Digital Nation: New Zealand

From a tech sector to digital nation

NZIER report to the New Zealand Technology Industry Association

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About NZIER

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice to clients in the public and private sectors, throughout New Zealand and Australia, and further afield.

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

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

NZIER was established in 1958.

Authorship

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Key Points

- The tech sector matters to New Zealand because
  - It contributes strongly to growth in GDP and job creation
  - It is cross-cutting in its influence on all sectors and regions of the economy
  - It is export-intensive and tech inputs help other sectors to add value to their exports
- Our economic modelling finds a boost in tech sector growth would:
  - increase investment in the economy by over $1 billion
  - lift exports by $400 million
  - raise living standards to the tune of $1 billion and
  - have a positive effect across all regions of New Zealand.
- Our analysis undercooks the scope for positive effects of the tech sector on New Zealand's growth potential, because digital technology benefits consumers in ways that are not measured by GDP
- The tech sector plays a unique role in innovation, diffusion of ideas internationally and the potential to attract talented people
- New Zealand is a tech and innovation leader in some areas, including e-Government, the use of computers and the internet in schools, cloud-based business support software and systems, and select healthcare technologies
- But New Zealand businesses risk falling behind in the adoption of technology and business practices
- Closing this gap and fixing the technology 'diffusion engine' would have a beneficial impact on New Zealand's GDP and standard of living.

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Introduction

“In this small book I am unable to do all I would wish, for it would be necessary to have lists of all regions, in order to know which relics are said to be in each place and to make a comparison among them. And then it will be seen that each apostle had more than four bodies, and each saint at least two or three…”

Jean Calvin, Traité de Reliques, Geneva, 1543

Calvin’s opposition to the inflated claims made by the authorities of his day had far-reaching historical consequences. Sectarian difference become a pretext for waging war, national borders were redrawn, and huge numbers of people fled, by land and sea, to countries which offered greater freedom of conscience than those which they had left. Eventually, Calvin was himself accused of exaggerating his claims, or perhaps of enjoying his rhetoric too much. His famous observation, also in the *Traité de Reliques,* that if all the fragments of the True Cross were gathered together they would form a whole ship’s cargo was answered in 1870 by the French architect Charles Rohault de Fleury, who compiled precisely the list that Calvin called for, and discovered that the combined fragments would weigh less than 1.7 kilogrammes.

Technology is another field which impressive claims abound. Studies appear regularly with eye-watering assessments of the economic benefits to be attributed to technology. Robert Solow’s famous 1987 quip:

> *“You can see the computer age everywhere but in the productivity statistics.”*

has been largely ignored by the broad, rapid and constant stream of advocacy on behalf of technology that continues to this day.

Yet the advocates are not wrong. The world *is* different now. We *have* lived through waves of technological revolution, each of which *has* radically altered the way we interact with world. Technology now underpins almost all business processes, and for many New Zealanders the smart phone has become the remote-control for their lives. But it is difficult to escape the suspicion that if all the claims made on behalf of technology were true, first-world nations should have enjoyed double-digit GDP growth for the last couple of decades. It is not surprising that policy-makers have come to demand greater rigour in the analysis which supports the claims made for technology.

Against this background, NZIER was very pleased to have been invited by NZTech to measure the true footprint of the tech sector in New Zealand, and to estimate its impact. The tech sector is not easy to define, so we have adopted a pragmatic and conservative definition which includes ICT as well as high-tech and medium-high tech manufacturing, but excludes non-ICT professional services.

CGE produces a far more objective and conservative estimate of the impact of innovation and technology on the economy than, for example, survey methods, or the common, but simplistic, input-output multiplier analysis.

1. The importance of technology

1.1. What is technology?

Technology is a very broad term. A basic definition is:

> *The application of scientific knowledge for practical purposes, especially in industry*.[1]

In economics, the term is used to imply a collection of techniques, skills, methods and processes used to produce goods and services. Science is not necessarily a prerequisite. In this study we focus on high technology, where science is always nearby.

The essential characteristics of high technology are newness and complexity. High technology operates near the frontier of knowledge. It is any technology requiring the most sophisticated scientific equipment and advanced engineering techniques, such as microelectronics, data processing or telecommunications. Emerging technologies are prominent, promising cutting-edge technologies currently being developed and commercialised, exploiting possibilities in diverse areas, for example:

- Agriculture: *in vitro* meat, precision agriculture, vertical farming
- Energy: artificial photosynthesis, concentrated solar power, biofuels, grid energy storage
- Medical: genetic engineering, nanomedicines, body implants, suspended animation, de-extinction, stem cell treatments, personal genomics, robotic surgery
- IT and communication: augmented reality, artificial intelligence, cryptocurrencies, the Internet of things (IoT), wearable computers, machine translation, Li-fi
- Appliances: bead washing machines, magnetic refrigerators
- Displays: OLED displays / lighting, virtual retinal (screen-less) displays, bionic contact lenses
- Materials science: aerogel, conductive polymers, amorphous metal, graphene
- Robotics: powered exoskeletons, androids, unmanned vehicles
- Transport: airless tyres, electric and autonomous cars, autonomous drones, maglev trains, hover-trains.

Technology is everywhere and nowhere all at once. It can be embedded in machines, computers, devices and factories, operated by individuals who usually don't know, or need to know, how the components of these things work. This is typified by the synthesis of a programmer, a high speed internet connection and a cloud-based processor turning ideas into new software, new services, and new products. New possibilities are created on the back of high technology.

A wide range of industries produce high-technology, which is generally reflective of the sophistication of businesses as much as the sophistication of the industries in which they reside. But, it is the case that some industries have larger numbers of high-technology firms. Collectively, these industries make up the tech sector.

1 http://www.oxforddictionaries.com/definition/english/technology

We define the tech sector to include the ICT sector and the high-tech manufacturing sectors, reflecting in part the increasingly digital nature of both of these sectors of the economy and their high demand for similar computer science based skills and advanced engineering skills and novel applied science. The definitions of both the ICT sector and the high-tech manufacturing sector are based on OECD precedent that has also been adopted by MBIE (see Appendix A).

1.2. New technology is a crucial source of growth

Changes in technology are a crucial source of economic growth. Long-run per capita growth is driven by technical change rather than, for example, investment or employment. While investment and employment are the basic ingredients of economic activity, the only way to raise material living standards over the long term is through technological change.

On one view, growth is an evolutionary process of *creative destruction,* with waves of innovation periodically disrupting and restructuring markets.[2] New technologies such as steam power, electricity, vehicles, ICT and biotechnology spawn clusters of innovations, leading to investment booms and cycles of growth.

1.3. Innovation, adopting new technology, cements the gains to growth

Technology-led growth is not just about technology that is new to the world. The diffusion of existing technologies is just as important to growth. Businesses and whole economies can boost incomes, reduce costs and improve service and product quality by buying, importing or imitating technologies being used effectively by others. This is the essence of innovation, which, as a term, can capture technologies that are new to the world, new to the economy or new to a firm.

The defining characteristics of innovation are doing things differently and doing things better.

At the level of the firm, innovation has a major effect on productivity and hence the growth of firms. Indeed, continued innovation is of vital importance to the ongoing survival of many firms. The Oslo Manual[3] for measuring innovation defines four types of innovation (see Table 1). Clearly, there is a wide range of innovative activities that firms engage in, to survive and prosper within their markets.

[2] The so-called 'Schumpeterian' view (Schumpeter, Joseph, 1942. Capitalism, socialism and democracy).

[3] http://www.oecd.org/site/innovationstrategy/defininginnovation.htm

Table 1 Types of Innovation: the Oslo Manual

Innovation type	Description
Product	A new good or service, or one that is significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics.
Process	A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
Marketing	A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
Organisation	A new organisational method in business practices, workplace organisation or external relations.

Source: OECD, 2005.

Importantly, technological innovations, unlike other finite resources, accumulate and can be utilised simultaneously by a number of producers.

1.4. The tech sector is a hub for innovation and for growth

Evidence suggests that the tech sector is a hub for innovation and for growth. This can be seen in labour productivity statistics across the OECD where the computer electronics and ICT sectors have almost universally outperformed other sectors of the economy in terms of productivity growth.[4]

Hi-tech infrastructure is also a key enabler for growth and innovation. In a World Bank cross-country study[5] it was estimated that each 10% increase in broadband penetration adds 1.3 percent to a country's GDP.

The application and adoption of high-tech products and services can also foster innovation in a wide range of areas such as healthcare, education, communications and social networking.

In New Zealand the Productivity Commission has referred to ICT as the 'steam engine' for the services sector:

> *ICT is catalysing social and economic changes on a scale comparable to those resulting from previous breakthrough technologies such as steam power, the internal combustion engine, and electricity. In conducive economic environments, these technologies were largely responsible for the huge rises in the material living standards of much*

4 The one exception to this observation is Norway. See Figure 1.24 in the OECD (2015) Science, Technology and Industry Scoreboard.

5 Qiang, Christine Zhen-Wei, Carlo M Rossotto, with Kaoru Kimura, 2009. Economic Impacts of Broadband. In: Information and Communications for Development 2009: Extending Reach and Increasing Impact. World Bank: Washington. https://issuu.com/world.bank.publications/docs/9780821376058

of the world's population since the late 1700s. Such breakthrough technologies occur rarely – perhaps less than once in a generation.[6]

Manufacturing and Industry 4.0

A recent report by McKinsey talks about the Internet of Things heralding a fourth industrial revolution in the traditional industries: 'Industry 4.0', which is

> *…the next phase in the digitization of the manufacturing sector, driven by four disruptions: the astonishing rise in data volumes, computational power, and connectivity, especially new low-power wide-area networks; the emergence of analytics and business-intelligence capabilities; new forms of human-machine interaction such as touch interfaces and augmented-reality systems; and improvements in transferring digital instructions to the physical world, such as advanced robotics and 3-D printing.*

This, according to McKinsey, is the fourth major upheaval in modern manufacturing, following the lean revolution of the 1970s, the outsourcing phenomenon of the 1990s, and the automation that took off in the 2000s.

In this latest revolution a significant amount of value will come from upgrading existing systems to ensure interconnectivity for data collection, analysis and executing commands, for example by retrofitting sensors or adding additional software intelligence and interoperability. Only about 40-50% of manufacturing equipment would need to be replaced, whereas the last industrial revolution (industrial automation) saw 80-90% of equipment replaced.

The McKinsey research predicts that over the next 10 years, factories will worry less about buying new equipment and more about outfitting their spaces with an array of high-tech sensors and routers. Manufacturing will increasingly rely on in-factory sensors, more analytics and in-factory use of augmented reality such as Google Glass, and the use of 3-D printing for the mass market.

1.5. NZ needs to lift its innovation game

At the Productivity Hub Symposium 2015 in Wellington, Treasury Secretary Gabriel Makhlouf expressed concerns about technological diffusion in New Zealand. Weak international connections limit the extent to which new technology diffuses from the globally most productive firms to the most advanced New Zealand firms. Small and insular domestic markets may also reduce diffusion to firms within New Zealand further away from the productivity frontier, so-called laggard firms.

A study by the New Zealand Productivity Commission in 2015[7] explored technological diffusion among New Zealand firms using a model of convergence, in which a firm's productivity growth depends on its ability to catch up to its industry's productivity

[6] Productivity Commission, 2014. Boosting Productivity in the Services Sector, p154.

[7] New Zealand Productivity Commission, June 2015. Do New Zealand firms catch up to the domestic productivity frontier? Working Paper 2015/3. Authors: Paul Conway, Lisa Meehan & Guanyu Zheng. http://www.productivity.govt.nz/sites/default/files/nzpc-working-paper-productivity-convergence-among-NZ-firms-201503.pdf

frontier. The study found that firms do catch up, so technology does diffuse (if gradually) from high to low productivity firms. Other research suggests that NZ firms are relatively slow, by international standards, to take up new technologies, such as ICT.[8]

Whatever the diagnosis, a lift in innovation would raise New Zealand's growth rate and improve living standards.

1.6. Innovation comes from experience at the coal face

Innovation often comes from learning-by-doing and occurs in step changes. When it gets going it is apt to accelerate at an exponential rate.

Formal research and development is important but often businesses first try to develop new product concepts, based on their existing capabilities. If they get stuck, they might resort to spending money on R&D, but that is expensive and uncertain.[9] Thus R&D is just one part of the continuing problem-solving process of innovation.

A recent NZIER study[10] considered the experience of successful New Zealand technology firms under the Global Value Network[11] concept, and found repeated interactions and transactions with consumers can enhance the innovation cycle. In other words, for many technology firms, the R&D process is in fact to be found in the relationships and the transactions between customers and the firm[12].

This illustrates that some of the crucial ingredients for successful innovation are to be found in businesses operating at the coal face of industry, as opposed to research organisations.

1.6.1. Networks and information catalyse innovation

Information-sharing is another important catalyst for economic growth. Activities or networks – whether physical or social – can increase the flow and use of collective knowledge about new technologies or methods.

Spatial factors such as agglomeration and clustering also promote information sharing, as does internet connectivity and broadband access.

The focus on clusters of innovative businesses relies on the diffusion and sharing of information and ideas, and on collaboration, co-ordination, and relationships – and a systems approach to the innovation process:

8 Mason, G, 2013. Investigating New Zealand – Australia productivity differences: new comparisons at industry level. NZPC Working Paper 2013/02.

9 Firms often struggle to build innovation capability, which requires investment in tangible and intangible assets, including intellectual capital. Like other investments, managers or owners must decide how much to spend on current production versus R&D and other innovation spending. From an organisational incentive perspective this is a difficult trade-off to make because spending on R&D affects current profitability and its success is unpredictable.

10 NZIER, September 2015. *Global Value Networks: How to succeed in business without worrying about scale, distance or thin markets*. By Laurence Kubiak, Killian Destremau and Philip Riley. https://nzier.org.nz/publication/global-value-networks

11 A value network differs from a value chain in that there are more actors carrying out a wider variety of functions in a value network. In a value chain producer-distributor-consumer relationships predominate.

12 Ulaga, W and Chacour, S, 2001. Measuring Customer-Perceived Value in Business Markets, Industrial Marketing Management, Vol 30, pp33-48.

> *…innovation is an inherent property of the Global Value Network system, a feature of the competitive landscape and an objective around which a firm's resources can be organised to maximise the potential for value capture…value is not created by a single actor, so transactions between actors, in particular information shared between organisations can also give rise to open (collaborative) innovation*[13]*.*

1.6.2. Emerging sources of data innovation

In recent years the focal point of innovation itself has begun to shift, with increasing activity in a new generation of disruptive and ICT-related technologies. Data-driven technological changes, including 'Big Data' and the 'Internet of Things', are a key part of this trend. Globally the number of patents in these technologies, as an indicator of knowledge growth, have been growing at double digit rates.[14]

'Big data' is data that is difficult to handle because of its size or difficult to pin down because it is being updated and changed at a very rapid rate. Often it is both. Big data offers enormous potential for improving understanding about services and customers and production processes and tailoring investment, business models or consumer offerings in a way that better matches how the world actually works rather than stylised views of the world.

Big data is certainly a significant asset that can provide a comparative advantage for firms. All sectors of the economy can benefit from big data.

The analysis of big data can lead to improved production or delivery processes, targeted advertising and personalised recommendations, and improved management and decision making. Governments need to develop strong, forward thinking policies around privacy, access, collection, and use of this data.

Recent research[15] into data-driven innovation (DDI) captures the essence of big data. DDI is defined as "the innovation and consequent economic and social value that arises from the use of data analysis by private and public sector organisations to make better decisions and create new products and services." The paper estimates that in 2014, New Zealand consumers enjoyed benefits of $1.3b in the form of lower prices, and businesses benefited by $1.1b of higher revenue, lower costs and more efficient operations thanks to data driven innovation. Businesses, consumers and government could benefit by an extra $4.5b in the next five years if there is higher uptake of DDI by business and government.

1.7. The fast pace of technological change

We can define a tech sector, and measure the growth of its revenues or exports, but that is not the same as measuring technology or technological change.

A familiar measure of the rate of change in computer technology is Moore's Law – the doubling of computing power on a silicon chip every two years. As *The Economist*

[13] NZIER, September 2015. *Global Value Networks: How to succeed in business without worrying about scale, distance or thin markets*. By Laurence Kubiak, Killian Destremau and Philip Riley. https://nzier.org.nz/publication/global-value-networks

[14] See the OECD (2015) Science, Technology and Industry Scoreboard, pp.78-79.

[15] The Innovation Partnership, 2015. Data-driven innovation in New Zealand. Report prepared by Sapere and Covec.

newspaper noted in its tech survey in December 2015, the law has remained in operation since it was postulated in 1965, but some think it is coming to an end as the features packed onto a chip approach the size of atoms.

Kurzweil[16], a US scientist and futurist who studied Moore's Law, found that the exponential growth exhibited by the development of the silicon chip was not limited to computers. He found that once you take a domain and power it with information technology and information properties it starts to exhibit exponential growth. With the growth of computing power, connectivity and data we are starting to see this acceleration across a number of technologies and this has given rise to the term 'exponential technologies'. These exponential technologies, such as robotics, artificial intelligence, genomics and additive printing have the potential to further increase the pace of change.

1.8. A gap between technology and growth?

McKinsey & Co.[17] have identified a growing technology gap between the haves and 'have-mores' in the US economy, as distinct from the gap between the haves and have-nots. Using a series of metrics relating to technology expenditure, assets, and usage, their report indicates tremendous potential growth for those adopting and using technology to its full potential, and a sizeable gap down to the haves, who have the technology at their disposal but haven't yet been able to exploit it to its full potential.

Research by Sapere & Covec[18] estimated that data driven innovation will yield benefits to the New Zealand economy of $4.5b in five years. On a different scale, the McKinsey report predicts the US annual GDP will be 6-8% ($2.2 trillion) bigger by 2025 owing to just three big areas of potential: online talent platforms (e.g. LinkedIn), big data analytics, and the Internet of Things. Both reports are about economic growth based on technology that already exists, but both reports expect growth to be delayed by several years because of the difficulty of adopting and exploiting digital technology.

The gap that has opened up between digitisation and economic growth might just be a lag, or delay, as McKinsey & Co. expects. But there are certain benefits of digitisation that are not explicitly reflected in the GDP statistics. For example, the prices of ICT goods and services fell by 63% between 1983 and 2010 according to McKinsey, while the prices of other durable goods and services increased. Adjusting for these price falls could significantly increase the perceived relative importance of the ICT sector in the US economy.

1.9. Technology delivers benefits well beyond simple monetary measures

There are also some benefits of digitisation that will never be fully reflected in GDP. Some of the ICT services that are now delivered at reduced prices or for free to consumers are not necessarily used in market transactions. They may be apps used for recreation or convenience or comfort (e.g. Facebook), and that deliver definite

[16] Kurzweil, R, 2001. The law of accelerating returns. http://www.kurzweilai.net/the-law-of-accelerating-returns

[17] McKinsey Global Institute, December 2015. Digital America: a tale of the haves and the have-mores.

[18] The Innovation Partnership, 2015. Data-driven innovation in New Zealand. Report prepared by Sapere and Covec.

consumer benefits, but there are incomplete or missing markets for such services and amenities.

For example global IT consultancy IDC publishes data about the extent of consumer uptake of services such as Facebook that do not necessarily entail direct costs for consumers. On the other hand Facebook is an immensely valuable organisation. But it is not clear how social networking directly translates into either economic activity or consumer benefit.

IDC found approximately 80% of New Zealand households now have an Internet connection. Its global 2015 *ConsumerScape* study, which includes 1,500 New Zealand consumers, reported the following trends:

- New Zealand has the highest adoption rate of Facebook of any developed country. 85% of respondents had accessed Facebook in the last 30 days, compared with 80% in the USA
- 48% of New Zealand respondents have used their computer to stream movies or TV compared with 41% of USA respondents. On smartphones the figure is 12% compared with 22% in the USA

On balance it seems fair to conclude there is a wide gap between digitisation and economic growth. In part, consumers, businesses and government have difficulty exploiting the digital technology they have acquired. But there are significant benefits of digitisation that are not (and may never) be fully recognised in the GDP numbers. Then again, economists have known for a long time that GDP is far from being the perfect measure of economic welfare/well-being.

1.10. The New Zealand tech sector

The tech sector is a dynamic and growing part of the New Zealand economy, featuring high levels of innovation, connectedness and expenditure on R&D. Table 2 shows some summary statistics on the tech sector.

The combined tech sector accounted for an estimated 8% of GDP in 2015, contributed 9% to exports, and employed about 5% of the total workforce.

The ICT sector made up 6.2% of GDP and employed about 55,000 people in 2015. ICT exports were $1.7b in 2014. High-tech manufacturing contributed 1.8% of GDP and employed about 44,000 people. Exports in 2014 were $4.4b.

Table 2 Tech sector highlights

2015 estimates except exports (2014 actual)

	High-tech manufacturing	ICT	Combined
Contribution to GDP	$3.7b (1.8%)	$12.5b (6.2%)	$16.2b (8%)
Industry output	$8.7b (2.2%)	$23.5b (5.9%)	$32.2b (8%)
Contribution to exports	$4.4b (6.5%)	$1.735b (2.5%)	$6.1b (9%)
Employment	44,161	54,750	98,911

Source: NZIER, Statistics NZ

A feature of the tech sector as defined is that there are some overlaps between ICT and the high-tech manufacturing sectors. Table 3 shows the broad product and service categories included in the tech sector, the overlaps between certain manufactured goods that are also part of the ICT sector and examples of businesses in each group.

Table 3. The tech sector

Showing the ICT overlaps with tech manufactures

Tech Sub-Sectors	Categories	Examples
ICT	Telecommunications services	Spark, Vodafone, 2Degrees, M2, Chorus
ICT	Computer systems design and related services	Datacom, Xero, IBM, Microsoft, Orion Health, Fronde, GeoOp, Wynyard, PartsTrader, Serko, Invenco
ICT	Software publishing	Pingar, Sidhe
ICT	Internet service providers, web search portals & data processing services	Revera, Inspire.net, Greenbutton
ICT	Wholesaling of ICT goods	Ingram Micro, Duo
ICT / High-tech manufacturing	Communication equipment manufacturing	Tait Communications
ICT / High-tech manufacturing	Computer & electronic equipment manufacturing	Novel Ways, Smartrak
ICT / High-tech manufacturing	Other electronic equipment manufacturing	Rakon, Dynamic Controls
ICT / High-tech manufacturing	Professional & scientific equipment manufacturing	AuCom, MagriTek, AD Instruments, Atrak
ICT / High-tech manufacturing	Electric cable & wire manufacturing	General Cable Superconductors
High-tech manufacturing	Aircraft manufacturing & repair	Pacific Aerospace
High-tech manufacturing	Pharmaceutical & medicinal product manufacturing	PharmaZen, Argenta
High-tech manufacturing	Medical & surgical equipment manufacturing	F&P Healthcare
High-tech manufacturing	Basic chemical & chemical product manufacturing	Nuplex, Zelam, Arotec Diagnostics, Skinfood
High-tech manufacturing	Machinery & equipment manufacturing	Glidepath, Scott Technology, Compac Sort, Wellington Drive
High-tech manufacturing	Motor vehicles & parts manufacturing	Designline

Source: adapted from MBIE Sector Reports

1.10.1. The ICT sub-sector

ICT occupies a unique position in the tech sector owing to its cross-cutting impact and the pervasive benefits of digitisation throughout the economy. Businesses in some parts of the ICT sector also belong in the high-tech manufacturing sector.

Statistics NZ's biennial survey of the ICT sector[19] (see Table 4) states that sales of ICT goods and services in 2014 were up 3% from 2012[20] and exports of ICT services increased by 23%.

Table 4 New Zealand's ICT sector sales, 2014

As surveyed by Stats NZ

ICT sales	2014
Domestic ICT sales	$21.719b
- services	$12.821b
- software	$1.526b
- goods	$7.372b
ICT exports	$1.735b
- services	$697m
- software	$300m
- goods	$738m
Total ICT sales	$23.453b

Source: Statistics New Zealand

Sales of ICT services have been growing as a proportion of ICT sector sales since 2008 and, together with software sales, now contribute two thirds of total ICT sector sales. ICT services are provided by firms such as Datacom, Fronde, IBM, Fujitsu and Optimation, as well as ICT applications or products provided by New Zealand firms such as Xero, Orion Health and Vista Group.

ICT exports were $1.735b in 2014 and have grown strongly over the last few years. ICT services exports include IT technical support services, hosting and IT infrastructure provisioning services, and design, consulting and development services. ICT services exports rise to almost $1b if software exports valued at $300m are counted as ICT services exports, rather than ICT goods exports.

1.10.2. The high-tech manufacturing sub-sector

High-tech manufacturing sectors have grown strongly in recent years. This despite total manufacturing having slipped from 26% of GDP in 1972 to only about 15%. Virtually all categories of manufacturing have fallen, with the notable exception of dairy products, but the high-tech manufacturing sectors have grown strongly in recent years.

There are close links to services, the largest sector of the economy, through vertical integration (manufacturers that also provide services) and the fact that manufacturing

[19] Statistics New Zealand, 2014. Information and Communication Technology Supply Survey: 2014

[20] Note that total ICT sales significantly exceed the sector's contribution to GDP, which is only the value-added proportion (an estimated $12.5b in 2015).

uses services inputs and vice versa. The rate of innovation in New Zealand is around 46%[21], with service industries reporting more innovation than manufacturing industries.

High-tech manufacturing is a relatively small subset of the manufacturing sector, which is export intensive – NZIER estimates it generated $4.4b of exports in 2015.

Manufacturing in New Zealand relies on 'talent-driven innovation' to drive manufacturing competitiveness in niche sectors, according to Castalia[22] and Deloitte[23].

MBIE[24] describes how high-technology manufacturing has developed from the early 1990s to become a significant export earner. The high-tech manufacturing sector struggled with both the rising exchange rate and the Global Financial Crisis, but exports recovered strongly in 2011. The majority of high technology manufacturing firms export most of their output, and the major export destinations are the US and Australia.

Against this background it appears high-tech manufacturing is important to the internationalisation of the economy and may be able to help key sectors establish scale. The New Zealand economy – more than other countries – needs high performing exporters to compensate for the problems posed by isolation and small size. Being small and isolated means reduced access to new ideas and expertise, reduced competitive pressure, fewer options to specialise, and higher costs of infrastructure.[25] This contributes to lower productivity growth – and lower per capita GDP growth – than other countries.

This line of reasoning holds that exporting can help NZ Inc. to overcome size and location drawbacks by adding scale and providing closer connections with the global economy, new ideas and expertise.

1.10.3. Jobs and job creation

Jobs, growth and welfare

There are well established links between innovation, job creation and growth. The New Zealand Treasury Living Standards Framework[26] incorporates innovation as a flow process that impacts not only on the financial and physical stocks of capital, but also on the stocks of human, social and natural capital:

> *A society's knowledge and capability to use knowledge are critical for the flow of innovation and knowledge, which are important determinants of economic growth.*

Innovation in education, health, and environmental sustainability is critical to this multi-dimensional view of living standards.

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[21] Statistics New Zealand, 2012. Innovation in New Zealand 2011. See http://www.stats.govt.nz/browse_for_stats/businesses/business_growth_and_innovation/innovation-in-new-zealand-2011.aspx

[22] Castalia, February 2014. New Zealand Manufacturing Sector: Its Dynamics and Competitiveness. Report for Manufacturing NZ, a division of Business NZ.

[23] Deloitte LLP and the U.S. Council on Competitiveness, 2013. Global Manufacturing Competitiveness Index.

[24] Ministry for Business, Innovation and Employment (MBIE), 2013. High technology manufacturing report. The New Zealand Sectors Report, 2013. New Zealand Government.

[25] O'Connor, P, J Stephenson and J Yeabsley, 2012. Grow for it: how population policies can promote economic growth. NZIER Working Paper 2012/01, Wellington.

[26] See: http://www.treasury.govt.nz/abouttreasury/higherlivingstandards

Employment in the New Zealand tech sector has been steadily increasing over the last few years, enabling the growth in output and exports. We estimate total employment in the tech sector is now 98,911, with 44,161 in high-tech manufacturing and 54,750 in ICT.

Table 5 Employment in the New Zealand tech sector, 2015

Sector	Employment
High-tech manufacturing	44,161
ICT	54,750
Of which: Computer systems design	*29,190*
Approx. tech sector employment	**98,911**
Total employment in all industries	2,045,610

Source: NZIER estimates from Statistics NZ data

It is also worth noting that not all ICT workers work in the ICT sector itself. There are now more than 20,000 ICT workers in other sectors of the economy.

1.10.4. The future of work

The traditional link between innovation and growth (and therefore employment) is now threatened by the rise of so-called disruptive technologies, such as autonomous electric vehicles, more efficient solar panels and batteries, distributed generation, the Internet of things (IoT), UFB connectivity and digital platforms. Manufacturing is being revolutionised by new materials and new processes such as 3-D printing, easy-to-use robots and collaborative manufacturing services that are available online. Back-office IT services jobs are predicted by Computerworld to fall by 25% by 2020[27], and banking also features as an at-risk profession.

Uber is disrupting the taxi industry, Airbnb is upsetting the hotel industry and companies like Xero are challenging the accountancy profession: no-one is immune from automation, it seems.

NZIER recently released a report prepared for the Chartered Accountants of Australia and New Zealand arguing that 885,000 or 46% of New Zealand jobs are at risk of automation in the next two decades.

The NZIER study also stressed that numerous jobs will likely be created in the implementation and delivery of new services and products and, as shown time and again over history, in the longer run, technological change is enormously beneficial. In short, predicting half of today's jobs will be automated in 20 years does not mean half the workforce will be unemployed.

Rather, it seems likely that people will do different jobs, or that they will do their existing jobs differently: Italian economist Enrico Moretti estimated in 2012[28] that each new high-tech job in the U.S. could (in the long term) create five additional jobs in the service economy. Moretti used the example of Apple, generating five times as many indirect jobs as direct jobs.

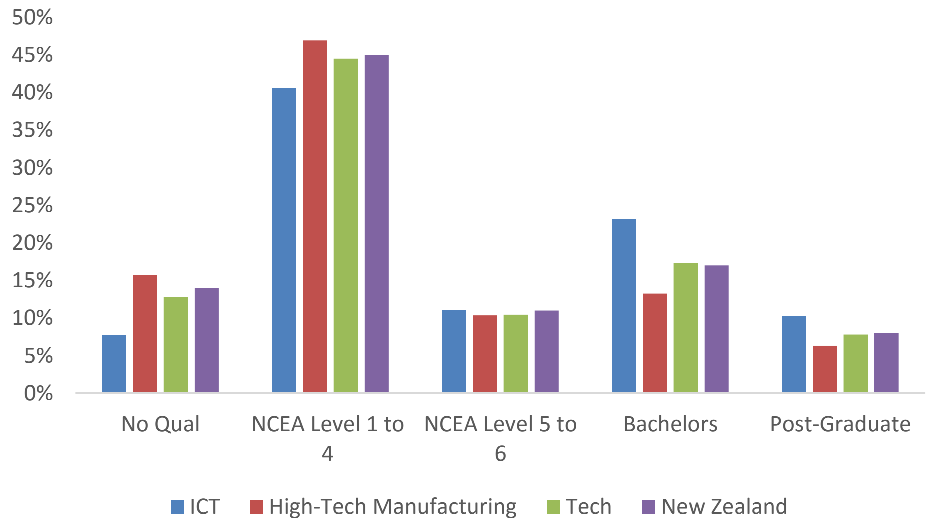
[27] See http://www.computerworld.com/article/2994377/it-careers/automation-expected-to-cut-workforce-needs-by-25-at-it-services-firms.html

[28] Moretti, Enrico, 2012. The New Geography of Jobs. Houghton Mifflin Harcourt.

1.10.5. Qualifications and earnings

We examined data on qualifications and earnings of employees throughout the economy to see if workers in the tech sector have more formal educational qualifications and are paid more than workers outside the tech sector. The results showed that employees in tech sector have higher qualifications than average and that the ICT sector in particular has a high proportion of tertiary-qualified employees (see Figure 1).

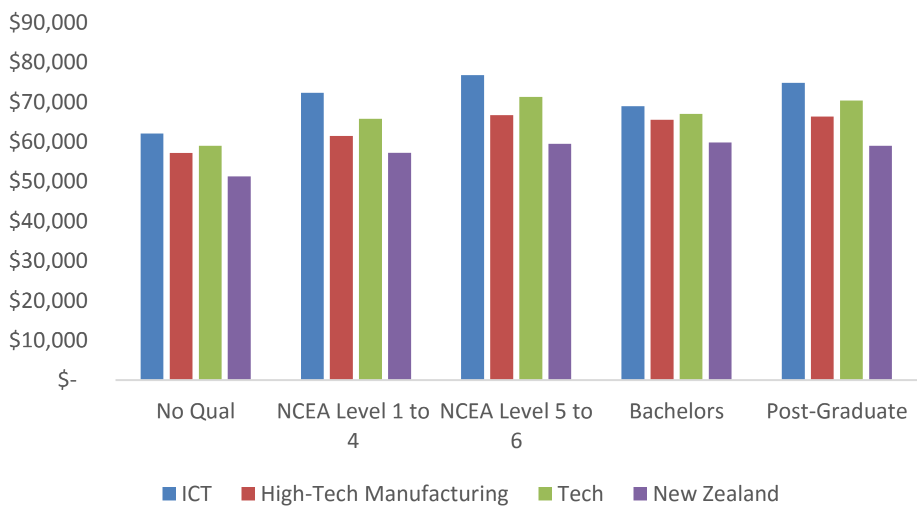
Figure 1 Highest qualification, percent of employees



Source: Statistics New Zealand, Census 2013

Given employees in the ICT and high-tech manufacturing sectors are more highly qualified than average, one would expect them to earn higher levels of personal incomes. This is confirmed in Figure 2, which shows average incomes are highest for employees in ICT, followed by the high-tech manufacturing sector, and in turn average tech-sector incomes are higher than the national average.

Figure 2 Mean personal income by sector



Source: Statistics New Zealand, Census 2013

A technique called principal components analysis was applied to identify how the data on median personal incomes and qualifications moves together by clusters of industries. The results of the analysis confirmed the effect that on-the-job experience on earnings can outweigh qualification levels.

1.10.6. Tech exports

New Zealand is not going to get rich by selling to itself. The small size of our domestic market constrains the potential for New Zealand businesses to grow without trading. The ability of businesses to sell their goods and services to customers in overseas markets is critical. Equally, imported technology goods and know-how are critical inputs for the domestic tech sector. The benefits of trade are traditionally seen as the ability to specialise in areas of comparative advantage, and to export the surplus in exchange for imports of goods and services in which there is relative disadvantage.

Modern thinking also recognises the importance of developing scale and the diversity of consumer preferences, to explain trade in branded goods and services, where countries are both exporters and importers of similar products.

Connections to international markets also allow us to access resources, including capital through foreign direct investment, technology goods and knowledge-based capital that can close technology gaps and stimulate innovation.

Global connections are critical for a geographically isolated country like New Zealand, and to a degree, technology and connectedness have conquered distance to maintain or create new opportunities for trade in diverse sectors.

Recognising the importance of trade the New Zealand government has, in terms of its Business Growth Agenda (BGA), set a high-level goal of increasing the ratio of exports to GDP to 40% by 2025. This should increase per capita GDP, levels of employment and prosperity.

New Zealand's exports are predominantly focused on primary products with more than half of all exports to June 2015 coming from primary products ($35.7b)[29]. While natural resources will remain the basis of our competitive advantage for years to come there are natural limits to how big the primary sector can become and there is a need to ensure sustainability by working within environmental constraints. Longer-term risks to primary sector products are looming with the advent and imminent commercialisation of various synthetic protein versions of products such as beef and milk. Ultimately, for New Zealand to diversify its export base, technology will play an increasingly critical role by helping create new exports and higher-value niche products that complement our existing national specialisation in agriculture.

Since 1990, exports from New Zealand's high tech manufacturing sector have grown from under $100m to an estimated $4.4b in 2015. Exports of high-tech goods and services from the ICT sector have grown to a predicted $1.7b in 2015. Therefore in total the tech sector generated an estimated $6.1b of exports in 2015, making it one of the largest export sectors for New Zealand in its own right, quite apart from the technology

[29] See MPI's December 2015 update to the Situation and Outlook for Primary Industries (SOPI) report.

that is embodied in the exports of all other industries. By comparison, dairy exports were $11.5b in 2015, tourism exports $9.7b and meat exports $6.8b[30].

The tech sector is also more export intensive than New Zealand industries on average. In other words, a higher proportion of total sector output is exported than average.

In addition to the tech sector being an important exporter, the use of technology by other sectors bolsters their exports. Statistics New Zealand[31] demonstrated the importance of collecting export orders by internet, for businesses of different sizes, as shown in Figure 3. A high proportion of businesses of all sizes now use the internet to collect international sales orders.

Figure 3 Internet sales and exports – by business size

Source: Statistics New Zealand, 2013

From the same survey, the (dollar-value) information presented in Figure 4 indicates it is mainly the goods-producing industries rather than the services sector that use the internet to collect international sales orders. The research also indicates substantial opportunity for our primary sectors to improve their use of the internet to collect sales orders.

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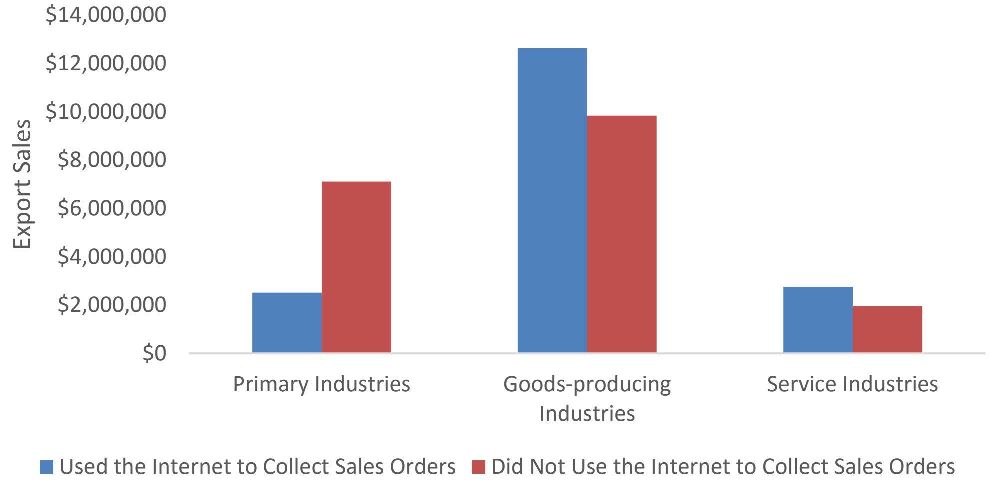
[30] See: http://www.stats.govt.nz/browse_for_stats/industry_sectors/imports_and_exports/GoodsServicesTradeCountry_HOTPYeDec15.aspx

[31] Statistics New Zealand, 2013. Strong connection between ICT and business growth activities. New Zealand Government. See: http://www.stats.govt.nz/browse_for_stats/businesses/business_growth_and_innovation/ict-use-business-characteristics.aspx#growthactivity

Figure 4 Internet sales and exports – by business sector

Average export sales per business; 2012 financial year-end



Source: Statistics New Zealand, 2013

1.10.7. The importance of underlying networks

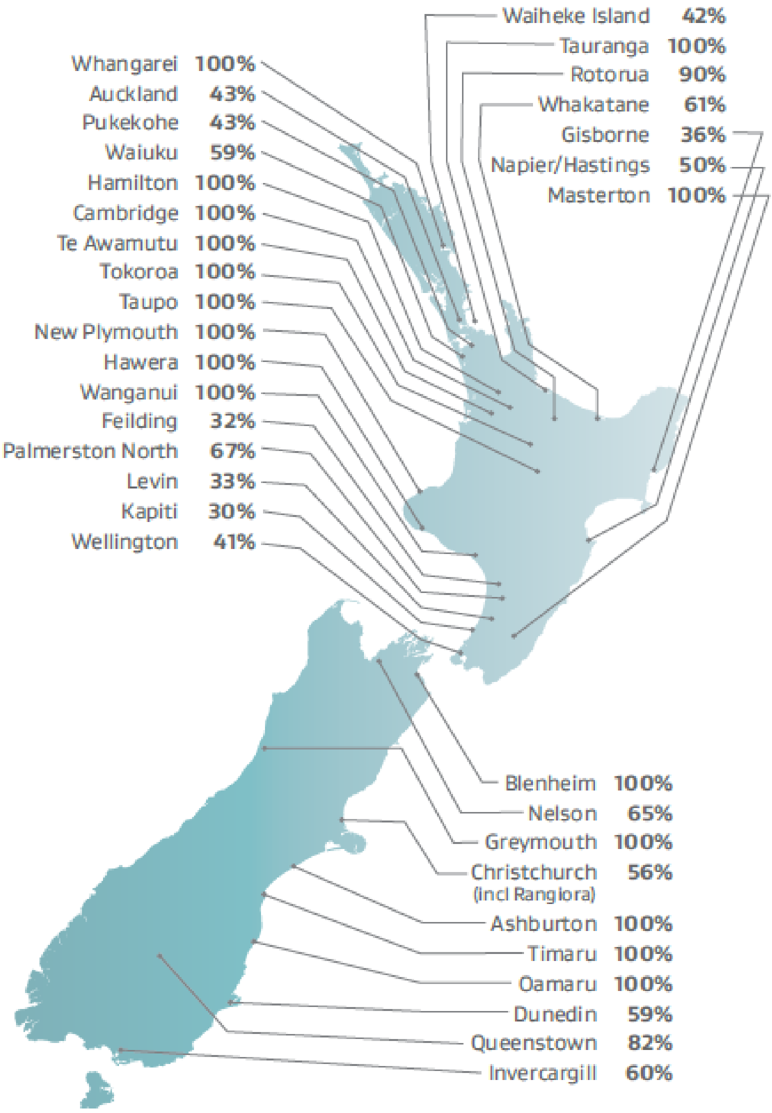
New Zealand is well placed among developed countries in the rollout of fibre, wireless and international cable networks. The government's Ultra-Fast Broadband (UFB) programme and Rural Broadband Initiative (RBI) are well advanced and the production and use of these networks are critical drivers of productivity growth and employment across the economy.

Nevertheless there are still huge potential gains for households and businesses, as the current uptake of UFB is only 18.6%, whereas by December 2015 the UFB network was available to 875,000 households and businesses[32]. This is 60% of the target of connecting 1.459m households and businesses with fibre to the premises by the end of 2019, which corresponds to 75% of New Zealanders. Note (Figure 5) that there are still substantial backlogs in the two tech centres of Auckland (43%) and Wellington (41%), indicating not only the greater workload to get through but also the greater potential for users to benefit from the rollout and subsequent uptake of fibre connection.

[32] MBIE, 2016. Broadband deployment update, December 2015. See: https://www.crownfibre.govt.nz/wp-content/uploads/2014/05/Quarterly-Broadband-Deployment-Update.pdf

Figure 5 UFB Deployment Update

December 2015



Source: MBIE, 2016

As for the RBI, Government has partnered with Chorus and Vodafone for the first phase to build and upgrade wireless towers, upgrade or install rural telecommunications cabinets and extend Chorus's existing fibre network by about 3,350 kilometres.

Effectively all priority users (schools and rural hospitals) have now been connected through the UFB or RBI.

Government has now further extended the UFB programme and the RBI. An investment of $210m from the Future Investment Fund will raise the targeted number of New Zealanders with access to UFB from 75% to 80%, so about 50 more small towns will have access to UFB. Government will invest another $100m to extend the RBI into more rural areas, and Government is talking to businesses and communities to fix mobile coverage black spots along main highways and at major tourist sites.

Rollout of the infrastructure is just the first step – the second step, as mentioned, is actual connection or uptake by households and businesses. Then follows a learning process during which users gradually realise and start to exploit the potential of the new infrastructure. For example, many small businesses will start off by replacing costly 'resilience assets' such as servers, by transferring data storage to the cloud.

This reinforces the importance of the broader ICT sector to productivity and economic growth. It also emphasises the huge value of the underlying networks and the positive network effects that are generated by rollouts of network infrastructure that now carries not only voice, but also Internet, media and data.

A recent report on the telecommunications sector by Sapere[33] noted telecommunications investment compared with sector revenue put New Zealand near the top of the OECD in 2013 and that total telecommunications investment reached $1.7b in 2014 (including the UFB and RBI investments in fibre). These investments facilitated the uptake of internet services, and the number of uncapped broadband connections jumped from 8% of broadband connections in 2014 to 33% in the year to June 2015.[34]

The OECD found the ICT sector's contribution to New Zealand's GDP growth was higher than that of any other OECD country, including our 10 main OECD export competitors in two periods: 2001 to 2007 and 2008 to 2013.

1.10.8. The economic impact of the internet

A Sapere report[35] prepared for Google in 2014 examined the economic impact of the internet for businesses outside the ICT sector. Firms that make more extensive use of internet services were found to be 6% more productive than average firms in their industry. The significance of the 6% result was calibrated against the average annual labour productivity growth of 1.5% 1996 to 2012. The authors concluded firms that use internet services more extensively are, in a sense, four years ahead of the average in their industry in terms of business competitiveness.

The report also estimated that if all firms adopted higher usage of Internet services, the productivity impact on the level of national GDP could be up to $34b.

NZIER's own research relied on more conservative assumptions and complex methods of computable general equilibrium (CGE) analysis. We considered the potential impact on economic growth of the underlying internet infrastructure becoming 10% more productive. The absolute numbers are small because the internet is only one-third of one percent of the economy, so a 10% boost is only equivalent to a one-thirtieth of a percent of GDP.

But our results show that a 10% improvement in the internet infrastructure would lead to much larger impacts on GDP than what the internet infrastructure improvement might cost.

It is important that the nature of the stimulus we are modelling here is illustrative, and that it is a 10% improvement in the internet infrastructure, not a 10% reduction in the cost of internet services. But, if the internet infrastructure is suddenly 10% better, in that it works faster, is more reliable, or reaches more homes and businesses, then we can say

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[33] Sapere Research Group, 2015. Telecommunications Industry Sector Report, by Peter MacIntyre and Aaron Schiff, for the New Zealand Telecommunications Forum.

[34] A caveat is that all sectors undergo investment cycles, so one year's data might not indicate a trend.

[35] Sapere Research Group, 2014. The value of internet services to New Zealand businesses. Report prepared for Google by Hayden Glass, Preston Davies, Eli Hefter and Gary Blick.

it is *as though* the price of internet services has fallen by 10%, and that is how we incorporate it into our model.

Note that in the past few years, the price of internet services has fallen by much more than the simulated 10%, as internet speeds have risen and as the price of data has fallen. Therefore the impacts on growth and employment of those actual price falls (and quality-adjusted price falls) could have had larger impacts than our analysis estimates.

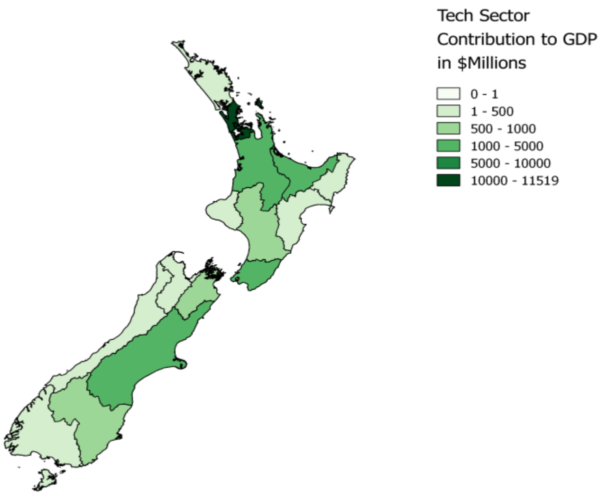
2. The significance of the tech sector in New Zealand

2.1. The tech sector is important in all regions

Regional economic growth across New Zealand is crucial for the overall economic growth of the country. Economic activity in general is concentrated in Auckland, Wellington and Christchurch. These three regions account for almost two thirds of national GDP and are the connections to the rest of the world. However, New Zealand's rural regions are the drivers of our largest industry sector, primary production.

Adopting technology is essential for the survival and economic growth of rural New Zealand. It is common sense that the further away you are from other people, the more important it is to be connected to them somehow. Therefore investment in the RBI is critical. Each region has a different economic DNA but, as Figure 6 shows, the tech sector already plays an important role in all regions of New Zealand.

Figure 6 Tech-sector activity across New Zealand



Source: NZIER

NZIER researched the spatial clustering of tech-sector economic activity and although there are clusters of activity in and around Auckland, Wellington and Christchurch, technology and connectivity are important across all regions of New Zealand.

Auckland, Wellington and Canterbury are the primary regional hubs for the tech sector, as they benefit from agglomeration, information sharing, and developed infrastructure, including the UFB network. There are several benefits of agglomeration. Agglomeration saves on the cost of moving goods (inputs and outputs) from one point to another[36], and when people cluster together in cities they tend to exchange ideas, which fosters innovation[37]. But new insights[38] recognise that manufacturers no longer seek to locate their facilities in expensive, densely populated urban areas, because logistics costs have fallen, so it is not as crucial for manufacturers to be located in the city centre. But with the ICT sector, and to a lesser degree the high-tech manufacturing sector, there is still the incentive to cluster together and exchange ideas.

In this section we take a closer look at the tech sector in Auckland, Wellington, Canterbury and Otago; the other regions are discussed in brief in Appendix B.[39]

Auckland

The mix of Auckland's industry is moving towards the knowledge-intensive sectors, including ICT, media, (e.g. screen and television productions) and financial and insurance services, which are both big users of tech services.

Table 6 shows that while Auckland has a third of New Zealand's population, it accounts for about half of the tech sector's income, employment, GDP and exports.

Auckland is home to more than 60% of the fast-growing $2.85b export education industry, which adds to the information-sharing benefits generated by the agglomeration of Auckland's many public and private research organisations, including its world-class universities. Basic and applied research is thriving in the areas of life sciences and biotechnology, and Auckland leads the country in the number of patent applications.

Table 6 Tech sector regional snapshot: 2015

Percentage

Regional share of →	Population	Tech sector income	Tech sector employment	Tech sector GDP	Tech sector exports
Auckland	34	47	48	48	45
Wellington	11	14	14	15	11
Canterbury	13	16	15	15	17
Otago	5	2	2	2	3

Source: NZIER estimates from Stats NZ data

Analysis of spatial employment data reveals that for the ICT sector, there are some patterns showing the location of ICT employment. These patterns are most evident for Auckland (see Figure 7 and Figure 9).

Very different spatial patterns are evident in the results for the various subsectors of the high-tech manufacturing sector. To some extent, the spatial patterns in high-tech manufacturing reflect what has happened to the wider category of all manufacturing in New Zealand. Less concentration around urban areas, and not as much concentration or

[36] See Krugman, P, 1991. Increasing Returns and Economic Geography. Journal of Political Economy, 99(3):483-499.

[37] See Marshall, Alfred. 1890. Principles of Economics. London: Macmillan and Co.

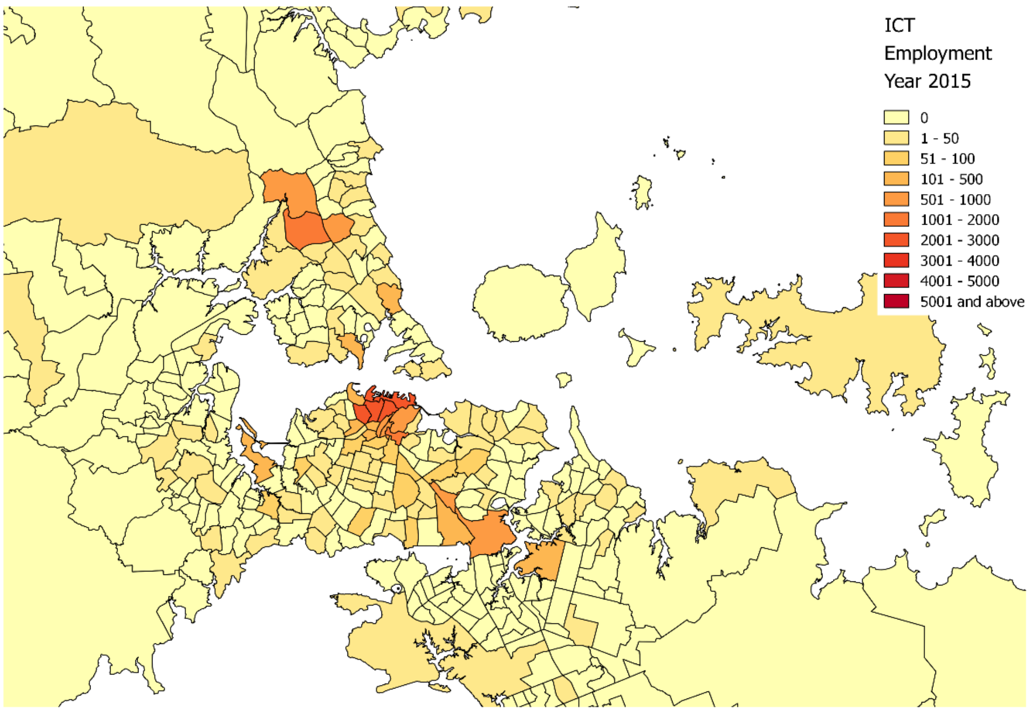
[38] See Glaeser, EL and JD Gottlieb, March 2009. The Wealth of Cities: Agglomeration Economies and Spatial Equilibrium in the United States. NBER Working Paper No. 14806.

[39] This section relies on information in MBIE, 2015. Regional Economic Activity Report 2015.

agglomeration close to the heart of urban areas. As transport costs have fallen, it is no longer critical for manufacturers to be in city centres, and there is not the same incentive related to information sharing that drives urban clustering in the ICT sector. The expense of locating manufacturing facilities in dense urban areas therefore means manufacturers can relocate on the fringes of the big cities.

For example, consider a subsector of high-tech manufacturing in Auckland (the manufacturing of other transport equipment – see Figure 8). There are patches of presence, not particularly concentrated close to the city centre, and not showing much agglomeration or density of employment. This is in stark contrast to the employment patterns we observe for the ICT sector. As stated, this reflects the changing priorities of manufacturing versus ICT – more land-intensive and less priority on transport costs or the need for information sharing than is the case for the ICT sector.

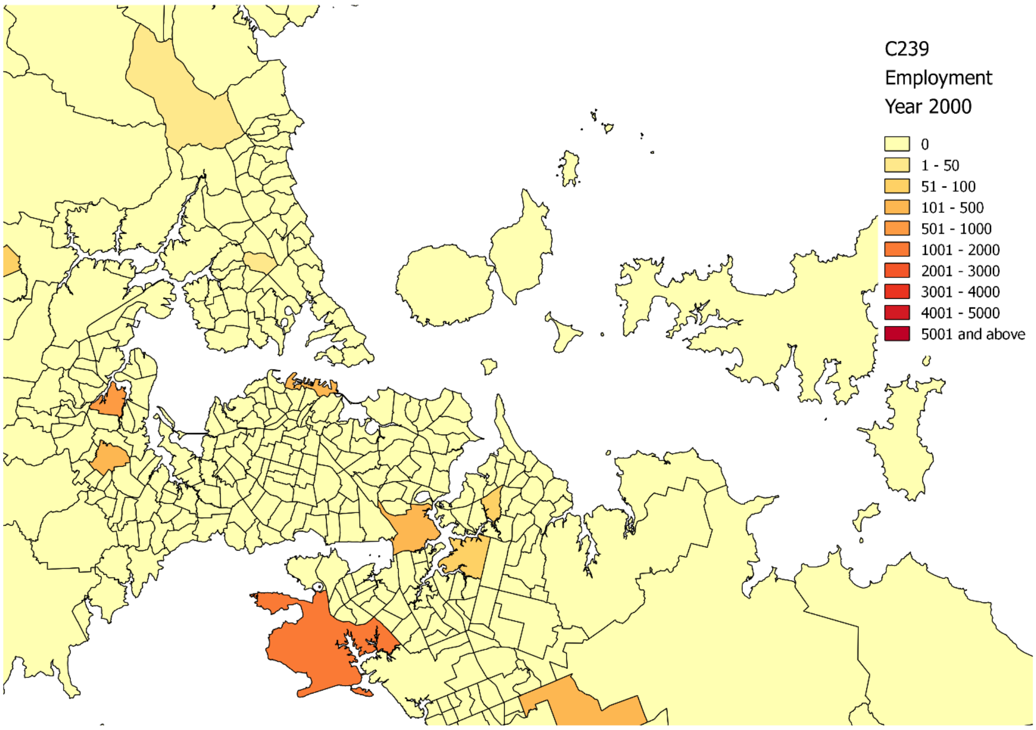
Figure 7 Employment density in the Auckland ICT sector, 2015



Source: NZIER, Statistics New Zealand

Figure 8 Employment patterns in high-tech manufacturing: Auckland

Other transport equipment manufacturing (ANZSIC category C239)

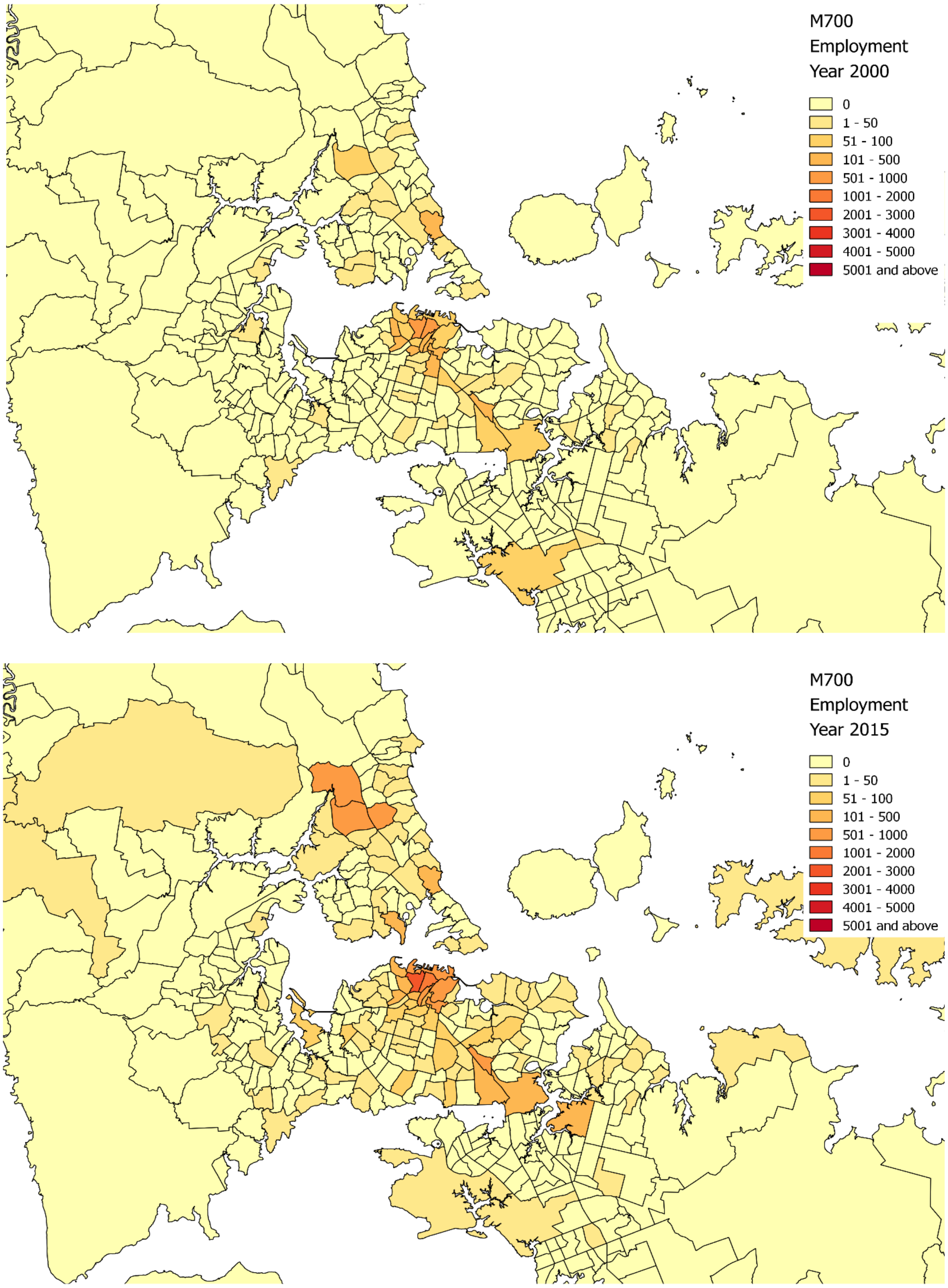


Source: NZIER, Statistics New Zealand

We examined changes over time in spatial employment patterns for the important (and export-intensive) ICT subsector 'computer system design and related services' (see Figure 9). Here there are clear signs of the significant growth and employment of the subsector in Auckland in the period 2000-15. The sector's presence and reach has increased, and there are signs of greater concentration of employment, which should be associated with a greater focus on innovation.

Figure 9 Employment clustering in ICT: Auckland, 2000 & 2015

Computer System Design and Related Services (ANZSIC category M700)



Source: NZIER, Statistics New Zealand

Wellington

Earning New Zealand's highest household incomes, three-quarters of Wellingtonians are employed in high-skilled occupations. The region has a tech sector with high levels of innovation, R&D and business collaboration.

Wellington is also home to a large and thriving software development industry, and the region has a high proportion of employees in other knowledge-intensive industries, from ICT to financial and insurance services. The film industry has also agglomerated in Wellington and generates 80% of industry revenue, via a cluster of post-production and visual effects technology businesses, which are likely to be big users of tech sector products.

Cloud-based accounting software company Xero is rated the most innovative company in the world by Forbes[40] and is headquartered in Wellington. Forbes ranks companies by their 'innovation premium', or the difference between market capitalisation and a net present value of cash flows from existing businesses.

Many tech sector products play an important role in the provision and delivery of public services, such as health, education and government administration. Those services are concentrated in major urban areas, and play a particularly important role in the expansion of the Wellington economy.

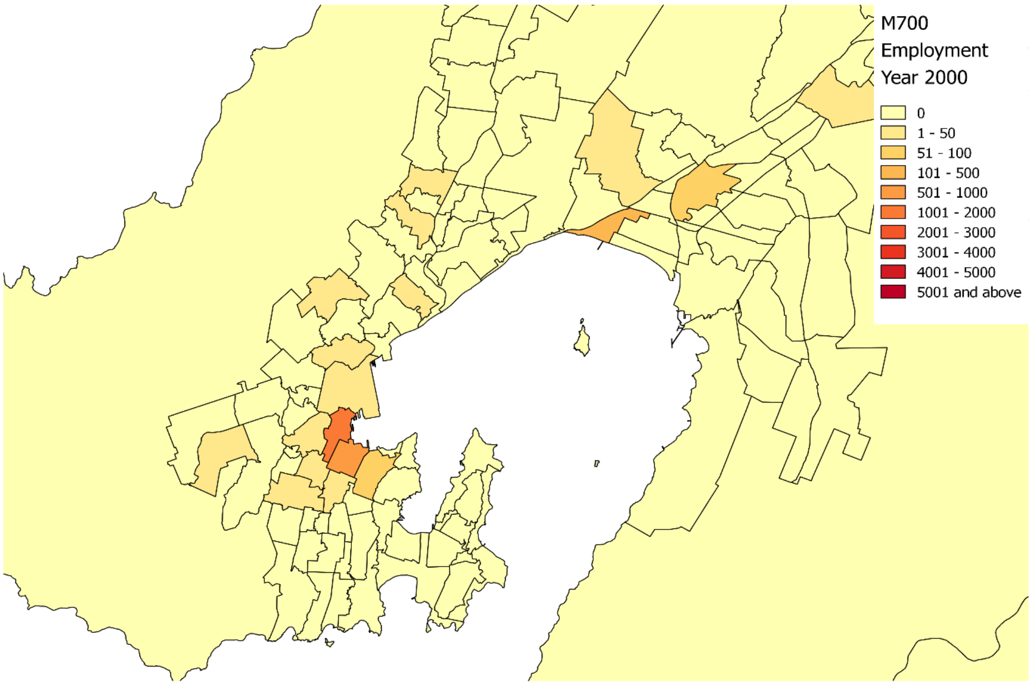
The changing spatial patterns of employment in the Wellington ICT sector are illustrated in Figure 10. The small size of the Wellington CBD maximises the benefits of agglomeration, such as the opportunities for bumping into people on the street and sharing ideas and information with them.

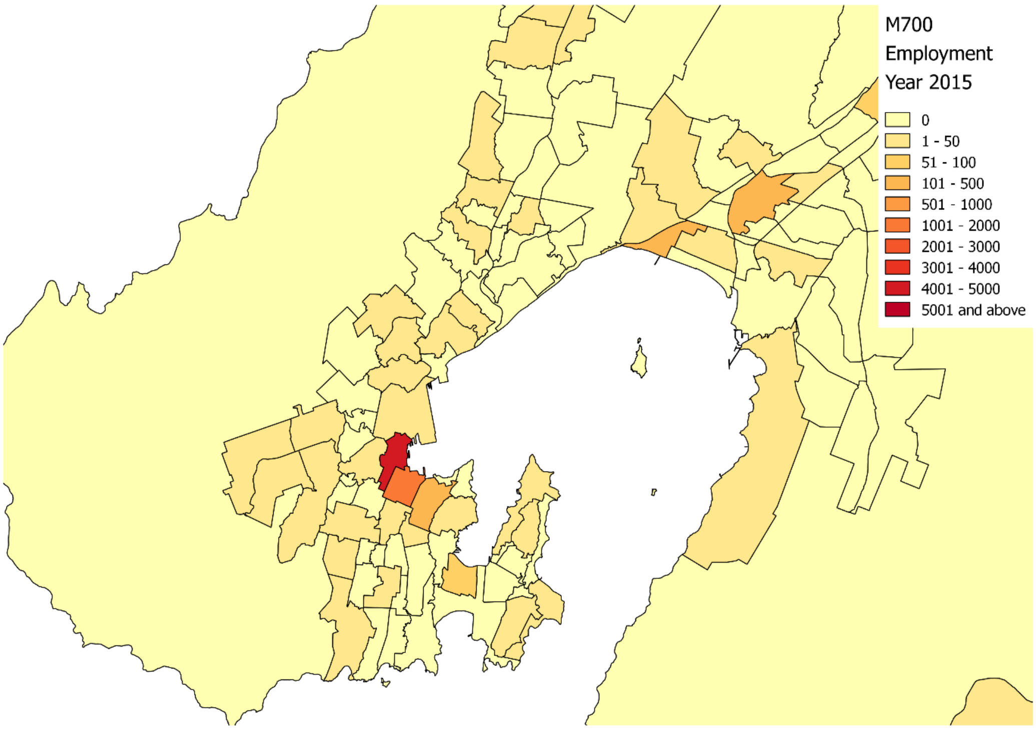
As is the case for Auckland, there are clear patterns of concentration exhibited for the ICT subsector 'computer system design and related services'. Employment within that subsector has grown strongly in the period 2000-15 as businesses have opened up in more and more suburbs of Wellington, mainly in the city centre but also expanding west, south and east, and up along the motorway routes SH1 and SH2.

[40] See www.forbes.com

Figure 10 Employment clustering in ICT: Wellington, 2000 & 2015

Computer System Design & Related Services (ANZSIC Category M700)





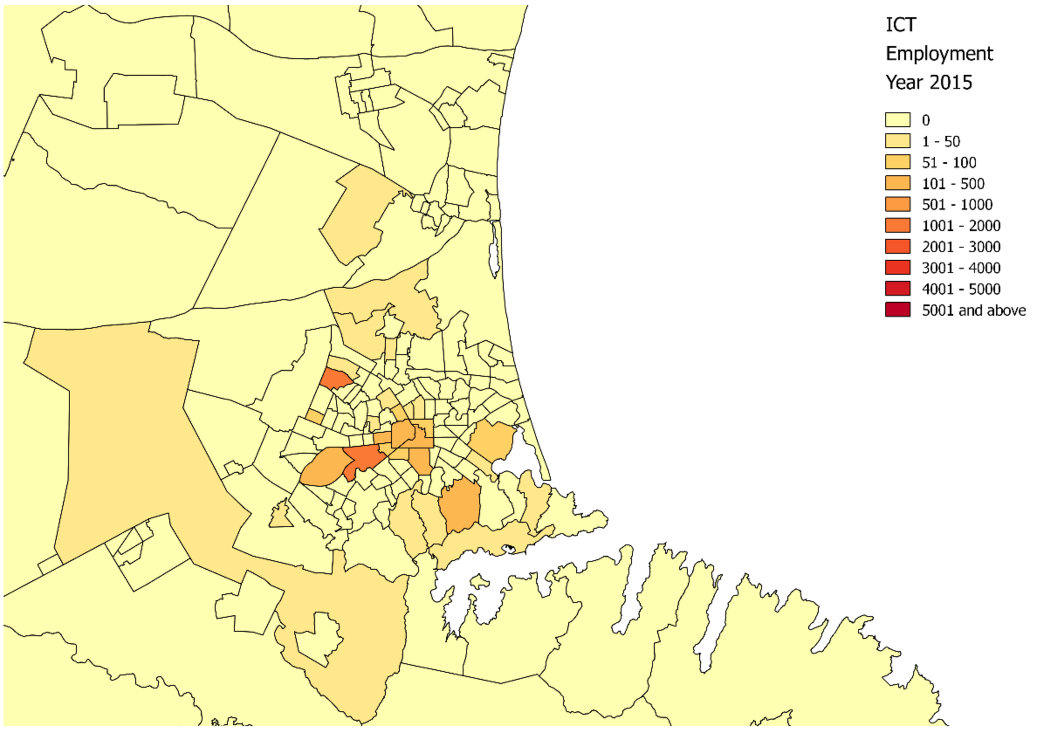
Source: NZIER, Statistics New Zealand

Canterbury

New Zealand's largest region has a huge agricultural sector, with sheep, beef, grains, and dairy conversions/intensification in recent years. Continued growth in the dairy sector depends on the innovative use of farm management techniques, including water and nutrient management and irrigation, as farmers must comply with water quantity and quality limits. Christchurch is the manufacturing centre of the region and post-earthquakes reconstruction is still an important part of economic activity. It is promising that Canterbury has a low proportion of youth not in employment, education or training (NEET). Table 6 shows that like Wellington, Canterbury's share of tech sector measures corresponds to its share of the population.

In the decade before the Canterbury earthquakes, Christchurch's IT services sector grew at more than 1.5 times the national rate, but since the earthquakes, Christchurch ICT sector employment fell by 7% (2012-14) while New Zealand ICT sector employment overall increased by 6.2%[41]. The long-term Tech Sector Strategy targets the development of talent, connecting with local partners such as the Canterbury Software Cluster and Innovation Precinct tenants, and increasing global exposure.

Figure 11 Employment density in the ICT sector, Canterbury 2015



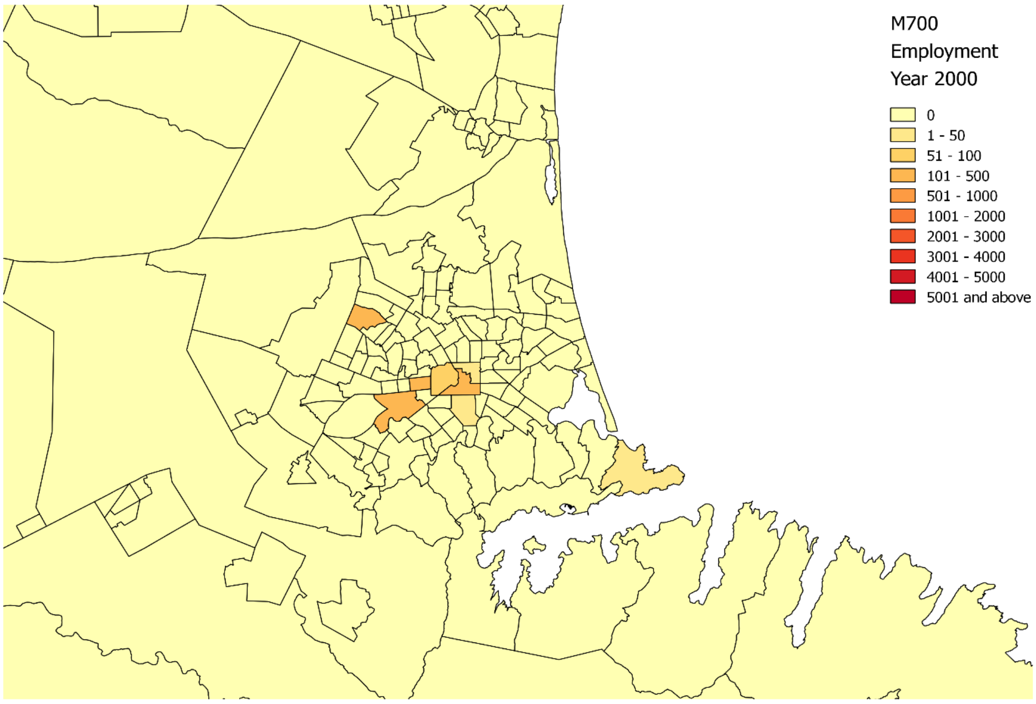
Source: NZIER, Statistics New Zealand

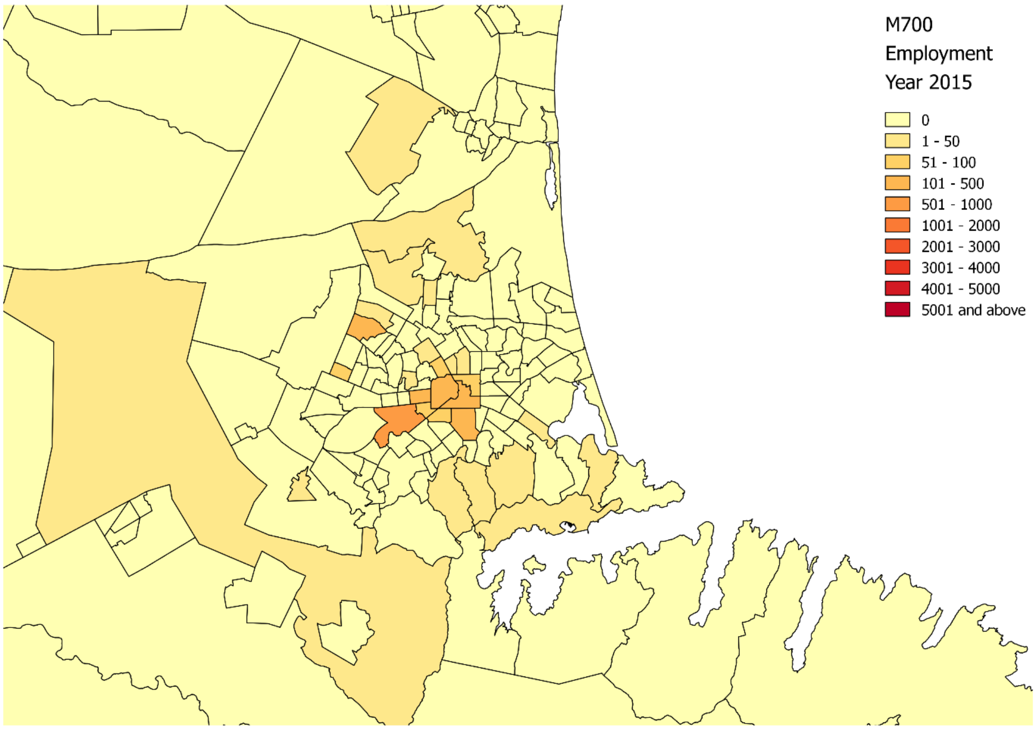
Figure 11 shows the employment density for the ICT sector, in and around Christchurch in 2015. Some clustering around the city centre is evident. At a more disaggregated level, Figure 12 shows changes in the period 2000-15 in the clustering of employment in the key subsector, computer system design and related services. There is more evidence of clustering in and around Christchurch, and over time there is clearly a concentration of existing patterns, plus a spread of the sector to outlying areas of Christchurch.

[41] Canterbury Development Corporation, 2014. Christchurch's Tech Sector Strategy, 2015-2025. See http://goo.gl/W9jwiU

Figure 12 Employment clustering in ICT: Christchurch, 2000 & 2015

Computer System Design & Related Services (ANZSIC category M700)





Source: NZIER, Statistics New Zealand

Otago

Otago has a relatively small share of the country's population, GDP, and tech sector activity and employment. While the Clutha and Waitaki districts of Otago are specialised in farming – sheep, beef, grain, and dairying – economic activity in Dunedin is concentrated on education and healthcare. This bodes well for the development of high-tech services and manufacturing in ICT, health technologies and biotechnology, and food processing.

Dunedin City Council's Digital Strategy for 2010-13[42] was focused squarely on government's 'four Cs' – connection, content, confidence and capability – rather than the digital sector. At that time the Strategy noted that many businesses, community groups and schools were not serviced by fast, high-quality digital networks.

Gigatown

Dunedin was the winner of the online competition Gigatown, developed by Chorus to help educate and inspire New Zealanders about the possibilities that a country connected with ultra-fast broadband can provide.

To earn points in the competition, supporters created relevant discussions on social media with town-specific hashtags, and completed different challenges that focused on the social and economic benefits of gigabit services. During the 13-month long competition, 990,917 people visited gigatown.co.nz and there were 5,950,000 conversations on social media about Gigatown and the power of UFB.

Dunedin's prizes for winning Gigatown included Chorus making a special 1Gbps UFB service available in Dunedin at entry level broadband prices.

Winning Gigatown will boost Dunedin's UFB connectivity and enable the realisation of the ideas devised during the competition. Dunedin's Gigatown Plan envisions a smart city, with the Internet of Things transforming public transport, museums and art galleries, and public health delivery, and the Plan is to empower existing smart companies such as Fisher & Paykel Design, Scott Technology, ADInstruments, Escea and Animation Research to create high-value jobs.

[42] See: http://www.dunedin.govt.nz/__data/assets/pdf_file/0008/152864/Corporate-Dunedin-Digital-Strategy-27-9-2010.pdf

2.2. Joined-up regions

Our analysis shows there are clusters of tech sector activity in the major centres, reflecting the benefits associated with agglomeration, including information sharing. In regions where such clusters do not exist, connectedness can nevertheless act as a substitute for actual proximity to customers, markets, and suppliers, including employees. In this way, the UFB fibre rollout and the RBI can join up regions and extend some of the benefits of clustering and agglomeration in smaller towns and rural areas across New Zealand.

2.3. The tech sector benefits the wider economy

The state of technology influences how efficiently the inputs of commodities and factors of production (land, labour and capital) can be transformed into technology outputs. In turn, these outputs are often the inputs used by other industries for their production processes. Such linkages mean an improvement in technology or productivity in one sector can benefit growth in all industries and regions of the economy.

The impact of innovation on the economy can be modelled and estimated using computable general equilibrium (CGE) methods. For the analysis we used NZIER's TERM-NZ CGE model[43] to see what impact an increase in productivity[44] in the tech sector[45] would be likely to have on the rest of the economy. We also simulated an improvement in the productivity of the internet infrastructure.

We chose to simulate the impact of a 4% productivity improvement in the tech sector. The way this works is that we suppose there has been an invention or innovation that enables the tech sector to produce 4% more output than before. This improvement can be thought of as an improvement to current sector practice, perhaps a new compound or new software code which makes products cheaper or faster for the sector to make. It can also be thought of as the tech sector producing new products and services, such as cloud-based computing services or a new pharmaceutical, which open up new possibilities for others and make the sector's products more valuable to other businesses and consumers.

Our simulation is well within the bounds of the kinds of productivity gains that we have seen in the tech sector recent decades. We estimate that overall productivity growth in the New Zealand tech sector has averaged 1.2% per annum in the past 15 years.[46] That is half a percentage point faster than overall productivity growth in the New Zealand

43 'TERM-NZ' stands for 'The Enormous Regional Model' of the New Zealand economy. NZIER's TERM-NZ is a static, bottom-up, CGE model of the New Zealand economy and its key regions. The database of the model has been updated to the year 2014, and the model covers 106 industries and 205 commodities. The database and model were developed at NZIER by Dr Erwin Corong and are based on the original Australian TERM model created by Prof Mark Horridge of the Centre of Policy Studies at Victoria University in Melbourne, Australia. http://www.copsmodels.com/term.htm

44 We used a 4% productivity increase to represent an estimate of the boost that might be delivered by higher Internet usage and connectivity. A four percent boost was also used in the study by Gouranga (2008).

45 Industries included in 'the tech sector' were high-technology manufacturing, medium-high technology manufacturing, and ICT.

46 This estimate is based on so-called 'total' or 'multi-factor' productivity indices at the industry level with industry indexes combined using the shares of tech sector (nominal) current output in each industry. This index is not ideal but is the best estimate we can construct within the limits of publicly available data.

economy of 0.7% over the same period. The improvement we are measuring here is, for example, equivalent to productivity growth in the sector in 2011.

Labour productivity growth has been particularly strong in the New Zealand tech sector, with growth of 3.1% - twice that of the national average.[47]

Our model indicates that a 4% tech sector productivity improvement of this nature would cause New Zealand GDP to expand by 1.0%.[48] This amounts to a $2.7b expansion of the market economy, while labour income and capital income would grow by approximately $1.6b and $798m respectively[49] [50].

The expansion is spread across all regions. Auckland would grow most ($1.0b) followed by Canterbury ($391m). See Appendix C for the further results by region and by sector.

With the tech sector comprising 8% of total production in the economy, a 4% stimulus within that sector is like stimulating the entire economy by only 0. 32%[51]. Thus growth of 1.0% is three times the value of the initial stimulus. This magnification of growth comes about because tech sector productivity growth increases household income, nationwide investment and export income.

Businesses that buy products from the tech sector also benefit, whether from lower cost tech sector products or higher quality products. Those businesses then also attract higher investment, produce more output and exports, and generate higher incomes. The effect is cumulative so that when all is said and done, the economy as a whole has benefited by more than the assumed increase in productivity.

Such effects are not entirely unique to the tech sector. Productivity growth applied to any sector would have a compounding effect on economic growth. But the characteristics of the tech sector, particularly its outward focus relative to the average, mean that it has impacts that are higher than they would be for many other sectors; in particular, sectors that are labour intensive and reliant on domestic demand.

Furthermore, if the tech sector is a hub for innovation, it is more likely that the tech sector will achieve stronger productivity growth than other sectors.

The benefits of broad-based tech sector expansion are reinforced by our analysis of an increase in the efficiency of the internet infrastructure, which is estimated to be associated with economic growth of double the value of the internet efficiency gain.

2.3.1. Impacts could be much larger than we can model

There are good reasons to expect that growth in the tech sector would drive greater innovation and economic growth in ways not captured by our modelling. This would be

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47 Our comparisons here are with the national level indices that are not adjusted for labour force composition – seeing as our index is a simple weighted average and we cannot control for differences in labour composition which are specific to the tech sector.

48 For ease of reading, the results reported in the text are generally rounded to 3 decimal places which corresponds to 1 decimal place when shown as percentages. This 1.0% impact is actually estimated to be 0.97%, rounded to 1.0%.

49 These values reflect the dollar impacts on the economy based on the size of the economy today. If tech sector productivity growth occurs it will, however, occur in the future and on top of underlying growth. This means the dollar impacts would be larger than shown here. We do not take this into account because to do so would conflate the effects of assumptions about baseline growth and the effect of the productivity increase. Taking account of baseline growth matters if we are considering a policy analysis but in these circumstances, of testing a growth shock, it is not necessary and would reduce the transparency of our analysis.

50 The difference between the sum of these figures and the GDP impact is contributions from production taxes, commodity taxes and land.

51 The calculation behind this figure is simply: 8% at 4% = 0.08 x 0.04 = 0.0032 = 0.32%.

the case if expansion of the tech sector increased the diffusion of technology from overseas. It may also cause an increase in local innovation in new goods or services. Or it might spur an inflow of skilled migrants. None of these things are captured in our analysis, but any or all of them would further expand the tech sector and have further and larger economic impacts on the wider New Zealand economy.

In addition, as mentioned earlier in this report, there is extensive research (e.g. by Sapere & Covec, and McKinsey & Co.) showing that many new services involve non-market transactions that are nevertheless valued by consumers.

In short, our analysis understates the benefits of the tech sector to the wider economy. But it does show many of the dynamics of an expansion of the tech sector and some of the different channels of effect that would cause all New Zealanders to gain from an expansion of the tech sector, whether or not they work in the sector.

2.3.2. Tech productivity growth will drive investment

One of the more important effects of tech sector growth is increased investment. The greater productivity of the tech sector not only raises output but profits too, and a portion of these profits would be re-invested in the economy. Our model estimates the 4% productivity gain in the tech sector would raise returns or profits in the sector and that in turn would increase the level of investment in the economy by 0.8%, around $400m in today's prices.

Investment would also come from overseas as external investors observe the rising levels of productivity and profitability in New Zealand, and react by investing in the economy in the hope that they too will earn better returns on their investments here. This is an important part of the growth story of the expansion of the tech sector. Foreign investment will grow the New Zealand economy without the need for New Zealanders having to defer current consumption (which is part of growth) to fund the expansion themselves.

Overseas investment does have to be paid for – through regular interest and dividend payments, and capital repayments, to overseas investors – but the New Zealand tech sector and wider economy are still more dynamic for it and the investment enriches the economy through, for example, higher wages.

Some, but not the majority, of investment would come from local sources. Expansion of the tech sector means that incomes of New Zealanders rise and they have more to invest. Inevitably, some of that will go back into the tech sector, as well as other sectors of the economy.

The new investment would mainly flow into the tech sector but most other industries would also see increased investment. The industries that would be likely to attract investment would be major users of tech sector products, such as the air transport sector, and sectors like retail which both use tech-sector products and benefit from increased domestic spending as a result of economic growth.

While overall investment will grow, some sectors will find it harder to attract capital when the tech sector grows. This will reduce their growth prospects. This includes some primary and services export sectors such as horticulture and accommodation services. The growth prospects of these other sectors are also negatively affected by an appreciation of the currency when New Zealand's growth prospects improve: as investment flows into New Zealand and exports rise, the demand for kiwi dollars rises, and the exchange rate versus other major currencies appreciates.

2.3.3. Export growth will improve because the tech sector is outward facing

Another result of the increased productivity of the tech sector is that exports would increase by 0.9% or $630m. This is almost entirely an increase in tech sector exports and exports of sectors closely related to the tech sector. Exports from other sectors will tend to contract, because exchange rate appreciation make exporting less profitable, while the rising economic growth makes selling to domestic consumers relatively more profitable.

Overall, export growth is spurred by the fact that the tech sector is export-intensive. The tech sector has a higher than average propensity to export because its output is readily traded internationally. This is not the case for many domestically produced goods and services which tend to be 'non-tradable', at least directly - such as electricity.

2.3.4. Households benefit from cheaper goods and higher wages

A 4% increase in tech sector productivity is also associated with a 1.0%, or $1.3b, increase in household consumption spending. This increase in living standards comes from a combination of higher wages and lower prices for and higher quality of goods and services.[52]

The analysis shows that wage increases are one of the largest effects of the tech sector expansion with real wages up 1.4%.[53]

At the same time, an increase in the exchange rate, while not positive for some (exporters), helps most households by reducing the price of imports. Imports increase 0.1%.

2.3.5. Positive impacts nationwide but benefits are concentrated in urban centres

Figure 13 and Figure 14 show impacts on GDP and wages across the regions. Regions gain across the board but there are regional variations in the magnitude of gains, reflecting a combination of pre-existing strengths in the tech sector in the major urban areas and also the high use of tech sector products in industries in urban centres.[54]

A feature of some tech sector products is that they play an important role in public services such as health, education and government administration. Those services are concentrated in major urban areas and play a particularly important role in the expansion of the Wellington economy.

52 For our purposes (in the modelling) lower prices and higher quality are synonyms. Getting more for less can either be interpreted as more quality for the same price or lower price for the same quality.

53 In our analysis we measure labour market impacts at the national level in terms of changes in wage income, after inflation. This could be expressed as an increase in employment instead but it is, in general, more appropriate to describe economic growth effects in terms of wages.

54 The full set of impacts on national and regional value-added across 106 industries are charted in the Appendix.

Also, all three major urban centres have relatively high shares of their economy in the tech sector and thus they exhibit the largest growth impacts.

Auckland has the largest growth impact (up 1.3%), followed by Canterbury (1.1%) and then Wellington (1.0%).

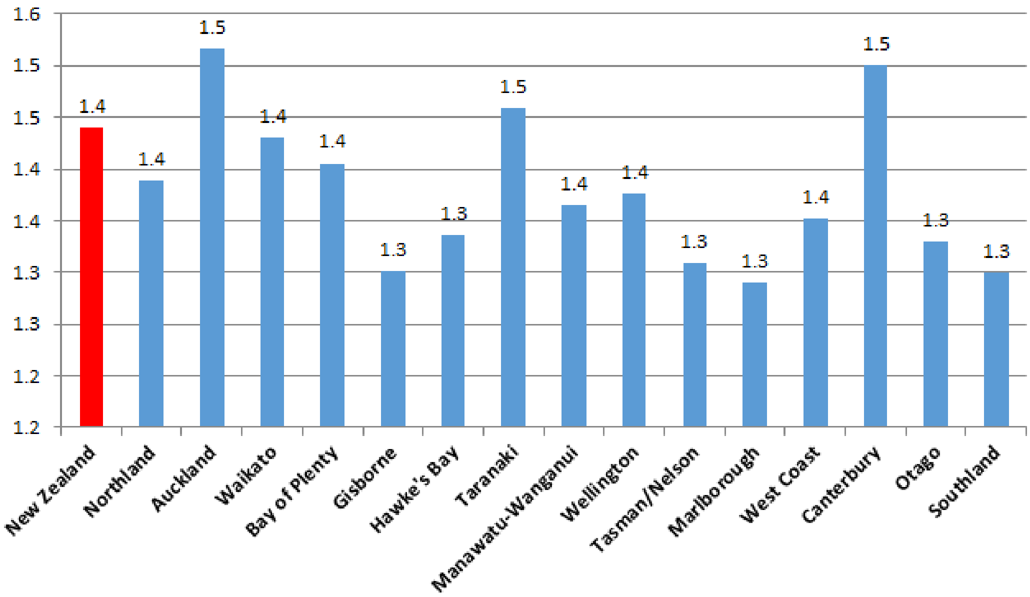
Changes in wages are more evenly spread across the regions than GDP impacts. Most regions see wage increases of similar amounts (around 1.4%). The difference between GDP impacts and wages is mostly down to higher investment in urban centres driving higher growth and this draws workers to urban centres.

Our analysis of the effects of a 10% improvement in the internet infrastructure also showed economic impacts, but these were much less variable across the regions than the impacts of the 4% expansion of the wider tech sector. This is shown in Figure 15. The numbers are small because the scenario we modelled affected a small part of the economy.

But the small size of the impact is secondary to the important observation that the impacts are evenly balanced and not concentrated in Auckland and Canterbury – although Wellington has one of the higher impacts. This suggests that an expansion in the speed, efficiency or quality of the internet, while not being as strong an engine of growth as a wider tech expansion, could nonetheless have an advantage from some perspectives as benefits are not skewed in favour of the urban centres. Note that this conclusion does assume that the internet improvements are distributed evenly (proportionately) in the first place.

Figure 13 Impact of tech sector expansion on regional wages

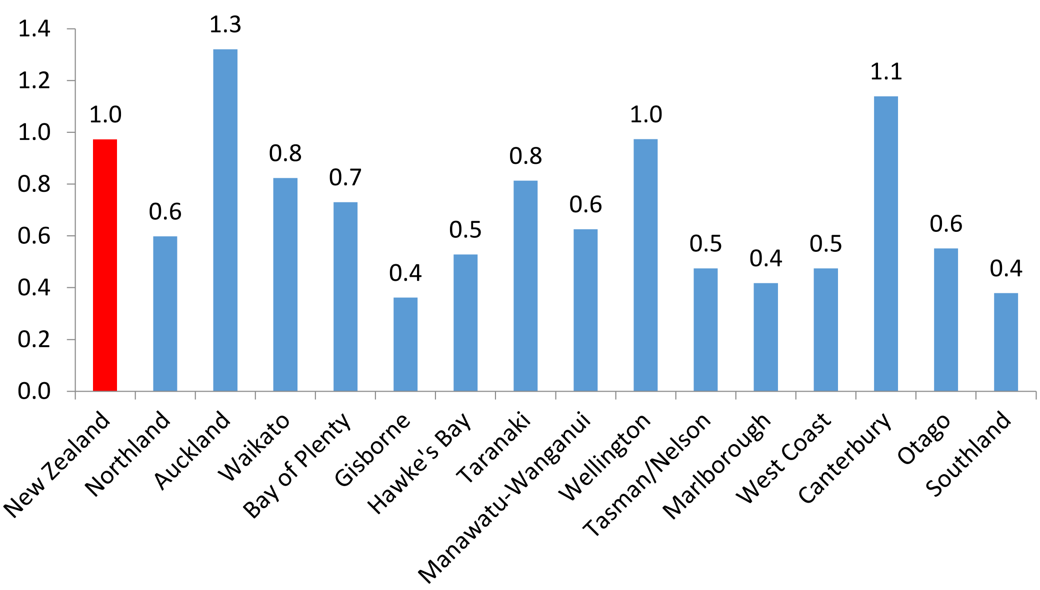
Increase in wages (%) when innovation lifts tech sector productivity by 4%



Source: NZIER analysis

Figure 14 Regional economic impacts of tech sector growth

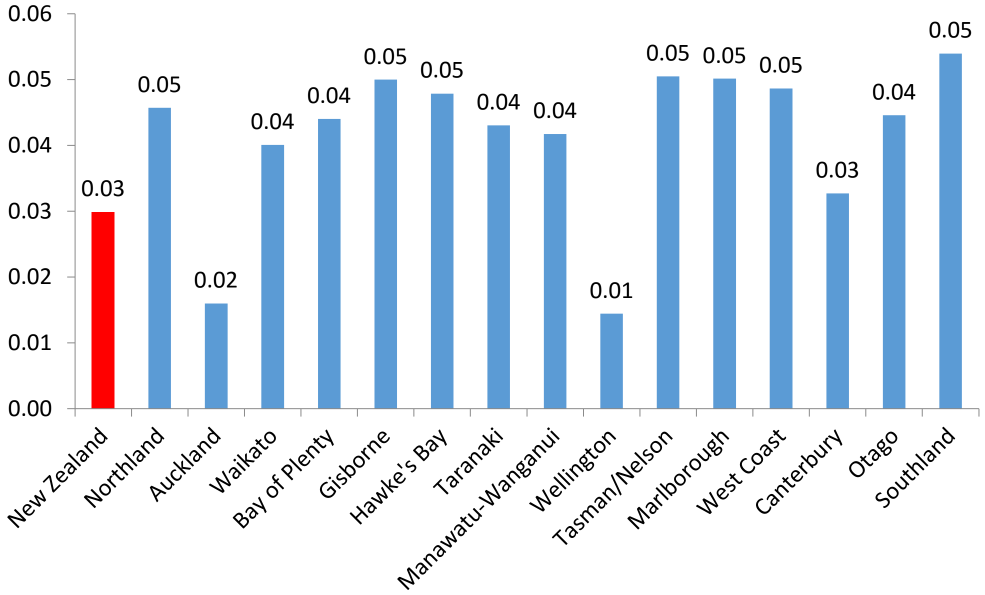
Increase in economic activity (GDP) from a 4% rise in tech sector productivity



Source: NZIER analysis

Figure 15 Regional impacts of improved internet

Percent increases in economic activity (GDP) from a 10% improvement in the internet infrastructure



2.4. The tech sector benefits other industries in a variety of ways

When the tech sector innovates, whether through cheaper or better products or altogether new products, this enables growth in a range of different industries. These effects arise through four different channels:

- **Income generation,** when the tech sector expands, through increased innovation or, for example, international competitiveness and exports, this boosts domestic income and the demand for other industries' products.
- **Cost reductions**, when tech sector innovation results in cost savings in other industries. An example of this is where small firms can access the same professional services they've always used but via a web-based service that is lower cost than conventional sources.
- **New production techniques or business models,** where tech sector innovation enables businesses to change the way they operate and improve their productivity. An example of this is where scanning and sorting equipment, produced by a hi-tech manufacturer, allows a primary sector business to reduce inventory holdings and better match product varieties to different markets and do so in a more timely way.
- **New or more effective products,** where tech sector innovation is a catalyst for innovation in other sectors in terms new products or more effective products. An example of this is where the tech sector produces medical equipment that enables new medical procedures that were hitherto impossible.

These different channels of effect all create economic gains but the long-run effects will depend on which sectors are most affected and whether, in those sectors, the gains are passed on (partly or fully) to consumers in the form of lower prices or better outcomes, reinvested in product development, or distributed to shareholders. In general, the biggest gains (longer term) come from reinvestment and flow-on innovation in terms of new techniques or new products and markets.

Our earlier analysis of the wider economic impacts of tech-sector productivity gains can begin to capture some of these effects, but not all of them. In particular, it cannot capture the breadth of ways in which tech sector innovation enables innovation in other industries. Below we touch on both quantitative measures of the effects of tech sector expansion on other industries – from our modelling of a so-called 'productivity shock' – and also discuss the range of ways in which the tech sector can drive innovation and growth in other industries beyond what can be explained with our model of the economy.

To emphasise the extent of the tech sector's impacts, including conventional growth metrics and in terms of wider social benefits, we also split our discussion up into:

- Commercial: examples from manufacturing and retail
- Government sector: administrative and consumer impacts
- Rural: examples from rural broadband and irrigation
- Public services: examples from health and education.

2.5. Commercial & industrial sector impacts

Here we consider the impact of the tech sector on output and employment in the commercial and industrial sectors, which we represent here by the manufacturing and retail sectors of the economy.

Numerous technological developments are transforming the manufacturing and retail sectors. For example, in manufacturing there are huge strides that have been made in materials science, 3-D printing, and robotics, whereas retail is being revolutionised not only by the growth of online sales but by shops communicating with consumers via their smartphones. Both manufacturing and retail are being shaped by the Internet of Things, whereby inputs such as parts and machines are connected to the internet, and consumer goods are able to notify their owners of the need for upgrades, servicing, or replacement.

All of these developments promise impacts of cost reduction – greater efficiency and productivity – so that the same quantity of inputs can produce higher outputs or better quality outputs of goods or retail services.

Improved internet connectivity will benefit both the retail and manufacturing sectors, for example by enabling the connection of goods and machines to each other and to suppliers and consumers.

2.5.1. Manufacturing: optimisation through equipment innovation and retrofitting

The implications of some of these trends for manufacturing, is that manufacturers are increasingly able to expand output and increase the quality of their products by implementing better processes that depend on retrofitting and upgrades of their existing plant, rather than the replacement of machinery and equipment.

Such improvements correspond to what we have analysed as an improvement in tech sector productivity: the use of connectivity, software, data analytics, sensors, routers and the like to boost the performance of existing manufacturing processes and machinery. The impact of these tech sector improvements on manufacturing is cost reduction, although new manufacturing technologies also allow manufacturers to increase quality and introduce new product varieties.

Recent advances in sensors (see box) and the potential to connect them via information networks and the internet in order to increase the productivity of manufacturing would be boosted significantly by improvements in tech sector productivity and the internet infrastructure.

A New Zealand example of high-tech manufacturing success stories is Scott Technology, which produces meat processing machines that measure carcass dimensions with X-ray technology to optimise cutting accuracy and product cut selection. This creates the opportunity for processors to extract higher-value products from the same carcass.

Another local high-tech manufacturer is Glidepath, which uses camera sensing technology on its innovative FastDrop bag drop system that allows air travellers to check in their own baggage in 10 seconds and avoid long queues.

Other significant productivity improvements driven by tech sector advances in 3-D printing, robotics, materials science and sensors, means the nature of the impacts on the manufacturing sector will extend beyond cost-savings to the creation of new products and varieties.

Sensors in manufacturing

Sensors have become better, cheaper, ubiquitous, and connected via information networks to each other and to processes, products, platforms, services, businesses and customers. These improvements – originating in the tech sector – are increasing the productivity of manufacturing processes, and leading to rising output and returns.

Traditionally, machinery was calibrated at the start of manufacturing processes and it was hoped the machines would carry on working for a reasonable period of time. Sensors were used simply to monitor parameters such as temperature, pressure, and composition. But as materials science has advanced and processing has become more complex, sensors are needed to monitor changes in the product itself during the production process, and online measurement and feedback allows for real-time process control, which could be essential if the process uses or generates toxic or hazardous chemicals.

Advances in sensor technology (e.g. the development of sensors to measure microscopic properties) together with increases in computing power and communication speed have facilitated the use of intelligent processing systems in the manufacturing sector. Intelligent processing uses sensed information to direct the process automatically, adapting to the occurrence or prediction of a process event that requires intervention.

2.5.2. Overall manufacturing sector benefits from tech sector growth

The results of our model analysis show how important technology is to manufacturing and how innovations in the tech sector can boost overall manufacturing sector output.

Increased productivity in the tech sector would have a strong impact on GDP and jobs in the wider manufacturing sector. As discussed above, this might involve the tech sector selling more efficient sensors to manufacturers or providing them with better internet services, enabling machinery, parts and processes to be connected more efficiently to each other.

Our analysis of a 4% rise in tech sector productivity shows an associated increase in total manufacturing GDP of $700m. Most of this, $500m, is from expansion of the tech sector itself – hi-tech and medium-tech manufacturing – but $200m is from expansion of other manufacturing not in the tech-sector such as metal fabrication.

Of the growth that occurs in the manufacturing sector around two-thirds ($460m) is an increase in wage income.

Manufacturing output and wage incomes expand in all regions but the effects are strongly concentrated in Auckland and Canterbury because of their relatively strong existing manufacturing industries. In our analysis Auckland's manufacturing sector expands by $330m (42% of the nationwide manufacturing sector increase) and Canterbury expands by $125m (18% of the nationwide increase).

2.5.3. Retail sector gains from improved connectivity, with inventory and with customers

The retail sector would respond quite strongly to a productivity rise in the tech sector, through the benefits of the latest sensor technology, improved inventory management, better connectivity to retail services and, overall, more effective connections between retailers and customers.

Increased GDP and jobs would be observed in the retail sector following a sensor-driven productivity increase in the tech sector. Particularly impacted would be the retail centres of Auckland, Wellington and Christchurch.

Sensor technology and associated information systems have become more advanced and capable. Sensors are being embedded into products, which are then connected to each other via information networks, creating new business models, improving processes, and reducing costs and risks.

In-store experiences and store profitability can be improved through sensors that monitor and deliver new services to shoppers – the emergence of so-called 'smart stores'. Sensors can be used to monitor shelf stock levels and analyse shopper traffic patterns. Technology exists for special sensors to detect where shoppers' eyes linger, and even to react to a shopper's attention by providing a special offer on that product in real time.

Online sales have grown tremendously and, while most retail sales are still concluded in physical stores, rising productivity of internet infrastructure and continued innovation in shopping applications can be expected to lift output and employment in the retail sector, perhaps partly by boosting online sales, and partly by facilitating the connectedness of sensors to goods, services and consumers.

Google research[55] found 84% of smartphone shoppers use their phones while in a physical store. The tendency for consumers to rely on their mobile devices to help them shop has led retailers to start using sensors to trigger messages delivering highly relevant content to shoppers' devices while they browse the store.

These innovations are increasing the efficiency of retail marketing and promotion activities and boosting prospects for growth of retail sector sales and profitability.

[55] Google, April 2013. Mobile in-store research: how in-store shoppers are using mobile devices. See: https://ssl.gstatic.com/think/docs/mobile-in-store_research-studies.pdf and https://www.thinkwithgoogle.com/research-studies/mobile-in-store.html

2.5.4. A strong economy makes for a strong retail sector

Our analytical modelling can't begin to capture the gains to the retail sector that could come from technological innovations. However it does capture the gains that the sector gets from more effective technology, particularly ICT services. Moreover, the gains to the sector from a more robust economy and wealthier customers.

Our analysis shows a 4% rise in tech sector productivity boosts the retail sector's contribution to GDP by $200m. Much of this impact resides in Auckland (46%).

Consumers benefit a great deal too, with efficiency gains passed through to customers to the point where prices fall and sector output declines slightly even as value added increases by $200m.

2.6. The impact of the tech sector on government

Key channels of effect of the tech sector on government are via cost reductions and new modes of service delivery that both reduce costs and improve experiences for the Government's 'customers'.

2.6.1. Government's push for innovation

Government's commitment to innovation is clear in its Business Growth Agenda:

> *The Government is working to improve alignment, co-ordination and collaboration within the system – from the generation of new ideas, to the conversion of these ideas into value.*

Tech sector increase in productivity can yield benefits for government in terms of labour savings. But these are only the first-round benefits: there are second-round productivity dividends for the economy because people spend less time travelling to and from government offices, standing in queues, and waiting for official forms to arrive or be returned.

Delivering efficient government services

There are clearly identifiable impacts of tech sector productivity improvements across the government sector. These impacts are primarily in the categories of cost savings, and more effective service delivery.

Treasury's 'BASS Report'[56] (BASS stands for Benchmarking Administrative and Support Services) shows the 26 measured government agencies spent nearly $1.7b on administration and support in 2013/14, two-thirds of which was attributable to the ICT function. Rising ICT expenditure reflects invest-to-save initiatives and a wide acceptance that technology can transform businesses, improve service delivery, strengthen productivity, and support decision making.

[56] New Zealand Treasury, 2014. Administrative & Support Services Benchmarking Report for the Financial Year 2013/14

Government has implemented cross-cutting innovations, such as improving the way departments and agencies collaborate to use the connectivity of the Internet and the accessibility of data. This contributes to the accumulation of social capital, another measure of living standards. Treasury (2011) has emphasised the importance of social capital for living standards:

> *When there are high levels of participation, interconnection and cohesion, there are correspondingly high levels of social capability; that is, a high level of the ability of various interests in society to co-operate towards common goals [...] Aspects of social capital also have benefits for the economy, particularly in terms of decreasing transaction costs and encouraging cooperative behaviour.*

2.6.2. Results of the analysis

The CGE analysis estimates the likely impacts of a 4% boost in tech sector productivity and a 10% rise in the productivity of the internet, on government sector activity and employment.

As might be expected, there are small impacts on employment in the government sector and on the value added to GDP by government activity. Higher productivity driven by technology means better government services can be delivered using fewer resources, but it is likely that in the short term, government will need to retain current staffing levels to meet the rising uptake of online services. There are likely to be significant backlogs and pent-up demand from customers who couldn't previously be served before technology transformed the way government delivers its services.

In the longer term though, unlike a business, government is not expected to respond to efficiencies by delivering higher quantities of services, although it may be that additional services can be offered that were not previously viable. Tech sector productivity and internet infrastructure improvements promise huge savings in labour costs for the government sector in the long run because government, as the largest employer, can manage its people costs better.

ICT Strategy

The Government ICT Strategy and Action Plan to 2017[57] was revised in 2015 to ensure that, in a dynamic technology environment, it can achieve the government's aim of an ICT-enabled transformation of public services, so customers can experience seamless, integrated and trusted public services.

Not all government services need to be integrated, but for those that do, a new approach is necessary. Agencies and departments must agree on how to deliver so-called federated services and rationalise service delivery channels.

It is critical for the government to understand the preferences, behaviours and needs of its customers and to derive insights from the big data that is now collected. But most information is locked away in agency silos, and cannot be accessed or analysed in ways that could add millions of dollars of value. A key focus area should be on open data and sharing by default, supported by privacy and security settings.

[57] See www.ict.govt.nz/

These are government's conscious efforts to exploit the potential impacts from adopting tech sector innovations – and an illustration that the same is true for any sector: benefiting from technology does not happen automatically.

Results 9 and 10

There is a set of government initiatives[58] referred to as 'Results 1 to 10', of which Results 9 and 10 are clearly efforts to benefit from improvements in tech sector productivity and the internet infrastructure.

The objective of Result 9 is that New Zealand businesses should have a one-stop online shop for all government advice and support they need to run and grow their business. Two powerful examples of progress towards Result 9 are the achievements of Inland Revenue and the Intellectual Property Office (IPONZ), both of which have successfully implemented a large range of online services in the last few years:

- Inland Revenue's myIR service is now used by more than 1.7m registered taxpayers to manage their tax affairs online – an example of tech sector productivity improvements being applied by Inland Revenue to deliver time and cost savings to almost all taxpayers
- IPONZ has streamlined and simplified its business processes and is now 100% online – a world first for an IP Office, and a real cost reduction for those involved in innovation.

The objective of Result 10 is that New Zealanders should be able to complete their transactions with government easily in a digital environment. It is closely aligned with the link between tech sector productivity improvements and the impact on the economy. The aim is for an average of 70% of New Zealanders' most common transactions with government to be possible in a digital environment by 2017.

These are good examples of government exploiting tech sector productivity improvements to deliver cost savings and more effective service delivery.

Saving people costs

The main impact of government adopting tech sector innovations is the freeing-up of human resources. Cost savings from automation and digitisation are critical for government departments that cannot generate more revenue but need to optimise the use of their existing resources to increase their service levels and output.

For many government departments, the biggest expenditure is on people – so in some cases the imperative is to achieve more by using more technology and less human resource.

The examples given above are driven by government's objective to get out of people's way, so they can get on with their work rather than wasting time filling in forms and standing in queues. An indirect benefit, as mentioned, is the potential cost saving for government, particularly on people costs.

58 See www.ssc.govt.nz/bps-results-for-nzers

2.7. The impact of technology on rural New Zealand

Rural New Zealand is predominantly devoted to agricultural activities. Despite being outside the tech sector, agriculture is a big user of technology. The rollout of internet connectivity and the increasing availability of UFB – driven by the Rural Broadband Initiative – are transforming the way the agricultural sector operates and integrates into the supply chain – from pasture to plate, and to the export markets.

Internet connectivity and broadband access are perceived as a big change by farmers, whereas urban dwellers have always been more connected. There is the prospect of increased digital customer interactions for businesses such as Alliance, Farmlands, and Fonterra, and opportunities for the application of big data and analytics. For example, online transactions and data transfers between dairy farmers and Fonterra and the Livestock Improvement Corporation (LIC) reduce transactions costs and improve logistical co-ordination and farm management.

The Primary Growth Partnership (PGP), administered by the Ministry for Primary Industries (MPI), enables innovation in the primary sector and facilitates collaboration across the value chain. Business expenditure on R&D in the primary sector increased sharply between 2010 and 2012, thanks in large part to PGP co-funding.

Tech sector innovations are being adopted in programmes such as *Transforming the Dairy Value Chain*.[59] Some of the impacts being targeted are efficiencies related to:

- discovering the relationships between animal phenotype and genotype to increase the rate of genetic gain in New Zealand's dairy herds
- developing knowledge on pasture persistence to exploit new forage cultivars
- the application of Precision Agriculture on-farm
- supporting industry-wide information capture and utilisation through the development of the Dairy Data Network.

Inherent in all of these activities is the application of technology. Whether it is precision agriculture, data capture and analysis or pasture monitoring and development, technology will play a central role in enabling productivity improvements throughout rural New Zealand.

For example, Fujitsu has developed a 'connected cow' product that detects oestrus signs in dairy cattle from changes in step count data. Cows are fitted with pedometers, connected to on-farm receivers. Step count data is transmitted to a cloud-based service that detects oestrus signs and sends an alert email to the dairy farmer: a sharp increase in the step count is a reliable indicator of oestrus. Dairy farmers can arrange for insemination at exactly the right time, a huge time saver that improves farm management and reduces the lost opportunities from missing the signs of oestrus.

[59] See MPI's website page http://mpi.govt.nz/funding-and-programmes/primary-growth-partnership/primary-growth-partnership-programmes/transforming-the-dairy-value-chain/

2.7.1. Results of the analysis

The impact of better internet connectivity on rural New Zealand is expected to be significant, as it directly alleviates the problems of remoteness and isolation. Farmers become connected with their suppliers, service providers and customers, and can participate directly and in real time in the global marketplace for their products.

For a simulated tech-sector rise in productivity, significant impacts on agricultural sector value-add were estimated in Taranaki, Auckland, Wellington and Waikato, and smaller impacts on labour income and returns to capital.

The impact of the simulated 10% increase in internet productivity was a moderate impact on GDP but a relatively greater increase in employment, illustrating the importance of internet connectivity and usage in rural areas and the potential for growth in online and cloud-based services in agricultural applications.

2.7.2. Technology and irrigation

Irrigation is essential for consistent, quality food production on the summer-dry, east coast regions. Government's Irrigation Acceleration Fund (IAF) supports investment in irrigation to increase land productivity: irrigated farmland typically generates three times the production of an equivalent area farmed under dry-land systems, and studies of the socio-economic effect of irrigated agriculture show for every $1 of wealth created on an irrigated farm at least another $3 is created in the wider rural and urban communities. [60]

Tech sector innovations are being applied to derive cost savings and efficiencies from investments in irrigation. In particular, tech sector productivity advances in high performance irrigation systems and SMART 'just in time' irrigation practices are being adopted. But there are concerns about the environmental impacts of increasing agricultural output. For example, the potential environmental impacts of land intensification associated with large irrigation schemes include elevated levels of nitrogen leaching, phosphorus and sediment runoff, microbial contamination and an over-allocation of water resources.

Therefore, irrigators must now manage water quality and quantity to limits. Increasingly, regional councils require independently audited farm environmental management plans (FEPs) that include nutrient, riparian and irrigation management plans.

Internet connectivity, broadband access, and the use of sensors and cloud software services will increasingly be required to help farmers and irrigators use water and nutrients more efficiently and precisely. The Internet of Things can minimise the application of nutrients in precision farming. Equipment with wireless links to data collected from remote (airborne and satellite) and proximal (ground) sensors can monitor crop conditions and adjust the way each individual part of a field is farmed — for example, by spreading more fertiliser on areas that need more nutrients, or by spatially varying the amount and timing of irrigation.

[60] See the Irrigation NZ website: http://irrigationnz.co.nz/about-us/irrigation-facts/fast-facts/

Technology promises to cut costs and enable faster repayment of both irrigation scheme and farm infrastructure capital, whilst allowing farmers to demonstrate their compliance with environmental and other regulatory requirements.

2.8. Tech sector impacts on health and education

Health and education are both important cross-cutting activities within the economy, and they account for a large share of government expenditure on social services. Technology is impacting in many diverse ways on the health and education sectors.

The nature of work has been radically changed by technology. A large proportion of the workforce now perform sedentary jobs, causing medical problems such as lower back pain and elevated risks of certain cancers. Technology has also transformed the demands placed on the education system, to produce graduates who can master and exploit the potential of technology.

While cutting-edge technology is applied to develop patented pharmaceuticals and sophisticated imaging devices, there is also scope to exploit digitisation and connectivity to integrate and improve the delivery and effectiveness of healthcare services. In education, it is not only teaching students about new technology that matters, but making sure that tech sector innovations are applied to deliver more effective education in schools.

2.8.1. Computers and e-learning

A shift is occurring from teacher-driven education to a more personalised, self-directed, and collaborative learning experience. Increased use of computers in classrooms and increased internet connectivity are impacting on education, not only by making teachers more efficient and saving schools money, but also by improving the quality of education which still relies heavily on Victorian-era lecturing methods.

The OECD reported that only Australia has more computers in its classrooms than New Zealand.[61] There are 0.9 Australian school students per computer in each classroom, while the figure is 2.1 students per computer in New Zealand (2012 data). The percentage of 15-year old students using computers at school is 86.4% in New Zealand and 93.7% in Australia. The OECD surveys indicate there is an intermediate, 'sweet spot' amount of time that students should spend using their computers at school – not too much, and not too little. It could be that:

- building deep, conceptual understanding and higher-order thinking requires intensive teacher-student interactions, and technology sometimes distracts from this valuable human engagement; and/or

[61] OECD, September 2015. Students, computers and learning: making the connection. Programme for International Student Assessment (PISA). OECD Publishing. See www.oecd.org/education/new-approach-needed-to-deliver-on-technologys-potential-in-schools.htm

- we have not yet become good enough at the kind of pedagogies that make the most of technology; that adding 21st century technologies to 20th century teaching practices will just dilute the effectiveness of teaching.

Government recognises the cross-cutting importance of communications infrastructure and has prioritised the education sector for the rollout of broadband connectivity, and it has met its policy goal for all schools to be connected by 2015.

The Ministry of Education also aims to provide a device for every learner in year 4 and above by 2017 but with budget constraints schools might need to support bring-your-own-device (BYOD) to meet the target.

However the OECD research indicates that there is no direct link between increased tech spending and educational outcomes. Rather, tech sector improvements are difficult to apply to education in a way that translates into better learning (more effective service delivery) as well as cost efficiencies.

Students are not only taught using technology, but must also learn a lot about technology to protect themselves and their schools against security threats, such as avoiding online scams, and maintaining computer security. Students also need to learn how to use social media properly and how to avoiding cyberbullying.

Ultimately, getting the mix right between teacher-student interaction and the role of online educational activities promises huge payoffs. Perhaps educationists and governments have not yet realised the scale of investment that might be needed to exploit the tech sector improvements in productivity and the internet infrastructure, to derive meaningful impacts in the education sector.

2.8.2. Healthcare quality and affordability

In recent years healthcare expenditure has increased, with ageing populations and the availability of better but more expensive treatments. But the technology discussed in this report – from big data to sensors and the Internet of Things – promises huge advances in both the quality of healthcare for patients, as well as greater efficiency in managing healthcare costs.

Exploiting big data in the healthcare setting is an easy way to secure big impacts from tech sector innovations. Data on patients is now easy to collect, can be monitored and updated frequently, analysed and interpreted in real time, and automatically shared with other medical practitioners such as pharmacists, specialists, radiologists and pathologists.

Healthcare is a fast-growing user of IT as the industry looks to technology to contain the escalating cost of healthcare delivery, whilst maintaining or improving services, healthcare outcomes and patient satisfaction. There has also been an enormous amount of activity around healthcare ICT strategies, roadmaps, and implementation plans by district health boards (DHBs) and regional plans over the last two years.

2.8.3. Managing healthcare personnel costs

Technology can bring huge cost savings to the health sector, which is extremely labour-intensive. For example, two-thirds of the Ministry of Health’s expenditure is payroll. Providers such as AMS are able to apply connectivity and computing power to integrate rostering and payroll (R2P) and achieve huge cost savings as well as reductions in the number of back office staff. The complexity of rostering medical staff around the clock, and subject to the constraints of certification, qualifications, unions, and hugely variable human resource costs, means that successfully integrating rostering and payroll can yield significant cost savings.

According to analysis by Cranleigh, following the implementation of an advanced end-to-end roster to payroll system by one of New Zealand's largest District Health Boards (DHB), $325,000 worth of annual benefit was identified. The cost savings were primarily generated through automation of HR processes within the DHB, freeing up resources to deliver better health outcomes.

2.8.4. Connecting with patients

The health sector – like education – was a Government priority for rollout of broadband services, with a policy goal for all health facilities to have access by 2015. By the end of 2015, it was confirmed that all hospitals across New Zealand and all 39 rural health facilities have access to UFB, and about 96% of the (numerous) urban health facilities and providers have access to UFB.

UFB will underpin the implementation of the National Health IT plan – to improve access for primary providers, to support common e-prescribing processes and a uniform approach to information sharing in general, and to enable remote access and cloud solutions for effective patient administration.

There are endless opportunities for connecting patients to healthcare providers, and for sharing patient information and prescriptions between medical professionals. Greater use of analytics on the big data surrounding healthcare can be used to save lives and money.

2.8.5. Monitoring patients

At the level of direct interaction with patients, advanced sensors and data links allow the real-time and low-cost monitoring of patient symptoms, behaviour (e.g., their compliance with treatment regimens) and healing progress.

For example, Silhouette is an easy-to-use, laser-based, 3D wound-imaging, measurement and documentation system produced by Aranz Medical that provides accurate wound information at the point of care, and supports the clinical management of wounds.

Patients with chronic illnesses can be fitted with sensors to monitor their condition continuously and remotely, without confining them to hospitals or their homes. The Internet of Things is applied in healthcare as an early warning system, and can save lives and expensive unplanned treatments in hospitals.

From the examples above it is clear that tech sector improvements in productivity and in the internet infrastructure are being vigorously exploited by government and private healthcare businesses to secure impacts in the categories of cost savings, value-added products and services, and more effective service delivery.

2.8.6. Results of the analysis

Education

Tech sector productivity has only a moderate link with education sector contribution to GDP, labour incomes and return to capital, and likewise small but positive impacts from the simulation of a 10% more productive internet infrastructure.

The information-intensive nature of education and the recent push to connect all schools with internet access suggests however that there is huge long-term potential for technology-led growth in education sector GDP and employment.

Health

The results of the two simulations indicate mediocre impacts of both tech-sector and internet infrastructure productivity gains. The health sector relies heavily on information processing and connectivity to deliver and co-ordinate increasingly complex services. For this reason the low estimated impacts appear anomalous but like the education sector, there are tremendous long-term impacts that are expected.

3. References

Arrow, Kenneth, 1962. Economic welfare and the allocation of resources for invention, *in:* The rate and direction of inventive activity: economic and social factors. National Bureau of Economic Research, p 609-626.

Calvin, Jean, 1543. Traité des Reliques, suivi de l'Escuse a Messieurs les Nicodémites. Éditions Bossard, Paris 1921.

Canterbury Development Corporation, 2014. Christchurch's Tech Sector Strategy, 2015-2025. See http://goo.gl/W9jwiU

Castalia, February 2014. New Zealand Manufacturing Sector: Its Dynamics and Competitiveness. Report for Manufacturing NZ, a division of Business NZ.

Centre of Policy Studies (CoPS), 2006. The TERM multi-regional CGE model. Victoria University, College of Business, Melbourne, Australia. http://www.copsmodels.com/term.htm

Committee for Economic Development of Australia (CEDA), June 2015. Australia's future workforce?

Das, Gouranga, 2008. Technology Diffusion, E-commerce and Trade Facilitation in a model of Northern hub vis-à-vis Southern spokes – A Tale of Two Souths. Paper presented at the 11th Annual Conference on Global Economic Analysis, Helsinki, Finland 2008. Global Trade Analysis Project (GTAP), Purdue University. http://www.gtap.agecon.purdue.edu/resource/res_display.asp?RecordID=2591

Deloitte LLP and the U.S. Council on Competitiveness, 2013. Global Manufacturing Competitiveness Index.

Dunedin City Council, 2010. Dunedin Digital Strategy, 2010-2013.

http://www.dunedin.govt.nz/__data/assets/pdf_file/0008/152864/Corporate-Dunedin-Digital-Strategy-27-9-2010.pdf

The Economist, 5 December 2015. The creed of speed (Briefing: time and the company), p20-22, vol. 417, no. 8967. London.

Fagerberg, Jan, David Mowery and Richard Nelson (eds.), 2004. The Oxford Handbook of Innovation. Oxford: Oxford University Press.

Glaeser, EL and JD Gottlieb, March 2009. The Wealth of Cities: Agglomeration Economies and Spatial Equilibrium in the United States. NBER Working Paper No. 14806.

Google, April 2013. Mobile in-store research: how in-store shoppers are using mobile devices. See: https://ssl.gstatic.com/think/docs/mobile-in-store_research-studies.pdf and https://www.thinkwithgoogle.com/research-studies/mobile-in-store.html

[The] Innovation Partnership, 2015. Data-driven innovation in New Zealand. Report prepared by Sapere and Covec.

Krugman, P, 1991. Increasing Returns and Economic Geography. Journal of Political Economy, 99(3):483-499.

Kurzweil, R, 2001. The law of accelerating returns. http://www.kurzweilai.net/the-law-of-accelerating-returns

Marshall, Alfred. 1890. Principles of Economics. London: Macmillan and Co.

Mason, G, 2013. Investigating New Zealand-Australia productivity differences: new comparisons at industry level. NZPC Working Paper 2013/02.

McKinsey Global Institute, 2011. Internet matters: The Net's sweeping impact on growth, jobs, and prosperity.

McKinsey Global Institute, December 2015. Digital America: a tale of the haves and the have-mores.

Ministry for Business, Innovation and Employment (MBIE), 2013. High technology manufacturing report. The New Zealand Sectors Report, 2013. New Zealand Government.

Ministry for Business, Innovation and Employment (MBIE), 2014. Knowledge Intensive Services Report. The New Zealand Sectors Report, 2014. New Zealand Government.

Ministry for Business, Innovation and Employment (MBIE), 2014. The New Zealand Sectors Report, 2014: an analysis of the New Zealand economy by sector. New Zealand Government.

Ministry for Business, Innovation and Employment (MBIE), 2015. Information and Communications Technology Report 2015. New Zealand Sectors Report Series. New Zealand Government.

Ministry for Business, Innovation and Employment (MBIE), 2015. Regional Economic Activity Report 2015. New Zealand Government.

Ministry for Business, Innovation and Employment (MBIE), 2016. UFB deployment update, December 2015. See: https://www.crownfibre.govt.nz/wp-content/uploads/2014/05/Quarterly-Broadband-Deployment-Update.pdf

Ministry for Primary Industries, December 2015. SOPI 2015 Update.

Moretti, Enrico, 2012. The New Geography of Jobs. Houghton Mifflin Harcourt.

Motu Economic and Public Policy Research, June 2015. The impact of R&D subsidy on innovation: a study of New Zealand firms. Authors: Adam Jaffe and Trinh Le. Motu Working Paper 15-08.

The National Business Review, 7 December 2015. Chinese deal for Martin Aircraft Jetpacks. NBR Last Call, by Calida Smylie. (www.nbr.co.nz)

NZIER, 2015. Disruptive technologies: risks, opportunities – can New Zealand make the most of them? Drew, A; Kubiak L et al. Report for Chartered Accountants Australia and New Zealand.

NZIER, 2015. Global Value Networks: How to succeed in business without worrying about scale, distance or thin markets. Kubiak, L, Destremau, K and Riley, P. NZIER 2015.

NZIER, 2015. The role of structural policies in innovation. APEC 2015 Economic Report (AEPR), by Gill, D. NZIER 2015

New Zealand Productivity Commission, 2014. Boosting Productivity in the Services Sector, p154.

New Zealand Productivity Commission, June 2015. Measuring the innovative activity of New Zealand firms. Working Paper 2015/2. Authors: Simon Wakeman (NZPC) and Trinh Le (Motu).

New Zealand Productivity Commission, June 2015. Do New Zealand firms catch up to the domestic productivity frontier? Working Paper 2015/3. Authors: Paul Conway, Lisa Meehan & Guanyu Zheng. http://www.productivity.govt.nz/sites/default/files/nzpc-working-paper-productivity-convergence-among-NZ-firms-201503.pdf

New Zealand Treasury, 2012. Economy wide impacts of industry policy, by Anita King. Treasury Working Paper 12/05.

New Zealand Treasury, 2014. Administrative & Support Services Benchmarking Report for the Financial Year 2013/14.

O'Connor, P, J Stephenson and J Yeabsley, 2012. Grow for it: how population policies can promote economic growth. NZIER Working Paper 2012/01, Wellington.

OECD, 2002. Merger review in emerging high-innovation markets. OECD policy roundtables. OECD Publishing. www.oecd.org/daf/competition/roundtables.htm

OECD and Eurostat, 2005. Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition, The Measurement of Scientific and Technological Activities, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264013100-en

OECD, 2013a. Supporting investment in knowledge capital, growth and innovation. OECD Publishing.

OECD, 2013b. Innovation Strategy: Defining Innovation. OECD Publishing

OECD, 2013c. Knowledge Networks and Markets (OECD Science, Technology and Industry Policy Papers No.7)

OECD, 2013d. Raising the Returns to Innovation: Structural Policies for a Knowledge-based economy (OECD Economics Department Policy Notes No, 17 may 2013)

OECD, September 2015. Students, computers and learning: making the connection. Programme for International Student Assessment (PISA). OECD Publishing. See www.oecd.org/education/new-approach-needed-to-deliver-on-technologys-potential-in-schools.htm

OECD, 2015. Science, Technology and Industry Scoreboard, pp.78-79.

Qiang, Christine Zhen-Wei, Carlo M Rossotto, with Kaoru Kimura, 2009. Economic Impacts of Broadband. In: Information and Communications for Development 2009: Extending Reach and Increasing Impact. World Bank: Washington. https://issuu.com/world.bank.publications/docs/9780821376058

Rohault de Fleury, Charles, 1870. Mémoire sur les instruments de la passion de Notre Seigneur Jésus Christ. Lesort, Paris 1870.

Sapere Research Group, 2015. Telecommunications Industry Sector Report, by Peter MacIntyre and Aaron Schiff, for the New Zealand Telecommunications Forum.

Sapere Research Group, 2014. The value of internet services to New Zealand businesses. Report prepared for Google by Hayden Glass, Preston Davies, Eli Hefter and Gary Blick.

Schumpeter, Joseph, 1942. Capitalism, socialism and democracy.

Smith, Keith, 2006. Public Policy Framework for the New Zealand Innovation System. Ministry of Economic Development (now MBIE), Occasional Paper 06/06.

Solow, Robert, 1957. Technical change and the aggregate production function, *Review of Economics and Statistics*, Vol 39 no. 3, p 312-20.

Statistics New Zealand, 2012. Innovation in New Zealand 2011. See http://www.stats.govt.nz/browse_for_stats/businesses/business_growth_and_innovation/innovation-in-new-zealand-2011.aspx

Statistics New Zealand, 2012. Innovation in NZ 2011 – tables. New Zealand Government.

Statistics New Zealand, 2013. Information technology's contribution to labour productivity growth. New Zealand Government.

Statistics New Zealand, 2013. Strong connection between ICT and business growth activities. New Zealand Government. See:

http://www.stats.govt.nz/browse_for_stats/businesses/business_growth_and_innovation/ict-use-business-characteristics.aspx#growthactivity

Technology Investment Network, 2015. TIN 100 Report 2015.

Ulaga, W and Chacour, S, 2001. Measuring Customer-Perceived Value in Business Markets, Industrial Marketing Management, Vol 30, pp33-48.

Verspagen, B, 2004. Innovation and Economic Growth, in: Fagerberg et al, 2004 (supra), p 487-513.

Appendix A

A.1 Defining the tech sector

A.1.1 Tech and R&D spending

The ratio of R&D expenditure to revenue has been used by the OECD as a criterion to split up manufacturing into low-tech, medium-high tech and high-tech manufacturing categories. High-tech manufacturing and medium-high tech manufacturing are subsets of manufacturing industries that on average have been found to have higher levels of R&D based on combined data from 25 developed countries. There is some overlap with the definition for the ICT sector as ICT manufacturing also sits within high-tech manufacturing.

The Ministry of Business, Innovation and Employment (MBIE) considered both of these categories together in its Sector Report on High-Technology Manufacturing.[62] We propose to do the same.

MBIE also produced a Sector Report on the ICT industry in 2015[63]. The OECD defines the ICT sector to include ICT manufacturing, telecommunications, and information technology services. The MBIE report only covered ICT services (ICT manufactures were excluded) and was mainly focused on Computer System Design and Related Services, which captures New Zealand's cohort of IT exporters.

The importance of ICT in the tech sector is evident in many of the technology-driven case studies in this report. The majority of these studies suggest digitisation is a key feature leading to business innovation and success across a wide range of sectors. Arguably the ICT sector has a cross-cutting impact on the wider economy, giving it a unique status within the tech sector.

Unlike MBIE, we include the whole ICT sector in our definition of the tech sector in order to fully understand the inter-relations of the parts of the sector and the combined impact this sector has on other parts of the economy.

A.1.2 A practical approach to the tech sector

As mentioned above, for our analysis we define the tech sector to include high-tech manufacturing (in which we include medium-high tech manufacturing) and the entire ICT sector.

With the focus on high-tech manufacturing and ICT, the primary industries in particular are excluded from the tech sector. But the primary industries are heavy users of technology inputs that are mainly supplied by the tech sector. Research by the Treasury[64] indicates that if such technology inputs lift agricultural productivity, the boost to production and exports is likely to be stronger and more direct than a similar productivity improvement in the manufacturing sector:

> *An increase in productivity in the agricultural sectors has a much larger impact on exports, imports, the exchange rate, and CPI than*

[62] MBIE, 2013. Report high-technology manufacturing

[63] MBIE, 2015. ICT Report, 2015.

[64] Treasury, 2012. Economy-Wide Impacts of Industry Policy, p20.

the equivalent change in the output-adjusted manufacturing sectors. As the agricultural sectors export a higher proportion of their outputs, the productivity improvement has a larger impact on export volumes than for the manufacturing sector.

The case of the agriculture sector illustrates the point that the concept of a tech sector is not necessarily cast in stone, and that other sectors outside the tech sector may nevertheless be intensive users of tech sector inputs and be invigorated by technology.

Appendix B The tech sector by region

This appendix contains some information on the regions (other than Auckland, Wellington, Canterbury and Otago, which are discussed in the main report). This is followed by detailed information on the tech sector at the regional level (estimates produced by NZIER from Statistics New Zealand data).

South Auckland has a young population, an advantage to developing tech skillsets. The region has high levels of employment in manufacturing and freight logistics, so there is potential to develop high-tech manufacturing businesses in South Auckland that can integrate into global value chains.

Hamilton is the innovation centre of the **Waikato** region, with strength in utilities, chemicals, manufacturing, ICT and agritech, and is the technology centre for value-added dairy product processing and the dairy herd improvement industry.

The **Bay of Plenty** has pockets of specialised chemical, mineral and metal manufacturing.

In rural regions such as **Gisborne** and **Tasman** there is potential to extend further the UFB network to smaller towns, and to increase rural broadband speeds through the Rural Broadband Initiative.

Seventy percent of the land area in **Hawke's Bay** is used for primary production (especially horticulture and wine) and the area is home to food and beverage manufacturers, and multinational food processing companies.

Specialist engineering, technical and manufacturing businesses support the **Taranaki** oil and gas sector which contributes about 40% of regional GDP.

The **Manawatu-Whanganui** area is well-located to benefit from increased production, and improved broadband access and connectivity should benefit on-farm efficiency and translate into better export earnings.

Nelson is almost completely urbanised, has high standards of education, particularly among the tech-savvy young. Nelson has potential for the marine construction and aviation manufacturing engineering clusters to develop further.

Marlborough has high-tech activity in aviation manufacturing and wood product manufacturing.

The **West Coast** region has growing employment and potential in the professional, scientific and technical services, particularly architecture, engineering and construction.

Southland's economy has a large manufacturing sector, focused on dairy processing, meat processing and metal manufacturing (including aluminium smelting). There is also potential for the development of the IT, pharmaceuticals and electronics manufacturing sectors, although there is a skills shortage as many skilled young graduates leave the region.

Table 7 Regional Tech Sector GDP (estimates for 2015)

Except figures for regional GDP and regional population (from MBIE, 2015)

Region	Region GDP	Region population	Region high-tech manufacturing sector GDP	Region ICT sector GDP	Regional combined tech sector GDP	
	%	%	$m	$m	$m	% of region's GDP
Northland	2.5	3.7	67	124	191	3.3
Auckland	**35.3**	**33.9**	**1,622**	**6,168**	**7,791**	**11.6**
Waikato	9.0	9.6	327	722	1050	5.9
Bay of Plenty	5.2	6.3	203	342	545	4.7
Gisborne	0.7	1.0	12	30	43	2.3
Hawke's Bay	2.8	3.5	73	175	248	3.5
Taranaki	4.0	2.5	97	187	284	4.5
Manawatu-Wanganui	4.0	5.2	129	279	409	4.4
Wellington	**13.2**	**10.9**	**225**	**2,188**	**2,413**	**9.8**
Tasman/Nelson	1.8	2.2	44	123	167	3.8
Marlborough	1.0	1.0	35	49	84	3.2
West Coast	0.7	0.7	10	34	44	3.0
Canterbury	**13.1**	**12.7**	**710**	**1,717**	**2,428**	**9.1**
Otago	4.3	4.7	82	248	330	3.5
Southland	2.4	2.1	39	95	134	2.6
New Zealand	**100**	**100**	**3,677**	**12,482**	**16,159**	**8.0**

Source: NZIER, MBIE (Regional Economic Activity Report, 2015)

Table 8 Regional tech sector labour incomes (estimates for 2015)

Region	Regional high-tech manufacturing sector incomes		Regional ICT sector incomes		Regional combined tech sector incomes	
	$m	% of total incomes	$m	% of total incomes	$m	% of total incomes
Northland	44	1.6	64	2.4	108	4.0
Auckland	**1,022**	**3.0**	**2,955**	**8.6**	**3,977**	**11.6**
Waikato	210	2.5	368	4.4	578	6.9
Bay of Plenty	130	2.3	184	3.2	314	5.5
Gisborne	7	0.8	16	1.7	23	2.5
Hawke's Bay	47	1.4	92	2.7	139	4.0
Taranaki	61	2.3	94	3.6	156	5.9
Manawatu-Wanganui	83	1.7	144	2.9	227	4.7
Wellington	**138**	**1.1**	**1,004**	**7.7**	**1,142**	**8.8**
Tasman/Nelson	29	1.3	68	3.0	97	4.3
Marlborough	24	2.0	22	1.8	46	3.8
West Coast	7	0.9	19	2.6	26	3.5
Canterbury	**465**	**3.5**	**848**	**6.4**	**1,313**	**10.0**
Otago	55	1.2	121	2.6	176	3.8
Southland	26	1.1	54	2.3	81	3.5
New Zealand	**2,350**	**2.3**	**6,053**	**6.0**	**8,403**	**8.4**

Source: NZIER

Table 9 Regional tech sector exports (estimates for 2015)

	Regional high-tech manufacturing sector exports		Regional ICT sector exports		Regional combined tech sector exports	
	$m	**% of total exports**	**$m**	**% of total exports**	**$m**	**% of total exports**
Northland	80	4.2	14	0.7	94	4.9
Auckland	**1,893**	**9.5**	**826**	**4.2**	**2,719**	**13.7**
Waikato	381	6.0	91	1.4	472	7.4
Bay of Plenty	241	5.8	42	1.0	283	6.8
Gisborne	18	2.2	4	0.5	22	2.7
Hawke's Bay	108	3.1	22	0.6	130	3.7
Taranaki	123	4.2	22	0.7	145	4.9
Manawatu-Wanganui	162	5.6	37	1.3	199	6.9
Wellington	**307**	**5.7**	**332**	**6.2**	**639**	**11.9**
Tasman/Nelson	57	3.0	17	0.9	74	3.9
Marlborough	33	2.9	5	0.4	38	3.3
West Coast	19	2.0	4	0.4	23	2.4
Canterbury	**808**	**8.7**	**220**	**2.4**	**1,028**	**11.1**
Otago	118	3.7	32	1.0	150	4.7
Southland	59	2.0	12	0.4	71	2.4
New Zealand	**4,408**	**6.5**	**1680**	**2.5**	**6,088**	**9**

Source: NZIER

Table 10 Regional tech sector employment (estimates for 2015)

Region	Regional high-tech manufacturing sector employment		Regional ICT sector employment		Regional combined tech sector employment	
	Counts of people employed	**% of total counts of employed**	**Counts of people employed**	**% of total counts of employed**	**Counts of people employed**	**% of total counts of employed**
Northland	781	1.4	504	0.9	1,285	2.3
Auckland	**19,312**	**2.8**	**28,370**	**4.1**	**47,682**	**6.9**
Waikato	4,038	2.3	2,571	1.5	6,609	3.8
Bay of Plenty	2,567	2.2	1,356	1.2	3,923	3.4
Gisborne	151	0.7	201	1.0	356	1.7
Hawke's Bay	889	1.2	677	0.9	1,566	2.1
Taranaki	1,329	2.6	568	1.1	1,897	3.7
Manawatu-Wanganui	1,532	1.6	759	0.8	2,291	2.4
Wellington	**2,151**	**0.9**	**11,282**	**4.7**	**13,433**	**5.6**
Tasman/Nelson	540	1.2	495	1.1	1,035	2.3
Marlborough	483	2.2	343	1.5	826	3.7
West Coast	181	1.2	49	0.3	230	1.5
Canterbury	**8,604**	**3.0**	**6,233**	**2.2**	**14,837**	**5.2**
Otago	994	1.0	910	0.9	1,904	1.9
Southland	610	1.2	433	0.9	1,043	2.1
New Zealand	**44,161**	**2.2**	**54,750**	**2.7**	**98,911**	**4.9**

Source: NZIER

Appendix C Impacts of technology on regional output

The following tables indicate the estimated impacts on regional economic incomes, growth and other macroeconomic indicators, of a 4% stimulus in the tech sector – where the tech sector is defined as high- and medium-high tech manufacturing, plus ICT.

Table 11 Impacts of tech sector on regional income generation

Change in $m in 'factor' income by 'factor'

Region	Land	Labour	Capital	Tax	Total
Northland	-1	41	22	7	70
Auckland	6	631	312	117	1,065
Waikato	-2	136	68	23	225
Bay of Plenty	1	90	44	15	149
Gisborne	-0	12	5	2	19
Hawke's Bay	-1	49	22	8	78
Taranaki	11	44	27	7	89
Manawatu-Wanganui	-1	72	29	11	112
Wellington	4	194	86	32	317
Tasman/Nelson	-0	30	12	4	46
Marlborough	-0	15	7	2	24
West Coast	0	10	4	2	16
Canterbury	-2	235	117	42	391
Otago	1	64	33	11	108
Southland	-1	31	11	4	45
Total	**14**	**1,654**	**798**	**286**	**2,753**

Source: NZIER

Table 12 Impacts on industries by region

Percentage changes in GDP by industry[65] by region

Region	Manuf	Retail	Govt	Agric	Educ	Health	Util.	Services
Northland	1.9	1.7	1.1	0.0	1.3	1.3	1.5	1.0
Auckland	3.5	3.1	0.9	1.2	1.0	1.3	1.6	1.0
Waikato	2.9	1.8	1.0	0.0	1.1	1.3	1.5	0.9
Bay of Plenty	2.8	1.7	1.0	0.3	1.2	1.2	1.4	0.9
Gisborne	1.4	1.3	1.4	0.2	1.3	1.3	0.5	1.0
Hawke's Bay	1.6	1.3	1.2	0.1	1.3	1.2	1.5	0.9
Taranaki	2.5	1.6	0.9	1.1	1.2	1.2	1.5	0.9
Manawatu-Wanganui	2.5	1.7	1.3	0.0	0.9	1.2	1.6	0.9
Wellington	2.3	1.4	1.3	1.1	0.9	1.2	1.6	1.0
Tasman/Nelson	1.4	1.3	1.3	0.1	1.3	1.2	1.6	0.9
Marlborough	0.9	1.0	1.3	0.2	1.5	1.3	1.7	0.9
West Coast	1.9	1.5	1.2	0.3	1.3	1.3	1.9	0.9
Canterbury	3.3	2.2	0.8	0.0	1.0	1.2	1.7	1.0
Otago	2.0	1.5	1.2	0.3	0.8	1.2	1.5	1.0
Southland	1.2	1.5	1.3	0.0	1.4	1.2	1.5	0.9
Total	2.8	2.1	1.1	0.3	1.0	1.2	1.6	1.0

Source: NZIER

[65] Manuf = Manufacturing; Govt = Government; Agric = Agriculture; Educ = Education; Util. = Utilities (water, electricity, gas, sewerage, waste), Services = transport and services not elsewhere specified.

Table 13 Impacts of tech sector on main regional macroeconomic indicators

Percentage changes in real (inflation adjusted values)

Region	Household spending	Investment	Exports	Imports	Employment[66]
Northland	0.9	0.9	0.1	-0.1	-0.1
Auckland	1.1	0.9	1.8	0.3	0.1
Waikato	1.0	0.7	0.7	0.0	0.0
Bay of Plenty	0.9	0.9	0.5	0.1	0.0
Gisborne	0.7	0.5	-0.3	-0.3	-0.1
Hawke's Bay	0.8	0.2	0.0	-0.2	-0.1
Taranaki	1.0	0.3	0.6	-0.3	0.0
Manawatu-Wanganui	0.8	0.4	0.4	-0.1	-0.1
Wellington	0.8	0.8	1.1	-0.1	-0.1
Tasman/Nelson	0.7	0.7	0.1	-0.2	-0.1
Marlborough	0.7	0.9	-0.1	-0.1	-0.2
West Coast	0.8	0.5	-0.1	-0.2	-0.1
Canterbury	1.1	0.8	1.4	0.2	0.1
Otago	0.8	0.7	-0.1	-0.1	-0.1
Southland	0.7	0.7	-0.2	-0.3	-0.2

Source: NZIER

[66] Employment impacts reflect changes in internal migration so reductions imply increased outward migration, not an increase in unemployment.