Economic effects of hearing loss

A CGE modelling analysis

NZIER report to New Zealand Hearing Industry Association

June 2020

About NZIER

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NZIER was established in 1958.

Authorship

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Key points

NZIER was commissioned by the New Zealand Hearing Industry Association to assess the social costs of hearing loss and evaluate the economic benefits of mitigating some of the effects of hearing loss

- The prevalence of hearing loss varies from 7.5% to 20.8% across the New Zealand population.
- The literature review highlights a wide range of social and economic impacts from hearing loss such as early retirement, increased needs in aged care and informal care, reduction in the quality of life, decreased in learning ability and development for children with hearing loss, reduced employment and decreased labour productivity.

We estimate the potential social and economic benefits of mitigating the hearing loss effects at work

We focus on three main effects of mitigating hearing loss:

- **A labour productivity increase** through less absenteeism and presenteeism.
- **An employment increase** to show what might happen if the unemployment gap was reduced between people with hearing loss and the rest of the population.
- **Social impacts** of hearing loss for those over the retirement age, including the value of participating in society. We use our Computable General Equilibrium (CGE) model to assess the economic impacts of the first two effects and a non-market valuation consistent with Treasury CBAx impacts database to explore the social impacts of hearing loss among the older population.

The labour productivity effects lead to an annual real GDP growth by between $556 million and $716 million

Results of our modelling for a productivity increase show significant macroeconomic benefits from less absenteeism and presenteeism of workers with hearing loss. Other macroeconomic effects include:

- Real household spending (our measure of living standards) grows by between $316 million (low scenario) and $408 million (high scenario), annually.
- Exports volume grow by $137 million to $176 million annually, under the low and high scenarios, respectively.
- Industry outputs increase by an annual $979 million (low scenario) to $1.263 billion (high scenario) to answer the increase in foreign and domestic demands.

The economy-wide employment increases lead to an annual GDP growth by between $294 million to $588 million

Our modelling of a reduction in the employment gap also shows macroeconomic benefits from improving labour market access to workers with hearing loss.

Other macro-economic effects include:

- Real household spending grows by between $168 million (low scenario) and $335 million (high scenario), annually.
- Exports volume grow by an annual $72 million to $145 million annually, under the low and high scenarios, respectively.
- Industry outputs increase by between $519 million (low scenario) and $1.037 billion (high scenario), driven by increased foreign and domestic demands.

The social benefit of addressing the unmet for hearing aids is in the hundreds of millions of dollars annually

- A conservative estimate indicates that 80,723 people aged 65 and over had an unmet need for hearing aids or other mitigations in 2019.

  The value of the social benefit from increasing participation in society by mitigating hearing loss was estimated to range from $795 million to $1.4 billion, depending on social value of participation.

More action and New Zealand-based research is needed to lower the impact

- The lack of current research is a major factor hindering policy development and shows the need for investment by Government in research to better understand the local situation.
- Research is only as good as the action that follows it. This report highlights the social cost of unmet need for hearing loss mitigations such as hearing aids.

The 'size of the prize' in terms of gains to GDP and living standards suggests that a better work environment and improved accessibility to the job market for people suffering from hearing loss is worth further consideration from policy makers.

This report was prepared prior to Covid-19. The pandemic highlights need to act.

- Covid-19 has amplified the impacts of hearing loss and made it more difficult for those with hearing loss to cope. The use of masks is a communication barrier for those that lip-read and physical distancing is a challenge for those relying on proximity to cope with hearing loss. Covid-19 was not the subject of the report. But the pandemic experience highlights the importance of reducing the burden of hearing loss through the following actions:
  - Contemporary New Zealand based research on hearing loss
  - Preventing hearing loss in the workplace, including the unintended consequences of open plan offices
  - Ensuring access to adequate funding for hearing aids and specialist services
  - Removing the social stigma sometimes associated with hearing loss
  - Consider a national hearing loss strategy.

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1 Introduction

1.1 Purpose

The purpose of this report is to determine the social costs of hearing loss and investigate the economic and societal benefits of mitigating some of the effects of hearing loss.

1.2 Approach

The report applies the following four stage research approach. The stages reflect a discovery exercise that is consistent with a burden of disease methodology.

Table 1 Research approach

Stage	Name	Description
1	Prevalence and burden	The prevalence and burden of hearing loss in New Zealand, including the variation in prevalence estimates and the projected prevalence in the future.
2	Literature review	A wide-ranging literature review about the effects of hearing loss to guide the choice of the modelling scenarios.
3	Economic analysis	Using a computable general equilibrium (CGE) model to understand the flow-on effects of selected scenarios.
4	Social impacts analysis	Consideration of non-market effects of selected social impacts.

Source: NZIER

The research approach is designed so that each stage builds on the foundation constructed by the previous stage and we are using robust economic approaches, techniques and logic to investigate a real-world issue that effects the lives and well-being of people every day.

1.3 Scope

The scope of this project includes the social and economic effects of hearing loss. Hearing loss covers both gradual hearing loss that occurs over time and hearing loss associated with disability and impairment. The data on hearing loss often combines disability and progressive hearing loss.

2 The prevalence and the burden of hearing loss

Hearing loss is a common, significant and global health issue which impacts on people's quality of life, employment opportunities, social participation, safety and mental well-being.

At the global level, the World Health Organization suggests the following:

- Around 466 million people worldwide have hearing loss, and 34 million of these are children.
- It is estimated that by 2050 over 900 million people will have disabling hearing loss.
- Hearing loss may result from genetic causes, complications at birth, certain infectious diseases, chronic ear infections, the use of drugs, exposure to excessive noise, and ageing.
- 60% of childhood hearing loss is due to preventable causes.
- 1.1 billion young people (aged between 12–35 years) are at risk of hearing loss due to exposure to noise in recreational settings.
- Unaddressed hearing loss poses an annual global cost of US$750 billion. Interventions to prevent, identify and address hearing loss are cost-effective and can bring great benefit to individuals.
- People with hearing loss benefit from early identification, use of hearing aids, cochlear implants and other assistive devices, captioning and sign language, and other forms of educational and social support.
- Current estimates suggest an 83% gap in hearing aid need and use, i.e., only 17% of those who could benefit from use of a hearing aid actually use one (World Health Organization 2020).

2.1 The prevalence of hearing loss in New Zealand

There are a range of estimates of the prevalence of hearing loss among the population of New Zealand. Table 2 illustrates the variation in prevalence, aggregated to a total population.

Table 2 Hearing loss prevalence and estimates in New Zealand

Source	Aggregate prevalence of hearing loss
Institute for Health Metrics and Evaluation (IHME) (2017)	20.8%
Exeter et al. (2015)	7.5%
Anovum (2018)	10.1%
Stats NZ (2013)	9%

The prevalence varies from 7.5% to 20.8% of the population. The IHME (2017) estimates of prevalence are the highest in this case. The IHME uses standardised methods that allow for inter-country comparison drawing on specific country data.

Variation in the prevalence estimates was expected and the explanations for variation in the estimates include the following:

- self-reporting bias

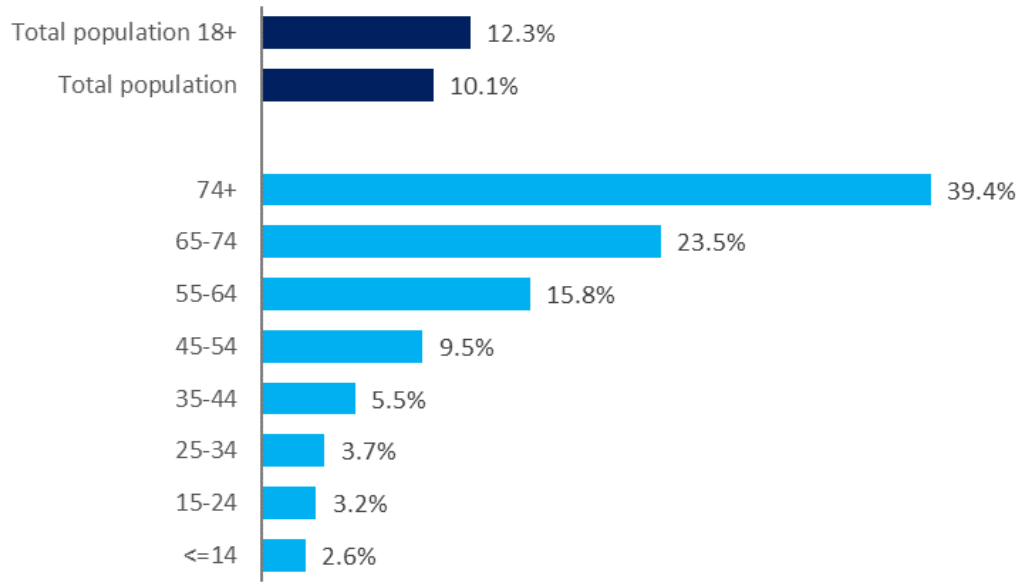
- the definition of hearing loss, which can include disability, impairment, age-related effects and occupational induced hearing – this can be confusing for survey respondents.

The New Zealand Hearing Industry Association and NZIER decided to use the prevalence estimates from Anovum (2018) for the following reasons:

- It was the most recent estimate
- It represented a middle ground from among the estimates.
- The estimate was conservative.

Figure 1 shows Anovum's estimated hearing loss prevalence by age group.

Figure 1 The prevalence of hearing loss by age group in New Zealand



Source: Anovum (2018)

The purpose of the review of prevalence estimates was to establish a credible estimate of the proportion of the population the experiences hearing loss at the age group level (Table 3). This was used to estimate the number of people effected by hearing across for different periods, by applying the prevalence at the age group level to the projection population at the age group level.

Table 3 Hearing loss prevalence and estimates in New Zealand, by age group

2018

Age (years)	Population	Hearing loss prevalence	Estimated population with hearing loss	Estimated working population with hearing loss
0-14	948,600	2.6%	24,664	-
15-19	315,060	3.2%	10,082	10,082
20-24	339,100	3.2%	10,851	10,851
25-29	353,360	3.7%	13,074	13,074
30-34	323,830	3.7%	11,982	11,982
35-39	301,010	5.5%	16,556	16,556
40-44	294,550	5.5%	16,200	16,200
45-49	325,800	9.5%	30,951	30,951
50-54	312,560	9.5%	29,693	29,693
55-59	312,220	15.8%	49,331	49,331
60-64	271,240	15.8%	42,856	42,856
65-69	236,400	23.5%	55,554	-
70-74	194,220	39.4%	76,523	-
75-79	137,550	39.4%	54,195	-
80-84	88,960	39.4%	35,050	-
85 years and over	86,570	39.4%	34,109	-
Total	**4,841,030**		**511,671**	**231,576**

Source: Stats NZ, Anovum (2018)

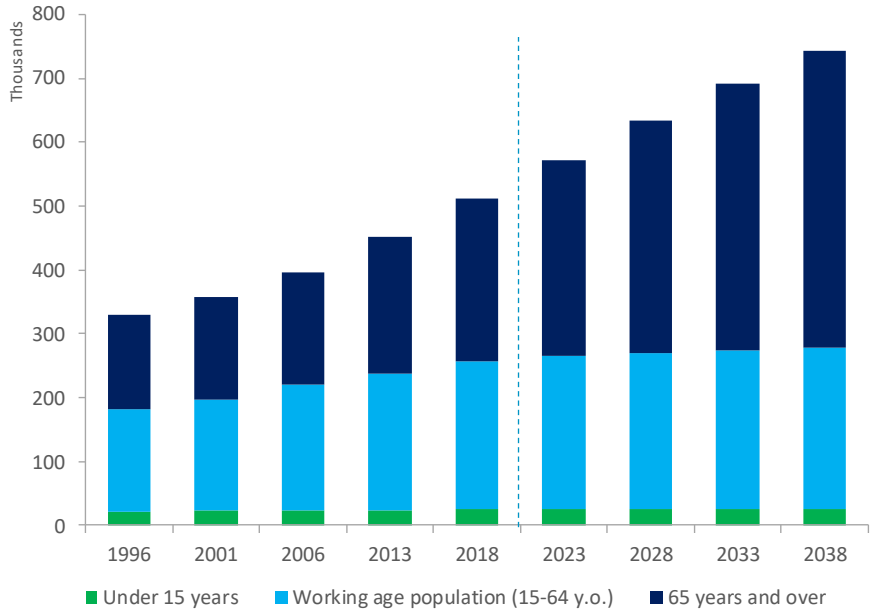
Figure 2 shows the estimated prevalence of hearing loss for past and future Census years. The population is disaggregated into three broad cohorts:

- Children under 15 years old
- The working age population, those aged between 15-years-old and 64-years-old inclusive
- Those aged 65 years old over.

The figure shows that hearing among the working age population is relatively stable between 1996 and 2038. Whereas, the older population experience faster growth in the estimated number of people affected with hearing loss. This result is consistent with age-related hearing loss and probably reflects the long-term effects of occupation-related hearing loss as well. The years to the right of the dotted line are a projection using the prevalence rates discussed above and the projected population according Stats NZ. The Stats NZ projections are not updated with the latest Census results.

Figure 2 The prevalence of hearing loss over time

People with hearing loss

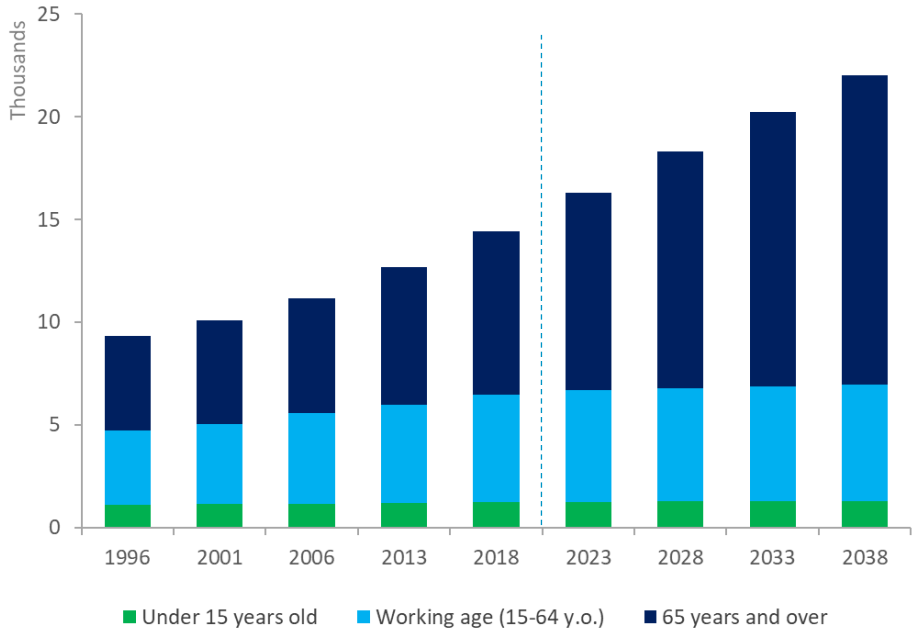


Source: NZIER

The burden of hearing loss is measured in disability adjusted life years (DALYs). The World Health Organization describes one DALY as one lost year of 'healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability (World Health Organization, n.d.).

Figure 3 The burden of hearing loss over time

Disability adjusted life years



Source: NZIER

3 Literature review

3.1 The impacts of hearing loss are wide-ranging

Hearing is one of the five senses and hearing loss will naturally have an impact on all sorts of human experiences and interactions with society and the world around us. The aim of the literature review was to provide an evidence-based foundation to the modelling. We took a funnel-shaped-approach to the literature review, which meant from the outset, we looked at all types of sources and didn't exclude any areas.

The effects of hearing loss can be grouped into the following themes:

- The effect of early retirement due to hearing loss
- Impact of hearing loss on aged care and quality of life
- Impact of children's hearing loss on learning ability
- Effect of hearing loss on informal care
- Potential impacts of hearing loss on labour productivity, employment and government revenue.

3.2 Hearing loss can lead to early retirement

While there is a certain amount of literature existing on the relationship between health status and retirement (Feldman, 1994), we found that little research has been conducted on the impacts of hearing loss on early retirement.

Helvik et al. (2013) found a correlation between the degree of low-frequency hearing loss and early retirement in Norway. Their study also shows that people with perceived hearing impairment are more likely to enter retirement early and are more likely to work part-time.

Fischer et al. (2014) found a correlation between hearing loss and retirement decisions. However, they also found that the decision to retire for people with hearing loss was also dependent of the effects of age, gender and health.

3.3 Hearing loss effects quality of life for older people

Research has shown that hearing loss has a negative impact on overall health and is correlated with increased use of healthcare and a higher burden of illness in older adults even when all other relevant variables are controlled for. Hearing loss is associated with more frequent falls (Lin and Ferrucci, 2012) and with several other health conditions such as diabetes (Kakarlapudi et al., 2013), stroke (Gopinath et al., 2009) and sight loss (Chia et al., 2006 & 2007).

People with a hearing impairment are more likely to feel socially isolated and lonely, which puts them at a higher risk of depression, cognitive decline, dementia, and other health conditions, which can lead to early dependency and mortality (Davis et al., 2016; Berkman et al., 2000; Karpa et al., 2010).

A study from the Johns Hopkins Center on Aging and Health (Lin et al., 2013) found strong evidence of an association between hearing loss and accelerated cognitive decline or impairment among older adults. Findings of this study are consistent with other studies

such as Yuan et al. (2018), which shows that older people with greater levels of hearing disability are at higher risk of cognitive impairment.

An Australian study (Hogan et al., 2009) used the 2003 Australian Survey of Disability, Ageing, and Carers to examine the impact of hearing loss on older people. This study showed that, among older people with hearing impairment, 71% experienced reduced communication. This study also found that hearing loss in older people is associated with reduced physical and mental health, especially for those affected with more severe hearing loss. An earlier study from Chia et al. (2007) looked at data from 2431 participants of the Blue Mountains Hearing study and found a correlation between age-related hearing impairment and health-related quality of life among older people.

Research studies from Lin et al. (2011a,2011b, 2013) and Lin and Ferrucci (2012) are also widely cited when linking hearing loss with cognitive decline. Their research showed that people with severe hearing loss have a higher risk of developing Alzheimer's disease, having an accelerated cognitive decline due to an accelerated atrophy of the brain from the hearing disability.

3.4 Hearing loss in childhood contributes to developmental delays

Children with hearing impairments are likely to be at risk of developmental delays. The American Speech-Language-Hearing Association (2015) identified the following main channels through which children are affected by hearing impairment:

- Developmental delays in children's speech and language skills
- Increased difficulties in learning which leads to lower academic grades and reduced future employment opportunities
- Higher risk of social isolation and poor self-esteem due to increased difficulties in communication.

Yoshinaga-Itano et al. (1998) found that early detection of hearing loss and intervention led to better outcomes in terms of language development among children.

In a 2008 report, the Centre for Allied Health Evidence reviewed 22 research studies to assess the correlation between age at detection of hearing loss and children's outcomes. Their literature review concluded that early detection had favourable outcomes for language and speech skills, but evidence is mixed when it comes to social and emotional development, academic achievement, reading and writing skills.

Barriers to educational achievement can reduce labour productivity of people suffering from hearing impairment. Rycx et al. (2015) found a positive relationship between educational achievement and productivity. Education and the development of human capital is key to increasing productivity and stimulating economic growth (Barro and Sala-i-Martin, 1995).

The international literature on the impact of glue ear on educational outcomes is quite mixed. Some studies find hearing loss in young children can have a significant impact on academic and behavioural outcomes. One American study found that many school leavers who suffered hearing impairment had a reading age equivalent to a student completing primary school, rather than secondary school. Other studies did not find such a clear effect, pointing to the confounding effect of household socio-economic conditions on educational outcomes.

Further research is needed as studies are mixed internationally and no studies in New Zealand have looked at the link between childhood glue ear and adult economic outcomes. Such work would be a significant research project on its own. At a minimum there is enough evidence for a qualitative discussion on the impacts in this project.

3.5 Hearing loss has a knock-on effect to carers

To date, there has been little research that has studied the correlation between hearing loss and spousal well-being and mental health and when such studies exist, they present contradictory findings which highlight the need for more research to assess the extent to which hearing loss may affect spousal well-being.

Wallhagen (2004) showed that partners of people suffering from hearing disability are more likely to experience a decrease in their well-being, whether it is psychological, physical or social. Conversely, Ask et al. (2010) concluded that a strong correlation between hearing loss and spousal well-being and mental health is unlikely.

Additionally, results from the *New Zealand Disability Survey* (Stats NZ, 2006) showed that people with hearing disability are the least likely to be receiving help from informal care compared with those with intellectual or mobility disabilities. Among people suffering from hearing loss, about 5% of those aged between 0–64 and 19% of those aged 65 or older received informal care in New Zealand in 2016.

Parents of children who suffer from hearing impairment are also at higher risk of stress, are more likely to face out-of-pocket expenses and take more days out of work than other parents (WHO, 2016).

Hearing loss also affects labour productivity of family members and friends who spend time providing support to people with a hearing disability. Access Economics (2006) estimated the total cost of informal carers, received from family and friends, at AU$2.6 billion in Australia, split between lost income, forfeited government taxes and deadweight losses.

3.6 Hearing loss reduces employment and productivity

There has been little research conducted in New Zealand about the impacts of hearing loss on employment and labour productivity. The existing literature mainly comes from international studies. We have identified three channels through which hearing loss affects labour productivity:

1. Reduced employment

People with hearing loss are at higher risk of missing out on employment outcomes due to the additional difficulty in job search or through self-selection out of the labour market. Jensen et al. (2005) used data from the 2001 *New Zealand Disability Survey* to measure the role of people's disabilities, including hearing loss, on their employment prospects. Authors found a 10% decrease in the probability of being employed for people suffering with hearing loss in New Zealand. Estimates have not been updated with the 2013 *New Zealand Disability Survey*. Therefore, Jensen et al. (2005) provide the most recent and only country-specific findings when it comes to measuring the effects of hearing loss on employment.

Jensen et al. (2005) findings fall within the range of other studies which assume a 6% to 24.4% employment gap between general labour force participation and those suffering from hearing loss, as shown in Table 4.

Table 4 Summary of findings on the impact of hearing loss on reduced employment

Reference	Country of study	Reduced employment (employment or labour participation gap)
Mohr et al. (2000)	USA	Labour participation gap (severe to profound hearing loss) is estimated at 18% for the 18–44 age category, 19% for the 45–64 age category and 6% for 65 and older.
Ruben (2000)	USA	Employment gap is found to be 10.4% for people with difficulty hearing and 24.4% for those unable to ear.
Jensen et al. (2005)	New Zealand	Employment gap is 10%.
Australian Bureau of Statistics (2015), Deloitte Access Economics (2017b)	Australia	Employment gap is estimated to be 13% for males with hearing loss and 9% for females with hearing loss.

2. Absenteeism

Workers suffering from hearing loss are more likely to take days off work. Nachtegaal et al. (2012) estimate that workers with hearing loss take an average of 3.5 days of annual sick leave due to their disability. Based on this assumption, Deloitte Access Economics (2017a) evaluates the total economic cost associated with absenteeism at NZ$66.7 million in 2016. We estimated that this is equivalent to a 1.6% loss in productivity based on the number of business days a year, annual average sick days taken and four-weeks annual leave.

Table 5 below presents a summary of our findings from the literature review on the impact of hearing loss on absenteeism.

Table 5 Summary of findings on the impact of hearing loss on absenteeism

Reference	Country of study	Increased annual sick days
Joore et al. (2003)	Netherlands	Authors found no difference (0 day) in the number of sick days before and after hearing aid fitting. However, their sample size (10 people) is not statistically robust.
Kramer et al. (2006)	Netherlands	Authors identified a significant difference of 20.3 days between people suffering from hearing loss and normal-hearing people.
Nachtegaal et al. (2012)	Netherlands	Authors estimated at 3.5 days the numbers of sick leave due to hearing loss. This study is the most representative, well-constructed and constructed.

3. Presenteeism

Workers suffering from hearing loss are likely to be less productive than other workers (Nachtegaal et al., 2012). Deloitte Access Economics (2017a) estimated a 3% productivity decrease due to presenteeism for people with hearing loss compared with other workers. They estimated the total cost associated with presenteeism at NZ$98.4 million for New Zealand in 2016.

4 Methodology and scenario design

Based on the discussion of the literature above and data availability, we focus on three main channels of transmission to explore the potential economic and social benefits in addressing and treating hearing loss, especially in the work environment:

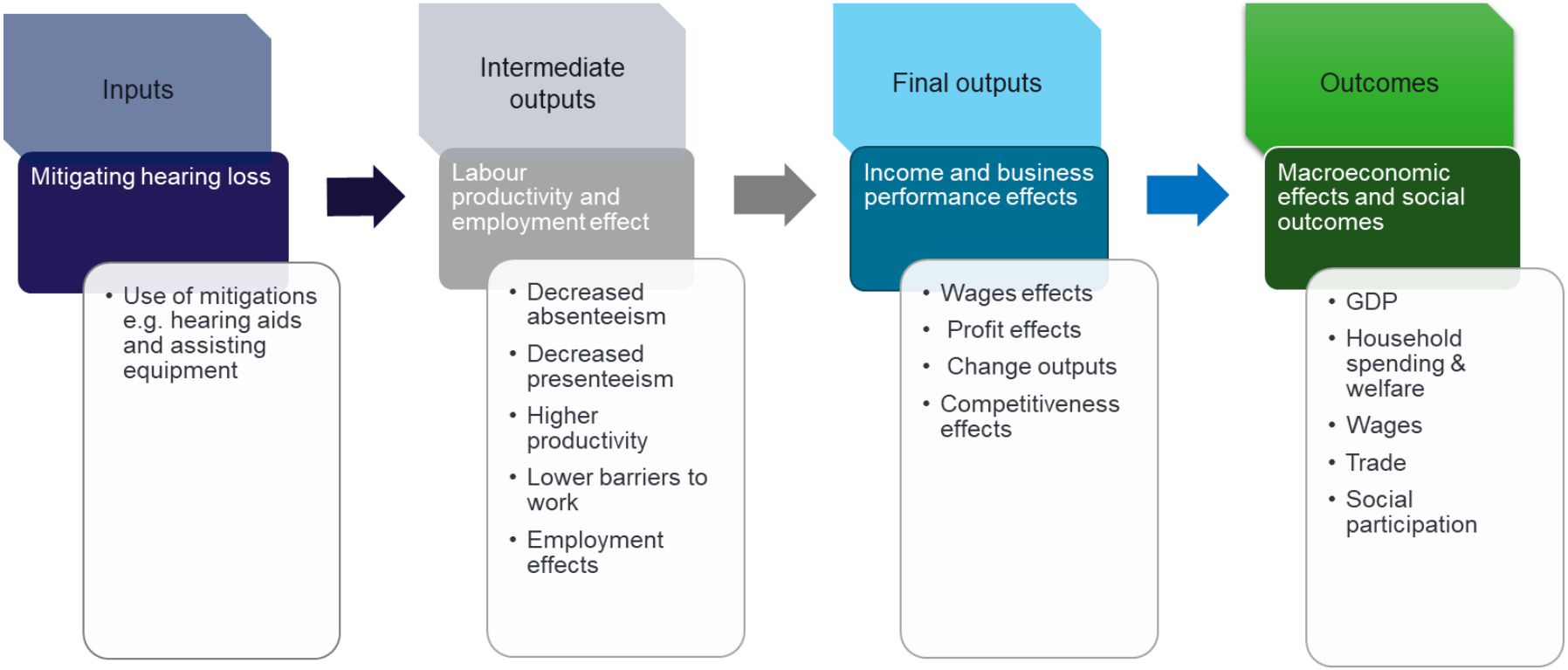
- A labour productivity increase through improved measures within the work environment, which would translate into lesser absenteeism and presenteeism.
- An employment increase among people with hearing impairment to show what might happen if the unemployment gap was reduced between people suffering from hearing loss and the national unemployment rate.
- Social impacts of hearing loss for those over retirement age including the value of participation and depression.

We use our Computable General Equilibrium (CGE) model to assess the economic impacts of the first two channels and a non-market valuation consistent with Treasury CBAx impacts database to explore the social impacts of hearing loss amongst the older population. CBAx contains a database of New Zealand specific publicly available estimates of value of social impacts. use to value impacts. These impacts can be positive or negative from society's perspective. The impacts include market values based on prices and non-market impacts based on quantitative estimates on impacts not reflected in the price of traded goods and services.

4.1 Organising framework

Figure 4 shows the intervention logic and the pathway from mitigating hearing loss to improved macroeconomic outcomes. Mitigating hearing loss leads to higher productivity at work and higher employment, which affects wages and business performance. This leads to positive ripple effects on the New Zealand economy, with increased household consumption, trade and GDP.

Figure 4 Pathway from mitigating hearing loss to improved macroeconomic outcomes



Source: NZIER

4.2 CGE modelling approach

We use our top-down CGE model of the New Zealand economy, ORANI-NZ[1], to look at the potential economic impacts of mitigating hearing loss amongst the working population.

ORANI-NZ is based on a Stats NZ's Input-Output tables that identify the structure of the industries involved. It contains information on 106 industries and 201 commodities.

CGE modelling is our recommended method for conducting policy analysis or sectoral impact studies, as it delivers more conservative, but more realistic, estimates of net benefits than commonly used (and widely criticised) alternatives such as multiplier analysis

CGE shows the full effect of a change which includes impacts from indirect effects which aren't immediately obvious. The cumulative impact of indirect effects can outweigh the direct effect of a change.

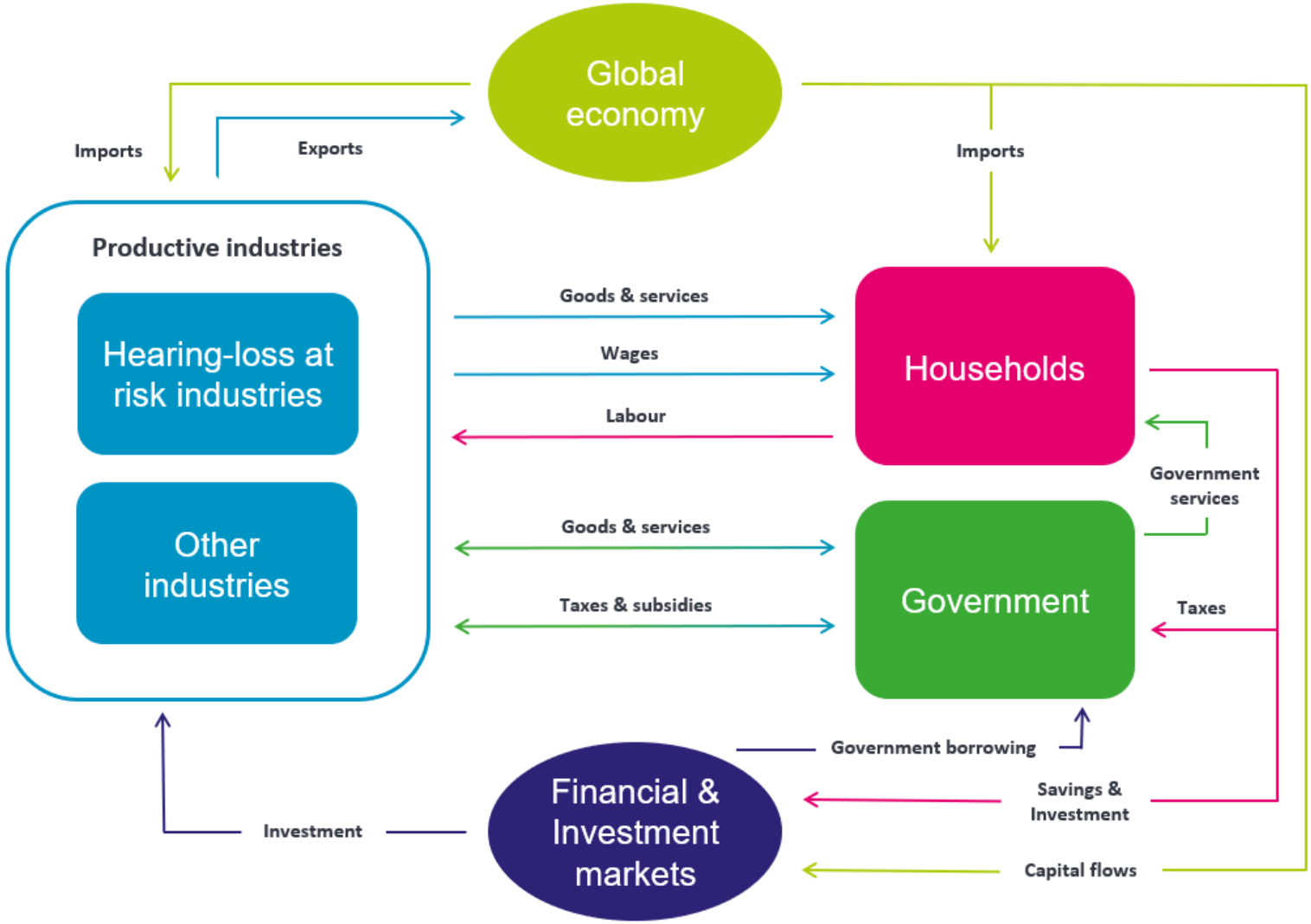
As our CGE model is 'static', it can only look at 'before' (i.e. current situation) and 'after'. We therefore do not explicitly model the timing of improving working conditions for people with hearing loss. Instead, we analyse a static, long-term scenario in which the capital that was initially used in various industries can eventually be used elsewhere (if not the physical capital, then the proceeds from selling it). We also assume that labour reallocates across industries which offer higher real wages but is fixed in aggregate as it reaches its natural level in the long run. This is a standard CGE modelling approach when we are thinking about changes to an industry/economy that might take longer than 1–2 years to occur. Further explanations on the closure can be found in Appendix A.6.

Figure 5 shows how our CGE model captures the various interlinkages between sectors, as well as their links to households (via the labour market), the government sector, capital markets and the global economy (via imports and exports). More details on the model can be found in Appendix A.

For reporting purposes, we aggregate the 106 industries into 50 broader sectors. The conversion of industries to sectors is shown in Table 17 in Appendix B.

[1] ORANI-NZ was developed at NZIER and is based on the original Australian ORANI model created by Professor Mark Horridge of the Centre of Policy Studies, Victoria University-Melbourne, Australia (https://www.copsmodels.com/ftp/gpextra/oranig06doc.pdf). NZIER maintains close connections with the Centre, ensuring that our modelling techniques reflect international best-practice.

Figure 5 Our CGE model represents the circular flows between all the agents and activities in the economy



Source: NZIER

4.2.1 Scenario design

For our scenario design, we implement shocks to represent what the national economy would look like if national labour productivity and employment increase as a result of mitigating the negative effects of hearing loss for workers across New Zealand industries.

We model two sets of scenarios:

- Labour productivity increase across all industries through improved measures within the work environment, which would translate into less absenteeism and presenteeism. In this set of scenarios, we assume a 4.6% labour productivity increase of workers with hearing loss if presenteeism and absenteeism were reduced. This percentage is derived from our literature review findings. It is the combination of a 3% labour productivity effect from presenteeism and a 1.6% labour productivity effect from absenteeism.
- National employment increase among people with hearing impairment to show what might happen if the employment gap was reduced between people suffering from hearing loss and the national employment rate. In this set of scenarios, we assume that only a portion of jobs are readily available (40%).

These scenarios are intended to establish the potential 'size of the prize'. They indicate the lower and upper limits of the potential benefits before considering the practical challenges and the cost of mitigating the challenges. The scenarios provide a counterfactual 'what if?' By quantifying the 'what if' scenarios, insights are gained into whether an improving labour market and work access for people with hearing loss is worthy of more detailed investigation by policy makers.

Given the lack of recent official data and for sensitivity analysis purpose, we define a low, central and high bound for each of these two scenarios. Table 6 below summarises the different shocks we model. Further detail on the methodology used to estimate these shocks are provided in Appendix A.5.3.

Table 6 Scenarios for labour productivity and employment increases from reductions in health loss

Indicator	Low	Central	High
Aggregate labour productivity increase	0.19%	0.22%	0.25%
Aggregate employment increase	0.10%	0.15%	0.21%

Source: NZIER

5 Economic effects of improving working conditions for people with hearing loss

5.1 Expected chain of effects from an economy-wide labour productivity increase

Figure 6 summarises the chain of economic effects from an economy-wide labour productivity increase. When considering these effects, it is important to remember that there are multiple moving parts that are at play within the economy.

On the supply-side, higher labour productivity leads to higher profits across all industries. These profits can be reallocated in three ways:

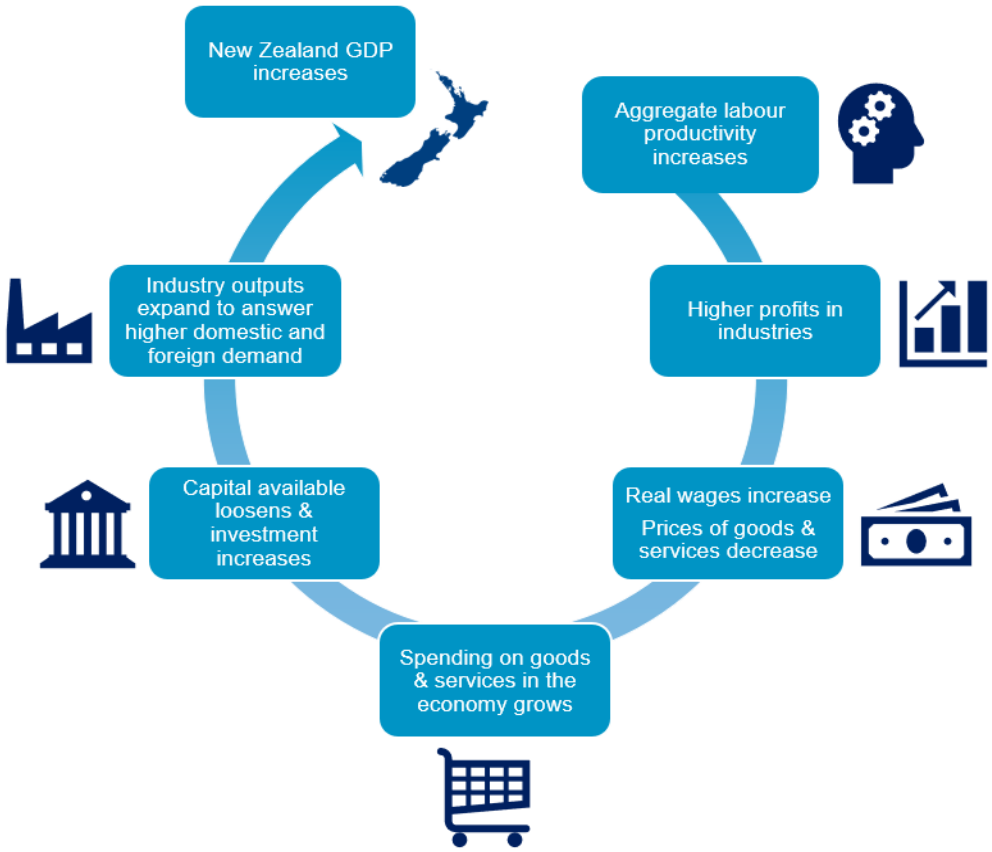
- Part of these profits can be allocated to capital, for additional investment or be distributed to shareholders.
- Firms and businesses can also reduce the price of goods and services to consumers, or at least, raise their prices by less than they would have without the productivity increase. This is especially the case when there is competition among producers.
- Given there is fixed aggregate labour supply, firms and businesses are likely to offer higher compensation to their workers in the form of higher real wages. Jobs are reallocated toward industries with higher real wages or those that are more labour intensive.[2]

On the demand-side, the increase in real wages and the reduction in prices encourage spending on goods and services. To respond to the increase in demand, industries in which households spend their money can expand their outputs. With the slight reduction in the terms of trade associated with the decrease in prices, export-oriented industries become slightly more competitive on the international market. This drives them to increase their output to respond to a growing foreign demand for exports.

Overall, the benefits of an initial labour productivity increase can have a ripple effect throughout the economy and drive growth in national GDP, household spending, output and trade.

[2] Employment is considered fixed at the national level, but labour is perfectly mobile between industries and moves based on real wage differences across sectors.

Figure 6 Main economic effects of an increase in labour productivity



Source: NZIER

5.2 Expected chain of effects from an economy-wide employment increase

Figure 7 summarises the chain of the economic effects from higher employment at the national level.

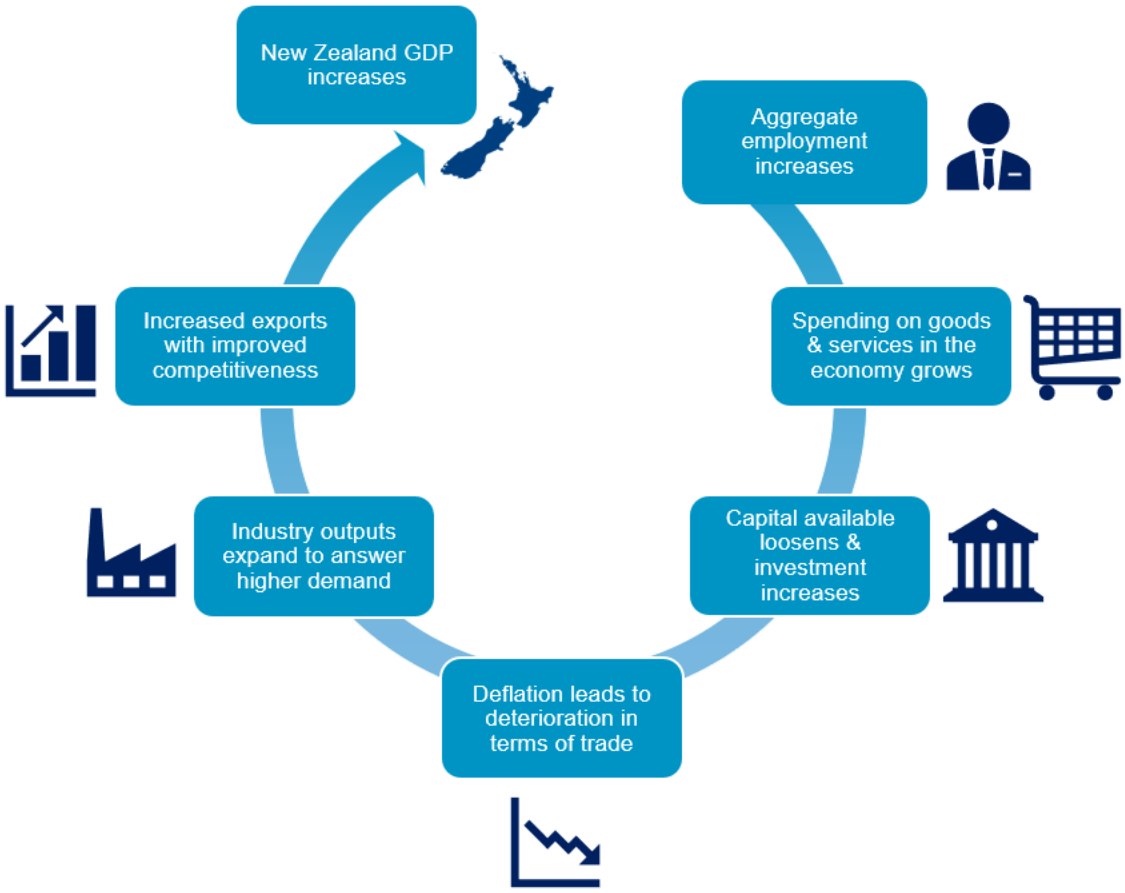
On the supply-side, a better access to the labour market for people with hearing loss leads to an increased aggregate level of employment. In turn, aggregate real wages decrease to reflect this new level of labour supply.

On the demand-side, households' overall wealth and confidence increase which stimulates spending on goods and services. To answer the growth in household demand, industries increase their productive capacity through investment.

The increase in the aggregate supply leads to a fall in prices of goods and services, which in turn, generates a slight deterioration in the terms of trade. Export-oriented industries become more competitive on the international market, which drives them to increase their output to respond to a growing demand for exports. In the short-run, deflation also increases the purchasing-power of households and encourage spending on goods and services.

Overall, the benefits of increasing employment level can have a ripple effect throughout the economy and drive growth household spending, investment, output, trade and GDP.

Figure 7 Main economic effects of an increase in employment



Source: NZIER

5.3 Headline economic impacts

The overall impacts on the New Zealand economy are analysed by focusing on key economic metrics, particularly gross domestic product (GDP), household welfare (measured by household consumption), wages, trade, capital stock and national output.

Both direct and indirect effects from labour productivity and employment increases of people with hearing loss are expected to positively impact these key macroeconomic indicators, as discussed previously.

5.3.1 Results from a labour productivity increase under our scenarios

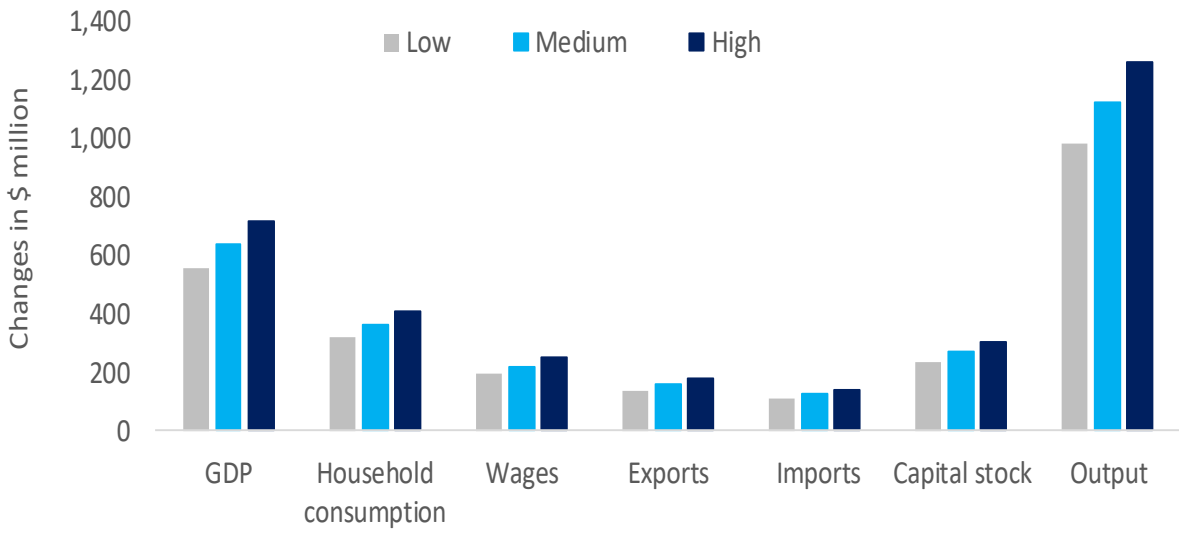
Figure 8 and Table 7 present the annual economy-wide effects of increasing labour productivity of workers suffering from hearing loss by 4.6%, which at the national level, and depending on the assumptions on the participation rate of people suffering from hearing loss into the labour force, translates into a labour productivity increase of 0.19%, 0.22% and 0.25% under the low, central and high scenarios, respectively. (See Appendix A.5.3 for further detail on the scenario design.)

- Economy-wide real GDP expands by $556 million (0.18%) to $716 million (0.24%) annually.

- Annual real household spending, our measure of living standards, rises by between $316 million (0.18%) and $408 million (0.24%), depending on the level of labour productivity increase (from low to high scenarios).
- The average annual real wage rises relative to the baseline by between $192 million (0.15%) and $248 million (0.19%) as national average labour productivity increases.
- Annual exports volume (i.e. excluding price changes) grows by between $137 million (0.16%) and $176 million (0.21%) annually, under the low and high scenarios, respectively. This is due to an increase in competitiveness of export-oriented industries as a result of a slight deterioration in the terms of trade.
- Industry outputs increase by an annual $979 million or 0.18% (low scenario) to $1,263 million or 0.24% (high scenario) to answer the increase in domestic and foreign demand.
- Volume of capital increases, through higher investment, by an annual $236 million (0.18%) to $305 million (0.24%) to ensure higher productive capacity and accommodate the growth in production.

Figure 8 Macroeconomic benefits from higher labour productivity

Annual changes from 2019 baseline, in $ millions (real terms)



Note: Changes from the baseline are net effects, taking into account the flow-on effects from our CGE modelling.

Source: NZIER

Table 7 Macroeconomic effects from an increase in labour productivity

Annual changes from 2019 baseline, in $ millions (real terms) and in percent

Indicator	Central scenario		High scenario		Low scenario	
	% change	Level ($m)	% change	Level ($m)	% change	Level ($m)
GDP	0.18%	$556	0.21%	$636	0.24%	$716
Household consumption	0.18%	$316	0.21%	$362	0.24%	$408
Wages	0.15%	$192	0.17%	$220	0.19%	$248
Exports	0.16%	$137	0.19%	$156	0.21%	$176
Imports	0.13%	$109	0.15%	$125	0.17%	$141
Capital stock	0.19%	$236	0.21%	$271	0.24%	$305
Output	0.18%	$979	0.21%	$1,121	0.24%	$1,263

Note: Changes from the baseline are net effects, taking into account the flow-on effects from our CGE modelling.

Source: NZIER

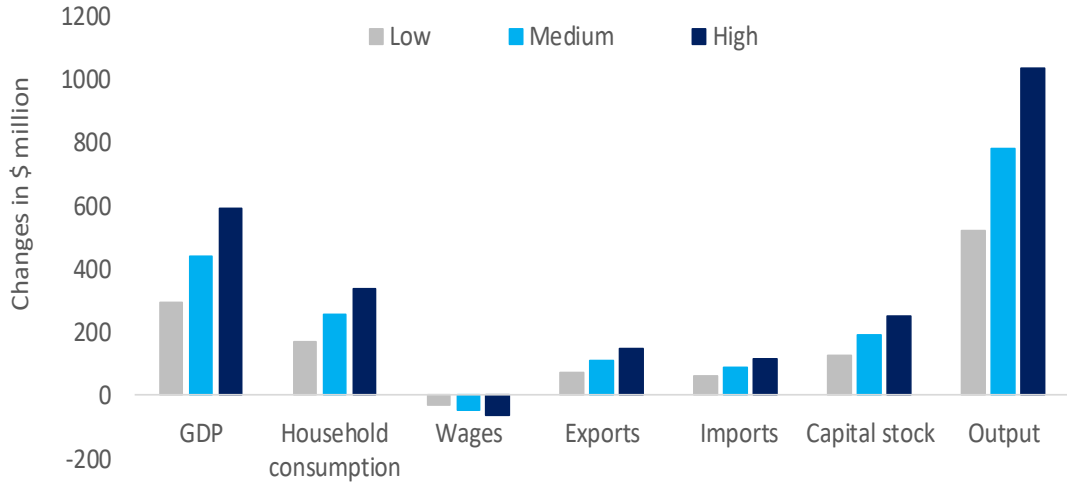
5.3.2 Results from increasing the employment level

Figure 9 and Table 8 show the annual economy-wide effects of a 40% reduction in the unemployment gap between people with hearing loss and national population. If we assume different levels of unemployment rate for people suffering from hearing loss (7%, 8.5% and 10%), a reduced unemployment gap translates into a 0.10%, 0.15% and 0.21% increase in national employment level under the low, central and high scenarios, respectively. (See Appendix A.5.3 for further detail on the scenario design.)

- Economy-wide real GDP expands by $294 million (0.10%) to $588 million (0.20%) annually.
- Annual real household spending, our measure of living standards, rises by between $168 million (0.10%) and $335 million (0.20%), depending on the level of labour productivity increase (from low to high scenarios).
- The average annual real wage falls relative to the baseline by between $32 million (-0.02%) and $64 million (-0.05%) as economy-wide employment increases.
- Annual exports volume grows by between $72 million (0.09%) and $145 million (0.17%) annually, under the low and high scenarios, respectively.
- Industry outputs increase by an annual $519 million or 0.10% (low scenario) to $1,037 million or 0.19% (high scenario) to answer the increase in domestic and foreign demand.
- Volume of capital increases, through higher investment, by an annual $125 million to $250 million to ensure higher productive capacity and accommodate the growth in production.

Figure 9 Macroeconomic benefits from increased employment

Annual changes from 2019 baseline, in $ millions (real terms)



Note: Changes from the baseline are net effects, taking into account the flow-on effects from our CGE modelling.

Source: NZIER

Table 8 Macroeconomic effects from an employment increase

Annual changes from 2019 baseline, in $ millions (real terms) and in percent

Indicator	Low scenario		Central scenario		High scenario	
	% change	Level ($m)	% change	Level ($m)	% change	Level ($m)
GDP	0.10%	$294	0.15%	$441	0.20%	$588
Household consumption	0.10%	$168	0.14%	$251	0.19%	$335
Wages	-0.02%	-$32	-0.04%	-$48	-0.05%	-$64
Exports	0.09%	$72	0.13%	$108	0.17%	$145
Imports	0.07%	$58	0.10%	$87	0.14%	$116
Capital stock	0.10%	$125	0.15%	$188	0.20%	$250
Output	0.10%	$519	0.15%	$778	0.19%	$1,037

Note: Changes from the baseline are net effects, taking into account the flow-on effects from our CGE modelling.

Source: NZIER

6 Social impacts of hearing loss

Hearing loss effects the ability to participate in society and interact with others in either a one-on-one situation or group environment. In this section the non-market cost of the effects of hearing loss on those 65 years and over are investigated.

As discussed in the literature review, social participation can include market benefits from increased consumption. Hearing loss and social isolation associated with hearing could therefore lead to a decrease in consumption with flow-on effects to businesses and industries. However, we found that there was not enough detailed research to support the development of a consumption-based scenario. Instead we considered the value of the non-market effects utilising the estimates of the value of participation used in Treasury's CBAx impacts database. This allows a consistent comparison with other appraisals.

The unmet need for hearing aids was estimated to quantify the potential scale of the social impacts of hearing loss for the population aged 65 years and over. Table 9 shows that in 2019, an estimated 213,924 people aged 65 years and over experienced hearing loss. Of those, 59% or 126,115, currently haven't started using hearing aids and represent the unmet need for hearing aids among the population aged 65 years old and over. This cohort represents the group most likely to experience negative social effects from hearing loss.

Table 9 Estimating the unmet need for hearing aids

In 2019

Hearing loss severity	People affected (65+)	Share of affected people	Aid adoption rate	Unmet need %	Unmet people
Severe + profound	34,224	16%	68%	32%	10,952
Moderate	111,228	52%	50%	50%	55,614
Mild	68,448	32%	13%	87%	59,550
Total people with hearing loss aged 65+	213,924	100%	41%	59%	126,115

Source: NZIER and Anovum (2018)

According to Anovum (2018), 64% of those with hearing aids surveyed wished they had got them sooner due to the social participation benefits. This implies that on a conservative basis 80,723 people aged 65 years or over could have experienced negative social effects of from unmitigated hearing loss in 2019.

Table 10 shows the range estimates for the social value of participation in society from Treasury's CBAx impacts database (The Treasury, 2019). The values of range from $2,639 for being part of a club, to $18,349 as the social benefit of reduced loneliness. These values suggest that the value of social participation is difficult to consistently define, estimate and monetise.

Table 10 Social values of participation

Social benefits of participation	Value per person 2020 $
Being a member of a club	$2,639
Having contact with neighbours	$8,920
Reduced loneliness	$18,349
Average	**$9,969**

Source: The Treasury (2019)

Table 11 shows the estimated social benefit of addressing the unmet need for hearing aids based on the estimated cohort of 80,723, for 2019. The social benefit ranges from $213 million to $1.48 billion depending on the social value of participation. Obviously hearing loss has much wider implications than the ability to participate in a club, because hearing loss effects a multitude of activities in everyday life. Therefore, the lower estimate considerably under-represents the social cost of hearing loss. The true social cost of hearing loss for those with an unmet need for hearing aids is more likely to fall between $804.8 million and $1.48 billion.

Table 11 Social benefit of addressing the unmet need for hearing aids

Annually

Social benefits of participation	Value to the affected cohort ($ million)
Lower	$213.0
Central	$804.8
Upper	$1,481.2

Source: NZIER

What would it cost the government to provide more hearing aids?

The cost of addressing the unmet need for hearing aids would be $13.85 million annually based on:

- a government subsidy of $434.44 (ex. GST) per hearing aid
- an average hearing aid life of 5 years
- 1.79 hearing aids per person
- a cohort of 80,723 people.
- a specialist appointment fee of $80 per person.

The social return on investment would be between $796 million and $1.4 billion, after excluding the lower estimate for the value for social participation. As it is unlikely to reflect the pervasive social impact of hearing loss.

7 Next steps

This scenario modelling exercise demonstrates the potential benefits of mitigating hearing loss on the New Zealand economy. The 'size of the prize' in terms of gains to GDP and living standards suggests that a better work environment and improved accessibility to the job market for people suffering from hearing loss is worth further consideration by policy makers.

The next steps based on the findings of this report are:

- More research is needed to better understand the potential policy interventions to:
  - increase hearing aid adoption rates and
  - fund the unmet need for hearing loss mitigations.
- More research into the impacts of hearing among children and the effects over their life course.
- Further efforts to reduce hearing loss in the workplace, which should include the risks associated with an open plan environment.
- More regular and consistent surveys on hearing loss and hearing as a disability.
- Increased action on hearing loss is also needed to make a difference.

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Appendix A CGE modelling

A.1 CGE modelling captures the full impact of hearing loss

We use our CGE model to capture the full impact of national labour productivity and economy-wide employment increases from mitigating the negative effects of hearing loss on workers across New Zealand industries.

CGE models are data-driven and used to capture the effects of a new policy or technology or other external shocks affecting economic activity. They capture the economy-wide effects of changes ('shocks' in modelling jargon) directly on the affected industry, as well as indirectly on supplying industries, competing industries, and factor markets (labour and capital). CGE models show the full effect of a change which includes impacts from indirect effects which aren't immediately obvious. The cumulative impact of indirect effects can outweigh the direct effect of a change.

CGE models also estimate the effect of a shock on macroeconomic variables such as GDP, employment, wages and trade.

CGE models are a powerful tool, allowing economists to explore empirically many issues on which econometrics or multiplier analysis would be unusable. For these reasons, CGE models have become widely used internationally (e.g. by OECD, IMF, World Bank) for economic impact analysis.

A.2 Why do we prefer CGE over multipliers?

Multiplier studies[3] are popular for economic impact analysis as they are relatively cheap and produce appealing big figures. However, they are based on several assumptions which requires them to be interpreted and considered with considerably care.

Key caveats include that multiplier studies:

- Do not consider the impacts of policy changes on the price of goods, services, intermediate inputs, labour (wages) and capital
- Assume that land, labour and capital are available in unlimited quantities, and at no additional cost to firms
- Cannot consider the opportunity cost of using additional resources in one industry on the rest of the economy – there are almost never any losers (i.e. contracting industries) in multiplier studies.

Because of these assumptions, multipliers overestimate the impacts of a change in an industry on the rest of the economy. Both the Ministry of Business, Innovation and Employment (MBIE) and Treasury have highlighted the inherent flaws in using multiplier studies for serious economic analysis.[4]

[3] Also known as 'input-output studies'

[4] For an overview of these weaknesses, see the New Zealand Treasury and MBIE. Both documents, and Gretton (2013), clearly state that multipliers over-state economic impacts and thus lack credibility for economic analysis. Or in Treasury's words: "Unless there is significant unemployment of people with the requisite skills, **it is therefore likely that multiplier effects do not exist**".

For all these reasons, we prefer to use CGE models as they better align with our independence and reputation for delivering high quality, data-driven analysis.

A CGE model provides an estimation of opportunity costs (between action and inaction), winners and losers. Resources are limited. It also considers price impacts of shocks and can capture linkages between industries as well as spill-over effects.

NZIER's CGE models are highly regarded amongst government agencies with whom we have worked to conduct policy analysis or sectoral impact studies. This includes MBIE, Treasury, the Ministry of Foreign Affairs and Trade, the Ministry for Primary Industries and the Ministry for the Environment.

A.3 How do CGE models work?

A CGE model consists of equations which describe model variables. It also uses detailed data on the structure of the economy that is consistent with these model equations.

This data provides a snapshot of the economy in a particular year, which is used as a starting point for a baseline (or business as usual (BAU)) against which to compare policy simulations or economic changes.

The model data is linked together through a set of equations which capture how the economy evolves over time in response to a shock. These equations, which are based on the economic theory of general equilibrium, ensure supply and demand for goods, services and factors of production in the economy are balanced, and determine how firms and households react in response to changes in incentives.

Most CGE models are written and solved in a specific software system, usually GAMS[5] or GEMPACK.[6]

In any CGE model, we must choose what is to be determined within the model (the endogenous variables) and what is to be considered external to the model (the exogenous variables). A CGE model is just a way of explaining the endogenous variables in terms of the exogenous variables.

Where we draw the line between endogenous and exogenous variables, and which ones can vary or must remain fixed, depends on several factors, including the purpose for which the model simulations are to be used. The choice that we make is called the model closure.

Determining the closure is a key part of any modelling exercise and it is very important that the modeller be transparent about what is a result of the modelling and what has been imposed by assumption via the closure.

The difference between the initial and the new equilibrium can then be analysed to determine the effect of the shock on a range of economic indicators, such as GDP, employment, wages and living standards.

5 General Algebraic Modelling System: https://www.gams.com/

6 General Equilibrium Modelling Package: https://www.copsmodels.com/gempack.htm

A.4 Our CGE model ORANI-NZ

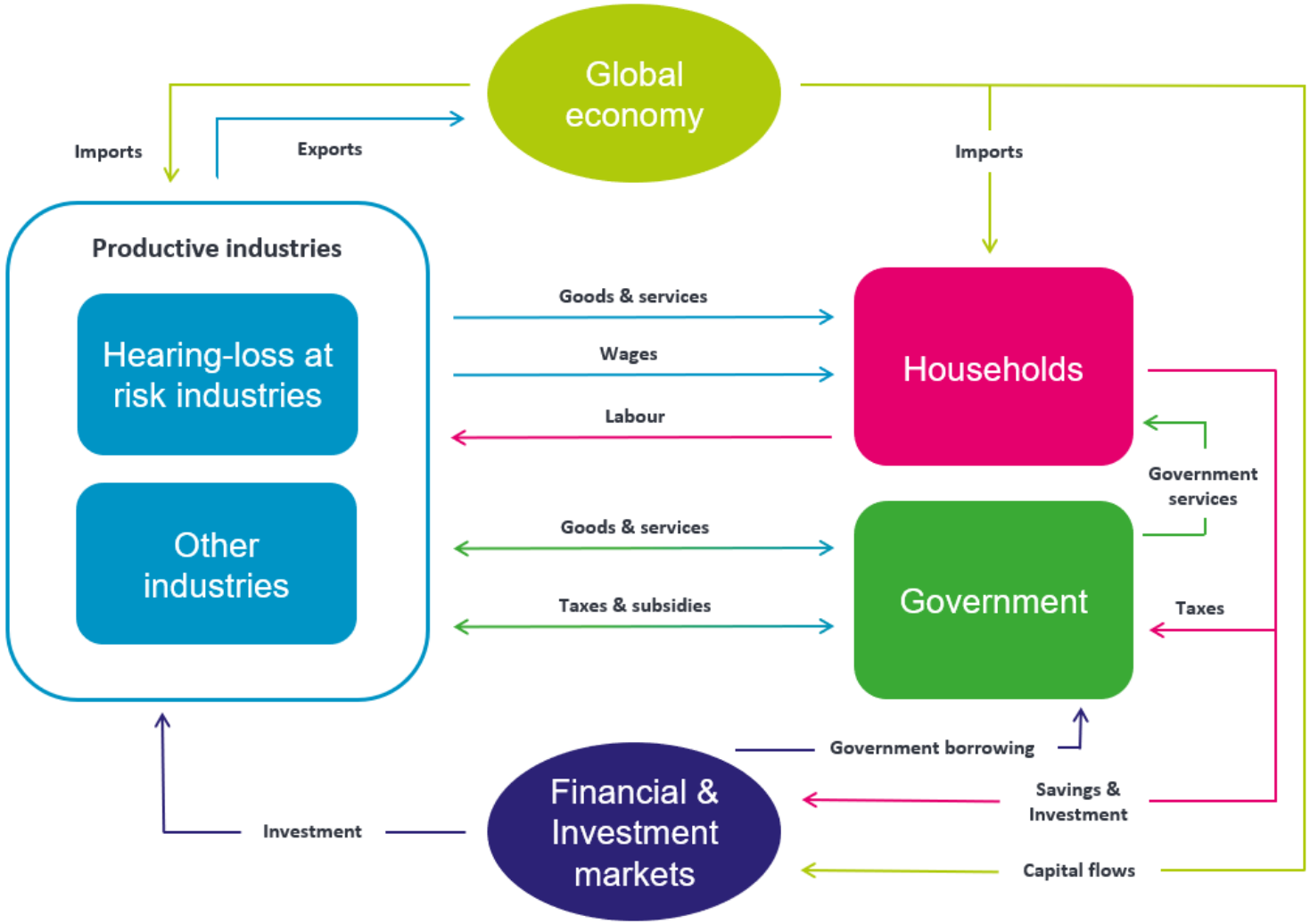
NZIER's ORANI-NZ[7] model is a top-down CGE model of the New Zealand economy.

ORANI-NZ is based on a Stats NZ's Input-Output table that identifies the structure of the industries involved. It contains information on 106 industries, 201 commodities. It therefore offers a unique capability to highlight the benefits of mitigating some of the effects of hearing loss on the New Zealand economy, especially those related to the work environment.

Figure 10 shows how the model captures the complex and multidirectional flows between the various actors of the national economy and how they interact with the rest of the world. More technical details on the model are available upon request.

[7] ORANI-NZ was developed at NZIER based on the original Australian ORANI model created by Professor Mark Horridge of the Centre of Policy Studies, Victoria University-Melbourne, Australia. https://www.copsmodels.com/oranig.htm. NZIER maintains close connections with the Centre, ensuring that our modelling techniques reflect international best-practice.

Figure 10 Our CGE model represents the circular flows between all the agents and activities in the economy



Source: NZIER

A.5 Our modelling approach

A.5.1 Core data is based on Stats NZ's Input-Output tables

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

The database has been sourced initially from Stats NZ's 2013 Input-Output tables (released in November 2017).

A.5.2 Business-as-usual 2019

Our first step is to develop a baseline or BAU picture of the economy. To do so, we calibrate our model of the national economy to the latest available data from Stats NZ's National Accounts (2019). This allows us to ensure we correctly benchmark the size of the various industries and gives us a BAU snapshot of the national economy.

A.5.3 Scenario design

As stated previously, we are interested in estimating the economic benefits of mitigating hearing loss in the working population.

For our scenario design, we implement shocks to represent what the national economy would look like with different levels of labour productivity and employment increases associated with measures taken to encourage employment and reduce absenteeism and/or presenteeism of people suffering from hearing loss.

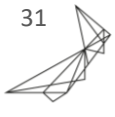
These scenarios are intended to establish the potential 'size of the prize'. They indicate the lower and upper limits of the potential benefits before considering the practical challenges and the cost of mitigating the challenges. The scenarios provide a counterfactual 'what if?' By quantifying the 'what if' scenarios, insights are gained into whether improving labour market and work access for people with hearing loss is worthy of more detailed investigation by policy makers.

Given the lack of recent official data and for sensitivity analysis purpose, we define a low, central and high bound for each of these two scenarios. Table 6 below summarizes the different shocks we model.

Labour productivity increase

In this scenario, labour productivity increases across all industries through improved measures within the work environment, which would translate into lesser absenteeism and presenteeism.

In this set of scenarios, we assume a 4.6% labour productivity increase of workers with hearing loss if presenteeism and absenteeism were reduced. This percentage is derived from our literature findings. It is the combination of the 3% labour productivity effect from presenteeism and 1.6% labour productivity effect from absenteeism.



To design a shock on labour productivity at the aggregate level, we used data from official sources (Stats NZ) and from the literature to estimate:

- Labour force participation rate for people with hearing loss
- People employed with hearing loss and their share in the total labour force
- Labour productivity effects on people with hearing loss.

From these estimates, we translate the labour productivity increase of people with hearing loss into a labour productivity shock at the national level. Given the lack of official statistics regarding the labour force participation rate of people with hearing loss, we model a national labour productivity increase with three different range:

- Low scenario: 0.19% labour productivity increase
- Central scenario: 0.22% labour productivity increase
- High scenario: 0.25% labour productivity increase.

Table 12 and Table 13 highlight the data used, their sources and the different steps to estimate our labour productivity shocks for the low, central and high scenario.

Table 12 New Zealand labour market

2018

Indicator	Indicator	Population	Source
National population	Unemployed in labour force	119,000	Stats NZ, 2018
	Employed in labour force	2,587,100	
	Total labour force	2,706,100	
	Labour force participation rate	71%	
	Unemployment rate	4%	
People with hearing loss	Working age population	231,576	Derived from Table 3, Stats NZ 2018
	Potential of labour productivity increase (3% for presenteeism, 1.6% for absenteeism)	4.60%	Derived from literature review, NZIER

Source: Stats NZ (2018), NZIER

The last row in Table 13 presents our estimates for a national labour productivity shock under our low, central and high scenarios.

A 4.6% labour productivity increase of workers suffering from hearing loss (Table 12) translates into a national labour productivity increase of 0.19%, 0.22% and 0.25% under the low, central and high scenario, respectively, depending various assumptions on the participation rate of people suffering from hearing loss into the labour force.

Table 13 Labour productivity shocks

2018

Indicator	Low	Central	High	Source
Estimated labour force participation rate for people with hearing loss	47%[8]	54%[9]	61%[10]	Stats NZ, Jensen et al. (2005)
People employed with hearing loss	108,841	124,588	140,335	Derived from estimates on the working age population with hearing loss (Table 12) and labour force participation rate for people with hearing loss (this table)
Share of employed people with hearing loss in total labour force	4.21%	4.82%	5.42%	Derived from total labour force estimates (Table 12) and employed people with hearing loss (this table)
Pro-rated labour productivity shock-	**0.19%**	**0.22%**	**0.25%**	Derived from potential of labour productivity increase (Table 12) and share of employed people with hearing loss in total labour force (this table)

Source: NZIER

Employment increase

Under this scenario, national employment increase among people with hearing impairment to reflect what might happen if the employment gap was reduced between people suffering from hearing loss and the national employment rate. In this set of scenarios, we assume that only a portion of jobs are readily available (40%).

Similarly, to labour productivity scenario, we used data from official sources (Stats NZ) and estimates from the literature to define three different levels of economy-wide employment increase:

- Low scenario: 0.10% national employment increase
- Central scenario: 0.15% national employment increase
- High scenario: 0.21% national employment increase.

Table 14 below describes the different data used and steps to estimate an economy-wide shock on employment for the low, central and high scenarios.

We assume that the unemployment gap for people with hearing loss is reduced by 40% and that there is no displacement of existing employees. A reduced unemployment gap therefore translates into a 0.10%, 0.15% and 0.21% increase in national employment level under the low, central and high scenarios, respectively, if we consider different levels of unemployment rate for people suffering from hearing loss (7%, 8.5% and 10%).

8 Stats NZ, Disability and the labour market: Findings from the 2013 Disability Survey. http://archive.stats.govt.nz/browse_for_stats/health/disabilities/disability-and-labour-market/labour-force-partic.aspx

9 Our own assumption calculated as the median labour participation rate for people with hearing loss between low and high estimates

10 Jensen et al. (2005)

Table 14 Employment shocks

2018

Indicator	Low	Central	High	Source
Unemployment rate for people with hearing loss	7%[11]	8.5%[12]	10%[13]	Stats NZ, Jensen et al. (2005)
Unemployment gap of people with hearing loss compared with national average	3%	4.5%	6%	Derived from national unemployment rate (Table 12) and unemployment rate estimates for people with hearing loss (this table)
Unemployment gap, population	6,947	10,421	13,895	Derived from working age population with hearing loss (Table 12) and unemployment gap rate (this table)
Unemployment gap of people with hearing loss is reduced by 40%[14]	2,779	4,168	5,558	Derived from unemployment gap population (this table) and a 40% reduction of unemployment gap assumption
Pro-rated employment shock	**0.10%**	**0.15%**	**0.21%**	Reduction of the employment gap as a share of total labour force

Source: NZIER

Table 15 presents a summary of the different scenarios we modelled to simulate a labour productivity and employment increases, at the national level.

Table 15 Labour productivity and employment increases scenario

Changes from 2019 baseline in percent

Indicator	Low	Central	High
Industry labour productivity increase	0.19%	0.22%	0.25%
National employment increase	0.10%	0.15%	0.21%

Source: NZIER

A.6 Closure

As noted previously, in any CGE model, it is important to understand which factors have been allowed to vary and which remain fixed by assumption (also known as exogenous variables). The particular combination of fixed factors is known as the closure.

We choose a long-term closure as labour productivity and employment increases resulting from mitigating hearing loss negative effects tend to happen with some delay. This is because the adoption of measures and policies which can improve work access and

11 Stats NZ, Disability and the labour market: Findings from the 2013 Disability Survey. http://archive.stats.govt.nz/browse_for_stats/health/disabilities/disability-and-labour-market/labour-force-partic.aspx

12 Our own assumption calculated as the median unemployment rate for people with hearing loss between low and high estimates.

13 Jensen et al. (2005)

14 Assumption based on our literature review.

According to the NZ Disability survey (NZ Stats, 2013), about 50% of people with hearing disability find it difficult to get into the labour market. Another study focusing on the UK (RNID, 2006) states that 20% of the people suffering from hearing loss and sampled in the survey were unemployed and looking for work.

productivity of people with hearing loss might require some organisational adjustments to fulfil its potential.

Table 16 lists the main variables included in the modelling underlying this report.

- National employment is fixed but labour is completely mobile between industries and real wages adjust to labour market changes. This is consistent with the idea that both the labour force and the rate of employment are, in the long run, determined by mechanisms outside the model.
- Household and government expenditures move together to accommodate a fixed balance of trade as a share of GDP. This is to prevent negative welfare effects from having unsustainable trade deficit.
- Rates of return are exogenous, and capital is mobile between industries. This mobility can occur either in the form of machinery etc. being physically moved, or capital in one industry being allowed to depreciate without replacement while investment builds up the stock of another industry.
- Foreign currency prices of imports are naturally exogenous.
- Real government consumption is also exogenous.

Other exogenous variables include rates of production tax, technological coefficients, national population, and national labour supply.

Table 16 Fixed elements of the CGE model

Variables
Taxes on production
Technological change
Government demand
Gross growth rate of capital
Gross rate of return on capital
Number of households
National population
National labour supply
Import prices, foreign currency
Foreign demand for New Zealand exports
Land use

Source: NZIER

A.7 Assumptions and caveats

Below is a list of assumptions and caveats we made for our modelling exercise.

- Given the lack of sectoral data regarding the prevalence of hearing loss among workers, we have modelled economy-wide labour productivity and employment increases to reflect the economic benefits of mitigating hearing loss, especially amongst workers.

- There is also little recent literature and data on how hearing loss might affect labour productivity and employment in New Zealand.
- We have tried to reflect the uncertainty associated with the lack of recent literature and data available by modelling a range of scenarios (low, central, high). As more information and data becomes available on hearing loss, its prevalence and its associated costs, we will be able to carry out further economic modelling as required.
- The analysis is static, looking at the impacts of the changes on the New Zealand economy at a point in time. In reality, the benefits of mitigating the negative effects associated with hearing loss will be spread across a few years. We do not explicitly model the dynamics of increased labour productivity and employment over time.
- While the model database is highly disaggregated, it still invariably suffers from aggregation bias – we are modelling the effects of mitigating hearing loss effects on entire industries rather than at the firm-level.
- The CGE model is based on Stats NZ's 2013 Input-Output tables and updated to 2019 levels using Stats NZ's latest national accounts available.
- The CGE model is based on neoclassical economics. Structural changes to the economy that may rise with the uptake of cloud computing are therefore not captured in the modelling, nor are any non-competitive market structures. This means the actual distribution of costs and benefits may differ in reality if firms with market power absorb price and cost movements in their profits.

Appendix B Sectoral mapping

Table 17 Concordance table from 106 industries to 50 sectors

106 Industries	50 aggregated sectors
Horticulture and fruit growing	Horticulture
Sheep, beef cattle, and grain farming	Sheep and beef
Dairy cattle farming	Dairy cattle
Poultry, deer, and other livestock farming	Poultry
Forestry and logging	Forestry
Fishing and aquaculture	Fishing
Agriculture, forestry, and fishing support services	Agriculture services
Coal mining	Coal mining, oil and gas extraction
Oil and gas extraction	Coal mining, oil and gas extraction
Mining and quarrying	Mining and exploration
Exploration and other mining support services	Mining and exploration
Meat manufacturing	Meat processing
Seafood processing	Seafood processing
Dairy product manufacturing	Dairy processing
Food manufacturing	Fruit processing
Beverage manufacturing	Beverages and tobacco
Textile and leather manufacturing	Textile and clothing
Clothing and footwear manufacturing	Textile and clothing
Wood product manufacturing	Wood processing
Pulp and paper product manufacturing	Pulp, paper and print
Printing	Pulp, paper and print
Petroleum and coal manufacturing	Petrol manufacturing
Basic chemical manufacturing	Chemicals manufacturing
Fertiliser and pesticide manufacturing	Fertiliser manufacturing
Pharmaceutical manufacturing	Pharmaceuticals
Polymer and rubber manufacturing	Rubber
Non-metallic mineral product manufacturing	Metals manufacturing
Metal product manufacturing	Metals manufacturing
Fabricated metal product manufacturing	Metals manufacturing
Transport equipment manufacturing	Transport equipment
Electronic and electrical equipment manufacturing	Electrical equipment
Machinery manufacturing	Machinery
Furniture manufacturing	Other manufacturing
Other manufacturing	Other manufacturing
Electricity generation and on-selling	Electricity generation
Electricity transmission and distribution	Electricity generation

106 Industries	50 aggregated sectors
Gas supply	Gas and water supply
Water supply	Gas and water supply
Sewerage and drainage services	Sewerage/waste
Waste collection, treatment, and disposal services	Sewerage/waste
Residential building construction	Construction
Non-residential building construction	Construction
Heavy and civil engineering construction	Construction
Construction services	Construction
Basic material wholesaling	Wholesale
Machinery and equipment wholesaling	Wholesale
Motor vehicle parts wholesaling	Vehicle wholesaling
Grocery and liquor product wholesaling	Wholesale
Other goods wholesaling	Wholesale
Motor vehicle parts retailing	Retail
Fuel retailing	Retail
Supermarket and grocery stores	Retail
Specialised food retailing	Retail
Furniture and hardware retailing	Retail
Recreational and clothing retailing	Retail
Department stores	Retail
Other store-based retailing	Retail
Accommodation	Accommodation
Food and beverage services	Food and beverages
Road transport	Road transport
Rail transport	Rail transport
Other transport equipment	Other transport equipment
Air and space transport	Air transport
Postal and courier services	Transport and storage
Transport support services	Transport and storage
Warehousing and storage services	Transport and storage
Publishing	Media and communication services
Motion picture and sound recording activities	Media and communication services
Broadcasting and internet publishing	Media and communication services
Telecommunications services	Media and communication services
Library and other information services	Media and communication services
Banking and financing	Finance and insurance
Life insurance	Finance and insurance
Health and general insurance	Finance and insurance
Superannuation and individual pension services	Finance and insurance
Auxiliary finance and insurance services	Finance and insurance
Rental and hiring services	Property services

106 Industries	50 aggregated sectors
Residential property operation	Property services
Non-residential property operation	Property services
Real estate services	Property services
Owner-dwelling	Property services
Architectural and engineering services	Architectural services
Legal and accounting services	Business services
Advertising, market research, and management services	Business services
Professional services	Business services
Computer system design services	Business services
Travel agency services	Business services
Employment and other services	Business services
Building cleaning and other support services	Business services
Local government services	Local and central government
Government services	Local and central government
Defence	Local and central government
Public order, safety, and regulatory services	Local and central government
Preschool education	Education and health
School education	Education and health
Tertiary education	Education and health
Adult, community, and other education	Education and health
Hospitals	Education and health
Medical and other health care services	Education and health
Residential care and social assistance	Education and health
Heritage and artistic activities	Education and health
Sport and recreation services	Sport and recreation services
Gambling activities	Sport and recreation services
Repair and maintenance	Other personal services
Personal services	Other personal services
Labour unions and other interest groups	Other personal services

Source: NZIER