
| Canterbury | | -50 | -6 | 0 | 0 | **-56** | 59% | 20% | -2% | -8% | **41%** |
| Rest of New Zealand | | -215 | -7 | -1 | 1 | **-222** | 113% | 6% | 1% | -16% | **59%** |
| Tourism - all New Zealand | | 21 | -1 | 0 | 0 | **20** | -7% | 1% | 0% | -3% | **-4%** |
| Canterbury | | -16 | -5 | 1 | 0 | **-20** | 18% | 17% | -7% | -4% | **14%** |
| Rest of New Zealand | | 36 | 4 | -1 | 0 | **40** | -19% | -4% | 1% | -3% | **-11%** |
| **Freight transport costs** | | **Estimated change from baseline ($_{2016}$m)** | | | | | | | | | |
| Total increase New Zealand | | 424 | 242 | 111 | 31 | **808** | | | | | |

Notes: 1. This includes supply-side impacts on tourism businesses

As a proportion of the total economy, the biggest impacts occur shortly following the earthquake. The estimated loss to the New Zealand economy is 0.2% over the first 6 months, under both sets of infrastructure reinstatement scenarios. This is not, however, evenly spread with the loss during the first two weeks estimated at 0.9%. Much of this is attributed to the disruption experienced in Wellington where a substantial portion of New Zealand's services industries are located. Following this initial period of disruption there is a ramping up in the transportation services industry which, from a total economy perspective, helps to 'net out' some of the losses faced by other industries.

Over the longer time frames losses in incomes and increased transportation costs start to filter across economic industries throughout the New Zealand economy. Over the period 12-18 months after the event, the economic impacts are more than 60% greater for Scenario 3 compared with Scenarios 1 or 2. For the most part this can be attributed to the extended period of transportation disruption. By 18 months after the event the simulated losses are relatively negligible for Scenarios 1 and 2, calculated as a loss of 0.01% for Canterbury and 0.0% for the rest of New Zealand in annual GDP at this point in time. At 18 months after the event the losses are a little higher under Scenario 3 given the ongoing disruptions to transportation, calculated as 0.2% for Canterbury and 0.1% for rest of New Zealand. By 24 months after the event the losses fall to 0.1% and 0.1%, respectively for Canterbury and rest of New Zealand under Scenario 3.

### 4.4.2 Sector-level impacts

Over the entire 24 months the largest total losses in value added occur within manufacturing ($\$_{2016}$NZ 241 million for Scenarios 1 and 2, or 364 million for Scenario 3). It is also interesting that manufacturing's share of the total impact is substantially higher under Scenario 3 than under Scenarios 1 or 2 (71% compared to 52% of total industry value added change). As already explained, the major change between the scenarios is the period over which increased freight costs are incurred and manufacturing industries are heavily reliant on the transportation of goods.

The service sectors record a total loss of value added of $\$_{2016}$NZ 124 million under Scenarios 1 and 2, and $\$_{2016}$NZ 24 million under Scenario 3. The value added impacts are, however, very unevenly distributed among the services, with a gain recorded for utilities, construction and transport, and losses elsewhere under all scenarios analysed. Not surprisingly, most of the gain in value added for this sector group occurs in the first six months, when the increase in demand for transportation services is particularly high.

### 4.4.3 GDP impacts by component

To help explain how the total changes in GDP and value added are attributed to the three major categories of direct impacts or "shocks" described in preceding sections of this report (i.e. tourism impacts, changes in business operability (direct business disruptions), and impacts on freight transportation), MERIT was also run a number of further times, each time incorporating inputs for only

one of the impact component categories.[9] The calculated GDP impacts for the different components are reported in Table 4.11 and Table 4.12 under the heading "GDP impacts by component".

Approximately 45% of the total impact on GDP over 2 years is attributed to transportation cost increases under Scenarios 1 or 2, increasing to 51% under Scenario 3. At a regional level the results are also relatively consistent, i.e. 43% for Canterbury and 46% for Rest of New Zealand under Scenarios 1 or 2, and 49% for Canterbury and 52% for rest of New Zealand under Scenario 3. Although the values that enter MERIT to capture the changes in transportation costs are positive overall (i.e. over the 2 years there is a *net increase* in transportation margins of $\$_{2016}$NZ 490 million under Scenarios 1 or 2 and $\$_{2016}$NZ 808 million under Scenario 3), the impacts on GDP are negative overall. This occurs mainly because with higher transportation costs NZ consumers can afford to spend less on other goods, and goods produced in NZ become less competitive with overseas goods.

The reductions in business operability after the quake cause an estimated loss in GDP of $\$_{2016}$NZ 277 million under Scenarios 1 or 2, and $\$_{2016}$NZ 278 million under Scenario 3. The results are similar under the different scenario options because the direct operability impacts applied in both model runs are similar. The only differences are assumed extended disruptions for tourism-focused industries in Kaikoura (mainly retail trade and accommodation services) and extended operability disruptions to some transportation services for Scenario 3. These extended disruptions do not make a large difference to the model outputs because the loss in supply by disrupted businesses is largely picked up by increased supply from non-disrupted businesses. Note also that the demand-side impacts of international tourism disurptions are included in the 'Tourism' model runs, while the impacts of increased transportation costs are included in the 'Transport' model runs. Note that these GDP impacts will be lower than the total production/output losses incurred directly by impacted businesses. This is because there are some compensatory effects captured in MERIT that help to compensate for these direct losses, including the pick-up of supply by other businesses and price changes. Note that the impacts from business inoperability are almost entirely in the first six months. Following data from the Canterbury quakes we assume that businesses are relatively quick at recovering and adapting to disruptions. Nevertheless business operability impacts still account for over half of the total GDP impact under all scenarios.

At a total level the tourism impact is slightly positive. As already discussed in this report, there is strong evidence that in the first few weeks after the event there was actually an increase in international tourism expenditure. Interestingly, there is also some evidence of a similar outcome following the February 2011 Canterbury quake (see Smith *et al.*, 2016). For the remainder of the simulation period it has been assumed that tourism impacts are generally transfers, i.e. losses in international tourism demands in Canterbury are compensated by increases in international tourism demands in the rest of New Zealand.

It is worth noting that the total tourism impacts for the New Zealand economy are highly uncertain, and caution should be used when interpreting and using these MERIT outputs. The MERIT tourism module is still under development and requires further calibration. The model results are also highly sensitive to the input assumptions. We have so far collected tourism data only until the end of December and it is relatively uncertain how tourists will behave into the future. Importantly, none of the MERIT modelling has attempted to evaluate the impacts of changes in domestic tourism demands. There are high

[9] We do not expect the sum of the results for each separate component to exactly match the results for the model run incorporating all components. MERIT is an interconnected system and running individual impacts separately will not necessarily produce the same results as running all impacts together.

complexities and uncertainties involved in modelling the impacts of changes in domestic tourism demands on GDP. If domestic tourists reduce demands for tourism products there is a high likelihood that there will be some compensatory positive economic outcome, for example increased tourist demands in other locations or in the future, more expenditure on other types of goods/services, or higher savings. It is, however, difficult to determine the magnitude and distribution of these compensatory outcomes.

## 4.5 Rebuild Workforce Requirements

Table 4.13 below shows estimates of the reinstatement costs ($2016NZ millions) for each scenario following the 2016 Kaikoura earthquake.

**Table 4.13 Residential, Non-Residential and Infrastructure Reinstatement Costs ($2016NZ million) following the 2016 Kaikoura Earthquake for each scenario.**

| | Scenario 1 ($2016NZ million) | Scenario 2 ($2016NZ million) | Scenario 3 ($2016NZ million) |
|---|---|---|---|
| **Wellington Region** | | | |
| Residential building construction | 37 | 183 | 183 |
| Non-residential building construction | 712 | 3,558 | 3,558 |
| Heavy and civil engineering construction | 16[1] | 23[1] | 23[1] |
| **Canterbury Region** | | | |
| Residential building construction | 66 | 331 | 331 |
| Non-residential building construction | 58 | 290 | 290 |
| Heavy and civil engineering construction | 1,955[1] | 2,933[1] | 2,933[1] |
| **Rest of New Zealand** | | | |
| Residential building construction | 74 | 368 | 368 |
| Non-residential building construction | 54 | 270 | 270 |
| Heavy and civil engineering construction | 29[1] | 44[1] | 44[1] |
| **Total New Zealand** | **3000** | **8000** | **8000** |

Note: 1 These are based on proportions from crude estimates based on the 2010/11 Canterbury earthquake series and estimates of government infrastructure replacement costs of $2016NZ 2-3 billion.

Translating the costs in Table 4.13 into construction workers, including allowing for flow-on impacts within the New Zealand economy, generates Table 4.14, Table 4.15, and Table 4.16 estimates of total employment by region. Note that these results are based on the demand for workers, and do not take into account whether these amounts of workers are available, i.e. the supply-side. Employment is measured in terms of 'MEC years' i.e. the number of MECs required to complete the rebuild in a single year. In reality it is likely that workforce requirements would be spread over several years; nevertheless, they would in total sum to MEC year equivalents provided. Note that employment is not only generated in the heavily impacted Wellington, Canterbury and the rest of New Zealand (this includes the Marlborough, Nelson and Tasman regions) regions, but also to a lesser extent through supply chain linkages in the Auckland and Waikato/Bay of Plenty regions.

Under Scenario 1, a total rebuild cost of $2016NZ 3 billion, the total workforce requirements across New Zealand for two consecutive years was 26,796 MEC years (Table 4.14). Note that this includes both construction and non-construction related employment. Canterbury region workforce requirements for two consecutive years were highest, at 17,329 MEC years, while Wellington was 5,987 MEC years (Table 4.14).

A higher rebuild cost of $\$_{2016}$NZ 8 billion over the same timeframe (Scenario 2) requires a total workforce across New Zealand for two consecutive years of 71,933 MEC years (Table 4.15). Canterbury region workforce requirements for two consecutive years were highest, at 29,465 MEC years. However, requirements for the Wellington region were only slightly less, at 29,090 MEC years (Table 4.15).

A slower rebuild costing $\$_{2016}$NZ 8 billion (Scenario 3) requires a total workforce across New Zealand for four consecutive years of 71,757 MEC years (Table 4.16). Canterbury region workforce requirements for four consecutive years were highest, at 29,465 MEC years. Again, requirements for the Wellington region were only slightly less, at 29,004 MEC years (Table 4.16).

In summary, there is only a small difference between the total workforce requirements for Scenarios 2 and 3, which vary in the pace of the rebuild. In contrast, the rebuild scenario costing $\$_{2016NZ}$ 5b less in total (Scenario 1), requires approximately 63% (45,137 MEC years) less in workforce requirements.

**Table 4.14 Annual Residential, Non-Residential and Infrastructure Construction Workforce Requirements (All Occupations, MEC years) by region under Scenario 1 following the 2016 Kaikoura Earthquake.**

| Option 1 | Auckland Region | | Waikato & Bay of Plenty | | Wellington Region | | Canterbury Region | | Rest of New Zealand | | Total New Zealand | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 |
| Residential building construction | 38 | 37 | 16 | 16 | 168 | 168 | 231 | 230 | 332 | 331 | 784 | 782 |
| Non-residential building construction | 171 | 170 | 82 | 82 | 2,709 | 2,701 | 266 | 265 | 529 | 527 | 3,757 | 3,745 |
| Heavy and civil engineering construction | 403 | - | 128 | - | 241 | - | 16,338 | - | 618 | - | 17,728 | - |
| Total | 611 | 208 | 225 | 97 | 3,118 | 2,869 | 16,834 | 495 | 1,479 | 858 | 22,269 | 4,527 |

**Table 4.15 Annual Residential, Non-Residential and Infrastructure Construction Workforce Requirements (All Occupations, MEC years) by region under Scenario 2 following the 2016 Kaikoura Earthquake.**

| Option 2 | Auckland Region | | Waikato & Bay of Plenty | | Wellington Region | | Canterbury Region | | Rest of New Zealand | | Total New Zealand | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 |
| Residential building construction | 188 | 187 | 79 | 78 | 840 | 838 | 1,154 | 1,151 | 1,660 | 1,655 | 3,921 | 3,909 |
| Non-residential building construction | 855 | 852 | 409 | 408 | 13,546 | 13,505 | 1,328 | 1,324 | 2,645 | 2,637 | 18,784 | 18,727 |
| Heavy and civil engineering construction | 604 | - | 192 | - | 361 | - | 24,507 | - | 927 | - | 26,592 | - |
| Total | 1,647 | 1,040 | 680 | 487 | 14,747 | 14,343 | 26,989 | 2,475 | 5,232 | 4,292 | 49,296 | 22,637 |

**Table 4.16 Annual Residential, Non-Residential and Infrastructure Construction Workforce Requirements (All Occupations) by region under Scenario 3 following the 2016 Kaikoura Earthquake.**

| Option 3 | Auckland Region | | | | Waikato & Bay of Plenty | | | | Wellington Region | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | Year 4 | Year 1 | Year 2 | Year 3 | Year 4 | Year 1 | Year 2 | Year 3 | Year 4 |
| Residential building construction | 63 | 125 | 124 | 62 | 26 | 52 | 52 | 26 | 280 | 558 | 557 | 278 |
| Non-residential building construction | 285 | 568 | 566 | 282 | 136 | 272 | 271 | 135 | 4515 | 9004 | 8977 | 4475 |
| Heavy and civil engineering construction | 302 | 301 | - | - | 96 | 96 | - | - | 181 | 180 | - | - |
| Total | 650 | 994 | 691 | 344 | 259 | 420 | 323 | 161 | 4976 | 9742 | 9533 | 4752 |

| Scenario 3 | Canterbury Region | | | | Rest of New Zealand | | | | Total New Zealand | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | Year 4 | Year 1 | Year 2 | Year 3 | Year 4 | Year 1 | Year 2 | Year 3 | Year 4 |
| Residential building construction | 385 | 767 | 765 | 381 | 553 | 1,103 | 1,100 | 548 | 1,307 | 2,606 | 2,598 | 1,295 |
| Non-residential building construction | 443 | 883 | 880 | 439 | 882 | 1758 | 1753 | 874 | 6261 | 12485 | 12448 | 6205 |
| Heavy and civil engineering construction | 12,253 | 12,217 | - | - | 464 | 462 | - | - | 13,296 | 13,256 | - | - |
| Total | 13081 | 13867 | 1645 | 820 | 1899 | 3324 | 2853 | 1422 | 20864 | 28347 | 15046 | 7500 |

# 5 Next steps

During the course of this study a number of key insights into the usefulness of the modelling work were identified along with several opportunities for further research. We discuss these briefly below. It should however be noted that this is by no-means a comprehensive list, nor does it put forward a complete research agenda – rather it focuses on how the work undertaken in this study could be refined, enhanced and improved.

## 5.1 Key challenges

### 5.1.1 Rebuild and recovery

The modelling work deals solely with the economic impacts of the Kaikoura event. With the exception of the NCOM workforce requirements analysis, no attempt was made within this study to assess the economic impacts associated with rebuild and recovery. While MERIT is well-suited to do this, it was not part of the ERI programme under which the model was conceived. The processes, procedures and information requirements to do this, and importantly to do it quickly, have thus not yet been developed. An exploratory project is currently underway in the QuakeCoRE to investigate how rebuild/recovery might be incorporated. Specifically, this focuses on identifying what should be included (e.g. materials, skills etc.) along with creating a 'causal map' of the dynamics underpinning rebuild/recovery. No model development however will take place – it is also not due to be completed until well into 2018.

We feel this is the next obvious step for the Kaikoura earthquake and also for the ongoing development of MERIT. We would therefore be interested in discussing scenarios for how this might be undertaken. We are keen to align this with other MERIT-related initiatives, particularly the Resilience to Nature's Challenges National Science Challenge – coordinating efforts, avoiding duplications of costs, and maintain the open source nature (i.e. creative commons licensing) upon which MERIT is currently being built.

### 5.1.2 Calibration

Only an initial first-cut calibration of MERIT has been undertaken for a counter-factual scenario i.e. what would have happened otherwise. Establishing the counter-factual or baseline for analysis is not necessarily an easy task. It requires making assumptions about a future which will never happen. Under the ERI programme the MERIT team have focused largely on how to incorporate outages across multiple infrastructure types into the underlying economic modelling framework. While some effort has been directed at calibrating the model, further effort is required to better account for uncertainty in the results. The MERIT research team has the necessary skills to address this, but lacks the appropriate funds to do so. Developing the appropriate datasets, and processes to fully calibrate MERIT will require liaison with central government agencies including Statistics New Zealand, Inland Revenue Department, Treasury, Reserve Bank of New Zealand and others. A key project focus would be on achieving quick delivery of a fully calibrated counterfactual ultimately speeding up government response.

## 5.2 Additional research questions

This initial assessment of the Kaikoura earthquake has also identified several areas where opportunities exist for further research which would not only be beneficial to better understanding the impacts of the Kaikoura event, but also in the wider sense New Zealand's economic vulnerability to natural hazards and disruption events. These are listed below.

- Economic impacts of displaced Wellington workers – What really was the loss of productivity due to the disruption? While most of Government's services were operational several agencies experienced significant disruption including Statistics New Zealand, the New Zealand Archives, Greater Wellington and so on. This might also be extended to consider the impacts to Wellington-based head offices or larger businesses (e.g. Fonterra Wellington) or industry organisations (e.g. Beef and Lamb, Deer Industry New Zealand). In the case of head offices or larger businesses a key focus might be how productivity losses filtered through their business and impacted on production chains elsewhere in New Zealand.

- Understanding coastal shipping dynamics in rerouting goods through New Zealand – the Kaikoura quake has highlighted the vulnerabilities in New Zealand road and rail networks. The quake led to the emergence of NZ Connect (an initiative supported by KiwiRail, Ports of Auckland, Lyttelton Port Company and ANL Shipping); a freight-based coastal shipping service between Auckland and Christchurch. Understanding the barriers and enablers to coastal shipping including access to ships, freight re-routing and handling scenarios, meeting just-in-time delivery practices, pricing pinch-points, implementation timeframes, and the usefulness to rebuild/recovery etc. would be a key focus of the research. Gaining insights into this would be invaluable particularly in developing transport resilience across New Zealand following, for example, a natural hazard event in Wellington.

- Calibration of the MERIT Business Behaviours Module (BBM) – Access to Inland Revenue Department (IRD) data could significantly increase the accuracy of the MERIT work. The behavioural responses of businesses to the Kaikoura earthquake are, in this study, imputed from survey work carried out by Resilient Organisations following the Canterbury earthquake series in 2010-11. While this work provides a good starting point, it represents only an initial attempt at understanding how businesses respond to disruption. Analysis of IRD data (GST returns, PAYE, company tax etc.) would be invaluable in calibrating the BBM; this would require collection of data through time, say, up to 2 years following the event. We recommend working with IRD to establish protocols, procedures and conditions for release of data.

- Risk to stockpiled goods – the Kaikoura quake has also highlighted the risk to industries in the New Zealand economy which stockpile perishable goods, particularly through disruption to infrastructure which stores or maintains their quality (e.g. electricity, water and built structures) or delivers them (e.g. roads, ports). Associated with this risk is arguably a lack of preparedness by New Zealand's rural communities to large scale natural hazard events.

- Understanding the dynamics of freight price impacts throughout New Zealand – In the first few weeks following the earthquake the price of freight goods through impacted areas fluctuated significantly from the norm. Furthermore, these impacts rippled through the whole NZ economy

– with prices affecting non-impacted areas. Understanding these dynamics, in particular, the response within markets to 'perceived' delays, how long these persist, and potentially how they might impact the cost of the Kaikoura rebuild itself (i.e. the movement of materials for the rebuild), is a key area in need of further investigation.

- Tourism impacts – Under this study, ME Research worked closely with MBIE to track the economic implications of the earthquake on domestic and international tourists. This work has shown to date that while Canterbury, particularly Kaikoura, has been severely impacted, neighbouring regions have benefited. There has however been little discernible impact on New Zealand tourism as a whole. Nevertheless, these are only initial estimates with much of the tourism impact to play out over the remaining summer and autumn months. It is recommended that the analysis of MarketView data continue on a monthly basis over, the next 2 years – or to the point where there are no identifiable local impacts.

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