Economic potential of cloud-based business tools

NZIER report to Xero

Early March 2020, prior to COVID-19 Alert Level Two

Please note, this paper was developed prior to the COVID-19 pandemic impacting the New Zealand economy. Therefore, the specific details within this report need to be reviewed with this in mind.

About NZIER

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice.

We undertake and make freely available economic research aimed at promoting a better understanding of New Zealand's important economic challenges.

Our long-established Quarterly Survey of Business Opinion (QSBO) and Quarterly Predictions are available to members of NZIER.

We pride ourselves on our reputation for independence and delivering quality analysis in the right form and at the right time. We ensure quality through teamwork on individual projects, critical review at internal seminars, and by peer review.

NZIER was established in 1958.

Authorship

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Key points

Xero commissioned NZIER to investigate the economic potential of cloud-based business tools (herein references as cloud computing) to support the productivity and performance of New Zealand business and the flow-on impacts to the New Zealand economy.

Our approach to understanding the benefits of increasing cloud computing uptake in New Zealand

We used NZIER's computable general equilibrium (CGE) model of the New Zealand economy to estimate the economic benefits of a 20% increase in the uptake of cloud computing. The modelling was grounded in the results for businesses found in the literature.

We modelled three multi-factor productivity[1] improvement scenarios associated with a 20% increase in cloud computing uptake compared to baseline:

- Low scenario: +2.5% multi-factor productivity
- Central scenario: +3.5% multi-factor productivity
- High scenario: +4.5% multi-factor productivity.

We estimated that the economic benefit of a 20% increase in the uptake of cloud computing would be an increase of real GDP by between \$3.5 billion and \$6.2 billion.

Macro results are driven by higher annual production and profitability across industries

A 20% increase in the uptake of cloud computing by businesses would have the following estimated effects, at the national level:

- GDP increases by between \$3.5 billion and \$6.2 billion (1.2–2.1%).
- Household spending increases by between \$2.6 billion and \$4.6 billion, and living standards are improved.
- Output increases by between \$4.1 billion and \$7.3 billion annually.
- Real wages increase by between \$1.8 billion and \$3.3 billion.
- Capital stock increases by between \$1.1 billion and \$1.9 billion.
- Exports increase by between \$341 million and \$618 million.

1 See Appendix E for a discussion of what we mean by the term multi-factor productivity.

The benefits to businesses include:

- Increased multi-factor productivity with economies of scale and organisational changes.
- Improved accuracy of information by reducing manual inputs and risk of duplicate entries.
- Enhanced agility and mobility of staff through decoupling information with the location of the desk location.
- More time for management to spend on strategy and innovation by reducing administrative tasks.
- Enabling scalability on demand, while lowering the onsite investment pressures.

The barriers to using cloud computing include:

- The time required to understand how it could fit in with each unique business.
- Skill and knowledge development needed to adapt and use cloud-based tools.
- Concerns about security and privacy of information in the cloud.
- Infrastructure and network needing to have access anywhere and anytime.
- Costs of cloud-based tools and changing to new systems.

Realising the potential benefits requires increasing the level of adoption

In section 5 we suggest some industry and/or government actions to mitigate/reduce the barriers to adoption. Some actions require an industry-led approach, while others require either a government-led approach or joint action.

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1 Objectives

NZIER was commissioned by Xero to investigate the economic potential of cloud-based business tools to support the productivity and performance of business in New Zealand, which have flow-on effects to the wellbeing of people in New Zealand.

1.1 Research objectives

The research explored four key questions:

- What are the benefits and productivity effects of cloud computing?
- What is the current and projected uptake for New Zealand?
- What are the barriers to uptake?
- What is the role of government in facilitating or impeding use and uptake?

1.2 Scope of the research

The scope of the research includes:

- The benefits to business in New Zealand, including small business.
- The role of government in supporting the adoption of cloud computing.
- The impact on New Zealanders' wellbeing and living standards.
- Cloud accounting, but we looked at all types of cloud-based business tools.

The scope excludes the effect on businesses outside New Zealand, but it is clear that cross-border information flows and digital mobility are important issues.

1.3 Structure of the report

Section 2 outlines our approach to this research.

Section 3 covers the international and local experience of the benefits, barriers, and role of government associated with the adoption of cloud computing. The aim of this section was to provide a rich understanding of cloud computing to build the evidence base for the economic modelling in the next section.

Section 4 describes the scenario design and the economic effects of productivity improvements for businesses as a result of the increased use of cloud computing. The benefits for business flow-on to output effects, wage effects and capital investment. This leads to changes in household living standards and increases real GDP.

1.4 Research funding statement

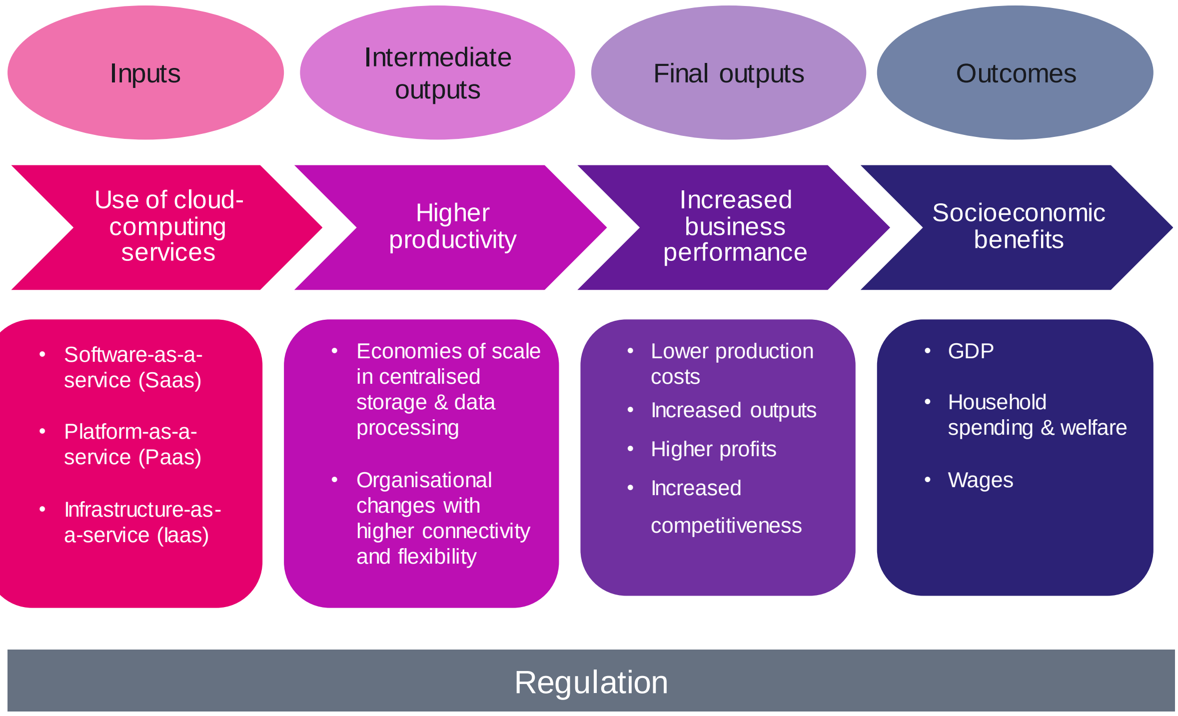
The research was funded by Xero.

2 Our approach

Figure 1 presents the intervention logic we used to investigate the economic benefits of increasing the uptake of cloud computing.

The intervention logic begins with greater uptake in the use of cloud-computing services as an input, which leads to higher productivity and drives improved business performance. A portion of businesses’ higher profits is reallocated toward increased real wages, which leads to higher household spending. As a result, household welfare and New Zealand’s GDP expand.

Figure 1 Intervention logic for cloud computing



Source: NZIER

As a starting hypothesis, we assumed that regulation can be a factor in all stages of the intervention logic because regulation provides the rules of the game. For cloud computing, regulation can support market confidence, professional codes of practice, privacy and international transactions.

The research had two stages. The first stage involved completing a literature review to test the intervention logic and investigate the following research questions:

- What are the benefits and productivity effects of cloud computing?
- What is the current and projected uptake for New Zealand?
- What are the barriers to uptake?
- What is the role of government in facilitating or impeding use and uptake?

The second stage involved modelling the effects of cloud computing on the economy using a computable general equilibrium (CGE) model of the New Zealand economy.

3 Literature review

We began by examining what the international and New Zealand literature says about the impact of cloud computing on businesses and the government. Findings from the literature helped us quantify the impact of cloud-computing tools on the New Zealand economy (Section 4). During this process, we discovered common themes across several studies. The literature is summarised in a manner that answers some common questions a reader may have about cloud computing and allows us to quantify its impact for New Zealand.

3.1 What is cloud computing?

Cloud computing can be traced back to the use of virtual machines in the 1990s (Foote 2017; Neto 2014). The term 'cloud computing' was coined by George Favaloro, a marketing executive for Compaq Computer and Sean O'Sullivan, founder of the now extinct business NetCentric but more widely used from 2006 when it was mentioned by Google's then CEO, Eric Schmidt (Daylami 2015).

The National Institute of Standards and Technology (NIST) defines cloud computing as enabling on-demand and convenient access to a shared pool of computing resources (e.g. applications, servers, storage, networks and services), which can be accessed rapidly with minimal interaction from the service provider (Liu et al. 2011). Cloud computing can be characterised by three services and four deployment models. The three services are:

- Software-as-a-service (SaaS): The software is installed on a remote computer, which the users can then access remotely without the concerns of installation and maintenance. Users can rent it on a pay-per use or a subscription model. Examples include Google Docs, Microsoft Office 365, etc.
- Platform as a service (PaaS): Service providers provide a development environment for application developers to implement and maintain their applications. Users do not need to worry about the amount of memory, storage and processing power required for their applications. PaaS provides a 'Software Lifecycle' since users can implement their applications on the cloud directly. Examples include Amazon Web Services (AWS), Google App Engine and Microsoft Azure.
- Infrastructure as a service (IaaS): Companies are provided with computing resources such as servers, networking, storage and data centre space. Users can deploy and run both operating systems and applications. The main benefit is that users have no responsibility on deployment, maintenance and administration. An example is Amazon EC2.

The four types of deployment models are public, private, community and hybrid. We describe each of these below.

Public cloud: Services are owned by companies that offer access to the general public over the internet. Users do not pay for hardware, software, or supporting infrastructure, which is owned by the provider. Issues with privacy and security are discussed with public cloud. Examples include email services, photo storage services, etc.

Private cloud: The infrastructure is for a single organisation. It can be managed and hosted internally or externally by a third party. There is a greater level of security as the data stored can only be accessed by trusted users in an organisation. The organisation may need to spend more on purchasing the software and hardware for having its own cloud.

Community cloud: Similar to private cloud. Services may be shared among organisations with similar goals and requirements and managed by third parties or the organisations themselves. The setup cost is cheaper than private cloud because the cost can be shared by multiple organisations. A drawback is that the data storage is shared by the multiple organisations. An example is educational cloud that can be shared between universities globally for research.

Hybrid cloud: A composition of two or more clouds – public, private or community. The clouds combine their resources to provide the service. Due to this, the advantages of public and private cloud can be achieved. It can be easier to handle security concerns as an organisation's data can be stored in a private storage. This cloud is usually used for backup purposes.

3.2 What are the benefits of cloud computing?

From our literature review, we identified five major benefits. While we summarise the literature within these themes, it was evident that the impacts from these benefits overlapped.

- Increased multi-factor productivity
- Improved accuracy of information
- Enhanced flexibility and mobility of staff
- More time for management to spend on strategy and innovation
- Enabling scalability on demand while lowering the onsite investment pressures.

Increased multi-factor productivity

In a nutshell, multi-factor productivity measures the increase in output from factors not directly related to production. These factors include technological change, advancement in knowledge, organisational changes, etc. (Solow 1957). Further details can be found in Appendix E.

There are productivity benefits from reduced IT infrastructure costs. Businesses reported an average productivity increase of 29.6% over 5 years (Deloitte Access Economics 2019). Productivity gains can be seen in increased sales revenue (Deloitte 2018).

In addition, Coyle and Nguyen (2018) estimated the productivity impacts through cloud computing in the EU to be a GDP gain of between 0.46% to 1.09%.

An OECD (2019) paper discussing the impact and role of government policy from cloud computing describes GDP growth in the EU ranged from 0.05% in the short run to 0.3% in the long run. Unemployment rate in the EU reduced between 0.2% in the short term (1 year) and 3% in the medium term (5 years).

A study of small businesses in the UK measured cloud computing productivity through sales per employee (Enterprise Research Centre 2018). It found that cloud computing leads to an increase of 13.5% in sales per employee after three or more years. Cloud accounting software leads to an increase of 11.8% in sales per employee after three or more years. Findings from research on digitalisation and productivity in European countries (Gal et al. 2019; Sorbe et al. 2019) show that increasing cloud computing uptake by 10 percentage points increases multi-factor productivity by 0.9% instantaneously, by 2.3% after three years, and by 3.5% after five years.

Improving the accuracy of information

Accuracy of information can refer to a reduction in error of processed information or better-quality information. This theme was common among studies that looked at cloud accounting, e-invoicing or digital invoicing. Automating invoices in the cloud means there is less room for error and a reduction in error from automating the data checking process as well. As the number of errors is reduced, the number of disputes can be reduced, which means an improvement in client relationships. Furthermore, invoice data on the cloud means the invoice is secure and undamaged during delivery (Deloitte Access Economics 2019; Collis, Alkhatib, and de Cesare 2018; Cedillo et al. 2018).

Fong and Connaughton (2015) found that e-invoicing led to an improvement in invoicing accuracy by 37% and an improvement in on-time payments by 32%.

In general, more accurate information on the cloud means better quality and up-to-date information available, e.g. TripAdvisor, as opposed to hard copy travel guide books (New Zealand Productivity Commission and Australian Government Productivity Commission 2019).

Enhanced flexibility and mobility of staff

With cloud computing, organisations can access cloud facilities anytime and anywhere. This benefit was identified by several researchers such as Radack (2012), Bidgoli (2018) and Coyle and Nguyen (2018). Users, therefore are not concerned about the platform used, e.g. Windows PC, Mac, Chrome, Firefox, etc. (Allahverdi 2017).

Furthermore, the agility and flexibility of cloud computing platforms can allow organisations to be more competitive (Badr and Asmar 2020; Deloitte Access Economics 2019) by enabling companies to share information with their clients in real time, which improves communication and collaboration (Dimitriu and Matei 2014). This in turn can create access to new customers (Deloitte 2018). Additionally, real time communication can make handling disputes easier (Cedillo et al. 2018). A study of cloud accounting revealed that implementing e-invoicing solutions can reduce the time spent on supplier inquiries by 34% (Fong and Connaughton 2015).

On an individual level, mobility can allow users to have a better work/life balance. This means users can spend more time advising clients and less time on labour-intensive tasks (Alexander 2017).

Management has more time to spend on strategy and innovation

There are a number of advantages for management strategy and innovation. The product development cycle is shortened with cloud computing. This accelerates product launch times and improves the quality and availability of cloud applications. IT management and computing are done in the cloud, management can reallocate their time to other areas of focus, such as strategy and innovation. IT can shift focus to greater automation, the organisation can now reallocate their time and resources to other areas of innovation and strategy (Bidgoli 2018).

Enabling scalability on demand while lowering the onsite investment pressures

A common view across several studies is the ability for companies to only pay for the cloud services they use and to be able to add and remove services as required (Deloitte 2017; Ma 2015). This business model is referred to as the 'pay-as-you-go' model.

The most notable savings from this type of business model is on IT infrastructure costs. Cloud adoption means there is less hardware to purchase and support, which is accompanied by lower maintenance and implementation costs. Mangiuc (2017), Allahverdi (2017) and Cleary and Quinn (2016) identify this as one of the largest economic benefits. These authors estimate **cloud computing can reduce IT costs by between 20% and 50%**.

An investigation of cloud computing in Greece (Chatzithanasis and Michalakelis 2018) found that there could be additional cost savings from backed-up data in case of a disaster. Additionally, this study estimates that **cloud computing could reduce IT costs by between 24% and 50% per month.** Furthermore, a study of cloud computing in the EU shows that 80% of firms that use **cloud computing in the EU saw a 10% to 20% reduction in costs** (Parlinska 2017)**.**

We also found that firms using cloud accounting or e-invoicing had:

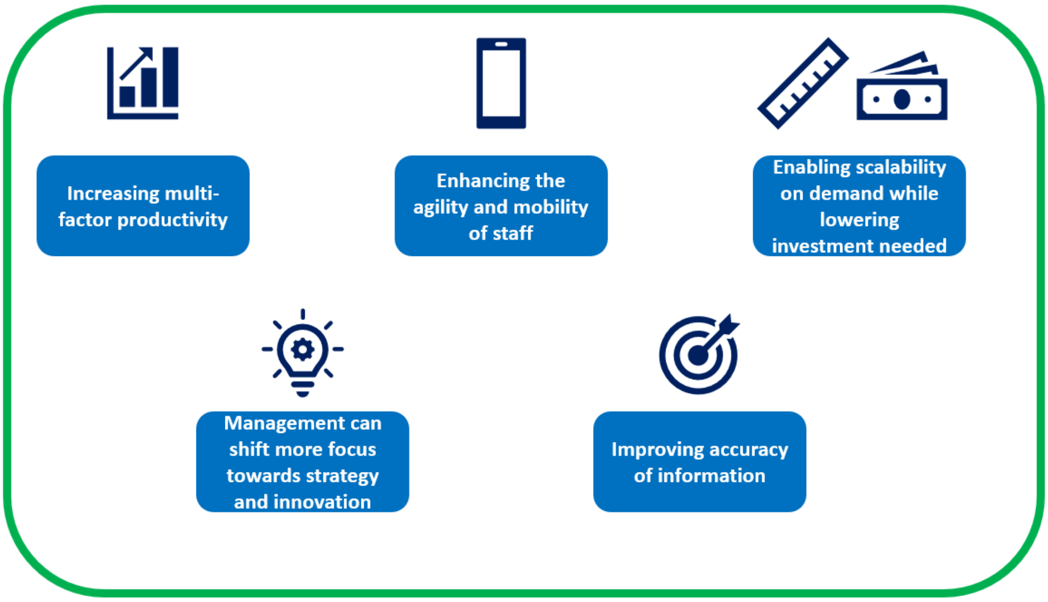
- Reduced paper invoicing costs by between 42% and 80% (Ali 2016; Fong and Connaughton 2015; Koch 2017).
- Created savings between 1% and 2% of turnover (Koch 2017).

Some flow-on effects from scalability and lower costs can include:

- More capital expenditure available for investment to encourage growth and productivity due to a shift from capital expenditure to operating expenditure (Deloitte 2017; Cleary and Quinn 2016; Bidgoli 2018).
- A reduction in energy consumption due to economies of scale and energy efficiencies at large data centres (Coyle and Nguyen 2018).
- Increased competitiveness and lower prices: If for example, organisations use a public cloud provider, the cost of this cloud service would be divided among several users, which makes it cheaper than traditional computing methods (Bidgoli 2018). This means smaller businesses can use the latest on-demand and powerful software and tools, which would previously only be used by larger firms (Badr and Asmar 2020; Arrowsmith 2017). Such business models can increase competitiveness and lower prices (New Zealand Productivity Commission and Australian Government Productivity Commission 2019).

The key benefits of cloud computing are shown in Figure 2 below.

Figure 2 Key benefits from the adoption of cloud computing



Source: NZIER

3.3 How big is the cloud computing market in New Zealand?

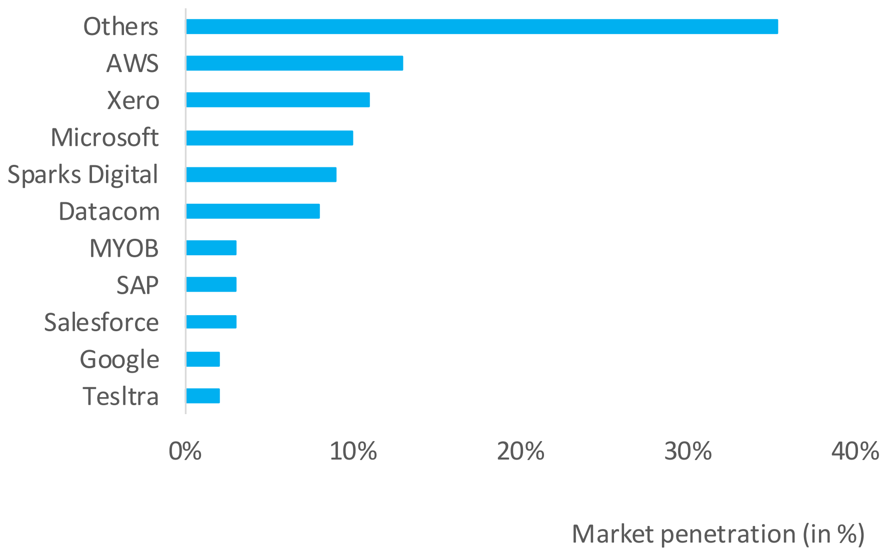
Cloud computing is a fast-growing market

The International Data Corporation (IDC) (2019) estimated that in 2018, the revenue from public cloud services in New Zealand to be $1 billion, and there has been 30.1% growth annually from 2017. The New Zealand cloud market is expected to expand to about $2.5 billion by 2021.

Software-as-a-service (SaaS) and Infrastructure-as-a-service (IaaS) are the main sources of public cloud services revenue but growth rates have declined to 30% and 26%, respectively, since 2017. Still, according to IDC, Program-as-a-service (PaaS) has experienced the strongest growth (45.6%) in 2018, mostly the consequence of businesses increasingly turning to cloud-native application development.

Figure 3 below presents the market penetration of the top 10 players in New Zealand for providing cloud-computing services in 2016. Excluding other businesses, Xero is ranked second with 11% market penetration, right behind Amazon Web Services (AWS), which has 13% market penetration.

Figure 3 Market penetration in New Zealand



Source: Ellington (2018)

3.4 What is the uptake of cloud computing?

Adoption rates of cloud computing vary significantly between countries with countries such as the UK exhibiting high adoption rates (88%) through to Latvia, Romania, Bulgaria, Greece and Poland exhibiting less than 10% adoption rates. Table 1 below shows cloud adoption rates for various countries.

Table 1 Cloud adoption rates vary significantly between countries

Various years

Country	Adoption rate	Additional comments	Reference
UK	88%	Cloud computing	Hostingtribunal.com (2019)
UK	40%	Cloud computing and cloud accounting. Small business uptake	Enterprise Research Centre (2018)
EU	26%	Cloud computing	Hostingtribunal.com (2019)
US	74%	Cloud computing. Small businesses uptake (50 employees or less)	Bidgoli (2018)
US	75%	Public cloud computing	Đorđević, Radović, and Bonić (2018)
Ireland	37%	Cloud accounting	Cleary and Quinn (2016)
Finland	51%	Cloud computing	Deloitte (2017)
Finland	53%	Cloud computing. Businesses with 10+ employees	Dahlberg, Kivijärvi, and Saarinen (2017)
Finland	73%	Cloud computing. Businesses with 100+ employees	Dahlberg, Kivijärvi, and Saarinen (2017)
Italy	40%	Cloud computing	Deloitte (2017)

Country	Adoption rate	Additional comments	Reference
Sweden	39%	Cloud computing	Deloitte (2017)
Denmark	38%	Cloud computing	Deloitte (2017)
Romania	<10%	Cloud computing	Deloitte (2017)
Latvia	<10%	Cloud computing	Deloitte (2017)
Bulgaria	<10%	Cloud computing	Deloitte (2017)
Greece	<10%	Cloud computing	Deloitte (2017)
Hungary	<10%	Cloud computing	Deloitte (2017)
Poland	7.3%	Cloud computing	Parlinska (2017)
Belgium	39% to 48%	Cloud accounting	Poel, Marneffe, and Vanlaer (2016)
Australia	42%	Cloud computing	Deloitte Access Economics (2019)

Source: Various

Uptake between countries can be difficult to compare as it relies on several factors such as government policy, country readiness, etc. This is evidenced by the large variations in adoption across EU countries. Furthermore, we find that adoption rates are slower in small to medium enterprises (SMEs) compared to medium and large businesses.

According to Deloitte (2017), there are differences in cloud adoption among industries as well. Finance and banking are the most intensive users of cloud computing, followed by the public sector and the telecom/media sector.

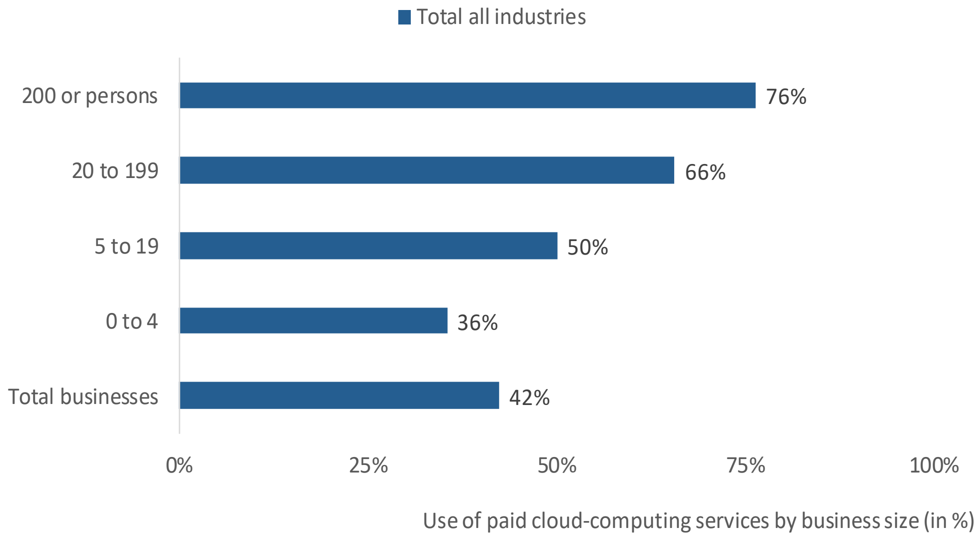
3.5 Are there any differences in uptake capability between SMEs and large businesses?

The use of cloud computing can vary depending on the size of businesses. Figure 4 shows that, across all industries in Australia, the use of paid cloud-computing services is the lowest in SMEs. Cloud computing services are used by 36% of businesses with less than 4 employees compared to 66% of businesses that employ 20 to 199 people.

Larger businesses (over 200 employees) have the highest use of paid cloud-computing services (76%).

Figure 4 Businesses use of cloud computing by business size for all industries

In percent, 2017/2018

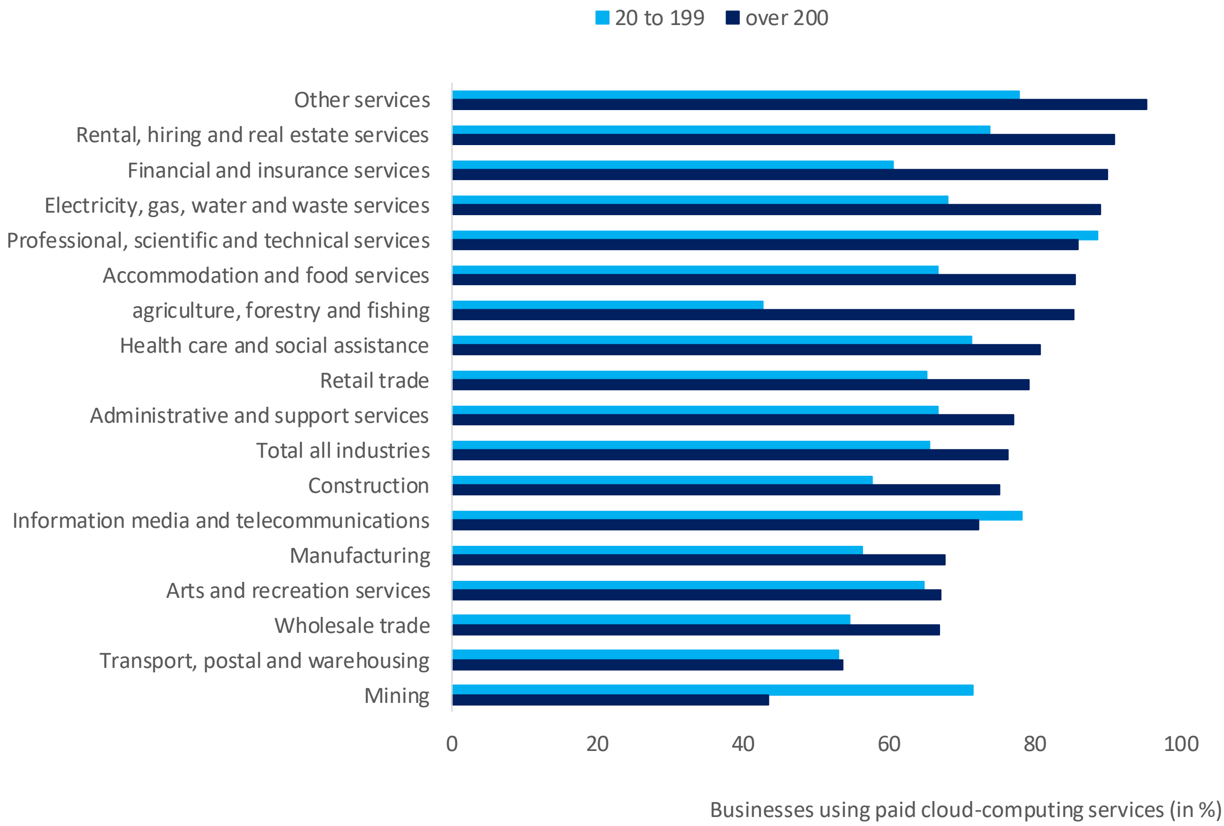


Source: Australian Bureau of Statistics

Figure 5 presents the use of paid cloud-computing services by industry and for businesses which employ 20 to 199 people and over 200 people. Except for mining, information media and telecommunication and, to a lesser extent, professional, scientific and technical services, businesses that employ over 200 people have a higher use of paid cloud-computing services compared to businesses with less than 200 employees.

Figure 5 Business use of cloud computing by industry and business size

In percent, 2017/2018



Source: Australian Bureau of Statistics

Additionally, cloud computing can give small businesses a competitive advantage over larger businesses because there is a reduced cost from no longer needing to invest in IT infrastructure upfront. This gives small businesses cheap access to leading edge applications (Bidgoli 2018).

3.6 What are the risks and challenges of cloud computing?

While there are several benefits of cloud computing, many studies have also discussed the risks and challenges that businesses face when adopting cloud computing.

A study on the European market (Deloitte 2017) revealed the following barriers:

- Data location requirements: these can limit the number of cloud computing options due to their costs.
- Security of data and data protection: there have been concerns about who has access to the data stored in the cloud and the measures in place to ensure there is no unauthorised access.
- Legal requirements and jurisdictions: if data is stored in different countries, each country may have its own laws, which may restrict data access.
- Lack of awareness and education about cloud computing: the low level uptake in some countries may be due to low levels of education around cloud computing.

These barriers can be translated into costs through internal staff spending time understanding and comparing the various cloud options for the users. Companies may also hire external advisors to help choose the most viable option.

Additionally, Allahverdi (2017)**,** Cleary and Quinn (2016) and Daylami (2015) discuss that there are challenges around**:**

- needing internet to access cloud applications.
- application performance.

Staff require training to get used to cloud accounting software. This can be time consuming, especially for staff that have previously used different software for several years (Arrowsmith 2017).

Several studies have shown the reduced IT infrastructure costs to be a benefit of cloud computing and cloud accounting. However, Fong and Connaughton (2015) noted that from a survey conducted, the cloud service provider fee was the biggest obstacle to e-invoicing adoption. Other barriers to e-invoicing adoption include lack of internal awareness, capacity to integrate tools, planning/resource constraints, and information about migrating to the cloud.

In-depth investigations into company management around cloud computing discussed: (Dahlberg, Kivijärvi, and Saarinen 2017; Howell 2015; The World Bank 2016):

- A firm's IT competency can influence its expectations and readiness of cloud computing deployment and performance.
- Most companies don't have a governance strategy so designing data governance that adequately covers the cloud can be a challenge.
- The transition from existing systems to the cloud requires managing change.
- As a company's needs evolve, they may face difficulties in switching between cloud vendors.
- If a company faces issues with its cloud-based software, it could suffer damage to its brand and reputation.
- Companies looking to switch to cloud computing may need to find a balance between cloud functionality and legacy systems.
- Some cloud solutions may not be suitable for larger companies, so those companies may take some time finding an appropriate cloud vendor.

While cost savings have been cited as a benefit of cloud computing, there can be costs incurred from switching to cloud systems as well as internal cultural issues (Deloitte Access Economics 2019; New Zealand Productivity Commission 2019; Schlagwein, Thorogood, and Willcocks 2014).

Table 2 ranks the barriers to the adoption of cloud computing in Australia and the US. Common themes include skill acquisition, skill shortages, privacy and security concerns, experience and costs.

Table 2 Key barriers to adoption of cloud computing

Percentages refer to the proportion of respondents who identified a barrier

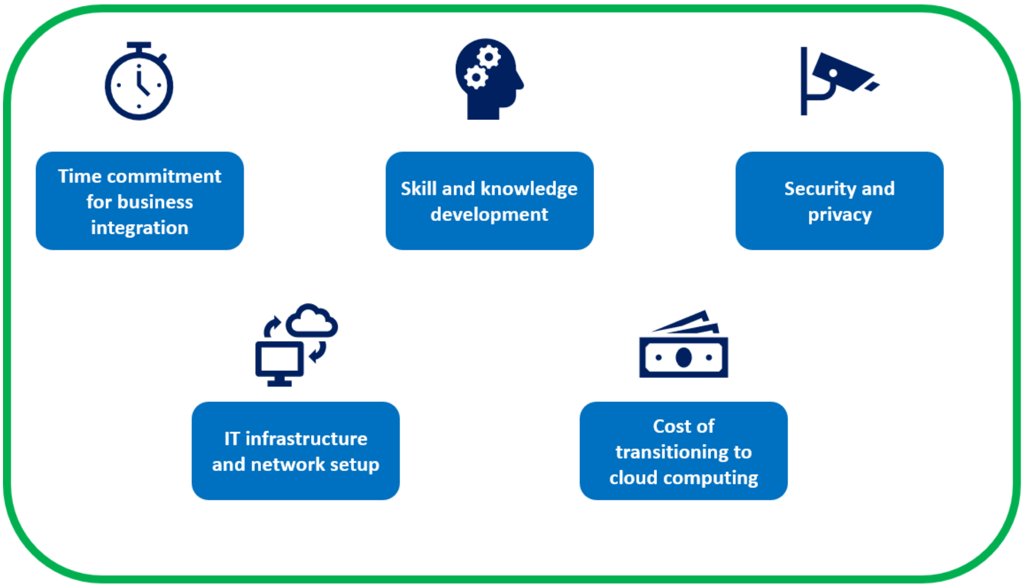
Australia	US
Challenges in staff education (37%)	Not relevant for their business (40%)
Issues in changing from legacy systems (37%)	Not effective for their business (38%)
Costs of adoption (35%)	Privacy and security concerns (34%)
Security issues (31%)	Inadequate experience with digital tools (30%)
Difficulty in switching data to new systems (30%)	Shortage of time to learn new systems (29%)
Change management issues (22%)	Costs of adoption (28%)
Skill shortages (22%)	Skill shortages (17%)
Cultural issues (9%)	No experience with digital tools (15%)
	Issues in changing from legacy systems (12%)
	Poor internet access (8%)

Source: Deloitte (2018); Deloitte Access Economics (2019)

For New Zealand, Small (2017) highlights that an improvement in internet connectivity in rural areas would increase adoption of cloud computing for agricultural purposes.

A summary of the key risks and challenges is shown in Figure 6 below.

Figure 6 Key risks and challenges of adopting cloud computing



Source: NZIER

3.7 The role of government in supporting or impeding uptake

It's easy to imagine ways the government could support the uptake of cloud computing, but we considered the ways the government could intervene in the market to improve the efficiency of the market.

The primary rationale for governments to intervene in markets is market failure. According to HM Treasury's guidance in the UK:

> "Market failure is where the market mechanism alone cannot achieve economic efficiency. Economic efficiency is achieved when nobody can be made better off without someone else being made worse off. Economic efficiency enhances social welfare by ensuring resources are allocated and used in the most productive manner possible." (HM Treasury 2018, p.13)

Digital New Zealand and accelerating government adoption of the cloud

The New Zealand government requires agencies to accelerate their adoption of public cloud services in a balanced way, so they can drive digital transformation. Actions include:

- enhancing customer experiences.
- streamlining operations.
- creating new delivery models.

The government (Digital.govt.nz 2019) has recognised the key benefits of using public cloud services include:

- **reducing costs** — public cloud services have very large economies of scale.
- **increasing workforce mobility** — cloud services can be accessed anywhere there is an internet connection.
- **improving collaboration** — people can work across teams, buildings and agency networks more easily.
- **greater agility** — new services can be established rapidly.
- **improved security** — public cloud services from global providers are typically more secure than traditional IT systems.
- **greater resilience** — using public cloud services means agencies can better manage their risks, reducing the impact of any single event.

The New Zealand government is also working on a wide range of digital inclusion initiatives

The work on digital inclusion is focused on people and communities. The digital inclusion initiatives include:

- The Digital Inclusion Blueprint, which sets out the government's vision for digital inclusion in New Zealand.
- The Digital Inclusion 2019 Action Plan, which identifies the government's areas of focus for digital inclusion.
- The Digital Inclusion Research Agenda, guides the government's future priorities for digital inclusion research.

How we assessed the role of government?

The role of government was investigated using the following three-stage approach:

- A literature review on the role of government in supporting or impeding cloud computing and other digital tools.
- A long list of potential interventions was compiled based on the ideas.
- The long list was then assessed against the criteria for a market failure.

The expectations of the New Zealand government concerning the design of regulatory systems are well defined.

> *"The government expects any regulatory system to be an asset for New Zealanders, not a liability. By that we mean a regulatory system should deliver, over time, a stream of benefits or positive outcomes in excess of its costs or negative outcomes. We should not introduce a new regulatory system or system component unless we are satisfied it will deliver net benefits for New Zealanders. Similarly, we should seek to remove or redesign an existing regulatory system or system component if it is no longer delivering obvious net benefits."* (New Zealand Government 2017)

Governments can support engagement with cloud computing

The OECD (2019) investigated the concept, impacts and the role of government policy for cloud computing and identified the ways government could support uptake of cloud computing:

- Raising awareness, education and supporting access to skill development.
- Acting as lead users of cloud computing.
- Supporting the research about the effects of the cloud.
- Developing infrastructure and networks.
- Facilitating standardisation, cross-border facilitation and security framework.
- Lowering the regulatory barriers where it is prudent to do so.

Small businesses often lack the resources and internal capability to develop the skills and stay across new innovations such as cloud computing. Governments can provide support for small business by raising awareness, education and supporting access to skill development. This will contribute to small businesses realising the productivity benefits of cloud computing.

As major users of IT infrastructure and services, governments can influence the overall demand for cloud services, which could help to foster the efficiency and agility of cloud services. The efficiency gains and innovations spawned from government demand can flow-on or be shared with business and households.

As an independent entity, the government is better placed to monitor the application and benefits of cloud computing. This can include completing or funding of research about cloud computing. Deloitte (2018) found the lack of time to learn about cloud computing was a barrier for 29% of SMEs in the US.

In the same way that governments are well-placed to provide transport infrastructure and networks, they have an important role in either providing or facilitating the development of the broadband infrastructure necessary to access and utilise cloud computing. Governments can also influence the cost barriers to access. Deloitte (2018) estimated the costs of cloud computing is a barrier for 18% of SMEs in the US.

Governments can encourage and support the development of cloud computing interoperability standards and use of the resulting standards. Governments are integral in facilitating the frameworks and the agreements the allow cross-border use of cloud computing. This is critical to ensure the productivity benefits can be used in global value chains and trade. It is also crucial to ensure that international innovations in cloud computing are accessible in local markets. Government has a pivotal role in shaping the security arrangements. Guidelines provide an essential high-level framework for addressing security in an opened and networked environment. Deloitte (2018) found that privacy and security concerns with cloud computing are barriers for 38% of SMEs in the US.

Regulatory barriers relate to regulations and policies dictating where data can and can't be stored as affecting what cloud services, businesses are able to use. This is a key area where government and industry will need to work in partnership to develop solutions and understand the risks around developing regulation to ensure they are balanced and fit for purpose.

Regulation has been identified as a barrier for the future development of cloud services

According to the Nutanix (2019) report on the Enterprise Cloud Index, the top three factors that industry thinks will influence the future of cloud development are:

- adequate inter-cloud security, 60.5%
- skills availability, 52.8%
- regulations and policies, 51.3%.

The Singapore government has an action plan and planned investments to accelerate the uptake of cloud computing

The Singapore government's nationwide digital transformation actions are underpinned by Singapore's Digital Economy Framework for Action. The Framework is a key strategic document for Singapore's Infocomm Media Development Agency. The Agency aims to develop and regulate the information, communications and media industries in a holistic way.

The Singaporean approach provides an overall umbrella strategy for the digital transformation of infrastructure, education, business and government. The Framework includes accelerating the transition to cloud-based business tools, but goes much wider than just tools and covers:

- talent development and action
- research and development
- policy, regulations and standards
- physical and digital Infrastructure.

In comparison, New Zealand has strategies for digital inclusion and digital government, alongside infrastructure plans and education programmes. These governmental initiatives do not appear to be part of a coordinated strategy and the initiatives are dispersed across multiple government agencies. This raises the question of whether New Zealand's approach could be strengthened through the introduction of an overarching strategy for digital transformation.

The government of Singapore has decided to directly invest in the digital transformation of small and medium size enterprises by providing services and grants. From the Framework the government launched the 'SMEs Go Digital' (IMDA 2019) programme in 2017 to encourage SMEs to move to cloud solutions. This programme has implemented the following initiatives to encourage cloud adoption:

- Industry Digital Plans: guidance provided to SMEs to adopt cloud solutions at every stage of growth.
- Pre-Approved Solutions: a 70% grant is provided to help businesses adopt a list of pre-existing solutions.
- Start Digital Pack: competitively priced solutions to help newly incorporated SMEs and those that do not use cloud computing.
- SME Digital Tech Hub: expert advisory service to help SMEs make the most out of their cloud solutions through data analytics, cybersecurity, etc.
- Project Management Services: SMEs can use a pool of skilled project managers who can help implement cloud solutions timely and correctly.

New Zealand is lagging other OECD countries on gathering statistics on digital transformation. Further research would help us to develop a firm-level understanding of the issues faced by business in New Zealand. Initiatives then could be tailored to the New Zealand context.

Information is critical in good policy design. For example, even with significant support from the government, digital transformation among small business has been challenging due to the significance of the changes that busy small business owners must complete to adopt cloud computing tools. So, a sole focus on cost barriers would miss other important barriers.

Any investment by the government of New Zealand in encouraging cloud-based computing would require a robust assessment of the costs and benefits and a clear problem definition. This report provides an assessment of the challenges associated with uptake and an estimate of the potential benefits. The benefits are significant and warrant further consideration of the actions the government could take to increase uptake.

Growing the digital economy and maximising opportunities for SMEs

Joint research by the Productivity Commissions of Australia and New Zealand identified a range of actions that the Single Economic Market Agenda could support that would assist the digital transformation of SMEs on both sides of the Tasman (see Table 3).

Table 3 Suggested additions to the Single Economic Market Agenda

Initiative	Action required	Expected benefit
Data sharing		
Trans-Tasman sharing of credit information	Minor changes and clarification to privacy legislation	Improved access to finance for individuals and SMEs operating trans-Tasman
New Zealand researchers to be considered trusted users in Australia's new data sharing and release framework	The upcoming *Australian Data Sharing and Release Act* would include specific mechanisms to enable New Zealand researchers to become trusted users	More trans-Tasman sharing of data and collaboration in research
Digital financial services		
Joint open banking standards	Including New Zealand representatives in the open banking working groups in Australia	Improved trans-Tasman banking services; growth in the fintech sector
Currency conversion	New Zealand Government action to mirror the Australian Competition and Consumer Commission inquiry into foreign currency conversion costs	Lower costs of trans-Tasman payments and funds transfers
Digital trade		
Digitalising trade compliance processes	Completing trials for mutual recognition of supply chain security and a secure trade lane, and moving to full implementation Aligning standards for the data collected from importers and exporters, such that data is collected once and shared across borders	More efficient trans-Tasman trade; less paperwork; lower compliance costs for SMEs
Trans-Tasman recognition of digital identity services	Agreement between the Australian and New Zealand Governments to recognise digital identity services	Streamlined online trans-Tasman interactions between individuals, firms and governments
Cross-border consumer protection	Develop a consumer protection framework that encompasses cross-border transactions	More trans-Tasman digital transactions; more effective consumer redress for unsatisfactory transactions
Addressing barriers to digital trade, such as shortcomings in intellectual property legislation	Updating intellectual property legislation in both countries	Enable more innovation and trade as well as greater adoption of digital technology
Improving global digital trade rules	Collaboration between the Australian and New Zealand Governments in international forums	Reducing, eliminating or avoiding non-tariff barriers to international digital trade

Source: New Zealand Productivity Commission and Australian Government Productivity Commission (2019)

The following long list of options for government intervention was drawn from the literature. Each option was assessed against the following characteristics for a market failure:

- a public good
- imperfect information
- moral hazard
- externalities
- market power.

Table 4 Assessment of options for the potential for market failures

Purple cells indicate where we think there is a potential for market failure

Options	Market failure				
	Public good	Imperfect information	Moral hazard	Externalities	Market power
Joint recommendations for the Australian and New Zealand Productivity Commissions					
Suggested additions to the Single Economic Market agenda					
Singapore style of government investment					
Industry Digital Plans					
Pre-Approved Solutions					
Start Digital Pack					
SME Digital Tech Hub					
Project Management Services					
OECD recommendations on the role of government					
Raising awareness, education and supporting access to skill development					
Acting as lead users of cloud computing					
Supporting the research about the effects of the cloud					
Developing infrastructure and networks (for inclusion and access goals)					
Lowering the regulatory barriers in a balanced way					
Facilitating standardisation, cross-border facilitation and security framework					

Source: Various

The assessment is an indicative view on the potential of the options to address a market failure. The suggested additions for the Single Economics Market Agenda go well beyond cloud tools and small enterprises, but the cross-border issues they seek to address are of a public good nature.

The government has a digital inclusion plan for people, but it could also develop one for small business to address the potential for imperfect information among stretched small business owners. It’s not at all clear what market failure would be addressed by the following four elements of the Singaporean plan:

- Pre-Approved subsidised solutions
- Start Digital Pack
- SME Digital Tech Hub
- Project Management Services.

All of these services could be provided by industry and there would be commercial benefits in providing them.

There is always a role for government in education, lowering regulatory barriers, facilitating cross-border efficiencies and developing equitable access to infrastructure. The suggest next steps are outlined in section 5, including potential actions for government and industry.

4 Impacts of an uptake in cloud-based computing tools on the New Zealand economy

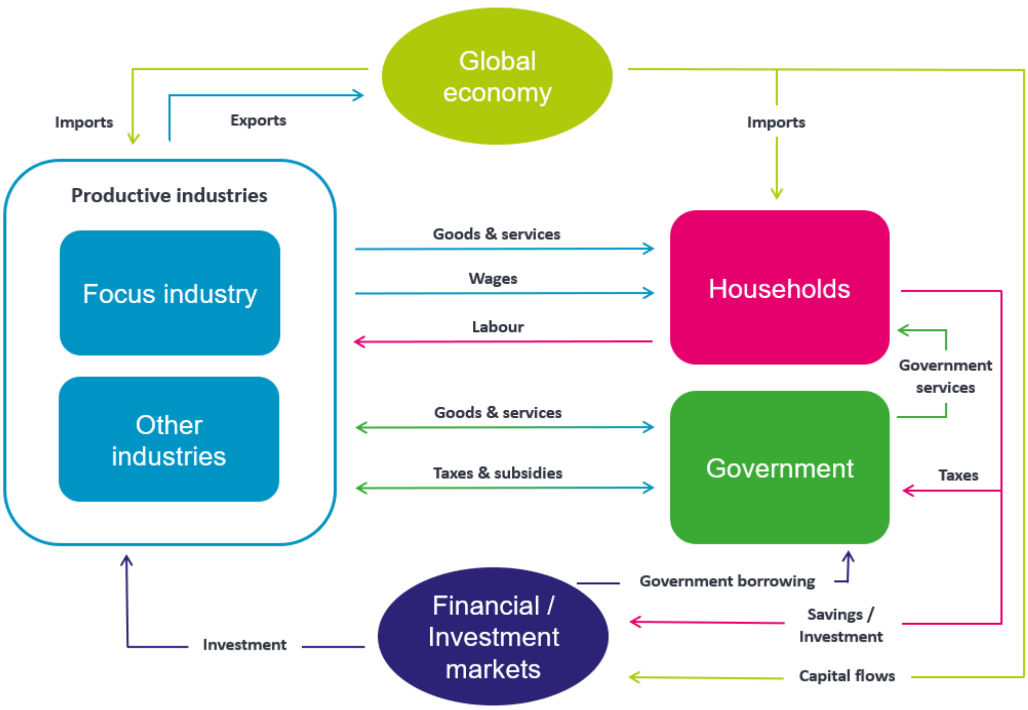
Cloud computing accounts for about $1 billion,[2] which represents 0.3% of New Zealand's total GDP (March 2019). In this report, we estimate the economic impacts of an increase in multi-factor productivity[3] flowing from a 20% uptake in the use of cloud computing across industries.

4.1 CGE modelling and scenario design

To evaluate these impacts, we use NZIER's ORANI-NZ[4] model, which is a top-down computable general equilibrium (CGE) model of the New Zealand economy. ORANI-NZ is based on a Statistics NZ's Input-Output tables that identify the structure of the industries involved. It contains information on 106 industries and 201 commodities.

Figure 7 below shows how the model captures the complex and multi-directional flows between the various actors of the economy and how they interact with each other. More details on the model can be found in Appendix A.

Figure 7 Our CGE model represents the circular flows between all the agents and activities in the economy



Source: NZIER

2 International Data Corporation (IDC), https://www.idc.com/getdoc.jsp?containerId=prAP45304819

3 See Appendix E for a full discussion of what we mean by multi-factor productivity.

4 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/ftp/gpextra/oranig06doc.pdf). NZIER maintains close connections with the Centre, ensuring that our modelling techniques reflect international best-practice.

For reporting purposes, we aggregate the 106 industries into 50 broader sectors. The conversion of industries to sectors is shown in Table 12 in Appendix C.

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 an increased use in cloud-computing services. Instead, we analyse a static, long-term scenario that estimates the overall annual economic effects of a multi-factor productivity increase in industries that use cloud computing services.

For our scenario design, we implement shocks to represent what the national and regional economies would look like with different levels of multi-factor productivity increases flowing from an increase in the use of cloud-computing services across New Zealand industries. We assume this uptake to be 20% based on our findings from the literature review.

Based on our literature review, we have modelled three scenarios for industries that use cloud-computing services:

- Low scenario: 2.5% multi-factor productivity increase
- Central scenario: 3.5% multi-factor productivity increase
- High scenario: 4.5% multi-factor productivity increase.

We pro-rate each of the above scenarios with the share of cloud computing use across industries (ANZSIC06 Level 1). No such statistics are publicly available for New Zealand. Therefore, we used data from the Australian Bureau of Statistics (ABS) for the year 2017/18 (see Table 13 in Appendix D).

We chose a long-run closure which allows capital stocks and real wages economy-wide to adjust over time. 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.

In the long-run, we assume that the capital (e.g. hard-drive, servers, etc.) that was initially used in various industries can eventually be used elsewhere (if not the physical capital, then the proceeds from selling it). This assumption implies that private investors are profit-driven and would invest in the next best profitable alternative associated with a 20% increase in the use of cloud computing for New Zealand businesses. We also assume that labour reallocates across industries and regions which offer higher real wages but is fixed in aggregate as it reaches its natural level in the long-run.

We then determine the flow-on effects of our shocks throughout the national and regional economies on GDP, employment, household income and industry output.

Our results are not forecasts, because we do not know precisely what is the use of cloud computing across New Zealand industries, i.e. what is the share of New Zealand businesses using cloud-computing services across industries. However, the results do help to quantify the potential economic impacts of a 20% increase in the use of cloud computing.

See Appendix A for further detail on our modelling approach and scenario designs.

In the next sections, we present our results as either annual percentage changes or annual changes in dollar values of 'cloud computing increased use' in the economy relative to the initial state.

4.2 The expected chain of effects on the New Zealand economy

Figure 8 summarises the chain of the economic effects from cloud computing uptake in various industries. When considering these effects, it is important to remember that there are multiple moving parts that are at play within the model.

With an uptake in cloud computing, multi-factor productivity increases occur in industries using cloud computing which, in turn, leads to higher profits in these industries. These profits can be reallocated in three ways:

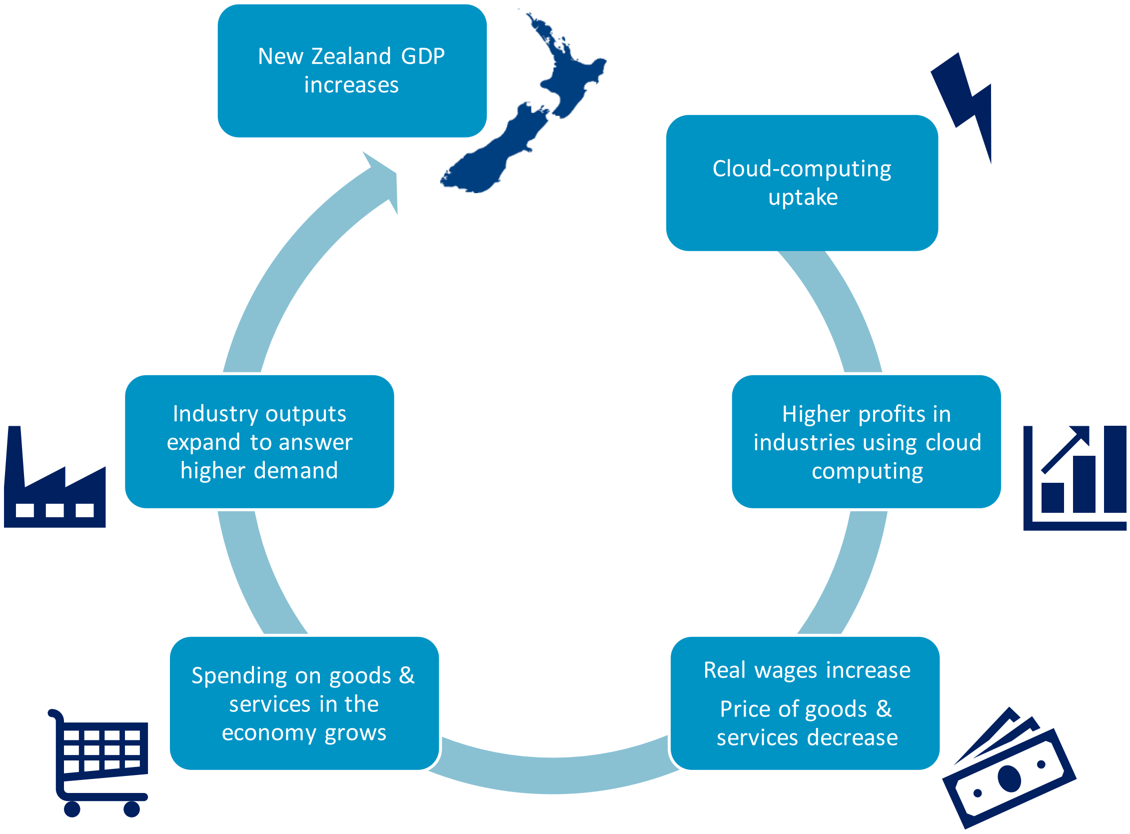
- Part of these profits can be allocated to capital, for additional investment or be distributed to shareholders.
- Firms and businesses can also reduce the price of goods and services to consumers, or at least, raise their prices by less than they would have without the productivity increase. This is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

All three impacts from a productivity increase can result in higher real incomes in the industry and the economy.

A multi-factor productivity increase can also have second-round effects. Higher real wages and reductions 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. This likely leads to growth in employment and/or income in these industries.

Thus, the benefits of an initial productivity increase can have a ripple effect from the affected industry and influence positively other industries and drive growth in New Zealand's GDP.

Figure 8 Main economic effects of a multi-factor productivity increase from an uptake in cloud computing



Source: NZIER

4.3 New Zealand's annual real GDP increases by between $3.5 billion and $6.2 billion

Table 5 and Figure 9 show the macroeconomic impacts of an increase in multi-factor productivity associated with an increase in the use of cloud-computing services across industries.

Depending on the scenario, economy-wide GDP expands by $3.5 billion (low scenario) to $6.2 billion (high scenario), while household spending increases by $2.6 billion (low scenario) to $4.6 billion (high scenario). Increases in household spending (our proxy for wellbeing) directly flows from the growth in national real wages, which rise by between $1.8 billion and $3.3 billion for the low and high scenarios, respectively. Capital stock increases by between $1.1 billion (low scenario) and $2 billion (high scenario).

Table 5 Headline impacts of productivity increases from adoption of cloud computing

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

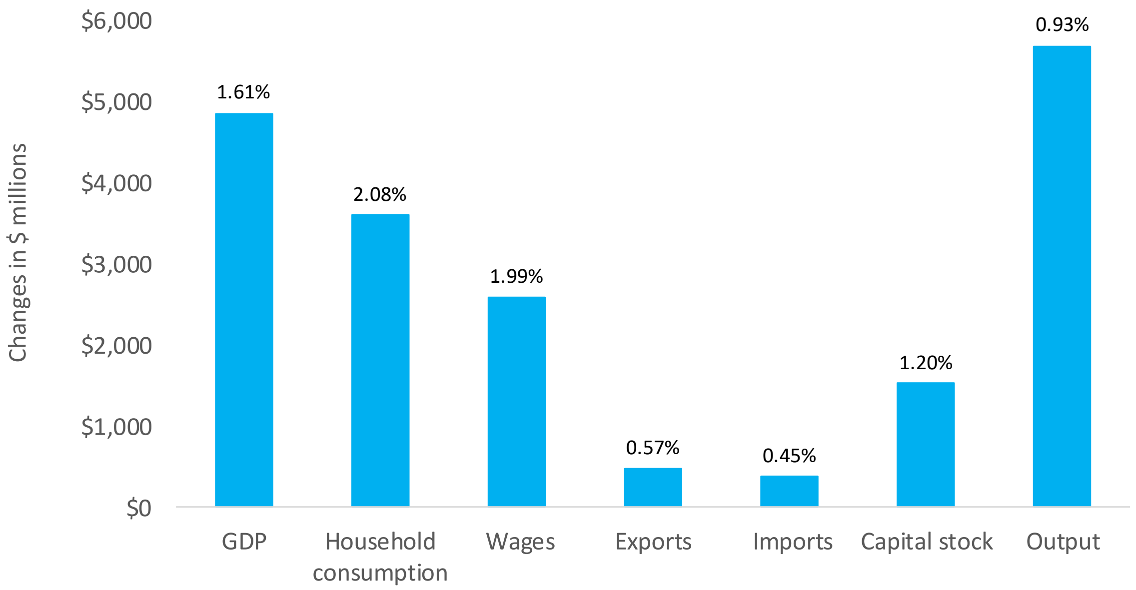
Indicators	Low scenario		Central scenario		High scenario	
	% change	Level ($m)	% change	Level ($m)	% change	Level ($m)
GDP	1.15%	$3,462	1.61%	$4,858	2.08%	$6,263
Household consumption	1.48%	$2,567	2.08%	$3,602	2.68%	$4,643
Wages	1.42%	$1,847	1.99%	$2,593	2.57%	$3,344
Exports	0.41%	$341	0.57%	$479	0.74%	$618
Imports	0.32%	$272	0.45%	$382	0.59%	$492
Capital stock	0.85%	$1,089	1.20%	$1,527	1.54%	$1,968
Total industry output	**0.67%**	**$4,057**	**0.93%**	**$5,687**	**1.20%**	**$7,325**

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

Source: NZIER

Figure 9 National economic impacts following a productivity increase

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



Source: NZIER

4.4 National output expands by between $4.1 billion and $7.3 billion

Table 6 presents the effects of a multi-factor productivity increase across selected industries (top 15). National output is the sum of all industry outputs in the economy and is expected to increase by $4.1 billion, $5.7 billion and $7.3 billion under the low, central and high scenarios, respectively.

In a first-round effect, output increases in industries with higher multi-factor productivity as they benefit from cloud computing uptake. Output expands the most in industries with the highest rate of cloud computing services, such as property services (rental, hiring and real estate services), local and central government services, finance and insurance, and business services.

In a second-round effect, industries where households spend their income are also likely to be affected by increased income that comes through employment and real wages, and increased returns to capital. Such industries include other personal services, retail, sport and recreation services, or food and beverage services. Other industries also include property services (housing and real estate), which take a large share of households' budgets.

Table 6 Flow-on effects: a wide range of industries are positively affected

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

Description	In $ millions			In %		
	Low scenario	Central scenario	High scenario	Low scenario	Central scenario	High scenario
Property services	$962	$1,349	$1,738	1.4%	2.0%	2.6%
Education & health	$528	$742	$957	1.1%	1.6%	2.1%
Local & central government	$308	$432	$556	1.5%	2.1%	2.7%
Business services	$300	$422	$545	1.0%	1.5%	1.9%
Finance & insurance	$249	$349	$450	1.1%	1.5%	1.9%
Other personal services	$171	$241	$310	1.9%	2.6%	3.4%
Electricity generation	$161	$226	$292	1.0%	1.4%	1.7%
Dairy processing	$156	$218	$280	0.6%	0.8%	1.0%
Sport and recreation services	$155	$218	$281	2.5%	3.5%	4.6%
Retail	$142	$199	$257	0.9%	1.2%	1.6%
Petrol manufacturing	$88	$123	$158	0.7%	1.0%	1.2%
Food and beverages	$76	$106	$136	0.9%	1.2%	1.6%
Meat processing	$73	$101	$130	0.6%	0.8%	1.0%
Wholesale	$70	$98	$125	0.3%	0.4%	0.6%
Media and communication services	$67	$93	$120	0.5%	0.7%	0.9%
All other industries	$551	$770	$989	0.2%	0.2%	0.3%
New Zealand industry output	**$4,057**	**$5,687**	**$7,325**	**0.7%**	**1.0%**	**1.3%**

Note: For reporting purposes, we aggregate the 106 industries into 50 broader sectors. The conversion of industries to sectors is shown in Table 12 in Appendix C.

Source: NZIER

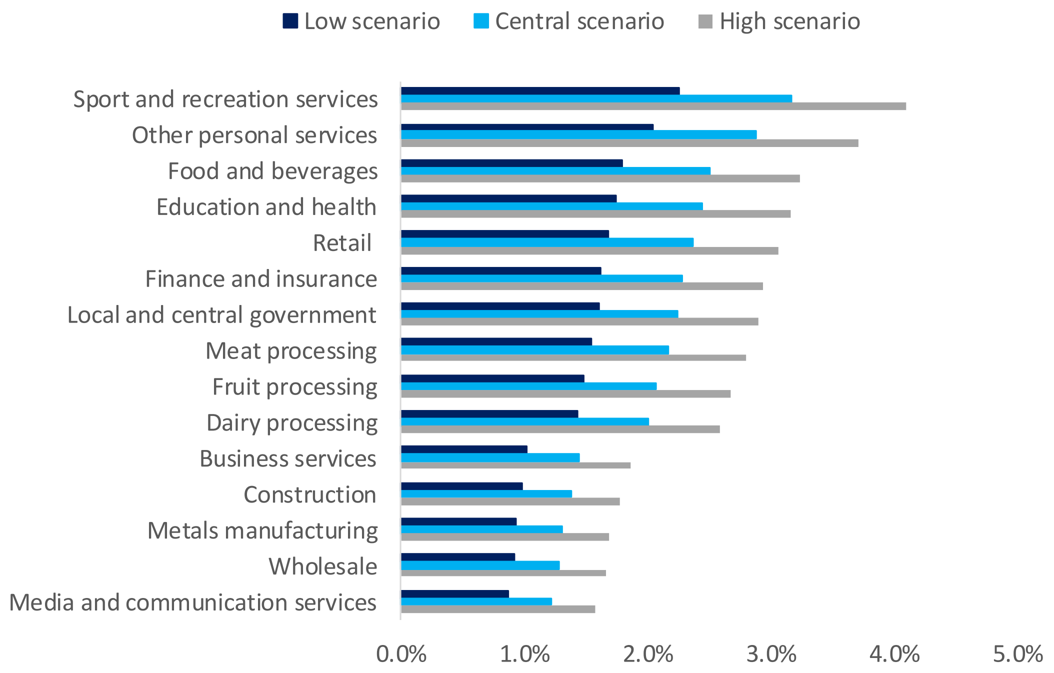
4.5 National wages increase and labour is reallocated across industries

Given that national labour supply is considered fixed in the long-run, the increase in multi-factor productivity induced by a 20% uptake in cloud computing translates into an increase in real wages across industries (Figure 10).

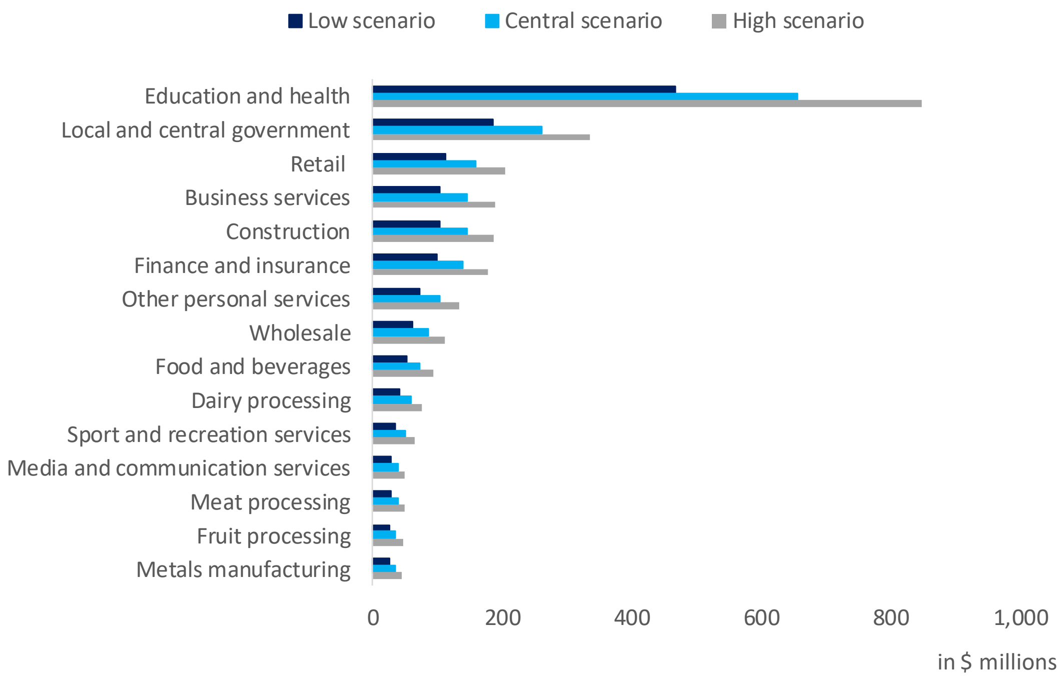
The effects of a real wage increase are expected to vary across industries, reflecting the importance of labour in each industry’s cost structure and the elasticity of demand to any price adjustments within each industry. Real wages (in dollar value) increase the most in industries with a higher share of cloud computing use and/or which are more labour intensive. This especially the case for services industries such as education and health, local and central government, retail and business services, for example. To a lesser degree, this is also the case for some manufacturing industries, such as meat, dairy and fruit processing.

Figure 10 Wage increases in the top 15 industries, by scenario

Annual changes from 2019 baseline, in percent



Annual changes from 2019 baseline, in $ millions



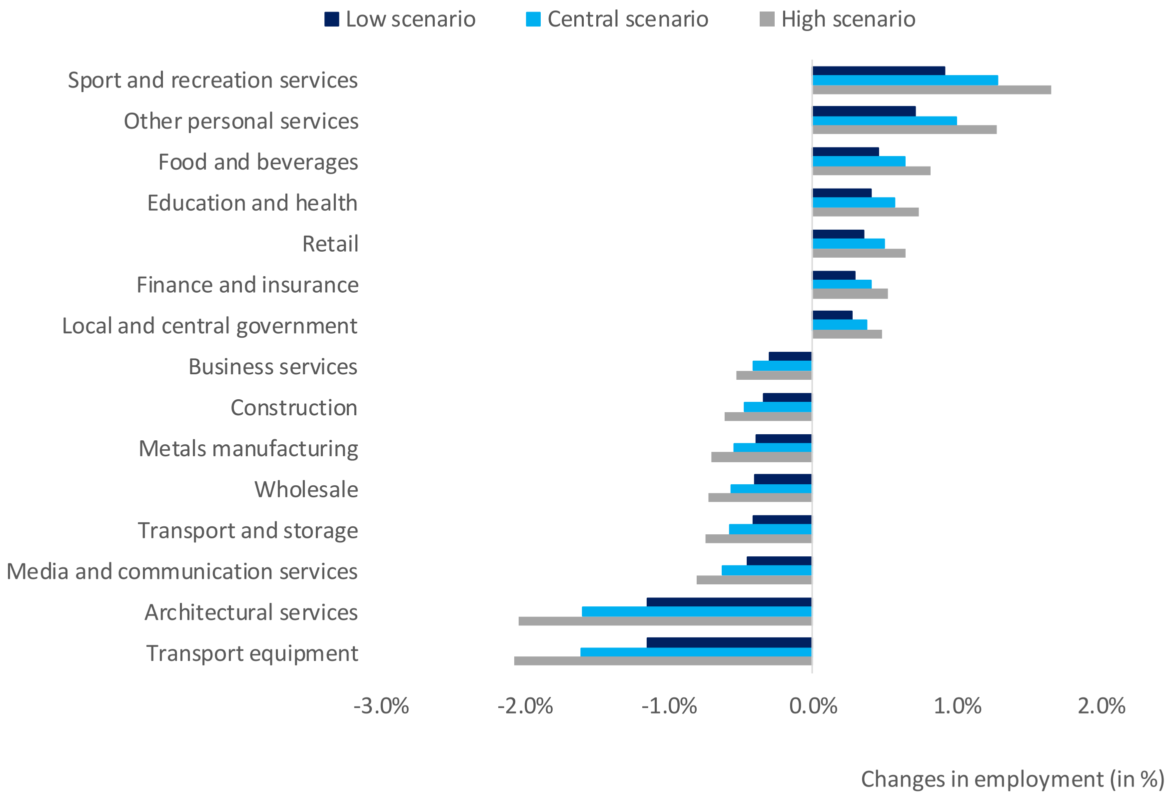
Note: For reporting purposes, we aggregate the 106 industries into 50 broader sectors. The conversion of industries to sectors is shown in Table 12 in Appendix C.

Source: NZIER

Increases in real wages leads labour to being reallocated across industries which offer higher real wages. However, national employment is assumed to be fixed as it reaches its natural level in the long-run. Figure 11 shows the effects of a multi-factor productivity increase on industry employment.

Figure 11 Labour reallocates across industries – selected industries, by scenario

Annual changes from 2019 baseline, in percent



Note: For reporting purposes, we aggregate the 106 industries into 50 broader sectors. The conversion of industries to sectors is shown in Table 12 in Appendix C.

Source: NZIER

Table 7 Labour reallocates across industries – selected top and bottom industries, by scenario

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

	$ million			% change		
Description	Low scenario	Central scenario	High scenario	Low scenario	Central scenario	High scenario
Sport and recreation services	$14	$20	$26	0.9%	1.3%	1.7%
Other personal services	$26	$36	$46	0.7%	1.0%	1.3%
Food and beverages	$13	$19	$24	0.5%	0.6%	0.8%
Education and health	$110	$154	$199	0.4%	0.6%	0.7%
Retail	$24	$33	$43	0.4%	0.5%	0.6%
Finance and insurance	$18	$25	$32	0.3%	0.4%	0.5%
Construction	-$36	-$50	-$64	-0.3%	-0.5%	-0.6%
Metals manufacturing	-$10	-$15	-$19	-0.4%	-0.5%	-0.7%
Wholesale	-$27	-$38	-$49	-0.4%	-0.6%	-0.7%
Transport and storage	-$10	-$14	-$17	-0.4%	-0.6%	-0.7%
Media and communication services	-$14	-$20	-$25	-0.4%	-0.6%	-0.8%
Architectural services	-$31	-$43	-$55	-1.1%	-1.6%	-2.0%
Transport equipment	-$14	-$19	-$25	-1.1%	-1.6%	-2.1%

Note: For reporting purposes, we aggregate the 106 industries into 50 broader sectors. The conversion of industries to sectors is shown in Table 12 in Appendix C.

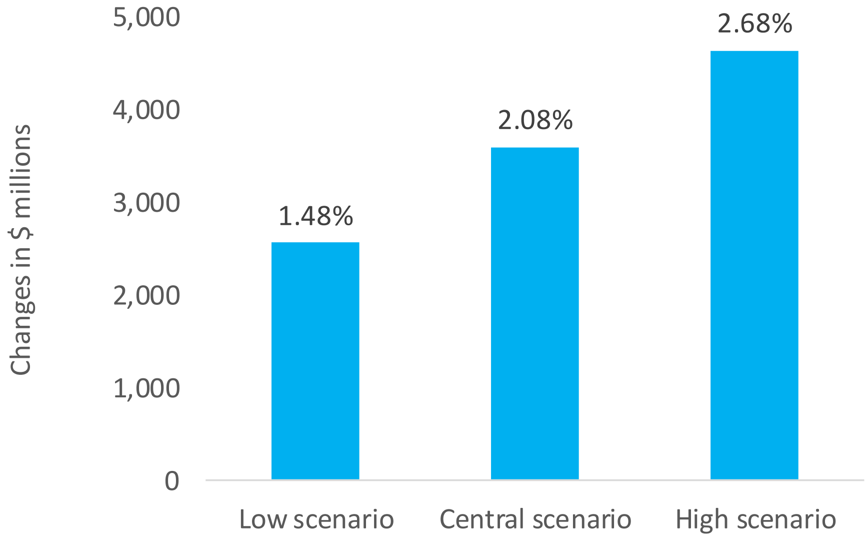
Source: NZIER

4.6 Household spending increases by between $2.6 billion and $4.6 billion

Figure 12 presents the effects of a multi-factor productivity increase, flowing from cloud computing uptake, on household spending. This increase in living standards comes from a combination of higher real wages and lower prices for higher quality of goods and services.

Figure 12 Effects of a multi-factor productivity increase on household spending

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



Source: NZIER

5 Next steps to encourage greater adoption

Realising the potential benefits found in this report requires increasing the level of cloud computing business tool adoption throughout New Zealand. This means understanding the barriers at the firm-level and finding mechanisms to lower the impediments. In Table 8 we categorise the barriers into five categories: human capital, systems, financial, regulatory and information. We suggest industry and/or government actions to mitigate/reduce each barrier. Some actions require an industry-led approach, while others require either a government-led approach or joint action.

Table 8 Next steps to encourage greater adoption

Barriers and gaps	Type	Industry action	Government action
Human capital barriers	Inadequate experience with digital tools	Explore options for co-investment in training and upskilling programmes.	
	Shortage of time to learn new systems	Promote awareness of the benefits of cloud-based tools. Showcase examples of benefits of adoption for SMEs Be transparent about time requirements, cost and benefits.	
System barriers	Privacy and security concerns	Industry-led security takes advantage of supplier economies of scale to develop high quality security while lowering small business costs and fees.	Ensure the privacy and security requirements are clear, easily accessible and consistent.
	Inertia of existing legacy systems and data compatibility	Helping organisations understand migration options including the timeframes and upfront costs.	
Financial barriers	Cost of adoption	Develop transition packages that lower or smooth out the one-off setup costs.	Ensure that the supplier market is competitive.
Regulatory barriers	Information location requirements		Continue to engage in international discussions re cloud regulation; act expediently to evaluate the adoption of recognised best-practice in New Zealand.
	Cross-border standardisation		
Information gaps	Internationally comparable statistics on digital adoption and inclusion		Develop statistical monitoring surveys for digital adoption and inclusion that are consistent with the ABS and the OECD.
	Further New Zealand based research	Invest in firm-level research to develop a more comprehensive understanding of the benefits and barriers in New Zealand's business environment.	

Source: NZIER

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Appendix A CGE Modelling

A.1 CGE modelling captures the full impact of using cloud-based computing tools

To capture the full impact of an increase in labour productivity resulting from the adoption of cloud-based computing tools in various industries, we use one of our suite of CGE models.

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[5] 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 a particular 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.[6]

[5] Also known as 'input-output studies'.

[6] 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 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[7] or GEMPACK.[8]

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 have to remain fixed, depends on a number of 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.

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

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

A.4 Our CGE model ORANI-NZ

NZIER's ORANI-NZ[9] model is a top-down CGE model of the New Zealand economy.

ORANI-NZ is based on a Stats NZ's Input-Output tables that identifies the structure of the industries involved. It contains information on 106 industries and 201 commodities and 15 regions. It therefore offers a unique capability to highlight the economic benefits of cloud-based computing tools used in various industries on the New Zealand economy.

Key features of the model are:

- Each industry can produce a number of different commodities.
- Production inputs are intermediate commodities (domestic and imported) and primary factors (labour, land and capital).
- The demand for primary factors and the choice between imported and domestic commodities are determined by Constant Elasticity of Substitution (CES) production nests. This means an increase in price of one input shifts sourcing towards another input.
- Intermediate goods, primary factors and other costs are combined using a Leontief production function. This means the proportion of production inputs is held constant for all levels of output.
- The production mix of each industry is dependent on the relative prices of each commodity. The proportion of output exported or consumed domestically is also dependent on relative prices.
- Policy impacts are often unevenly spread across industries and regions. To capture these heterogeneous effects, the model is extended to include a regional component. A 'top-down' approach is used to decompose national impacts to the regional level, using regional data as weighting.10

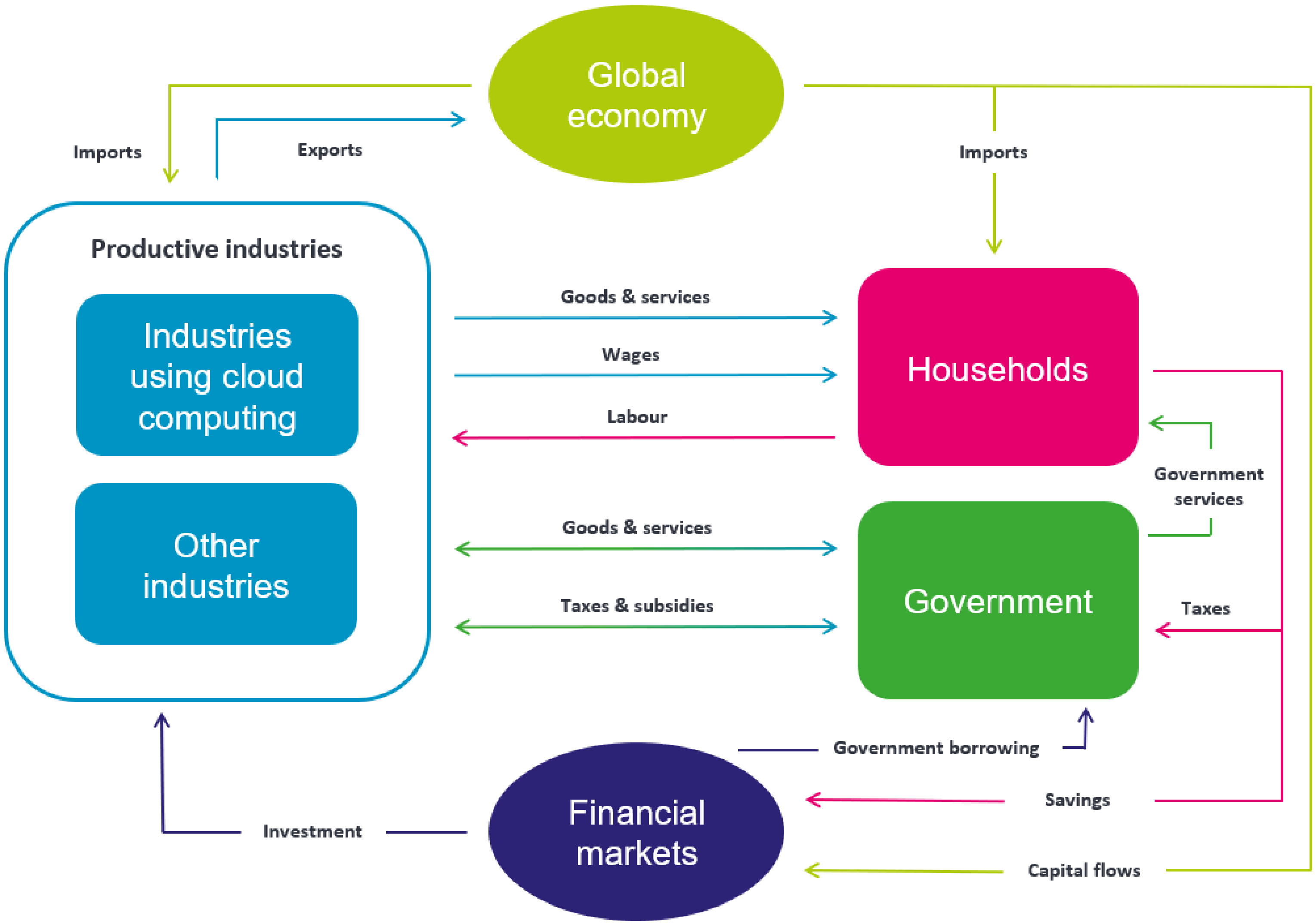
For reporting purposes, we aggregate the 106 industries into 50 broader sectors. The conversion of industries to sectors is shown in Table 12 in Appendix C.

Figure 13 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.

[9] 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/ftp/gpextra/oranig06doc.pdf). NZIER maintains close connections with the Centre, ensuring that our modelling techniques reflect international best-practice.

[10] The regions in the model are: Northland, Auckland, Waikato, Bay of Plenty, Gisborne, Hawkes Bay, Taranaki, Manawatu-Wanganui, Wellington, Tasman-Nelson, Marlborough, West Coast, Canterbury, Otago, Southland.

Figure 13 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 (2018). 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 contribution of using cloud-based computing tools.

We do not explicitly model the *timing* of the implementation of cloud-based computing tools in the different industries but instead, analyse a static, long-term scenario that estimates the overall contribution of the adoption of cloud-based computing tools to the New Zealand economy.

For our scenario design, we implement shocks to represent what the national and regional economies would look like with different level of multi-factor productivity increases flowing from an increase in the use of cloud-computing services across New Zealand industries.

We choose to focus on multi-factor productivity rather than labour productivity alone as changes in management practices, organizational structure, network effects, spill-over effects from production factors, adjustment costs, or economies of scale are usually associated with the adoption and diffusion of digital technologies, including cloud-computing tools (OECD 2019), in addition to an increase in labour productivity.

Additionally, an increase in multi-factor productivity takes into account the fact that *"productivity benefits from digital adoption appear greater in manufacturing than in services, generally tend to be higher in industries that are intensive in routine tasks*". (OECD 2019)

Based on our literature review, we have modelled three scenarios for industries that use cloud-computing services:

- Low scenario: 2.5% multi-factor productivity increase
- Central scenario: 3.5% multi-factor productivity increase
- High scenario: 4.5% multi-factor productivity increase.

We also assume a 20% uptake in cloud-computing services based on our findings from the literature review. We apply this share to the different levels of productivity increase.

Finally, we breakdown the multi-factor productivity increase flowing a 20% uptake in the use of cloud computing. We pro-rate each of the above scenarios with data on the share of cloud computing use across industries. To do so, and given that there is no publicly available data on cloud computing usage in New Zealand, we use data from the Australian Bureau of Statistics (ABS)[11] for the year 2017/18 as a proxy for cloud computing usage amongst New Zealand businesses across industries. Table 13 in Appendix D shows the ABS data we used to pro-rate the multi-factor productivity increases across ANZSIC06 industries (level 1).

With this set of scenarios, we simulate an increase in multi-factor productivity flowing from a 20% uptake in the use of cloud-based computing tools across New Zealand's industries. In effect, we are asking the model to determine how the national economy will adjust to an increase in productivity in these industries, in a way that uses the national economy 'resources most efficiently to return all markets to equilibrium.

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 productivity gains resulting from the adoption of cloud computing tend to happen with some delay. This is because adoption of cloud computing can induce a disruption in the production process in the short term and it might require some organisational adjustments to fulfil its potential.

Table 9 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.

11 Australian Bureau of Statistics (ABS), Characteristic of Internet Access, 2018: https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8167.02017-18?OpenDocument

Table 9 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.

- We have modelled a multi-factor productivity shock to reflect the effect of cloud computing uptake across industries.
- The analysis is static, looking at the impacts of the developments on the New Zealand economy at a point in time many years in advance. In reality, the benefits of an uptake in cloud-computing services will be spread across few. We do not explicitly model the dynamics of the uptake of cloud computing over time.
- While the model database is highly disaggregated, it still invariably suffers from aggregation bias – we are modelling the effects of cloud computing uptake 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 2018 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.
- As there is no publicly available data on cloud computing usage in New Zealand, we used data from the Australian Bureau of Statistics (ABS)[12] for the year 2017/18 as a proxy for cloud computing usage amongst New Zealand businesses across industries.

[12] Australian Bureau of Statistics (ABS), Characteristic of Internet Access, 2018: https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8167.02017-18?OpenDocument

Appendix B Additional modelling results

Table 10 Changes in industry output from a multi-factor productivity increase

Annual changes from 2019 baseline, in $ millions and percent

	$ millions			%		
Property services	$962	$1,349	$1,738	1.4%	2.0%	2.6%
Education & health	$528	$742	$957	1.1%	1.6%	2.1%
Local & central government	$308	$432	$556	1.5%	2.1%	2.7%
Business services	$300	$422	$545	1.0%	1.5%	1.9%
Finance & insurance	$249	$349	$450	1.1%	1.5%	1.9%
Other personal services	$171	$241	$310	1.9%	2.6%	3.4%
Electricity generation	$161	$226	$292	1.0%	1.4%	1.7%
Dairy processing	$156	$218	$280	0.6%	0.8%	1.0%
Sport and recreation services	$155	$218	$281	2.5%	3.5%	4.6%
Retail, recreation and sport retail	$142	$199	$257	0.9%	1.2%	1.6%
Petrol manufacturing	$88	$123	$158	0.7%	1.0%	1.2%
Food and beverages	$76	$106	$136	0.9%	1.2%	1.6%
Meat processing	$73	$101	$130	0.6%	0.8%	1.0%
Wholesale	$70	$98	$125	0.3%	0.4%	0.6%
Media and communication services	$67	$93	$120	0.5%	0.7%	0.9%
Beverages & tobacco	$64	$90	$116	0.9%	1.3%	1.6%
Construction	$62	$87	$112	0.1%	0.2%	0.2%
Fruit processing	$60	$84	$108	0.7%	1.0%	1.2%
Architectural services	$56	$79	$102	0.7%	1.0%	1.3%
Sheep & beef	$42	$59	$75	0.3%	0.4%	0.6%
Dairy cattle	$42	$59	$75	0.3%	0.4%	0.5%
Coal, oil, gas	$31	$43	$56	0.5%	0.7%	0.9%
Metals manufacturing	$23	$31	$40	0.2%	0.2%	0.3%
Sewerage/waste	$22	$31	$40	0.9%	1.3%	1.7%
Gas & water supply	$22	$31	$40	0.9%	1.3%	1.6%
Accommodation	$21	$29	$37	0.6%	0.8%	1.0%
Pulp, paper & print	$16	$22	$28	0.3%	0.4%	0.5%
Air transport	$15	$21	$27	0.2%	0.3%	0.4%
Road transport	$15	$20	$26	0.2%	0.3%	0.3%
Chemicals manufacturing	$13	$19	$24	0.9%	1.3%	1.7%
Textile and clothing	$12	$16	$21	0.4%	0.5%	0.6%

	$ millions			%		
Other manufacturing	$11	$15	$19	0.6%	0.9%	1.1%
Rubber	$10	$14	$18	0.3%	0.4%	0.5%
Pharmaceuticals	$9	$13	$16	0.5%	0.7%	0.9%
Transport & storage	$9	$12	$16	0.1%	0.2%	0.2%
Fertiliser manufacturing	$7	$10	$12	0.5%	0.6%	0.8%
Forestry	$7	$9	$12	0.1%	0.2%	0.3%
Poultry	$5	$7	$9	0.3%	0.4%	0.5%
Seafood processing	$5	$7	$9	0.2%	0.3%	0.4%
Vehicle wholesaling	$5	$6	$8	0.3%	0.5%	0.6%
Other transport services	$4	$6	$7	0.3%	0.4%	0.6%
Electrical equipment	$4	$5	$6	0.1%	0.1%	0.1%
Wood processing	$2	$2	$3	0.0%	0.0%	0.0%
Rail transport	$2	$2	$3	0.3%	0.4%	0.5%
Fishing	$2	$2	$3	0.1%	0.2%	0.2%
Mining & exploration	$0	$0	$0	0.0%	0.0%	0.0%
Agriculture services	-$3	-$4	-$5	-0.1%	-0.1%	-0.2%
Machinery	-$5	-$7	-$10	-0.1%	-0.2%	-0.2%
Horticulture	-$9	-$12	-$16	-0.2%	-0.3%	-0.4%
Transport equipment	-$27	-$38	-$49	-0.8%	-1.1%	-1.4%
Total New Zealand output	**$4,057**	**$5,687**	**$7,325**	**0.7%**	**1.0%**	**1.3%**

Source: NZIER

Table 11 Changes in industry wages from a multi-factor productivity increase

Annual changes from 2019 baseline, in $ millions and percent

	$ millions			%		
Education and health	$467	$657	$848	1.7%	2.4%	3.2%
Local and central government	$186	$260	$336	1.6%	2.2%	2.9%
Retail	$113	$158	$205	1.7%	2.4%	3.1%
Business services	$104	$146	$188	1.0%	1.4%	1.9%
Construction	$104	$146	$188	1.0%	1.4%	1.8%
Finance and insurance	$99	$139	$179	1.6%	2.3%	2.9%
Other personal services	$73	$103	$133	2.1%	2.9%	3.7%
Wholesale	$62	$86	$111	0.9%	1.3%	1.7%
Food and beverages	$52	$73	$95	1.8%	2.5%	3.2%
Dairy processing	$42	$59	$76	1.4%	2.0%	2.6%
Sport and recreation services	$35	$49	$64	2.3%	3.2%	4.1%
Media and communication services	$28	$39	$50	0.9%	1.2%	1.6%
Meat processing	$27	$38	$49	1.5%	2.2%	2.8%
Fruit processing	$26	$36	$46	1.5%	2.1%	2.7%
Metals manufacturing	$25	$35	$45	0.9%	1.3%	1.7%
Road transport	$22	$31	$40	1.0%	1.4%	1.9%
Transport & storage	$21	$30	$39	0.9%	1.3%	1.6%
Dairy cattle	$19	$27	$34	1.1%	1.5%	2.0%
Air transport	$17	$24	$30	1.2%	1.7%	2.2%
Property services	$16	$23	$30	0.9%	1.2%	1.6%
Beverages & tobacco	$14	$20	$26	1.5%	2.1%	2.7%
Accommodation	$14	$20	$25	1.4%	1.9%	2.5%
Electricity generation	$13	$18	$24	1.2%	1.7%	2.2%
Pulp, paper & print	$13	$18	$23	1.1%	1.5%	1.9%
Sheep & beef	$11	$16	$20	1.1%	1.5%	1.9%
Wood processing	$11	$15	$20	0.9%	1.2%	1.6%
Rubber	$9	$13	$16	1.0%	1.5%	1.9%
Electrical equipment	$9	$12	$16	0.8%	1.2%	1.5%
Coal, oil, gas	$8	$11	$14	1.2%	1.7%	2.2%
Horticulture	$8	$11	$14	0.7%	1.0%	1.3%
Machinery	$7	$10	$13	0.6%	0.9%	1.1%
Agriculture services	$7	$10	$13	0.8%	1.1%	1.4%
Other manufacturing	$6	$9	$12	1.4%	2.0%	2.5%
Textile & clothing	$6	$8	$11	0.9%	1.3%	1.7%
Sewerage/waste	$5	$7	$9	1.4%	1.9%	2.5%
Seafood processing	$5	$7	$9	1.0%	1.4%	1.8%
Pharmaceuticals	$5	$7	$9	1.3%	1.8%	2.3%

	$ millions			%		
Mining & exploration	$5	$7	$8	0.6%	0.9%	1.1%
Architectural services	$4	$6	$8	0.2%	0.2%	0.3%
Petrol manufacturing	$4	$6	$8	1.2%	1.7%	2.2%
Vehicle wholesaling	$4	$6	$8	1.0%	1.4%	1.8%
Poultry	$4	$5	$7	1.3%	1.9%	2.4%
Other transport services	$4	$5	$7	1.2%	1.7%	2.1%
Forestry	$4	$5	$6	0.8%	1.1%	1.5%
Chemicals manufacturing	$3	$4	$6	1.6%	2.3%	2.9%
Rail transport	$2	$3	$4	1.1%	1.5%	1.9%
Fertiliser manufacturing	$2	$3	$4	1.2%	1.6%	2.1%
Transport equipment	$2	$3	$3	0.2%	0.2%	0.3%
Gas & water supply	$2	$3	$3	1.4%	2.0%	2.6%
Fishing	$1	$2	$2	1.0%	1.4%	1.8%
Total New Zealand	**$1,731**	**$2,429**	**$3,134**	**1.3%**	**1.9%**	**2.4%**

Source: NZIER

Appendix C Sectoral mapping

Table 12 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

106 Industries	50 aggregated sectors
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
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

106 Industries	50 aggregated sectors
Food and beverage services	Food and beverages
Road transport	Road transport
Rail transport	Rail transport
Other transport services	Other transport services
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
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

106 Industries	50 aggregated sectors
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

Appendix D Data on cloud computing use in Australia

Table 13 Use of paid cloud computing and cloud services used in Australia

2017/2018

	Cloud computing use (in %)
Total All Industries	**42.4**
Agriculture, Forestry and Fishing	25
Mining	52.7
Manufacturing	45.2
Electricity, Gas, Water and Waste Services	42.9
Construction	35.7
Wholesale Trade	46
Retail Trade	41.8
Accommodation and Food Services	36.6
Transport, Postal and Warehousing	28.8
Information Media and Telecommunications	63.5
Financial and Insurance Services	55.6
Rental, Hiring and Real Estate Services	49.8
Professional, Scientific and Technical Services	58.1
Administrative and Support Services	42.4
Health Care and Social Assistance	44.8
Arts and Recreation Services	47.3
Other Services	33.2

Source: Australian Bureau of Statistics

Appendix E What is multi-factor productivity?

The concept of multi-factor productivity was first formalised by Solow (1957) in his journal article ‘Technical Change and the Aggregate Production Function’.

Multi-factor productivity, also called Solow residual, measures the increase in output that cannot be accounted for by changes in all inputs used in the production process. These include labour, capital, land, and intermediate inputs (e.g. energy inputs and purchased services). In other words, for any given changes in output, multi-factor productivity measures the contribution of technology, advances in knowledge, improvements in management practices, organisational change, general knowledge, network effects, spill overs from production factors, adjustment costs, economies of scale, or change in production techniques. Multi-factor productivity is therefore a more comprehensive measure of the productivity than single-factor productivity, such as labour productivity and capital productivity.

Multi-factor productivity is usually measured as an index or in annual growth rates. Multi-factor productivity is estimated using weighted inputs, to capture the relative importance of the inputs in production and to estimate the contribution of each input to changes in output. Weighted inputs are measured as the ratio between each input and the total cost of production of a firm or industry.

An increase in multi-factor productivity results in output growth and higher profits. These profits can be reallocated in three ways:

- Part of the 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 a fixed aggregate labour supply, firms and businesses are likely to offer higher compensation to their workers in the form of higher real wages.

All three impacts of a productivity increase can result in higher real incomes in the economy.

Multi-factor productivity increases can also have second-round effects. Higher real wages and reduction in prices encourage spending on goods and services. To respond to the increase in demand, industries in which households spend their money expand their outputs. This likely leads to growth in employment and/or income in these industries.

Thus, the benefits of an initial productivity increase can have a ripple effect from the affected industry and influence positively other industries and the economy.