Deloitte.
Access Economics

Universities New Zealand
Economic impact of universities' contribution to innovation

September 2018

Contents

Executive summary

Universities play a pivotal role in New Zealand that extends beyond educating the workforce. University research plays a crucial role in facilitating innovation, while the human capital that universities develop is critical for the future productivity of the New Zealand economy.

Universities New Zealand commissioned Deloitte Access Economics to conduct a literature review to inform the causal link between universities and innovation, as well as provide an assessment of the economic impact of university expenditure on research on local economies, and the wider New Zealand economy.

Universities have a critical role in contributing to innovation, within both the local and wider economy

While New Zealand literature is limited, international empirical evidence indicates that universities contribute much more to innovation in the local economy than just educating the work force. This report fills an important gap in the literature by providing more understanding of the economic impact of universities' research expenditure on the New Zealand economy.

Existing international literature establishes a consistently positive and significant relationship between universities and innovation in the local region where a university is situated.

The literature establishes two key ways in which universities contribute to a region's innovation:

- **Commercial products**: New services and technologies developed from university research or intellectual property (IP) contribute directly to innovation. The majority of studies that explore the contribution of universities to regional innovation focus on the role universities play in supporting product development.
- **Human capital:** There are many relationships through which universities can transfer knowledge. Many argue relationship with local industry and links to former students contribute more to local innovation than direct commercial activity.

New Zealand universities' contribution to innovation supports economic growth

To explore universities' contribution to innovation in New Zealand, this report quantified the economic impact of university research expenditure. While enhanced human capital may be a more prevalent driver of innovation, the difficulty of quantifying the relationship excluded it from this economic impact analysis.

The contribution of university research output – measured as recurrent expenditure on higher education research and development (R&D) – to economic output has been estimated using an econometric model of growth across countries.

University investment in R&D plays a significant role in the New Zealand economy. Increases in research investment by New Zealand universities over the last three decades have increased real gross domestic product (GDP) by a cumulative $129 billion.

Universities' investment in research and the subsequent effect on GDP over this period indicates a positive economic return on investment of greater than 5:1. This means there is a long-term return to the economy of over $5 for every dollar invested in university research in New Zealand.

Our model estimates the total stock of higher education research in New Zealand in 2017 to be $26 billion. This corresponds to a share of output attributable to around 9% of GDP.

These estimates of the long-term economic impact of university research demonstrate a strong relationship between university research and economic growth. However, the estimates do not include universities' contribution to innovation through enhanced human capital. These findings suggest that the quantified economic impact in this report represents a conservative estimate of the total contribution of universities to innovation within the local economy.

For every dollar invested in university research in New Zealand, there is a long-term return to the economy of over $5.

Chart 1.1 Contribution of university R&D expenditure to the New Zealand economy

The **total stock** of higher education research in New Zealand is estimated to be **$25.9 billion in 2017.** This corresponds to a share of output attributable to university research activity of around **8.9% of GDP**.

Increases in research investment by New Zealand universities from 1984 to 2015 cumulatively increased real GDP by **$129 billion** in 2017 dollars over the period.

Investment in university research and development generated an **economic return on investment of 5.1 to 1**. This indicates a long-term return to the economy of approximately $5.10 for each dollar invested in university research.

Universities' contribution to innovation through **enhanced human capital** is difficult to quantify, but international literature suggests the impact could be greater than direct contribution to innovation through commercial product development.

To unlock innovation in New Zealand in the future, it is important for policy-makers, universities, and investors to consider focusing on strengthening the contribution of universities to innovation.

1. Universities' contribution to innovation

Universities New Zealand commissioned Deloitte Access Economics to conduct a literature review to:

- Understand the causal link between universities and innovation.
- Assess the economic impact of university research expenditure.
- Provide an assessment of the implications universities have on the wider New Zealand economy.

The review was based on New Zealand and international sources that examine the links between universities and research, as well as the level of innovation and productivity in the local economy.

Although the relationships identified between universities and innovation internationally are significant and positive, the same relationships – and the size of likely benefits – will be different in New Zealand. Nonetheless, it is valuable to understand the ways in which universities could contribute to innovation in the New Zealand economy, particularly at a regional level.

The findings from international studies can provide us with direction as to how to shape policy or direct effort in order for local and regional economies to capture the benefits of innovative activities at universities. Although outside the scope of this paper, further work could be done to identify relevant critical success factors in the literature, and how they can be applied in the New Zealand setting.

Deloitte Access Economics defines innovation as "the activity of creating and capturing value from doing something new". Innovation is the creation of new, viable business offerings, adding value across the entire supply chain, and having material impacts on economic growth for a country.

Universities' research activity provides crucial support for the nation's innovation ecosystem. Research activity leads to knowledge discovery and adoption, contributing to technological progress. Universities facilitate the innovation process through knowledge transfer to local firms. Universities also attract new human capital, knowledge, and financial resources to the area. These effects tend to be strongest in local industries and firms that can best utilise the university research outputs.

There are generally two ways in which universities contribute to a region's innovative capacity, and literature tends to focus on these avenues:

Contribution to innovation through commercial products
This is the direct contribution to innovation through commercial products developed with university IP, such as patents, publications, and spin-offs. University R&D expenditure typically funds these types of activities, and the effect on economic growth is often direct and can be quantified.

Contribution to innovation through human capital
These are the informal and formal relationships that facilities the knowledge transfer between university and businesses, government and industry. University activity that contributes to innovation indirectly through enhanced human capital includes conferences and forums, researcher mobility, educating the workforce and students who become entrepreneurs. Research suggests that this impact on innovation is significant, but difficult to measure.

These two university functions are intertwined. Informal and formal relationships are often the precursor to a commercial venture between the university and industry.

Conceptual framework

Innovation supports economic activity by improving the productive capacity of resources within an economy. A key function of universities is to generate new ideas and knowledge, for example, in the form of research papers and patents. The transfer of these ideas to businesses, government, and industry as commercial ventures increases their productivity. According to the OECD, between 25% and 45% of productivity gains come from innovation.

Universities produce research that may not have occurred otherwise. Although universities accounted for less than a third of New Zealand's research expenditure in 2016, they accounted for over two thirds of basic research expenditure. Businesses tend to avoid this kind of research, as it is typically time consuming, expensive and often does not always lead to a financial payoff (Rosenberg & Nelson, 1994). Universities, therefore, play an important role by conducting research that otherwise may not have taken place.

Finally, the local economy captures many benefits of innovation. The basic premise behind this idea is that physical proximity makes the transfer of knowledge and technology easier from universities to industry, government and businesses (Lawton Smith, 2006). For example, firms tend to cluster around universities to take advantage of localised spillovers. In other words, firms located near universities can more easily take advantage of information and ideas at less than original cost. This result is discussed by Casper (2013), who found that firms who were close to universities were more successful at taking advantage of knowledge spillovers than those further away.

This report considers universities' contribution to innovation with this conceptual framework in mind.

Universities' contribution to innovation through commercial products

In 2016, New Zealand's eight universities spent a combined $877m on R&D, accounting for 54% and 38% total basic research and applied research expenditure, respectively.

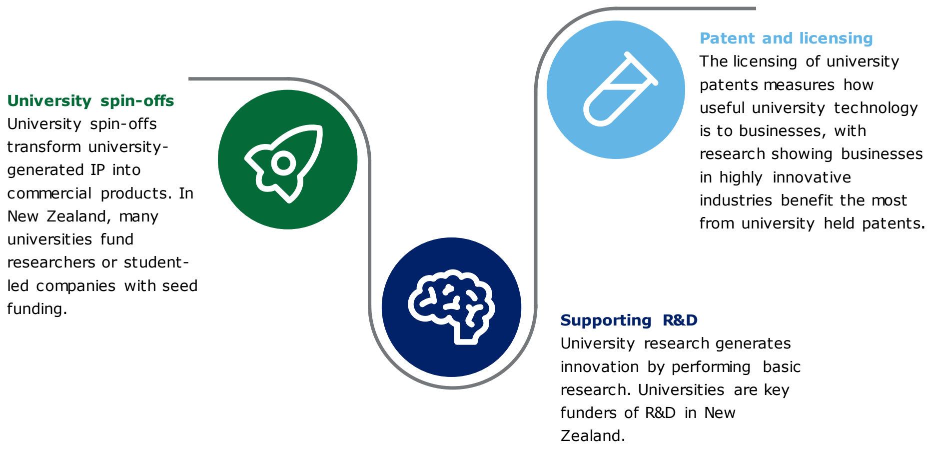
The positive effect of universities on the local region has been established in New Zealand literature. For example, Motu and Public Policy Research (2015) found firms who received grants for research and development were almost twice as likely to introduce a major innovation, such as a new product or service.

Apatov and Grimes (2016) also found a higher share of Equivalent Full Time Students (EFTS) to working age population is associated with higher population growth, and higher employment, in the local region. Drawing on a sample of 57 New Zealand Territorial Local Authorities between 1986 and 2013, they found a one percentage point increase in EFTS to working age population is linked to a 0.14% increase in employment.

Literature on the contribution of universities to regional innovation is generally concerned with the transfer of **technology between universities and industry in a commercial sense.** Universities directly contribute to economic growth through business activities, such as the formation of spin-off companies, patenting and licenses.

Due to the bundled nature of university products, it is often difficult to isolate the contribution to regional innovation. Therefore, expenditure on research and development can be used as a proxy for university output. Chart 1.1 provides a summary of university products discussed.

Chart 1.1 Key university products that contribute to innovation in a local economy



Source: Deloitte Access Economics

The effect of university expenditure on research and development

Internationally, the effect of expenditure on university research generally shows a positive relationship with private sector innovative activity. This relationship suggests that private firms benefit from university-produced IP.

For instance, Cincera et al. (2009) find a causal link between expenditure on R&D at higher education institutes and expenditure on R&D in the private sector, as well as the number of people employed beyond the university. They show that New Zealand is among the group whose public and university expenditure on R&D is most efficient in terms of providing stimulus to private R&D.

Cincera et al. (2009) showed that a firm's ability to access finance is a key determinant of how a firm responded to a change in university R&D expenditure. Furthermore, small businesses have the highest response to a lift in university R&D expenditure. Although the authors do not offer an explanation, it is possible that small businesses use external sources of research to supplement their own. New Zealand firms have relatively easy access to capital, with 94% of firms with 6-19 employees, and 95% of firms with 20-49 employees, able to access debt financing on acceptable terms in 2016, according to Statistics New Zealand's Business Operations Survey.

Businesses who have a higher propensity to invest will also respond more to university R&D expenditure, as shown by Aghion et al. (2009).

However, for firms who do not rely on technology for growth, Aghion et al. (2009) suggest that university research crowds out some private sector innovative activity that would have otherwise occurred. They find this effect exists in industries further away from the technology frontier. That is, those industries and areas that are not heavily reliant on new technology for growth.

For a location with a high proportion of industries far from the technology frontier, Aghion et al (2009) found a $1000 investment in university decreased local economic growth by 0.07 percentage points. This degree of crowding out likely exists because it more efficient for a firm who is not very innovative to adapt existing technologies than invent new ones. The adaption of university technology results in a less productive use of resources than had the technology been developed by the business using it (Aghion et al, 2009).

A key takeaway from the literature is that funding could be directed at industries that are technology intensive to achieve a higher degree of innovation in the business sector. Such industries could include pharmaceuticals and electronics.

University spin-offs

University spin-offs directly contribute to innovation within a local area by transforming technological inventions developed by students and graduates into commercial products. Spin-offs produce new materials, provide a key pathway for technology transfer from universities to industry, and tend to be more successful and employ more people than an average commercial start-up. The literature suggests a number of ways that university spin-offs contribute to innovation in a region.

Table 1.1: How university spin-offs contribute to innovation

Source	Date	Finding
Di Gergoio and Shane	2003	University based spin-offs contribute more to the economy than general business start-ups do. It is estimated that the average number of employees in university spin-offs in the US was 83 FTE between 1980 and 1999, compared to just 3.8 FTE in commercial start-ups. The chance of a university producing a spin-off is determined by the research quality of its faculty, as well as having an incentive structure that encourages universities to take an equity stake, rather than licensing royalty fees.
Audretsh and Lehmann	2005	There is also positive correlation between university spin-offs and other business start-ups in high tech industries within the same geographic area. This effect is likely due to the knowledge spill-overs between similar companies.
Power and Malmberg	2008	University spin-offs in research-intensive areas contribute more to innovation than in less research-intensive areas. For example, nine spin-off were created from Stanford University and Cardiff University between 2002 and 2009, with funding from Biofusion, a company set up to commercialise university IP. Many of these spin-offs have produced valuable new technologies, such as Demasq Ltd, which produces a range of bone and soft-tissue imaging products at a lower cost than traditional MRIs.

Source: Deloitte Access Economics

The transfer of technology and knowledge from universities to industry is more effective in areas that have a concentration of similar industries and research institutes (Ponds, van Oort, Frenken, 2009). For example, Victoria University of Wellington has developed a number of information technology spin-offs, patents and research, which aligns with Wellington's comparative advantage. According to Statistics New Zealand's Household Labour Force survey, 17% of employment in Wellington is in the scientific, technical, administrative and support services sector.

Similarly, Lincoln University and the University of Canterbury are strong in primary sector research, aligning with the area's known strengths. In the year to March 2018, 6.8% of the region's population was employed in the agriculture, forestry, and fishing industries. There is also a number of agriculture-related research institutes in Canterbury, including Plant & Food Research, and Lincoln University.

Universities in New Zealand also support university spin-offs in a number of ways, such as through commercialisation offices. Commercialisation offices undertake the patenting and commercialisation process, in addition to providing internal or external seed funding. For instance, the University of Auckland's UniServices supports researchers to transform university-owned research into commercial products or services. Similarly, AUTEL and Otago Innovation are Auckland University of Technology and University of Otago's commercialisation offices.

Through these offices, there has been a number of successful companies spun out of university innovations. For example, researchers from the University of Auckland founded a company called SapVax in 2016, which developed a novel vaccine to fight cancer cells. The team is also developing a number of different products to fight different cancers. Another example is DreamFlux, which develops virtual reality and immersive technologies, and was a spin-off created by researchers from Victoria University of Wellington.

Patents and licensing

Patents are a key university output. According to Astebro & Bazzazian (2009), university patent licenses as a form of technology commercialisation dominates university spin-offs, with eight times as many licenses as there were university-spin offs in 2007.

However, patents are often issued in the early stages of product development, and their production does not necessarily result in successful innovations. Alternatively, their licensing can be a useful proxy for innovation in a local region. A licensed patent suggests that the associated technology is being used in a commercial sense. Using an input-output approach, the Association of University Technology Managers (AUTM) (2017) estimated the economic impact of academic licenses on the US economy over twenty years. They found that academic licenses contributed between $148bn and $591bn (US dollars) to the US economy over the twenty years to 2009.

The contribution of university patents to regional innovation is well established. AUTM (2017) found that 72% of firms formed from patent licenses were located near the university the patents orientated from (Astebro & Bazzazian, 2010).

A second way to measure patent's effect on regional innovation is by the number of citations. Veugelers, Callaert and Van Looy (2012) used corporate patent citations of university patents to measure the usefulness of patents to business. The higher the instance of university citations suggests more reliance on university-generated IP when developing new technology. The degree of patent citation varies widely across countries. In the United States (US) and United Kingdom (UK), 15% of university-owned patents were cited by company patents in 2000. This compares to close to 50% in Japan.

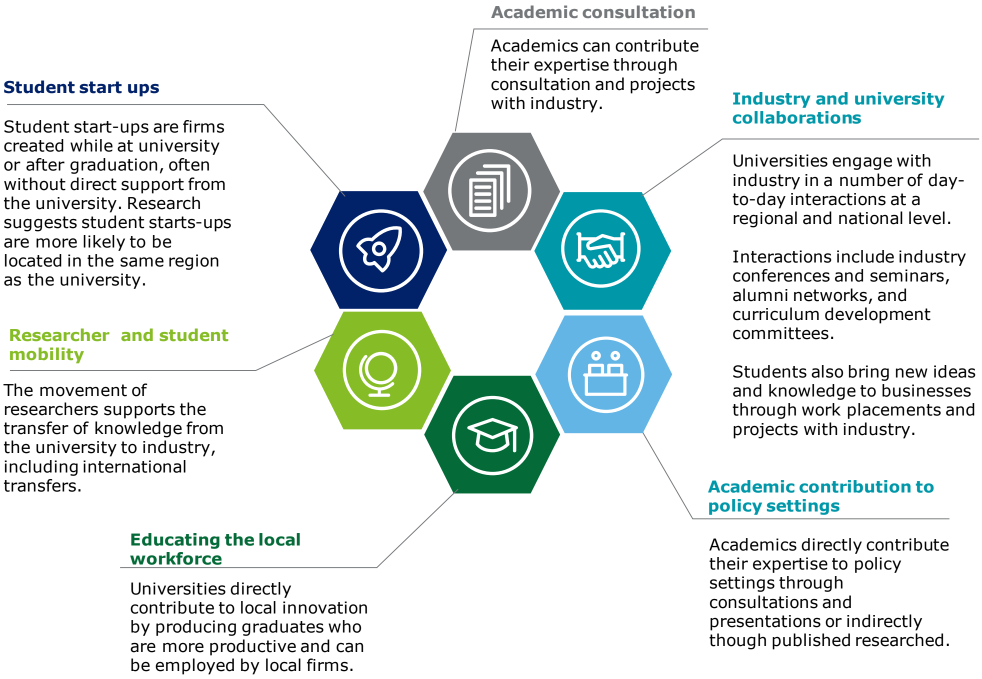
Universities' contribution to innovation through human capital

Although most universities in New Zealand are engaged with some commercialisation of university research, only a small percentage of research is successfully commercialised. This follows that formal commercialisation of university products is not necessarily the most important way that universities contribute to innovation.

Beyond the direct effect of university patents, licenses, spinoffs and R&D, there are many other avenues that universities support innovation in a region. These informal interactions are more difficult to quantify, but are arguably more important to supporting local innovation than formal relationships are (Veugelers and Del Ray, 2014).

Chart 1.2 provides a summary of informal and formal linkages discussed in the extended literature review. There are of course multiple other ways universities contribute to innovation through human capital. University academics provide input to policy settings, present for businesses, and undertake consulting work. Students undertake internships and complete joint research projects with businesses.

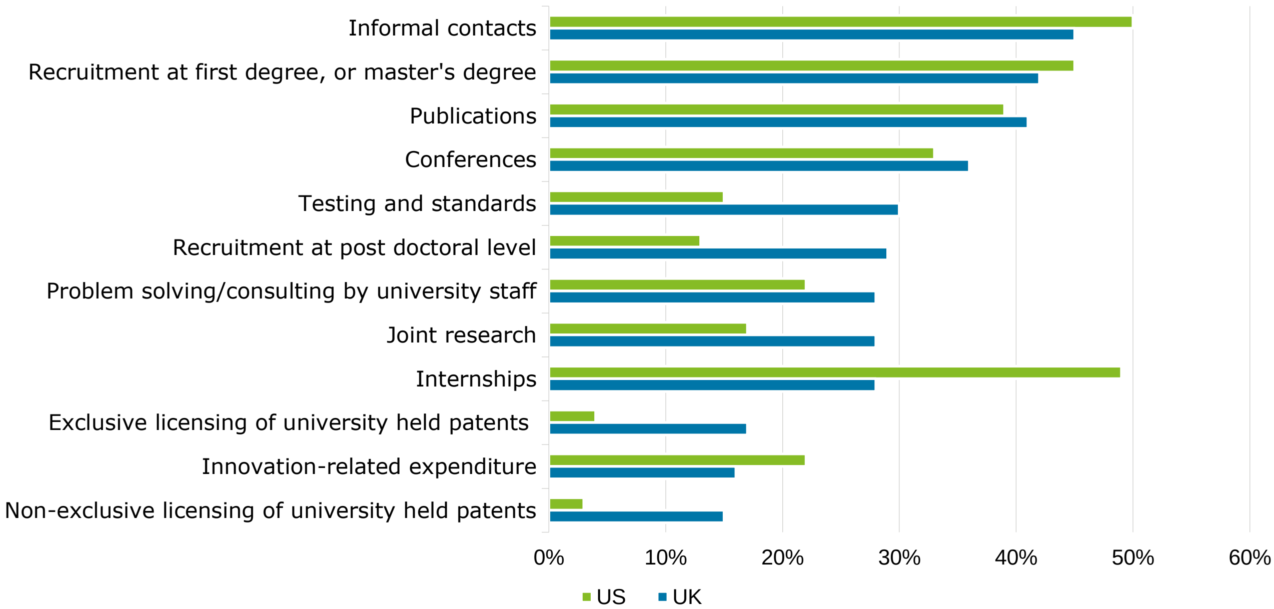
Chart 1.2 Universities' informal and formal linkages contributing to innovation



Source: Deloitte Access Economics

As shown in Chart 1.3, informal contacts were reported to be the most common type of university-industry interaction for contributing to a firm's innovation activities (Cosh, Huges, and Lester, 2006). These include alumni networks, meetings and conferences, hosting of forums, and curriculum development, along with a host of other activities.

Chart 1.3 Type of university-industry interactions' contribution to innovation (Percentage of ratings provided by firms)



Source: Deloitte Access Economics; Cosh, Huges, and Lester (2006)

This result shows that the expected impact of contribution to innovation through formal and informal relationships is likely to be higher than through commercial products.

Interacting and collaborating with government and industry

Universities interact with the business community in a number of day-to-day interactions, which by nature happen at a regional level. Cosh, Huges and Lester (2006) refer to these as 'public space functions'. Activities and functions of universities that fall into this category include alumni networks, meetings and conferences, hosting of forums, and curriculum development, along with a host of other activities. Survey data from Cosh, Huges and Lester (2006) shows that universities in the United Kingdom and United States engage in a number of public space functions and activities to facilitate knowledge transfer or as a precursor to a more formal engagement.

Other international studies found that the social networks of universities, as well as previous start-up expertise, are explanatory variables to spin-off creation (Lockett, Wright and Franklin 2003). The movement of researchers supports the transfer of knowledge from the university to industry according to a study by Kaiser, Kongsted and Rønde (2011). This is particularly valuable to science-based research, which is often difficult to interpret and apply in a business context.

Centres that promote entrepreneurship are also valuable ways in which universities interact with industry. For example, New Zealand's government funded Centres of Research Excellence (CoREs) are inter-institutional research networks that support collaboration between New Zealand and international universities. International research collaboration contributes to local innovation by raising the universities profile, attracting new students, and by receiving students and staff from overseas (Deloitte Access Economics, 2017).

Further benefits of these informal interactions and relationships are research grants provided to universities. For example, within the Marsden Fund in New Zealand, $78 million of research grants were directed to New Zealand universities. Another example is MBIE's Endeavour Fund, which granted $89 million to universities for research and ideas.

University academics directly contribute to policy settings through consultation with local and national government. In New Zealand, consultation is often through public participation, which is a legislative requirement in a number of Acts, including the Local Government Act 2002. University academics also contribute their expertise to government indirectly through academic output and knowledge sharing.

International literature suggests that policy makers do make use of academic research to some extent. Drawing on survey and interview data from Australian public servants, they find that 61% of respondents have written documents that has drawn on academic research within the past 12 months.

Many officials interviewed in Australia believed that academic research was too slow, too expensive, or too specialised. However, the majority of respondents agreed that academic research could have a larger role to play in Australian policymaking.

One respondent suggested that informal networks between academics and policymakers are more important than formal consultations, because it is necessary to know which expert to speak to before there is even a formal request for consultation in place (Newman, Cherney, Head, 2015).

Another way that universities collaborate with government and industry is on advisory boards and committees. For example, the Director of Property Services at Auckland University sits on the Ministry of Business, Innovation and Employment's Building Advisory Panel, and various university staff sit on the New Zealand Intellectual Property Office's Maori Advisory Committees.

Researcher mobility

The movement of researchers supports the transfer of knowledge from the university to industry, according to a study by Kaiser, Kongsted and Rønde (2011). This is particularly valuable to science-based research, which is often difficult to interpret and apply in a business context.

Using linked employer-employee data between 1978 and 2006, they show that the university-trained researchers benefitted the new and old employers in Denmark.

They also showed that the inter-firm linkages promoted cross-citation between the two firms. For each R&D worker employed from a patenting firm, the number of patents lifted by 22% across both firms. This compares to 2% had the joiner came from a non-patenting firm.

Using the same data, Ejsing et al (2013) established hiring university-trained researchers led to more innovation at the firm level. Ejsing et al (2013) says that this implies the employee is not only contributing to the firm's own R&D activities, but also enables firms to better absorb external R&D, presumably through increased firm capability and understanding of academic research.

International research collaboration contributes to local innovation by raising the universities' profile, attracting new students and staff, and by receiving students and staff from overseas (Deloitte Access Economics, 2017).

Student start-ups

Businesses formed by entrepreneurial students or former students contribute to innovation in the same way in which university spin-offs do - by transforming IP developed at university and after graduation into new products and services. However, the link between the business and the university is unclear, due to the difficulty in capturing start-up businesses formed by former students or researchers.

That being said, survey data suggests that the rate of student/alumni start-ups is higher than formal university spin-offs, with Astebro & Bazzazian (2009) finding that a recent graduate was twice more likely to start a company than their faculty was. Using three case studies, the authors show how universities stimulate students studying engineering and science to create new high-quality firms.

Furthermore, a lot of the positive spillover that student-led start-ups produce are captured by the local economy. Baltzopoulus and Broström (2010) show that student start-ups are most likely to set up their business in the region they studied, using a sample of 8,000 linked employer-employee records in Sweden between 1985 and 2005. Linked data allows analysis at an individual level rather than an aggregate level, which is a limitation of many similar studies.

Controlling for where students previously worked, Baltzopoulus and Broström (2010) found that if a student moved to another region to study from where they were born, over half of students located their business in the region where they studied. If a university graduate was born in the same region they studied in, this likelihood increased to 87%.

Educating the local workforce

Finally, a primary function of universities is to educate students, and this directly supports innovation economic activity. Firms benefit from employing university graduates who are more productive as a consequence of their studies, and who can provide an informal link back to the university. Furthermore, postgraduate students bring with them IP that can be utilized by businesses.

As found by Deloitte Access Economics (2015a), a 1% increase in the tertiary education attainment rate in Australia leads to an increase of between 0.15% to 0.20% increase in labour productivity (measured as GDP per capita) in Australia. A similar study by Holland et al. (2013) found a 1% increase in the proportion of the workforce with a university degree leads to a 0.2% to 0.5% increase in productivity in the long-run.

2. Economic impact of universities' contribution

Having established a relationship between universities and regional innovation through international literature, the question now becomes "to what extent do universities affect innovation in New Zealand, when considered at a regional level?"

The direct effect of universities on innovation can be estimated through using expenditure on R&D. However, the effect that relationships between universities and industry has on innovation is more difficult to quantify.

Therefore, to establish the impact of universities on innovation, this report uses an empirical model to quantify the impact of universities' research expenditure on GDP within the New Zealand economy.

The key findings are:

Chart 1.4 Economic impact of universities' research expenditure

8.9% of GDP in 2017
The contribution of the total stock of higher education research in New Zealand to GDP is estimated to be $25.9 billion in 2017, or around 8.9% of GDP.

$129 billion to GDP
Increases in research investment by New Zealand universities from 1984 to 2015 cumulatively increased real GDP by $129 billion in 2017 dollars from 1984 to 2017.

Return on investment of 5.1 to 1
Investment in university research and development generated an **economic return on investment of 5.1 to 1**.
This indicates a long-term return to the economy of approximately $5.10 for each dollar invested in university research.

Source: Deloitte Access Economics

Economic impact of university research expenditure

The economic impact of university expenditure on R&D was modelled as a proxy for universities direct contribution to innovation in the economy. Research and innovation are significant drivers of long-term economic growth. University research alone does not translate to increased economic activity. Instead, it is the application of this research, and its introduction into the marketplace, that can result in economic growth. The modelling in this chapter aims to quantify the economic impact of universities' historical expenditure on research and development, and its effect on economic activity in New Zealand.

This analysis includes cross-country macro-econometric analysis of university research expenditure and its impact on the level of economic activity in an economy. The model of economic growth extends upon the neo-classical Solow growth model adopted by Mankiw et al (1992), using a similar approach to that undertaken in the literature (Bassanini and Scarpetta, 2001; and Elnrasi and Fox, 2014).

This analysis is includes outputs from Deloitte Access Economics (2015a), which studied economic growth and higher education attainment for 37 countries from 1980 to 2010. The study found:

- Estimates of the relationship between higher education R&D expenditure and GDP (referred to as the elasticity between higher education research expenditure and GDP).
- An estimated convergence term that indicates the speed at which the economy moves to its new higher level of GDP as a result of additional research increasing an economies capacity.
- The supply of goods and services (referred to as an increase in the production possibility frontier to the new steady-state level of GDP).
- The implied shares of GDP per capita in 2017 attributable to expenditure on higher education R&D.

Further detail on the specific modelling methodology used in Deloitte Access Economics (2015a) is included in Appendix A.

The New Zealand model utilises the above parameters to estimate the increase in economic activity attributable to historical increases in university research funding. Specifically, this analysis compared historical GDP figures to an alternative scenario where investment in university R&D remains unchanged from 1984 levels in real terms. Given the historic volatility in university research funding, a smoothing process is applied by using the compounded annual growth rate over the years included in this analysis. This volatility is particularly prevalent in the late 1980's, which is potentially due to the inflation targeting regime implemented by the Reserve Bank of New Zealand in response to both high and volatile inflation. Alternate analysis that uses the unadjusted figures is presented in Appendix A.

In the New Zealand model, the effects of university research funding on GDP accrue over time due to:

- Time lags associated with the effects of research output on productivity.
- The economy transitioning to its new level of economic output caused by an increase in productivity.

As is the case with research, there can be long time lags between research completion and the subsequent impact on business and the economy. This can vary based on the style of research, who is undertaking the research, and its application to business including testing, implementation and refinement.

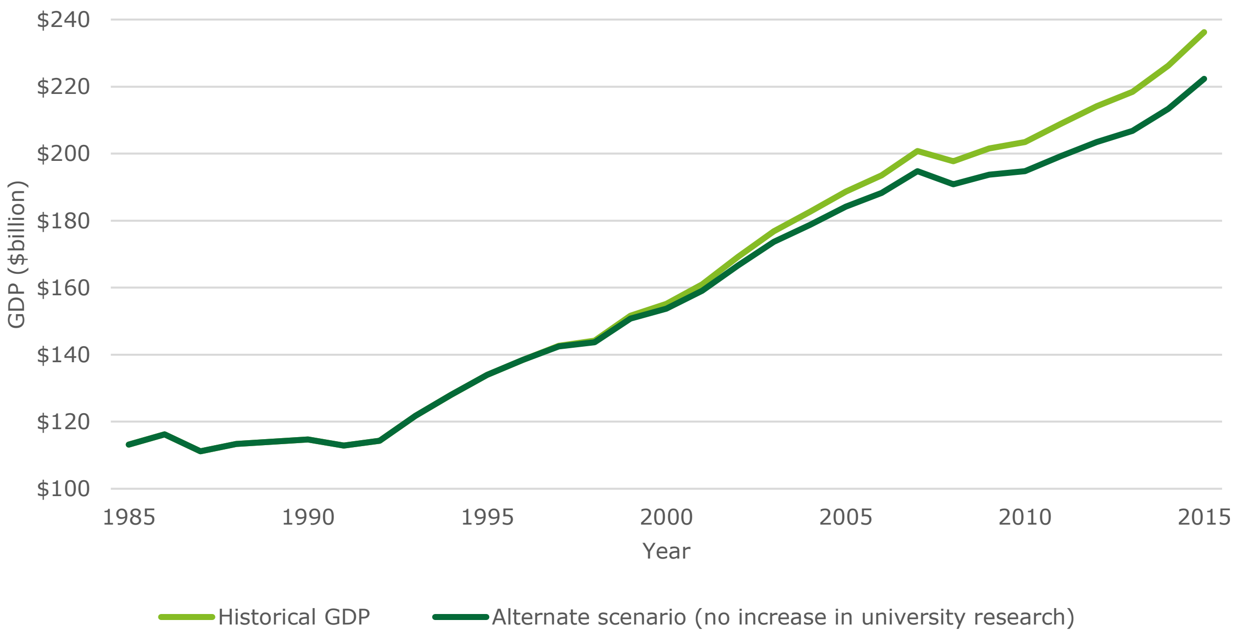
There are a wide range of estimates in international literature on time lags, most of which fall within a 5-20 year range. The analysis in this report adopts the assumption that research activity affects economic productivity after approximately 11.25 years. This is consistent with the literature reviewed by Deloitte Access Economics (2015a), and the approach used by Deloitte Access Economics (2018) in *Assessing returns on international collaboration*.

The timing of a productivity improvement effect on the economy is also governed by the transition dynamics of the economy. Specifically, how the economy reacts to increasing productivity through the accumulation of capital inputs. These transition effects can be approximated through the use of the convergence term, which is estimated in the econometric growth model in Deloitte Access Economics (2015a). The convergence term is estimated to be 0.177, which indicates that the economy will close 18% of the gap between the current level of output and the new steady-state output (the level of output that can be achieved based on a higher level of research and development expenditure) each year.

Results
The contribution of the **total stock** of higher education research in New Zealand to GDP was estimated to be **$25.9 billion in 2017**. This corresponds to a share of output attributable to university research activity of around **8.9% of GDP**.

A historical analysis of the increases in research investment indicates that **the increases in research investment by New Zealand universities from 1984 to 2015 increased GDP by $129 billion.** Chart 1.5 presents the modelled scenario where university R&D funding remains unchanged in real terms from 1984 figures against historical real GDP figures. As the model assumes a lag period from when university research funding takes place, and when there is a corresponding effect on GDP, the initial increases in funding around 1985 take some time to evolve into changes in GDP.

Chart 1.5: Comparison of historical GDP to scenario of GDP with no real increase in university R&D funding, 1985-2015



Source: Deloitte Access Economics, OECD

Historic investment in university R&D generated an **economic return on investment of 5.1 to 1**. This indicates a return to the economy on each dollar invested in university research of approximately $5.10. This figure is calculated by first applying a real discount rate of 7% to the stream of university research funding expenditure and the estimated change in GDP relative to the counterfactual scenario, where research and expenditure is retained at 1984 levels in real terms.

University investment in R&D has played a significant role in the New Zealand economy, particularly over the last three decades. Providing a positive economic return greater than five times its initial investment highlights the degree of benefits that university R&D can add to the New Zealand economy.

3. Concluding views

This report finds a strong relationship between universities' direct contribution to innovation and economic growth. It finds that the contribution of universities to GDP through higher education research is significant, and is estimated to be $26 billion in 2017, equivalent to 9% of GDP. Increases in research investment by New Zealand universities from 1984 to 2015 cumulatively increased real GDP by $129 billion over the period. This benefit of universities' research investment is important to local firms and to government. This is particularly true when setting the regulatory environment around R&D spending, and shaping strategies for economic growth and future prosperity.

This report also finds that universities' relationship with industry, the links formed with previous students and the public space they provide, often contribute more to local innovation than direct commercial activity does. Despite these benefits, New Zealand currently ranks 29th out of 33 OECD countries for collaboration between business and higher education or government institutions (OECD, 2017).

To unlock the benefits of innovation for New Zealand in the future, it is important for policy-makers, universities, and investors to focus on strengthening the contribution of universities to innovation.

Opportunities for further research and analysis to better understand what actions could have the greatest impact include:

1. Research into the type, and extent, of university-industry interactions' contributing to innovation in New Zealand, compared to other broadly comparable jurisdictions – perhaps other smaller economies not dis-similar in size to New Zealand – based around the approach applied in the study conducted in the UK and USA presented in Chart 1.3 in this report.
2. Research and analysis of the barriers faced by universities' seeking to contribute to innovation in New Zealand, based on consultations. For example, it is important to understand whether current policies are having the effect of promoting universities' role in innovation, and how this effect may vary between universities in different locations.
3. Assessment of agglomeration effects for universities in New Zealand. Agglomeration effects come about when businesses, universities, entrepreneurs, government, investors and other stakeholders concentrate in specific geographic areas to match skills, collaborate, or share knowledge and resources in a cost effective way. Deloitte Access Economics (2015b) found that knowledge-intensive services, such as those provided by universities, exhibit economies of agglomeration. In essence, the productivity of knowledge workers rises proportionally more when they are in proximity of one another, as their interaction stimulates creativity and innovation. A similar analysis could be conducted in New Zealand to improve understanding of this relationship.

4. Research into the current governance of university-industry collaboration. A recent report by the New South Wales Government on innovation precincts identified “formal governance that guides the interactions between different stakeholders, and a strong focus on commercialising research and IP that support collaboration and profit sharing” as key features to the success of an innovation precinct (NSW Government, 2018). This example illustrates the importance of good governance to drive effective university-industry collaboration.

This work would allow New Zealand to enhance innovation, and in combination with the findings in this report, inform and guide the development of future strategies and initiatives.

Appendix A: Econometric modelling approach

Macroeconomic model

In line with a large body of economic development literature, Deloitte Access Economics (2015a) developed a cross-country model of economic growth, which seeks to diffuse effects of human capital and higher education research and development (R&D) on national income. This model uses a neo-classical production function; the formal framework is first set out by Mankiw, et al. (1992) and its augmented-form implemented by the OECD (2001), among others. The model used in this report adheres closely to existing literature, with modifications provided to accommodate the focus on tertiary human capital and higher education R&D. The standard neo-classical growth model is derived from constant returns to scale production function with three inputs (capital, labour and human capital) that are paid their marginal products. Production (output) at time t is given by:

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} \big(A(t)L(t)\big)^{1-\alpha-\beta}$$

Where Y,K,H and L are respectively output, physical capital, human capital and labour, α is the partial elasticity of output with respect to physical capital, β is the partial elasticity of output with respect to human capital and A(t) is a measure of technological progress and economic efficiency, where:

$$A(t) = I(t)\Omega(t)$$

This research incorporates higher education R&D along with other R&D activities and exposure to international trade as key determinants of economic efficiency I(t), such that:

$$\ln I(t) = p_0 + \textstyle\sum_j p_j \ln V_j(t)$$

$$\ln I(t) = p_0 + p_1 Higher\ Education\ R\&D + p_2 Other\ R\&D + p_3 Exposure\ to\ trade$$

Technological progress is assumed to be exogenous and grows at rate g(t); that is:

$$\dot{\Omega}(t) = g(t)\Omega(t)$$

Substituting the steady-state values of physical capital and human capital yields the intensive form of steady-state output as a function of h*.[1]

[1] The steady-state stock of human capital h^* is not observed, but it can be expressed as a function of actual human capital: $\ln h^*(t) = \ln h(t) + \frac{1-\psi}{\psi} \Delta \ln\left(\frac{h(t)}{A(t)}\right)$

$$\ln(y^*) = \ln \begin{matrix} \Omega(t) + p_0 + \sum_j p_j \ln V_j(t) + \frac{\alpha}{1-\alpha} \ln s_k(t) + \frac{\beta}{1-\alpha} \ln h^*(t) \\ -\alpha(1-\alpha)\ln(g(t) + n(t) + d) \end{matrix}$$ [2]

The above is valid in empirical cross-country analysis only if countries are in their steady-states or if deviations from steady-state are independent and identically distributed. If observed growth rates include out-of-steady-state dynamics, then the transitional dynamics have to be modelled explicitly (Bassanini and Scarpetta, 2001). A linear approximation of the transitional dynamics can be expressed as follows (Mankiw et al., 1992):

$$\begin{aligned} \Delta \ln y(t) = {} & -\phi(\lambda) \ln y(t-1) + \phi(\lambda)\left(\frac{\alpha}{1-\alpha}\right) \ln s_k(t) + \phi(\lambda)\left(\frac{\beta}{1-\alpha}\right) \ln h(t) \\ & + \sum_j p_j \phi(\lambda) \ln V_j(t) + \frac{1-\psi}{\psi}\left(\frac{\beta}{1-\alpha}\right) \Delta \ln h(t) \\ & - \phi(\lambda)\left(\frac{\alpha}{1-\alpha}\right) \ln(g(t) + n(t) + d) + \left(1 - \frac{\phi(\lambda)}{\psi}\right) g(t) \\ & + \phi(\lambda)(p_0 + \ln \Omega(0)) + \phi(\lambda) g(t) t \end{aligned}$$

This equation represents the generic functional form that has been empirically estimated in this research. Further, the coefficient estimate φ(λ) represents the convergence parameter. The convergence parameter underlines the speed in which countries converge to their steady-state output.

In addition to estimating the steady-state solutions, we also estimate another functional form, adding short-term dynamics in the model to help isolate dynamic cyclical effects. This augmentation is advantageous as it relaxes the assumption that countries are in their steady-states and that deviations from the steady-state are independent and identically distributed. Its functional form can be expressed as follows:

$$\begin{aligned} \Delta \ln y(t) = {} & a_0 - \phi \ln y(t-1) + a_1 \ln s_k(t) + a_2 \ln h(t) - a_3 n(t) + a_4 t + \sum_{j=1}^{3} a_{j+4} \ln V_j \\ & + b_1 \Delta \ln s_k(t) + b_2 \Delta \ln h(t) + b_3 \Delta \ln n(t) + \sum_{j=1}^{3} b_{j+3} \Delta \ln V_j \end{aligned}$$

Similar to specifications used by the OECD (2001), our analysis uses a sample of 37 countries between 1980 and 2010 (Table A.1). Where appropriate, data is converted to constant 2010 US dollars using constant Purchasing Power Parity, consistent with OECD standards.

Table A.1 Countries included in regression

Country list				
Australia	Denmark	Iceland	Mexico	Slovak Republic
Austria	Estonia	Ireland	Netherlands	Slovenia
Belgium	Finland	Israel	New Zealand	South Africa
Canada	France	Italy	Norway	Spain

[2] Where y^* is the steady-state output per capita, s_k is the investment rate in physical capital, $n(t)$ is the population growth rate, and d is the rate of depreciation.

Chile	Germany	Japan	Poland	Sweden
China	Greece	Korea	Portugal	Switzerland
Czech Republic	Hungary	Luxembourg	Russia	Turkey
United Kingdom	United States			

Table A.2 outlines the parameters used in the estimation procedure.

Table A.2 Data sources

Parameter	Variable	Source
$y(t)$	Gross domestic product per capita	OECD
$h(t)$	Tertiary education attainment (% of 15+ population)	Barro-Lee (2010)
$n(t)$	Total population growth	OECD
$s_k(t)$	Gross capital formation (% of GDP)	OECD
$V_1(H\ R\&D)$	Expenditure on Higher education R&D per capita	OECD
$V_2(O\ R\&D)$	Expenditure on Other R&D per capita	OECD
$V_3(Trade)$	Exports and Imports of goods and services (% of GDP)	World Bank
t	Time trend	-

Table A.3 outlines the results from the econometric model.

Table A.3 Modelling results

Parameter	Model I: Steady-State	Model II: Short term dynamics
$\ln y(t-1)$	-0.204**	-0.149**
$\ln s_k(t)$	0.819***	0.454***
$\ln h(t)$	0.152*	0.233**
$n(t)$	-12.1*	-7.621
$V_1(H\ R\&D)$	0.175*	0.184***
$V_2(O\ R\&D)$	0.139*	0.150*
$V_3(Trade)$	0.123	0.128
$\Delta \ln s_k(t)$	-	0.162***
$\Delta \ln h(t)$	-	-0.0864
$\Delta n(t)$	-	0.265
$V_1(H\ R\&D)$	-	0.0731***
$V_2(O\ R\&D)$	-	0.174***
$\Delta V_3(Trade)$	-	-0.0425

Note: * p<0.05, ** p<0.01, *** p<0.001. Reported coefficients are transformed to exclude the convergence term per their functional form.

Production parameters

Estimates of steady-state coefficients as well as parameters of the production function can be retrieved based on the estimated coefficients presented above. For example, according to the functional form of the linear approximation given by Mankiw et al. (1992), the share of physical capital in steady-state output (α) is given by the coefficient estimate of the physical capital investment rate (s_k) and the convergence term (φ):

$$a_1 = \phi\left(\frac{\alpha}{1-\alpha}\right)$$

Table A.4 outlines the implied input shares of the estimated production function.

Table A.4 Implied share of income per capita

Implied share	Model I	Model II
Physical capital share (α)	45.02%	31.22%
Tertiary human capital share (β)	8.36%	16.02%
Residual share ($1-\alpha-\beta$)	46.62%	52.75%

Source: Deloitte Access Economics

Our results indicate the average share of tertiary human capital is around 12%, that is, around 12% of steady-state output can be attributed to tertiary human capital inputs.

Elasticities

The estimated coefficients can be interpreted as an elasticity on steady state GDP. For example, the steady-state effect of higher education R&D has the functional form of φp_j where φ is the estimated coefficient for $\ln y(t-1)$. p_j then represents the elasticity of higher education R&D on steady-state output, estimated to be around 0.175 under model I and 0.184 under model II. This implies that a 10% increase in higher education R&D per capita will increase steady-state output by around 1.8%.

Convergence

The convergence parameter φ plays an important role in explaining the modelling results. In all specifications the convergence parameter is significant, suggesting a (conditional) process of convergence as countries move towards their steady-state output levels. For example, under model II, the convergence term is estimated to be 0.149, this indicate that the economies will close 14.9% of the gap between their current level of output and their steady-state output each year. The convergence process is asymptotic, meaning that countries will never truly reach their steady-state levels but rather move very close to it.

Application of model to New Zealand

The estimation of model parameters is based on the cross-country regression of 37 countries, including New Zealand. For this reason, the application of the model in New Zealand is valid. However, specific country differences may vary the approach required. In New Zealand, for example, the volatility of university research funding and inflation, particularly in the 1980's may mean that the model results are potentially misleading. This is caused from disproportional emphasis placed on large changes in the data (particularly those that occur early on in the sample). Due to this volatility in university research funding data in New Zealand, a smoothing process is applied. Specifically, the compounded annual growth rate from 1985 to 2015 is used to grow the research funding consistently over the 30 years.

The results of the model using the raw data (filling in gaps using a linear trend) is presented in Table A.5 against the smoothed approach presented in the report. This assumption only varies the historical analysis of the impact on university R&D funding, with the estimation of the impact on New Zealand GDP in 2017 remaining the same.

Table A.5 Comparison of key results for smoothed and raw real increase in university R&D funding, 1985-2015

	Smoothed university R&D funding	Raw university R&D funding
Total GDP contribution of research funding (NZD $b)	129.2	217.8
Average GDP contribution per year (NZD $b)	4.3	7.3
Return on investment	5.1	6.9

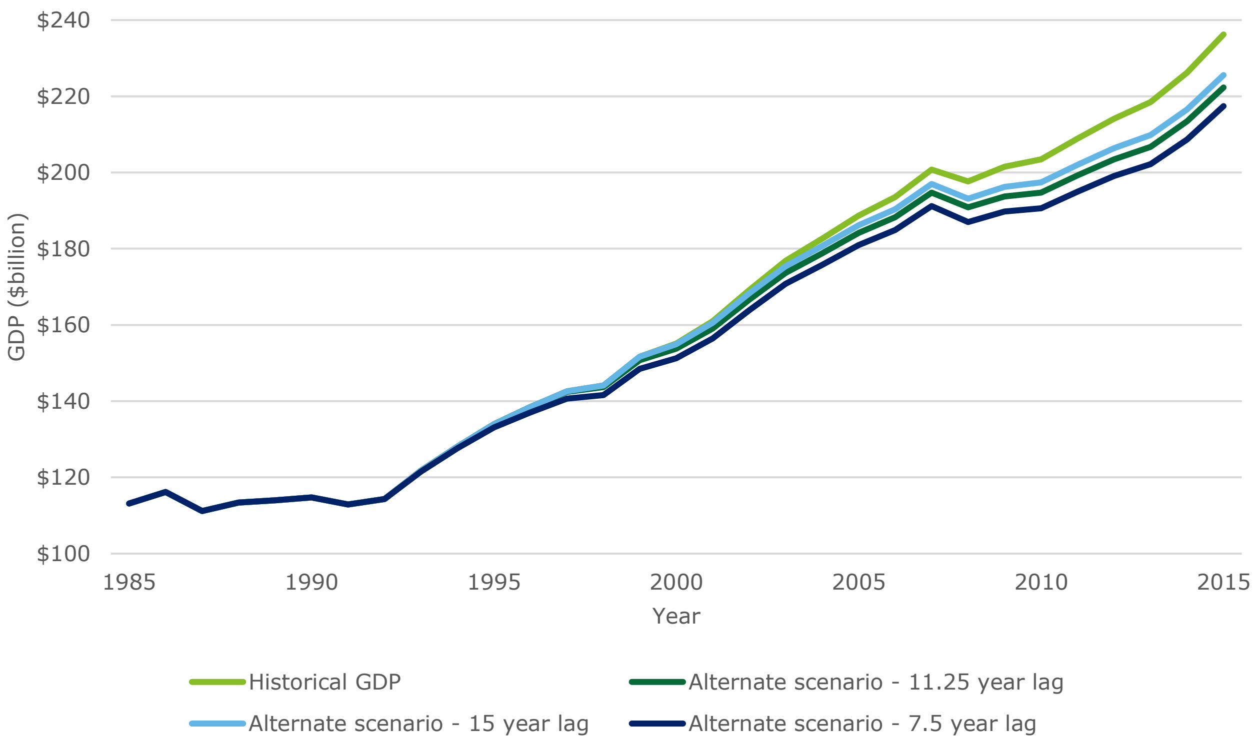
Source: Deloitte Access Economics

The results presented in this report apply parameters that are an average of the two models estimated above. This approach is consistent with Deloitte Access Economics (2015a) report.

Lag period sensitivity analysis

The historical increases in research investment can vary significantly based on the assumed lag between research funding and realised changes in the economy. The modelling in the report assumes a lag period of 11.25 years, however, upper and lower bound scenarios were also calculated with assumed lag of 7.5 and 15 years, respectively. Chart 1.6 presents these scenarios against the historical GDP and base scenario presented previously.

Chart 1.6: GDP scenarios with varied lag length for increases in university R&D funding, 1985-2015



Source: Deloitte Access Economics, OECD

A shorter lag length allows research to benefit the economy at a faster rate, consequentially allowing the overall impact on GDP over time to increase. A longer lag length has the opposite effect, decreasing the speed at which research is disseminated and productivity gains are realised, therefore decreasing the overall impact on GDP over time. Specifically, increases in research investment by New Zealand universities from 1984 to 2015 increase real GDP by:

- $85 billion assuming a lag period of 15 years
- $129 billion assuming a lag period of 11.25 years
- $207 billion assuming a lag period of 7.5 years

Limitation of our work

General use restriction

This report is prepared solely for the use of Universities New Zealand. This report is not intended to and should not be used or relied upon by anyone else and we accept no duty of care to any other person or entity. The report has been prepared for the purpose of providing the casual link between universities and local innovation, and the economic impact of university research expenditure on the New Zealand economy. You should not refer to or use our name or the advice for any other purpose.

References

Aghion, P., Boustan, L., Hoxby, C., & Vandenbussche, J. (2009). The Causal Impact of Education on Economic Growth: Evidence from U.S Brookings papers on eocnomic activity.

Astebro, T. B., & Bazzazian, N. (2009). Universities, Entrepreneurship and Local Economic Development. (E. Elgar, Ed.) HANDBOOK OF RESEARCH ON ENTREPRENEURSHIP AND REGIONAL DEVELOPMENT, 252-333.

Association of University Technology Managers (ATUM) (2017). SFY2016 Licensing Survey. Retrieved from: https://www.autm.net/resources-surveys/research-reports-databases/licensing-surveys/fy2016-licensing-survey/

Apatov, E., Grimes, A. (2016). Higher education institutions and regional growth: The case of New Zealand, Motu Working Paper 16-11, Motu Economic and Public Policy Research.

Audretsh, D., & Lehmann, E. (2005) Does the Knowledge Spillover Theory of Entrepreneurship hold for regions?. Research Policy, 8, 1191-1202

Baltzopoulos, A., & Broström, A. (2010). Attractors of talent: Universities, regions, and alumni entrepreneurs. (C. -C. Royal Institute of Technology, Ed.) *Working Paper Series in Economics and Institutions of Innovation 239*.

Bassanini, A., Scarpetta, S. (2001) The Driving Forces of Economic Growth: Panel Data Evidence for the OECD Countries. *OECD Economic Studies.* 32 (2), 9-56

Casper, S. (2013). The spill-over theory reversed: The impact of regional economies on the commercialization of university science. *Reseach Policy, 42*(8), 1313-1324.

Cheah, Y. (2016). Assessing economic impact of research and innovation originating from public research institutions and universities—case of Singapore PRIs. *Triple Helix A Journal of University-Industry-Government Innovation and Entrepreneurship*.

Cincera, M., Czarnizki, D., & Thorwarth, S. (2009). Efficiency of public spending in support of R&D activities. *Economic Papers*. Retrieved from http://ec.europa.eu/economy_finance/publications

Cosh, A., Huges, A., & Lester, R. K. (2006). UK plc: Just how innovative are we? Finidngs from the Cambridge-MIT Instiute International Innovation Benchmarking project. *Massachusetts Institute of Technology Working Paper Series*. Retrieved from https://ipc.mit.edu/sites/default/files/documents/06-009.pdf

Deloitte Access Economics (2015a). 'The importance of universities to Australia's prosperity'. A report prepared for Universities Australia.

Deloitte Access Economics (2015b). 'The purpose of place: Reconsidered. *Building the Lucky Country #5.*

Deloitte Access Economics (2018). 'Assessing returns on international collaboration'. A report prepared for Universities New Zealand.

Department of Industry, Innovation and Science. (2016). *How Regional Universities Drive Regional Innovation.*

Di Gregorio, D., & Shane, S. (2003) Why do some Universities generate more start-ups than others? *Research Policy, 32,* 209-227

Ejsing, A.-K., U. Kaiser, H., Kongsted, C., & Laursen, K. (2013). The Role of University Scientist Mobility for Industrial Innovation. *IZA DP No. 7470*.

Kaiser, U., Kongsted, H. C., & Rønde, T. (2011). Labor Mobility, Social Network Effects, and Innovative Activity. *IZA DP No. 5654.* .

Lawton Smith, H. (2006). Universities, innovation, and territorial development: a review of the evidence. *Environment and Planning C: Politics and Space, 25*(1), 98-144. Retrieved from https://doi.org/10.1068/c0561

Lockett, A,. Wright, M,. & Franklin, S. (2003) Technology Transfer and Universities' Spin-Out Strategies. Small Business Economics, 20(2), 185-200

Mankiw, G., Romer, D., Weil, D, N. A contribution to the Empirics of Economics Growth, *The Quarterly Journal of Economics,* 107(2), 407-437

MIT Skoltech Initiative (2014). *Creating university-based entrepreneurial ecosystems: evidence from emerging world leaders.*

Ponds, R.,van Oort, F., Frenken, K (2009). Innovation, spillovers, and university-industry collaboration: An extended knowledge production function approach. Papers in Evolutionary Economic Geography (PEEG) 0903.

Power, D., & Malmberg, A. (2008). The contribution of univeristies to innovation and economic development: in what sense a regional problem? *Cambridge Journal of Regions, Economy and Society, 1*, 233-245.

Rosenberg, M., & Nelson, R. (1994, May). American universities and technical advance in industry. *Research Policy, 23*(3), 323-348.

Science Business Innovation Board (2012). *Making industry-university partnerships work: Lessons from successful collaborations.*

Veugelers, R & Del Ray, E. (2014). *The contribution of universities to innovation, (regional) growth and employment.* European Expert Network on Economics of Education (EENEE).

Veugelers, R., Callaert, J., Song, X., & Van Looy, B. (2012). The participation of universities in technology development: do creation and use coincide? An empirical investigation on the level of national innovation systems. *Economics of Innovation and New Technologies, 5*, 445-472.

Østergaard, C., Timmermans, B., Kristinsson, K. (2011) Does a Different View Create Something New? The Effect of Employee Diversity on Innovation, Research Policy, 40(3), 500-509

Contacts

Linda Meade
Partner
Deloitte Access Economics
New Zealand

Tel: +64 (4) 470 3788
Email: lmeade@deloitte.co.nz

Lachlan Smirl
Partner
Deloitte Access Economics
Australia

Tel: +61 3 9671 7567
Email: lsmirl@deloitte.com.au

Key contributors

Economic impact of universities' contribution to innovation authors include:

Liza Van der Merwe
Deloitte Access Economics

Ben Lodewijks
Deloitte Access Economics

Christine Ma
Deloitte Access Economics

Hilary Parker
Deloitte Access Economics