The Economic Value of University Investment

Report to Universities New Zealand – Te Pōkai Tara

October 2010

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.

Our aim is to be the premier centre of applied economic research in New Zealand. We pride ourselves on our reputation for independence and delivering quality analysis in the right form, and at the right time, for our clients. We ensure quality through teamwork on individual projects, critical review at internal seminars, and by peer review at various stages through a project by a senior staff member otherwise not involved in the project.

NZIER was established in 1958.

Authorship

Prepared by: James Zuccollo and Chris Schilling

Quality approved by: John Ballingall and Jean-Pierre de Raad

Date: 13/10/2010 10:54 a.m.

8 Halswell St, Thorndon
P O Box 3479, Wellington
Tel: +64 4 472 1880
Fax: +64 4 472 1211
econ@nzier.org.nz
www.nzier.org.nz

Key points

University education and research can boost economic performance

Universities benefit the economy via education and research that boosts productivity and incomes.

Education improves labour productivity by increasing the skills of the population. It also increases the size of the labour force over the long term, due to the higher workforce participation rates of graduates. However it also draws people away from the labour market temporarily as they study instead of work.

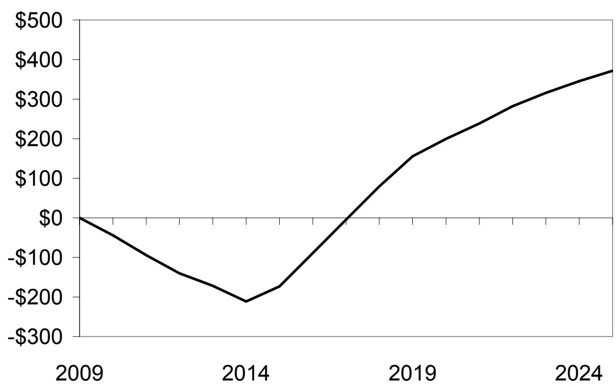
Research generates new technologies that lead to productivity benefits across a range of industries.

NZIER has investigated whether extra investment in university education and research can boost economic performance by 2025. Universities New Zealand - Te Pōkai Tara asked us to model the economic impact of an injection of $200 million over 5 years.

Long term benefits of increased university funding

A government injection of $200 million over the next five years funded through taxation will permanently increase GDP by 0.12% – or $370 million – by 2025, relative to baseline.

Figure 1 Change in GDP
$ million change from baseline



Source: NZIER

Private consumption – which represents the increased spending power of consumers – increases permanently by 0.029%, which equates to $44 million extra spending in 2025.

In the short term, the economy contracts as workers move from jobs to study and taxes increase to pay for the additional government funding. Once the greater pool of more highly educated graduates enters the workplace, the economy experiences ongoing productivity improvements in the longer term.

Borrowing the money has short term gains, long term costs

Our main scenario assumes that the investment is funded through extra taxation but, instead of taxing right away, the government might choose to borrow the funds now and pay them back later. Borrowing the funding from overseas instead of taxing households gives an initial benefit from the extra money circulating in the economy; however, but paying it back hurts the economy in the long run as households are forced to reduce consumption to pay back not only the principal but also the interest..

Compared to funding via direct taxation it costs the economy $71 million in welfare by 2025 to borrow the money from overseas and then repay by 2025.

Focussing solely on postgraduate degrees would miss the mark

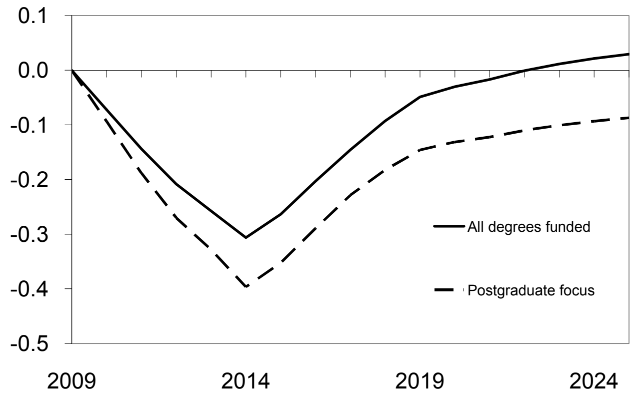
Studies show that the private returns to postgraduate education are greater than the returns to bachelor's degrees. We investigate whether targeting the extra funds to postgraduates would provide a greater benefit to the economy.

We find that focussing the spending solely on postgraduate students doesn't provide the same gains as increasing the education level of those without a bachelor's degree because the marginal gains – the difference between a bachelor's degree and a postgraduate qualification – are smaller than the marginal gains to an undergraduate qualification. It also costs the economy heavily when so many, already highly qualified, people are drawn from the workforce.

In sum, focussing on the creation of postgraduate places costs the economy $180 million in welfare by 2025.

Figure 2 Effect of postgraduate focus

Percentage change of welfare from BAU



Source: NZIER

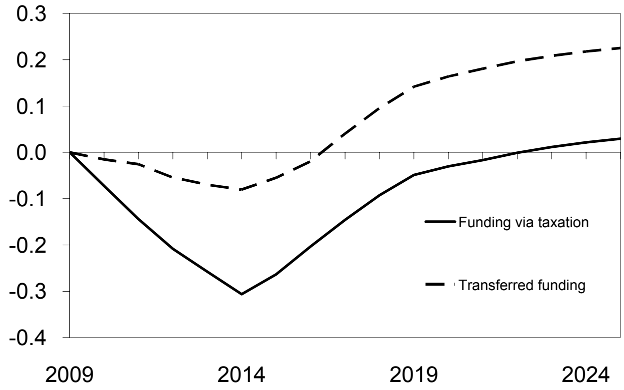
Undergraduate degrees are most productive

The evidence suggests that the returns on undergraduate bachelor's degrees are greater than the returns to level 1-3 tertiary qualifications. A third way of financing increased university places would be to transfer the funding from places in those courses. Indeed, the current Tertiary Education Strategy indicates a focus on bachelor's degrees.

We modelled the impact if the government were to fund additional university places through a revenue-neutral transfer of funding from level 1-3 tertiary qualifications. The average productivity differences between bachelor's graduates and level 1-3 graduates are significant and boost welfare $340 million by 2025. However this assumes that people who presently choose to study level 1-3 qualifications could indeed boost their productivity and income by switching to a bachelor's degree. Whether such a productivity boost is possible is an important topic for future empirical research.

Figure 3 Effect of funding transfer

Percentage change of welfare from baseline



Source: NZIER

Contents

Appendices

Figures

Tables

1. Introduction

Universities are one of the cornerstones of higher educational achievement and research excellence. The increased productivity generated by university research and education helps to boost incomes and provide a better quality of life for New Zealanders.

In the long term, increased incomes can only be generated by higher levels of productivity. One means of generating higher productivity is through greater skills and knowledge. Because of that, increasing labour force skills and generating innovative research are two of the key goals of the Minister of Tertiary Education's current Tertiary Education Strategy.[1] In this report we quantify the impact that an increase in government funding for universities may have on productivity levels and, consequently, on the New Zealand economy.

Universities affect the economy through two channels: education and research. Education increases the productivity of our workforce, while research provides new technologies that boost productivity across the economy. We model and estimate the size of each of these effects. Our report follows the work done by KPMG Econtech for Universities Australia[2] and draws heavily on their methodology.

Section 2 surveys the theory of returns to university funding and details the particular areas which we will include in the modelling process. Section 3 explains the modelling process we used and section 4 and 5 present the results of the modelling. Section 6 discusses the key conclusions arising from our results and considers their implications.

2. Returns to university funding

Universities presently spend about 40% of their government funding on research, with the remaining 60% funding education.[3] To estimate the benefit of an increase in funding it is necessary to calculate the returns to spending in each of these areas.

This section surveys the literature on returns to research and education to determine appropriate estimates of the returns to investment for our modelling.

2.1 University research

2.1.1 Productivity gains

The returns to research spending considered in this report are those which eventually manifest as higher productivity. KPMG's report extensively surveys the literature on

[1] *Tertiary Education Strategy 2010-2015*.

[2] *Economic Modelling of Improved Funding and Reform Arrangements for Universities*.

[3] PBRF funding is wholly included in the research component.

the returns to government funded research. They find average returns of 28 to 67 per cent depending on the methodology used and the sector studied. While it may be that returns to university research systematically differ from returns to other government research, we did not find any literature showing a quantifiable difference. Since universities garner two thirds of their research funding from contestable funds and contracts, it is reasonable to assume that they provide comparable benefits to other competing institutions for at least this portion of their research funding.

In particular, they note three New Zealand studies with divergent results. Scobie and Eveleens,[4] and Hall and Scobie,[5] have estimated the returns to government funded agricultural research in New Zealand and found returns of about 30%. That is significant since the single largest recipient of productivity benefits according to our split of funding is the agriculture sector. However, Johnson, Razzak and Stillman's estimates of the returns in New Zealand, across a number of sectors, vary from -22% to 1% depending on the industry.[6]

We have followed KPMG, and the weight of evidence, by using a return of 20% per annum, which is at the lower end of the international estimates and below the estimates for New Zealand's agricultural sector. However, if the work of Johnson et al provides more accurate estimates, our results will still be above the true outcome. Indeed, the one consistent element across all the studies is their caution that the results are very difficult to accurately estimate, and that all estimates should be used judiciously.

2.1.2 Timing

The second key issue is the timing of the returns: research takes time to gestate and develops a stream of benefits only after some lag. The work of Rapoport[7] and Wagner[8] suggests a lag of 18 to 30 months from project completion to commercial implementation.

If we consider that productivity benefits begin at the point of implementation then the lag from funding to benefits should be 2 years plus the time from funding to project completion. The time lag from funding to implementation is more difficult to estimate. We follow the approach of KPMG and use a 5 year lag, which appears to be broadly consistent with most proposed lag structures.[9] That is to say that a $1 investment in research today delivers a productivity benefit equal to an extra 20c of revenue for each year from the fifth onward.

[4] Scobie and Eveleens, "The return to investment in agricultural research in New Zealand."

[5] Hall and Scobie, *The role of R&D in productivity growth*.

[6] Johnson, Razzak, and Stillman, *Has New Zealand Benefited from its Investments in Research and Development?*

[7] Rapoport, "The Autonomy of the Product-innovation Process."

[8] Wagner, "Problems in estimating research and development investments and stock."

[9] Thirtle et al., "Modeling the length and shape of the R&D lag."

2.2 Returns to education

The four areas of significant public and private benefit from education are productivity, labour force participation, social cohesion and health. We discuss each in turn.

2.2.1 Productivity

Education has both private and social benefits. The private benefit of tertiary education is increased earnings: more educated people earn more. However, they also have skills that can be leveraged by those around them, which provides a social benefit through raising the productivity and earnings of those they interact with.

a) Private benefits

The private benefits to the student can be explained by a combination of two factors: increased skills and ‘sheepskin’ returns. The former is often referred to as human capital. The idea is that, as people study, they gain skills which make them more productive. That raises their value to employers and, hence, raises the wage that they command. These human capital returns boost productive efficiency in the economy.

Sheepskin, or signalling, returns are the benefits from simply gaining a qualification. Education can be seen as a way of distinguishing between employees of different ability levels. Higher ability individuals will gain higher qualifications, which signals to the employer that they are more productive and deserve commensurately greater pay. By gaining qualifications they earn more, even if they are no more skilled than when they began their studies. The productivity gains via this channel are gains in allocative efficiency: human resources are more effectively distributed across the economy due to better information about capabilities.

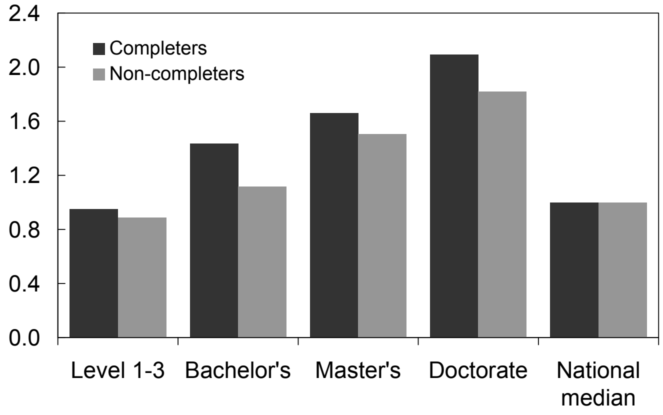
The total return to education for an individual is some combination of these two effects. In New Zealand, the total wage premium has been estimated most recently by David Scott. A chart of the estimated relative earnings at relevant qualification levels is shown in Figure 4.[10]

Observe that the jump from a level 1-3 qualification is large, but the increase from a bachelor’s degree to a master’s degree is minimal. That will become important when explaining some of our results in section 5.3.

[10] Scott, *What Do Students Earn After Their Tertiary Education?*, 24.

Figure 4 Relative earnings

Wage premium relative to national median earnings, 3yr post-study



Source: Scott (2009)[11]

Notably, Scott reports the wages earned by students who partially complete a qualification but do not graduate. Consistent with the theory detailed above, there are significant human capital, and some signalling, effects associated with completing courses rather than an entire qualification. Thus, a person who only partially completes a bachelor's degree will still earn 17% more than a person who has only a level 3 qualification by the third year of their working life. Similarly, a master's dropout will earn 5% more than a graduate with only a bachelor's degree. These high earnings for dropouts may be partially explained by selection bias: some of those who drop out do so to pursue better opportunities outside university.

Scott cautions that these estimates do not account for ability bias. It may be that the bachelor's degree graduates possess greater academic aptitude than those who gain level 1-3 certificates. That is certainly suggested by the significant signalling effect of a bachelor's degree. If so, the marginal return to another bachelor's degree graduate is unlikely to be as high as the average return estimated by Scott.

b) Productivity externalities

External, public benefits from knowledge spillovers are not accounted for by Scott's wage measures. If such spillovers significantly affect productivity then they must be added to the private wage benefits considered above.

The best such estimate comes from Daron Acemoglu and Joshua Angrist using US data,[12] and a subsequent meta-analysis.[13] They find no evidence that the external benefits are distinguishable from zero. Due to the lack of evidence for external productivity benefits, we do not include them in our modelling.

[11] We have used Scott's unadjusted estimates since there is no reason to believe that the current selection bias will not persist when further university places are created.

[12] Acemoglu and Angrist, "How large are human-capital externalities?."

[13] Psacharopoulos and Patrinos, "Returns to investment in education."

2.2.2 Labour force participation

Education is known to be correlated with the workforce participation rate: as people gain higher qualifications they are more likely to join the labour force. As a consequence, increasing the level of education in the labour force is also likely to swell it slightly. Increased labour force participation boosts the productive capacity of the nation and thus provides an economic benefit. We draw on data from Statistics New Zealand on workforce participation to generate the numbers in Table 21.

Table 1 Workforce participation rates

Percentage participation in labour force (Q4 2008)

Level 1-3 qualification	School qualification only	University qualification
57%	67%	84%

Source: Statistics New Zealand (2009)

2.2.3 Social cohesion

The benefits from increased education are not limited to productivity gains. There are also benefits that accrue to social cohesion and equity. For example, there is evidence that education helps people adapt to technological change in the workplace,[14] preserves cultural values,[15] induces more active democratic participation,[16] and lowers criminal behaviour.[17] All of these factors militate towards a more educated society. However, it is difficult to establish causal links for many of the effects which, in turn, makes the marginal effect of increased tertiary education very difficult to quantify. Following KPMG's report we have chosen not to include them in our modelling.

2.2.4 Increased health

There is a large body of literature reviewing the link between health and education. It has been estimated that the health benefits of an extra year of education could be the equivalent of an income increase of 3%.[18] Similar results confirm the lower probability of dying[19] and decreased incidence of bad health[20] in educated people. However, it has proven difficult to show a causal link between the two, which means that it is impossible to quantify any potential gain from increases in tertiary education. Given the lack of established causality, we have followed KPMG in excluding health benefits from our modelling of increased education levels.

[14] Chapman and Chia, "Financing higher education."

[15] McMahon, "Externalities in education."

[16] Brennan, "The structure of tertiary education fees."

[17] Webb, "Savings to society by investing in adult education."

[18] Groot and Maassen van den Brink, "The health effects of education."

[19] Lleras-Muney, "The relationship between education and adult mortality in the United States."

[20] Spasojevic, "Effects of education on adult health in Sweden."

2.3 Summary

Table 2 summarises our conclusions and shows what will be included in the modelling process.

Table 2 Summary of assumed effects

Effect	Modelled?	Rate of return
Research productivity	Yes	20% per annum from fifth year onward.
Student productivity	Yes, for private benefits only.	Per Scott (2009)'s wage estimates.
Labour force participation	Yes	Per Statistics NZ labour force data.
Social cohesion	No	N/A
Health benefits	No	N/A

Source: NZIER

3. Modelling approach

Our approach to modelling the impact of funding follows KPMG's. We develop a system of interlinked models that capture the various effects of extra funding to universities and the impact that they will have on the wider economy.

The particular change that NZVCC chose is a funding boost for universities of $40 million per year for five years. The reason for choosing a short term increase in funding, rather than a permanent change, is not to suggest that it would be preferable as a government policy. Rather, it is easier to see the effects of a 'shock' to the economy when the effects do not continue to accumulate indefinitely. Using a temporary shock we can show the way that the effects flow through the economy via a single cohort of students. That allows us to show how long it takes for the wider economic benefits of funding to accumulate and how long the initial costs persist for. In order to determine the effect of a permanent increase, the temporary increase can simply be summed over time.

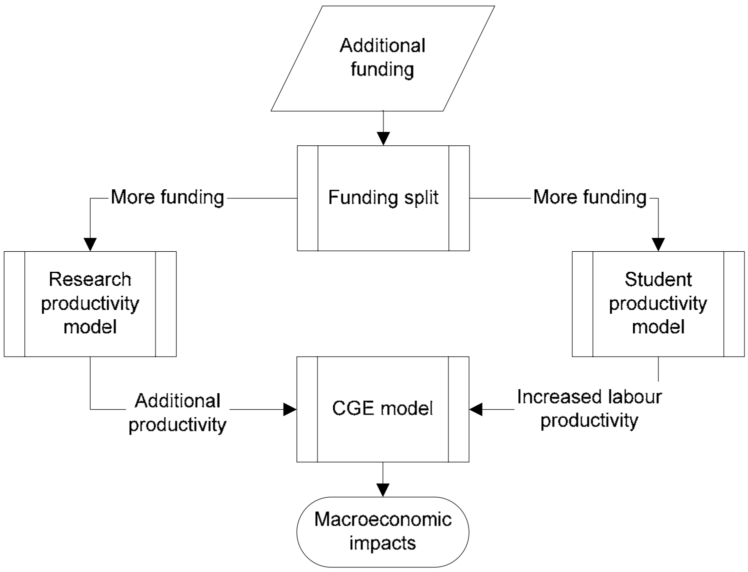
We then generate four scenarios that represent different policy options in order to compare their macroeconomic effect. Our primary scenario assumes that the increase in funding for universities is paid for by increased taxation over the five year funding period. That has the effect of temporarily reducing private consumption, which we use as a proxy for welfare (see section 3.2.3d) for more detail). Directing the cost of funding to our welfare measure allows easier measurement of the costs and benefits of the funding than alternative approaches such as reducing government spending on other social services. It should not be seen as an endorsement of such a policy but as a modelling device.

Scenarios two and four vary this assumption and draw the funding from overseas borrowing and from funding for Level 3 qualifications respectively. Scenario three replicates the first scenario's taxation mechanism but directs the funding to research and postgraduate places only. By contrast, the other three scenarios fund research, undergraduate and postgraduate places.

3.1 Conceptual framework

The framework that we use is illustrated in Figure 5. The initial shock to the model is the funding increase discussed above. That funding increase is then channelled into the separate models for research benefits and student productivity benefits. The split is made on the basis of current (2008) funding levels for students and research.

Figure 5 Interlinked models' structure



Source: NZIER

The research funding includes all revenue received by universities from external research contracts — primarily with the Foundation for Research, Science and Technology and the Marsden Fund — and the performance based research fund (PBRF). Student funding from the government is in the way of direct funding for students via Vote Education.

Once that split has been made on the basis of the current funding levels, the direct funding impacts are fed into productivity models that return a time series of productivity and labour force impacts. Finally, these indirect impacts are used as inputs to our computable general equilibrium (CGE) model of the New Zealand economy.

The final macroeconomic impact returned by the CGE model shows the change in the expected path of the economy as a consequence of the funding increase. The impact is expressed relative to the currently forecast path of the economy.

3.2 Interlinked models

3.2.1 University research model

The purpose of the university research model is to translate a funding increase for university research into a productivity benefit for the economy. That benefit is then fed into the CGE model as an input.

The first step in the process is to split the funding increase across the factors of production and industries that may benefit. For the external research funding received – about two-thirds of total research funding – we used the Ministry of Research, Science & Technology's (MoRST) science funding priorities, which project the allocation of funding priorities for the next funding round.[21] That resulted in 52% of the funding being split across specific industries according to MoRST's priorities. Some of the research goals did not appear to benefit a particular industry, but rather a particular factor of production. Thus, we allocate the remaining 48% of external research funding across factors rather than industries according to the factor that appears to benefit from the research MoRST propose to fund. To summarise, 16% was allocated to increases in labour productivity, 12% to capital and the remaining 20% to multifactor productivity benefits, consistent with the distribution in the MoRST document.

The PBRF funding goes towards both the support of students' research and funding university research grants; however, the universities are not required to allocate it to the departments that earn the funding. Consequently, it is not possible to determine which industry groups or factors of production might benefit from the research supported by PBRF funding grants. To deal with the uncertainty we have chosen to allocate the productivity benefit to multifactor productivity and distribute it across all industries according to current production. That is equivalent to assuming that the benefits are equally spread across capital and labour over the entire economy.

The next step is to apply the 20% rate of return on University research, as discussed in section 2.1.1. This gives a list of productivity gains that can be expected to accrue to specific industries as a result of the funding increase, which is then used as input into our CGE model. A summary of the expected productivity gains can be seen in section 5.1.2b).

3.2.2 University student productivity model

The student productivity model converts the increased funding for students places at university into a change in labour force productivity.

We assume that the increased funding creates new places for both graduates and undergraduates, and that those new students are drawn from both the workforce and outside the labour force. We then track their progress through university as they drop out, graduate or continue on to higher study.

---

[21] *New Zealand's Research, Science and Technology Priorities: feedback document*.

For each year we calculate the change in an index of labour productivity that takes into account both the changes in individual productivity and the change in labour force size. That index is then used as an input into the CGE modelling process.

In order to ensure that the model is tractable we make a number of simplifying assumptions. First, we discount the productivity of additional graduates by 10% to account for the likelihood of diminishing marginal returns to extra students. The returns estimated by Scott give the wages of a median graduate. Since the students in each cohort who benefit most from university education have the greatest individual incentive to attend, it is likely that they are already at university. Thus, it is likely that the productivity returns for the marginal graduate are not as high as that of the average graduate. This rate of return to university education is the key parameter motivating the final results; consequently, our assumption about its value is extremely important and we explore the effect of varying it in section 5.1.4.

Secondly, we assume that national net emigration rates do not change as a result of the extra University funding and places. At the macro level this appears plausible, given the relatively small scale of the change to student places. At the micro level, there may be an argument to suggest a person is more likely to emigrate after completing a degree; however we could find no data to support this.

Finally, we assume that 20% of undergraduates go on directly to postgraduate study.[22] The remainder of the postgraduate students are drawn from the general population.

Further technical details of the student productivity model are included in appendix C.

3.2.3 CGE model

a) The MONASH-New Zealand CGE model

To examine the effect of the funding on the New Zealand economy, we use NZIER's dynamic computable general equilibrium (CGE) model. CGE modelling is a highly-respected and well-developed technique that has a rich history for assessing policy, regional and industry questions. Our model was developed in close collaboration with Monash University, a global leader in building and applying CGE models.

The MONASH-NZ dynamic CGE model contains information on 131 industries and 210 commodities in its basic form; however, for this study we aggregated the database to 26 industries and commodities. It captures the various inter-linkages between these sectors, as well as their links to households (via the labour market), the government sector, capital markets and the global economy (via imports and exports). A visual representation is shown in Figure 6 highlighting the multidirectional relationships between the various parts of an economy.

[22] Based on the research in Scott, "Retention, Completion and Progression in Tertiary Education in New Zealand."

The database is projected forward each year to 2025 using economic forecasts from NZIER's *Quarterly Predictions* publication.

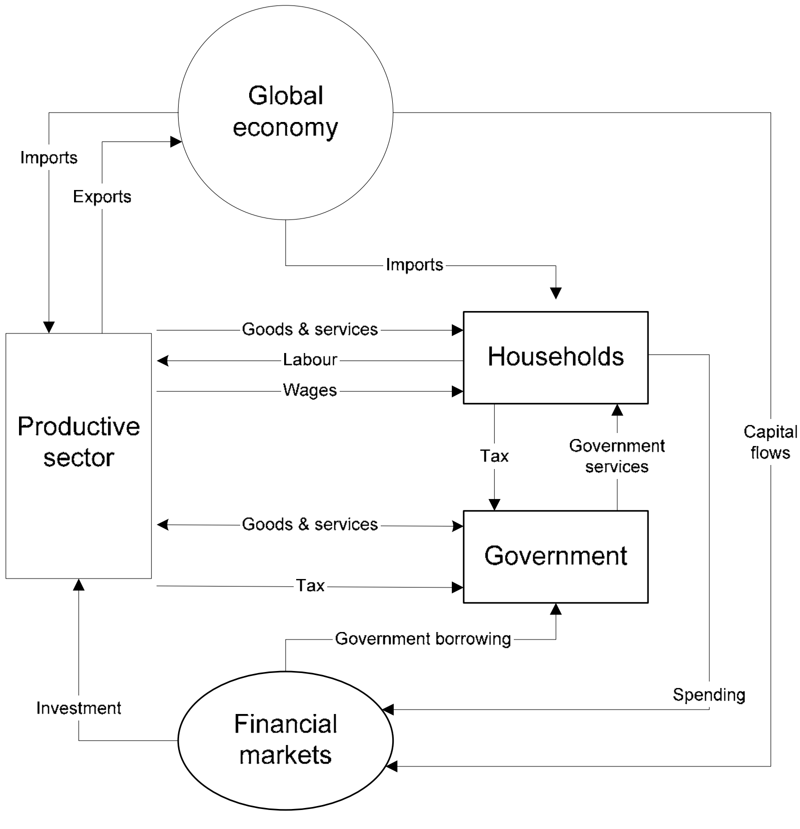
More technical detail on the model is presented in Appendix A.

b) Advantages of CGE modelling

Our dynamic CGE model is a more robust framework than alternative approaches for estimating the impact of the funding on the New Zealand economy. The most commonly used alternative is input-output (IO) or 'multiplier' analysis. IO or multiplier analysis has two significant limitations:

- It does not adequately consider the reallocation of resources following a 'shock' to the economy, such as a large funding boost to the university sector. In particular, multiplier analysis assumes that resources (land, labour, capital, energy, intermediate inputs) are available in unlimited quantities for the expansion of a sector. It does not consider how those resources might otherwise have been used in the economy – their opportunity cost.
- It does not account for relative price changes. For example, it assumes that wage rates do not change as the demand for labour rises or falls, and that the prices of intermediate goods such as business services do not change in response to shifts in demand.

Figure 6 Components of a CGE model



Source: NZIER

Multiplier analysis therefore tends to vastly overstate the economic impacts of changes in demand in a specific sector. These unrealistically large impacts are thus not particularly informative for policy makers.

CGE models explicitly address both resource allocation and relative price shifts, allowing for a more credible analysis of economic contribution. These models tend to produce lower estimates of the total impact, but are more consistent with economic theory and empirical evidence.

c) How the CGE model is used

The CGE model takes the productivity changes generated by the student and research productivity models as inputs. It then translates those inputs into changes in key macroeconomic variables, taking into account the trade-offs and opportunity costs of the movements in productivity.

We first introduce economic forecasts from NZIER's *Quarterly Predictions* into the model to form a business-as-usual (BAU) scenario. This gives a baseline to compare the funding increase to. The productivity effects of the funding increase are then applied, and the simulation out to 2025 is re-run. A comparison between the funding increase scenario and the BAU scenario gives the percentage change in key macroeconomic variables. These results are reported below in section 5.1.3.

d) Interpretation of results

The dynamic model used for this study generates results that give the percentage difference, in a given year, between the level of a variable in the base case and the scenario. For example, we provide numerical results for GDP later in this report for the final year of our simulations, 2025. Those results show the percentage difference between the level of GDP in 2025 under the proposed policy and without the policy. If a net present value of the policy were desired then those yearly changes would have to be discounted and summed back to the present day.

We also give value differences for some variables. Those dollar figures show the difference represented by the percentage change in today's dollars, based on current forecasts of future GDP. The dollar values are entirely dependent upon the forecast future level of GDP.

The presentation of our results incorporates two key macroeconomic variables: private consumption and GDP. The scenarios will have differing impacts on these two measures, and not always in the same direction. GDP is essentially a measure of how many goods and services New Zealand produces: it shows the size of the economy. Private consumption shows how household spending increases following a change in the economy. It is more appropriate than GDP as a measure of welfare.[23]

[23] Coleman, "Gauging Economic Performance Under Changing Terms of Trade."

3.3 Scenarios

There are four scenarios considered in this modelling exercise, as explained above. Each of them represents a different potential policy option for the government and universities. We have drawn on the universities' expertise and knowledge of the sector in order to formulate the four scenarios considered here. We detail the key elements of each below.

3.3.1 Added funding

This scenario closely follows KPMG's report. We increase funding to universities by $40 million per year for five years and fund that through additional taxation. The increased funding causes an increase in both research funding at the universities, and an increase in available student places. The additional places are split between postgraduate and undergraduate spots at the current ratio of postgraduate to undergraduate students.

3.3.2 Borrowed funding

Our second scenario replicates the first in all but the manner of funding. This scenario is funded by government borrowing for the five year period. The borrowing is then repaid over the course of the simulation by increased taxation such that it is fully paid off by 2025.

This government borrowing can be thought of as either direct funding to universities from overseas borrowing, or as an increase in student loan liabilities funded from offshore. The second interpretation would see the government allow universities to increase fees, which would also allow more places to be provided, and then let students borrow to fund the fee increase through their loans.

The two interpretations can both be modelled as an increase in government borrowing, but have different distributional implications. In the case of borrowing that is repaid by taxation, the cost of borrowing falls on all taxpayers. If the borrowing is channelled to universities via the student loan scheme then the cost of the overseas loan is borne solely by the students who borrow to attend university. We will not model these distributional concerns in our borrowing scenario, but they are important equitable considerations to bear in mind.

3.3.3 Postgraduate focus

The third scenario sees the government funding the universities through taxation again, but this time the money is used solely to create postgraduate places in masters and doctoral programmes.

3.3.4 University concentration

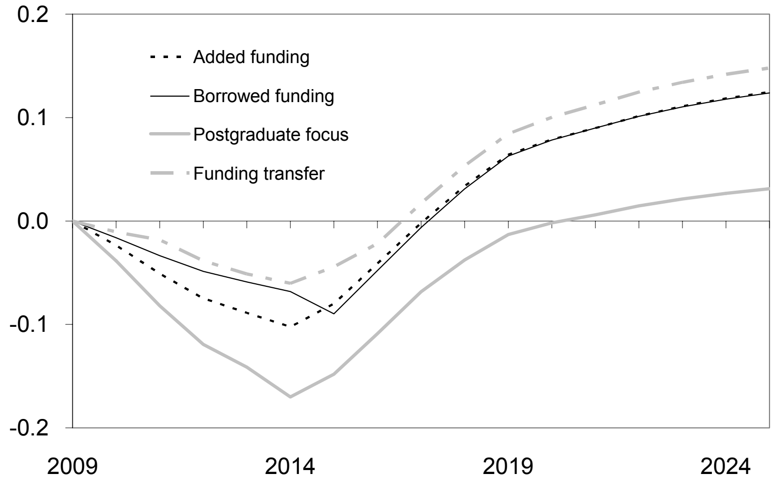
Our final scenario considers the effect of funding additional university places and research by transferring funding from level 1-3 tertiary qualifications. In all other respects it is the same as scenario 1. We simply reduce the number of available places in level 1-3 qualifications as we increase the number of places available in university qualifications.

4. Summary of results

The overall GDP comparison can be seen in Figure 7: scenario 4 is the most beneficial to economic activity because it incurs the least initial cost. That is because the average benefit of tertiary level 1-3 education, relative to completion of secondary school qualifications, is small. Thus, removal of access to tertiary level 1-3 qualifications has a low average cost to society relative to the other scenarios considered.

Figure 7 Effect on GDP

Percentage change from BAU



Source: NZIER

Scenario 1, in which households are taxed to pay for further places at universities is next most beneficial to GDP. While the initial cost is slightly higher than drawing the funding from level 1-3 qualifications, the productivity benefits are also greater. The borrowing scenario shows short term gains for a long term cost. Finally, the scenario focussing on postgraduate places produces the greatest short term costs and these persist over time. That is because it removes the most productive people from the labour force and gives them little additional productivity at a master's level.

The key numerical outcomes of each scenario are summarised in Table 3.

Table 3 Summary of results

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Funding source	Taxation	Borrowing	Taxation	Fund transfer from level 1-3
Funding target	All university	All university	Postgraduate only	All university
		Results in 2025		
%age change in GDP	0.12%	0.12%	0.031%	0.15%
$m change in GDP	$370	$370	$93	$440
%age change in consumption	0.029%	-0.018%	-0.087%	0.23%
$m change in consumption	$44	-$27	-$130	$340

Source: NZIER

Detailed explorations of these results are conducted in the next section (section 5).

5. Detailed results

This section provides greater detail on the impact of each scenario on the economy. We have broken down the impacts into three categories for each scenario:

- **Industry effects** are the immediate effects on the economy of the government's funding increase.
- **Productivity effects** are the next round of effects, which comprise the changes in the labour force and the changes in productivity resulting from the increase in university activity. These are the results generated by the university and research productivity models.
- **Macroeconomic effects** are the flow-on effects on the rest of the economy from greater productivity and increased labour force participation. These results are the final output of the CGE model.

Each scenario is considered separately below and particular attention is given to our lead scenario. In that section (section 5.1) we also test the robustness of our results to variation in some key assumptions.

5.1 Scenario 1: Added funding

5.1.1 Direct effects

The direct impact in our simulation is simply the increase in government funding to universities. That increase is assumed to be $40 million per year for the five years from 2010 to 2015.

The increased expenditure immediately creates jobs in the university sector as the universities allow more places for students and expand research grants. In this simulation we have assumed that wages are 'sticky' and do not respond immediately to the increased demand in the labour market. High unemployment in the labour market at present means that the increased demand is more likely to manifest as an increase in employment.

5.1.2 Productivity effects

The increase in places at university causes more students to enter university at both an undergraduate and graduate level. This implicitly assumes that universities are currently experiencing excess demand for places. Given that university enrolments consistently reach their government-imposed cap, and fee increases have not changed that, it seems reasonable to conclude that increasing the cap will increase enrolments.

Concurrently, researchers' efforts are aided by the expansion of grants for their work.

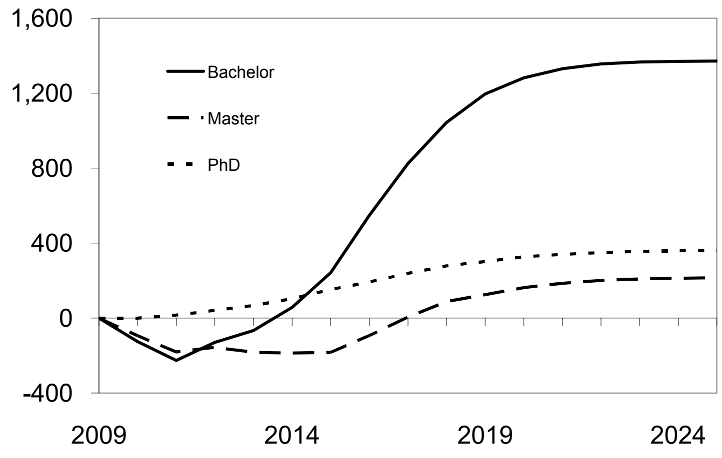
a) Effect via student productivity model

The increase in the number of students at university serves to alter the composition of the labour force, as shown in Figure 8. The graph shows change in the number of people with a particular qualification in the workforce. The number of unqualified people drops initially as they take up undergraduate places at university. Their numbers rise again slightly due to dropouts, but the final number is depressed below BAU since many go on to graduate.

The number of people in the workforce with undergraduate degrees initially declines as some leave to take up postgraduate study. As graduates start to emerge from undergraduate programmes, that number rises again to eventually result in almost 2000 further graduates in the labour force. Postgraduate numbers begin to increase as students start to graduate and enter the workforce with higher qualifications.

Figure 8 Impact on labour force composition

Change in labour force numbers by highest qualification obtained



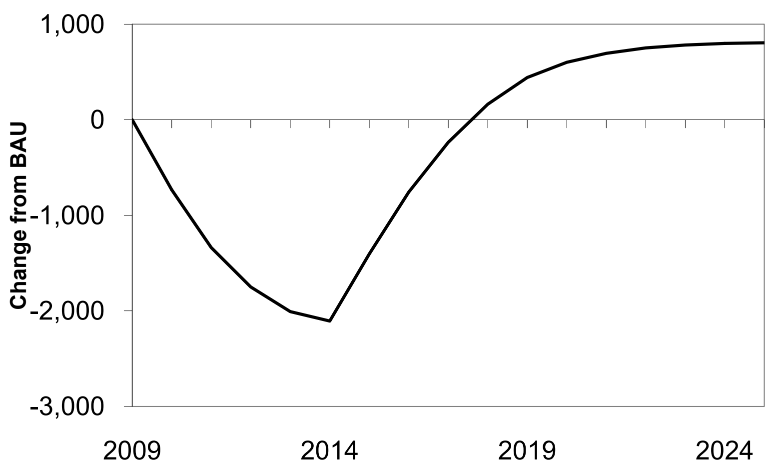
Source: NZIER

Thus the balance of the workforce shifts slightly towards those with university qualifications. The effect is twofold:

- The size of the labour force initially decreases as workers enter university, but then rises above baseline as graduates re-enter the labour force. This effect is due to the higher workforce participation rates of graduates relative to those without tertiary qualifications. By 2018, the total size of the labour force has grown beyond the baseline case and, by 2025, there are an extra 810 people in the workforce as a result of the higher participation rate of graduates (Figure 9).
- The productivity of the labour force rises due to the increased skill level of the workforce.

Figure 9 Impact on labour force size

Change in labour force size

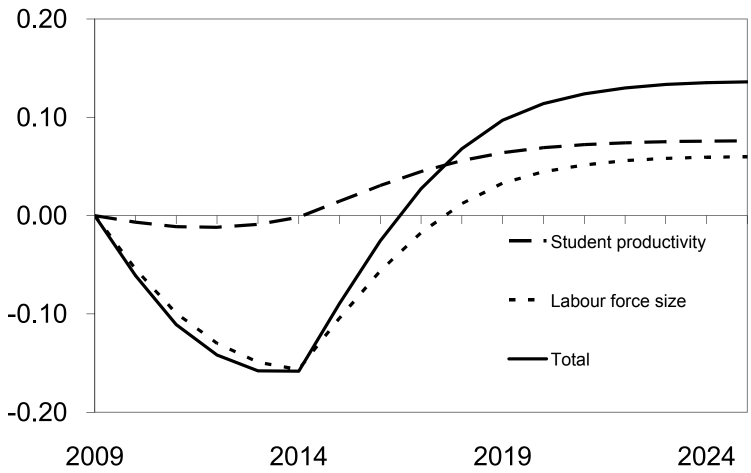


Source: NZIER

Initially, the decrease in labour force size dominates and effective labour force productivity declines, as shown in Figure 10. However, by 2016, the benefits of increased graduation cause labour productivity to exceed baseline. That is due both to the increase in education levels (the ‘student productivity’ line) and the increasing workforce participation rate.

Figure 10 Contributions to total student productivity

Percentage change in effective labour productivity



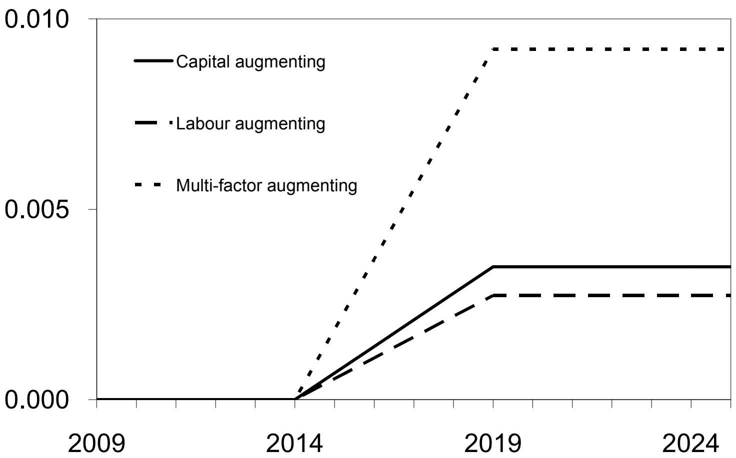
Source: NZIER

b) Effect via research productivity model

The benefits of the universities’ higher research grants begin to manifest as an increase in productivity across the economy by 2015. Figure 11 shows how the research benefits are spread across all factors of production, which reflects the diverse nature of the research conducted. These percentage changes are drawn from our breakdown of research priorities (see section 2.1.1).

Figure 11 Research productivity impact

Percentage change from BAU



Source: NZIER

c) Cost of funding

The cost of funding is 0.08% of the government's annual budget for each year from 2010-2014. Note that the cost to the government is passed on to consumers through higher taxes.

5.1.3 Macroeconomic effects

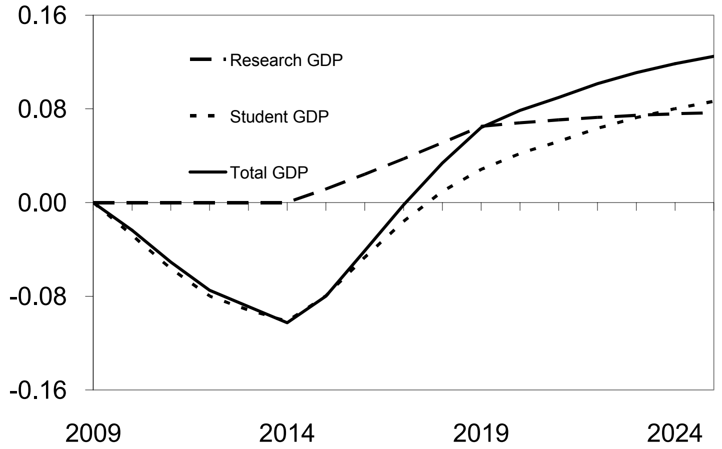
a) Value-added

The aggregate outcome is that, by 2025, GDP is 0.12% above the baseline scenario, which represents an additional $370 million in value added to the economy. The accumulation of these effects on the wider economy can be viewed in two stages: first, the costs of investment are seen and, secondly, the gains are reaped.

As Figure 12 shows, the initial decrease in the size of the labour force diminishes total gross domestic product (GDP). By 2014, GDP has dropped 0.10% below baseline. Furthermore, the increased investment in universities is funded by a commensurate increase in taxation, which reduces private consumption (Figure 13) to 0.31% below the baseline scenario.

Figure 12 Effect on GDP

Percentage change from BAU



Source: NZIER

However, as graduates begin to enter the labour force, the increase in productivity allows firms to produce more with the same resources and boost the value of their output. Consequently, GDP rises as more graduates enter the labour market and the average productivity of labour and capital increases.

The 'research GDP' and 'student GDP' plots separate out the effect of the research benefit and the benefit from the additional labour productivity of students. Research productivity doesn't begin to accrue for five years, then quickly increases GDP as firms utilise the new technology.

Student productivity is partially responsible for the initial dip as workers leave the labour force, but is also the largest contributor to the eventual increase in total GDP.

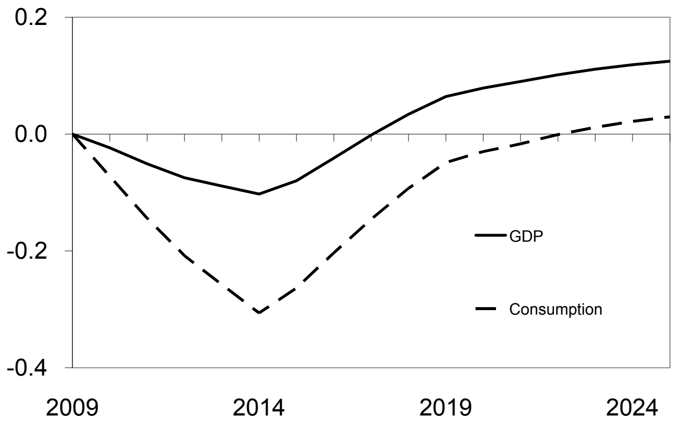
b) Welfare consequences

Despite the positive effect on GDP, the effects of the productivity increase take longer to pass on to consumers. While GDP is positive by 2018, private consumption – a common proxy for welfare – doesn't exceed the baseline case until 2023. That is because the increase in government spending is drawn from increased taxation, which reduces private consumption. That means that the increase in incomes trails the increase in GDP.

However, in the long run the increase in labour productivity results in higher wages and higher incomes, which boosts consumption and welfare above the baseline. Figure 13 shows the benefits to consumption and GDP increasing through to 2025. The benefits over the baseline will persist into the future with no additional cost, since the research and labour productivity benefits are then entrenched in the economy.

Figure 13 Welfare benefits

Percentage change from BAU



Source: NZIER

5.1.4 Sensitivity analysis

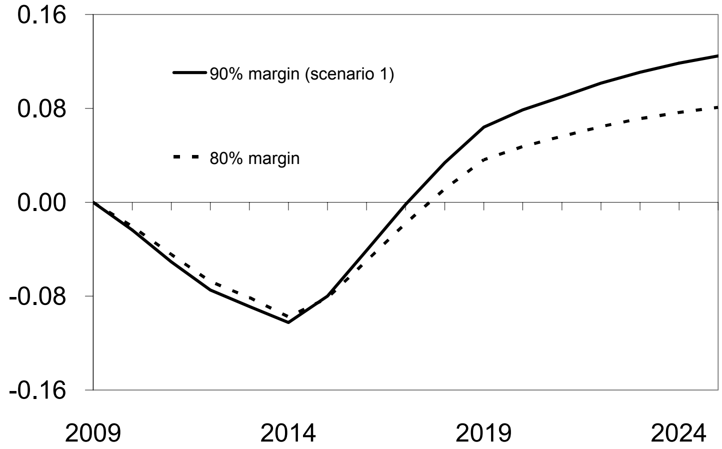
In this section we vary two of the key assumptions in our model and show the effect upon scenario 1's results.

a) Marginal returns to education

As mentioned previously, the results of our modelling are crucially dependent upon the assumed rate of return to education. For our primary scenario we assumed that additional graduates are 90% as productive as the present average graduate. However, data on the earnings of a marginal student is not available so it is important to have a sense of how changes in the marginal rate of return affect the macroeconomic outcomes.

In this section we re-run the simulation but vary the productivity of the marginal student down to 80% of the average student. The lower value is chosen because marginal students are likely to have a lower aptitude than the average student. Changing the marginal productivity changes the inputs into the CGE model: the value of labour productivity is adjusted in accordance with the change in the marginal value of education.

Figure 14 Sensitivity of GDP
Percentage change from BAU



Source: NZIER

Figure 14 shows that the downward change results in a decrease in GDP relative to the main scenario (90%) of $130 million in 2025. A 10% change in the marginal value of education causes a 35% change in the size of the deviation from baseline, which is substantial. That illustrates the caution with which our numerical results should be treated: small changes in assumptions can have significant effects upon the final outcome.

This is illustrated even more starkly in the consumption figures, which show that reducing our assumed marginal value to 80% of the average would keep consumption spending depressed $46 million below baseline in 2025 and $90 million below scenario 1, although it is still rising.

The results are similar, although the effect is smaller, when returns to research are varied.

It is important to note that these variations change only the lag with which GDP and consumption exceed baseline. As long as the returns to educating the marginal student are positive the long-run outcome will be an increase in welfare relative to baseline. Indeed, even if we were to change the returns drastically, we would only need to alter the timescale of our graphs throughout the results section.

b) Labour market assumptions

When students are drawn in to the student productivity model we assume that they come from both within and outside the labour force. In accordance with KPMG's methodology we draw them from these two groups according to their workforce participation rates. For example, people with only school-level qualifications have an average labour force participation rate of 67% so, if places opened up at university for them, we assume that 67% of the new students are lost to the labour force for the duration of their studies.

However, in a flexible labour market, the reduction in labour supply as people move into tertiary education may be rapidly compensated for by people joining the labour force and competing for the jobs that become available. Because the initial drop in GDP and welfare that we see in our simulations is due to the decrease in labour force size it is important to consider how reliant this result is on our assumption.

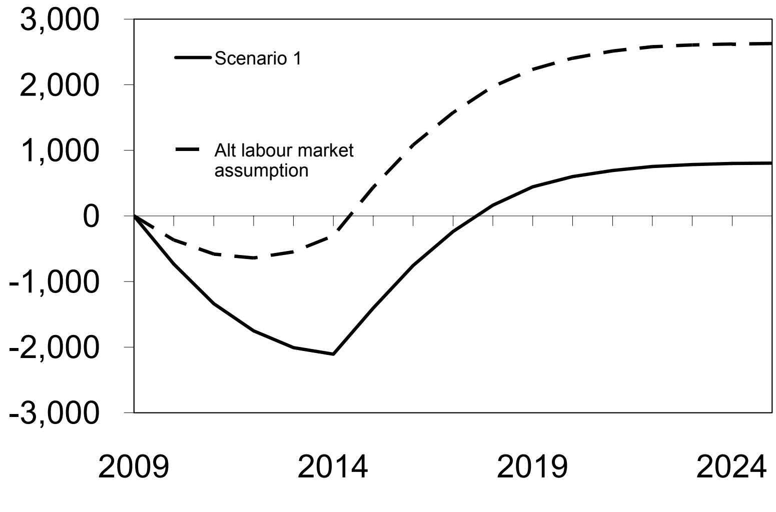
The variation reported here becomes particularly relevant when considering how to interpret our results at different points in the business cycle. During growth periods the assumptions we have made about a tight labour market are more applicable. During recessionary times the alternative outcomes reported in this section may be more realistic.

To test the sensitivity of our results we halve the number of students who are drawn from within the labour force and draw them instead from outside it. That reduces the negative impact of the additional university spots on the size of the labour force.

Figure 15 shows a comparison between the labour force size change (as in Figure 10) with our standard assumption and the alternative. As expected, drawing fewer students from within the labour force reduces the initial drop in size, while retaining all of the later gains. The end result is to double the productivity gain by 2025.

Figure 15 Change in labour force size

Percentage change from BAU

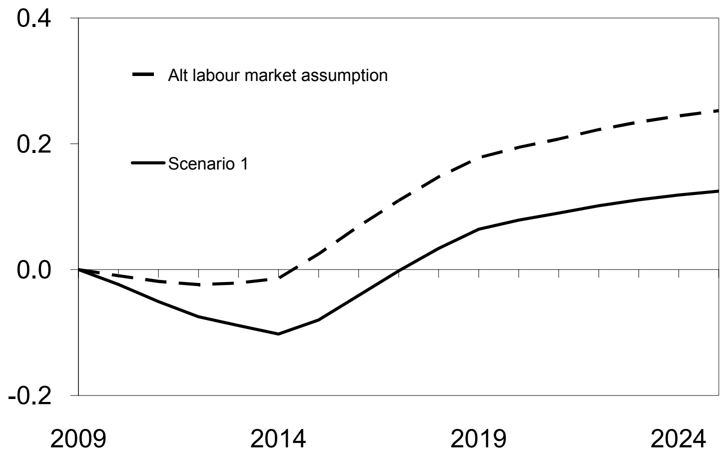


Source: NZIER

Feeding the revised assumptions into our CGE model again reduces the initial cost of the extra places while having no impact on the output gains in the economy (Figure 16). Indeed, GDP rises 100% more by 2025 under the revised labour market assumptions: that is an extra $380 million of economic activity.

These results illustrate the extent to which our final results can vary according to crucial assumptions about the current state of the labour market. If there were slack in the labour market at present then we may choose to use the revised assumptions as our base scenario; however, the low levels of unemployment in the economy at present have persuaded us to take a conservative approach and assume that places in the labour force cannot be costlessly filled.

Figure 16 Sensitivity of GDP
Percentage change from BAU



Source: NZIER

5.2 Scenario 2: Borrowed funding

5.2.1 Direct effects

The second scenario is identical to the first in the productivity and labour force impacts, but differs in the manner of funding. Rather than drawing the increased university funding from taxation, we assume that the government borrows from overseas for the five year funding period. Of course, borrowing must be paid back at some stage so we then assume that the government gradually repays the loan over the next decade. By the end of our simulation, in 2025, the government's additional foreign liabilities return to zero.

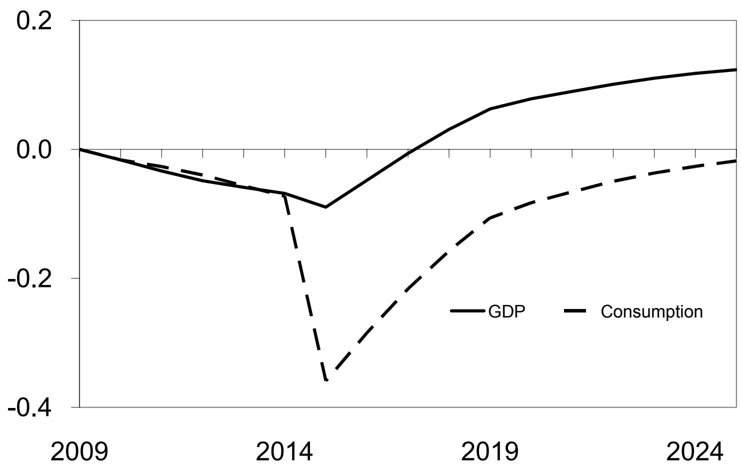
5.2.2 Macroeconomic effects

The effect of borrowing the funds from overseas is shown in the chart of GDP and consumption below (Figure 17). The borrowing up to 2014 provides an injection of money into the economy that boosts incomes and spending, thus increasing GDP and incomes. Some of that increase in consumption is offset by the decreasing labour force size, which explains the gradual decline in GDP from 2010 to 2015; however, the path is still well above scenario 1.

From 2015 to 2025 the borrowing is repaid through greater taxation. The switch from borrowing to repaying, along with higher taxes, causes an immediate fall in consumption spending, which also drags down GDP. The drop in GDP is dampened somewhat by an increase in exports as our currency depreciates, but consumption dips below scenario 1's.

Figure 17 GDP and consumption benefits

Percentage change from BAU



Source: NZIER

As productivity gains begin to filter through the economy, GDP and consumption both recover. However, they remain below the level of scenario 1 due to the cost of the borrowing. By 2025 GDP is $3 million below scenario 1, while consumption spending is $71 million below.

5.3 Scenario 3: Postgraduate focus

5.3.1 Direct effects

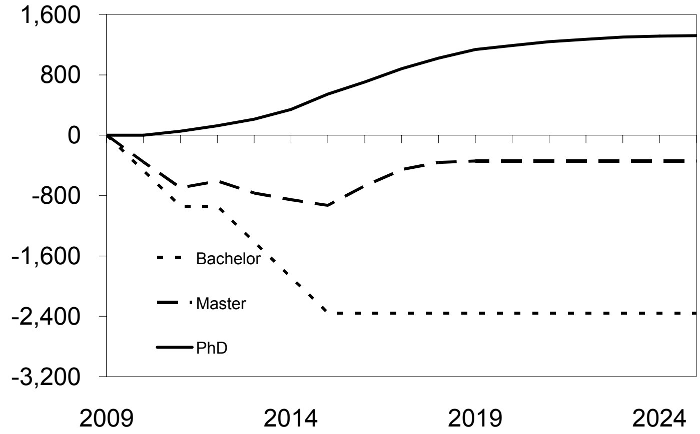
In this scenario we direct all of the funding toward the creation of university places at the masters and doctoral level. The funding is raised through taxation, as in scenario 1. Because graduate students cost approximately 25% more to educate than undergraduates we reduce the number of extra places accordingly.[24]

5.3.2 Productivity effects

The change in labour force composition as a result of the policy is plotted in Figure 18. The people drawn from the labour force are bachelors and masters graduates, and they are then returned as masters and PhD graduates. That is shown by the permanent reduction in the number of bachelors and masters degrees in the labour force and the increase in the number of PhDs.

[24] Figures drawn from the Tertiary Education Commission's funding for the Student Achievement Component of tertiary funding.

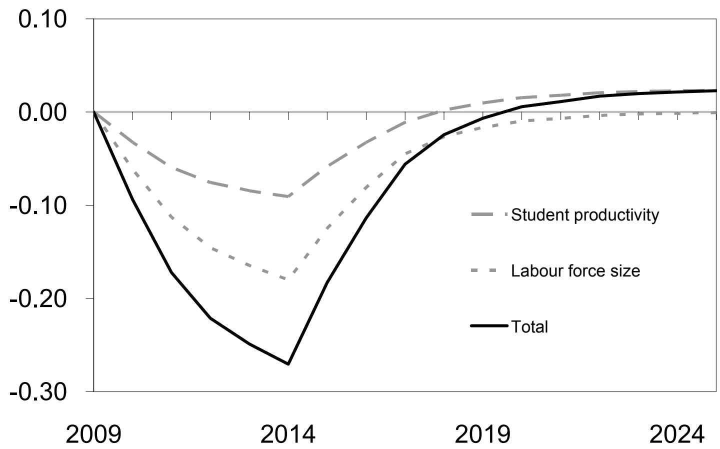
Figure 18 Impact on labour force composition
Change in labour force numbers by highest qualification obtained



Source: NZIER

The impact that has on labour force productivity is shown in Figure 19. Compared to scenario 1 (Figure 10), this policy produces a far greater dip in productivity early on, for little final reward. That is for two reasons: First, drawing masters and bachelors graduates from the labour force deprives us of our most productive workers and thus has a proportionally larger effect on productivity than removing people who do not have university education.

Figure 19 Contributions to total student productivity
Percentage change in effective labour productivity



Source: NZIER

Secondly, as indicated in Figure 4, the marginal gain in productivity when moving from a bachelor's degree to a master's degree is far smaller than when moving from level 1-3 qualifications to a bachelor's degree. PhD graduates gain more, but it is not enough to make up the loss in marginal productivity gain relative to scenario 1.

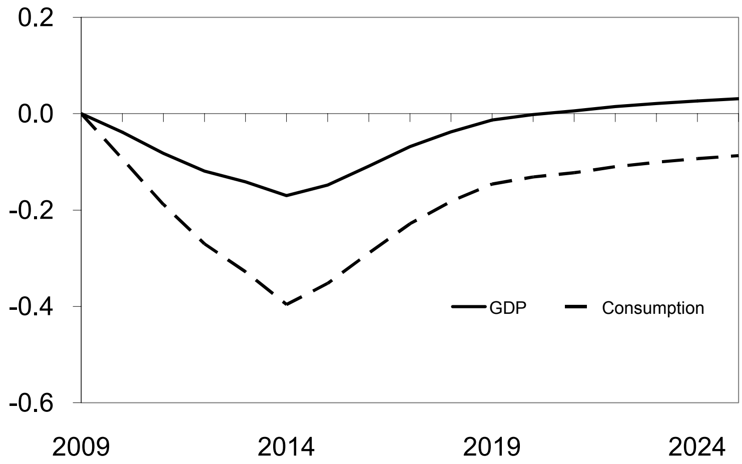
5.3.3 Macroeconomic effects

The macroeconomic outcome of the policy is driven by the changes in productivity. Consequently, the outcomes are not as strong as in scenario 1, but follow a similar pattern. Figure 20 shows the path of GDP and consumption in this simulation. As current graduates leave the workforce they reduce the average productivity of the workforce. That, in turn, leads to lower GDP, lower incomes and lower consumption. After 2014 the government ceases funding and taxing over the baseline level, which increases incomes. Furthermore, the research productivity starts to boost GDP and graduates return to the labour force. Thus, GDP recovers and incomes rise as the increased productivity is rewarded by higher wages.

As can be seen, GDP becomes positive in 2021 in this simulation compared to 2017 in scenario 1 and reaches only $93 million above baseline by 2025. Consumption remains below baseline by $130 million in 2025 as the lower productivity benefits generate slower gains in incomes.

Figure 20 GDP and welfare benefits

Percentage change from BAU



Source: NZIER

5.4 Scenario 4: University concentration

5.4.1 Direct effects

This scenario is identical to the first in the distribution of the funding increase and its size. However, rather than funding from taxation, this funding increase for universities is generated through cuts of $40 million per year to tertiary level 1-3 courses for the years from 2010-2014. The direct effect on the numbers of university graduates in the workforce is identical to that shown in Figure 8 but, in addition, there is a drop in the number of places available in level 1-3 qualifications.

Since the Tertiary Education Commission funds undergraduate courses at universities as the same rate as undergraduate courses at other tertiary institutions we reduce the number of places in level 1-3 qualifications by 1100 across the five years.

It is important to remember the assumption this implies: somebody who would choose to gain only a level 1-3 qualification is now being encouraged to gain a bachelor's degree. We assume that the person will then gain in skills and knowledge over the counterfactual of gaining a level 1-3 qualification. That assumption is only justifiable if the current cap on enrolments presents a significant barrier to entry into university education for those people. Consideration of those issues is beyond the scope of this report, but they should be borne in mind when interpreting the results.

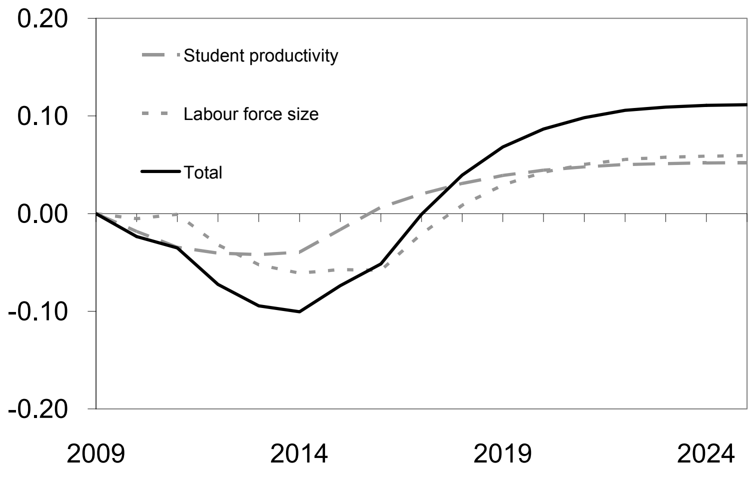
5.4.2 Productivity effects

Our productivity data does not separate out those who gain tertiary level 1-3 qualifications and those who have only secondary school qualifications. For the purposes of this scenario we have assumed that a person with only secondary school qualifications earns 85% of the national median wage. That is slightly less than the 89% earned by a dropout from a tertiary level 1-3 course. A graduate of a level 1-3 tertiary course would earn 95% of the national median.[25]

The small difference between the productivity of those who gain secondary school qualifications and graduates of level 1-3 courses results in a small cost of cutting the courses, relative to the other scenarios.

Figure 21 Contributions to total student productivity

Percentage change in effective labour productivity



Source: NZIER

That is reflected in Figure 21, which shows a smaller cost to labour productivity than in previous scenarios. The other side of that is a smaller gain in productivity from university education: students who would previously have gained a level 1-3 qualification now gain a bachelor's degree instead. That means that the marginal gain is the difference in productivity between a bachelor's degree graduate and a level 1-3 graduate, rather than a secondary school student.

[25] Scott, *What Do Students Earn After Their Tertiary Education?*, 28.

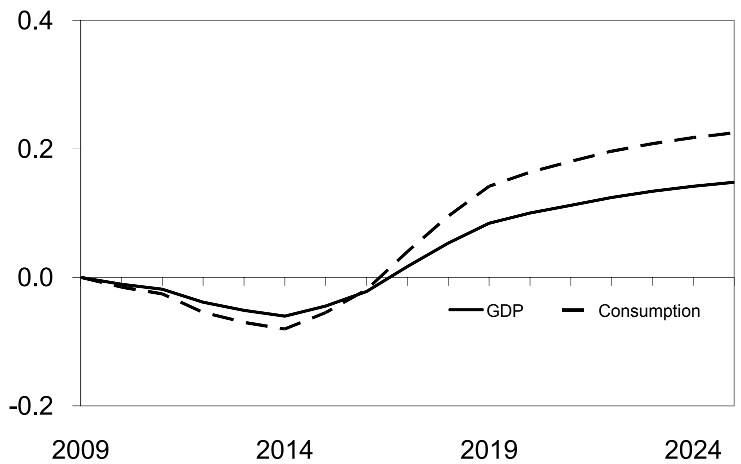
5.4.3 Macroeconomic effects

The low initial cost can be seen in the small initial reduction in GDP, which never dips more than 0.06% below baseline. Following 2015, when the productivity benefits make themselves felt, the lack of a tax burden or borrowing to repay allows consumption to rise rapidly with GDP. Consumers keep a larger portion of their incomes to spend compared to the other three scenarios and this is the only scenario in which consumption growth exceeds GDP growth.

By 2025 GDP has risen to be 0.15% above baseline, which creates an additional $440 million of value in the economy. The higher incomes generated by the added productivity results in consumption spending rising 0.23% above baseline by 2025, which allows households to spend $340 million more that they otherwise could.

Figure 22 GDP and welfare benefits

Percentage change from BAU



Source: NZIER

The gains shown in this scenario depend heavily upon the relative marginal productivity of graduates from level 1-3 qualifications and those with secondary school qualifications. Accurately estimating those returns is beyond the scope of this report; however, we note that the estimates we have used do not control for ability bias and self-selection, which is likely to play a significant role in determining the relative returns. If the selection bias of further graduates is less strong than in the past then our estimates may be skewed. Further empirical investigation of those returns would be required to optimally trade off between university and level 1-3 qualifications.

6. Implications and next steps

- Funding for universities generates benefits above and beyond the direct impacts on universities' balance sheets.
- There are broader economic benefits which raise the welfare of New Zealanders, particularly once graduates re-enter workforce.

- There may also be health and social benefits, which we did not attempt to model.
- Our modelling shows the importance of understanding the lags in funding, labour force participation and productivity changes. Returns to additional funding take time to filter though so this needs to be a long term strategy and requires long term funding commitments.
- More research on the relationship between university education and workforce composition would benefit NZVCC by helping them better understand the impact of other reform policies on the national economy.
- Further research into the marginal gains from education would better inform modelling work and lend greater weight to the estimates derived.

Appendix A Bibliography

Acemoglu, D., and J. Angrist. “How large are human-capital externalities? Evidence from compulsory schooling laws.” *NBER macroeconomics annual* 15 (2000): 9–59.

Brennan, G. “The structure of tertiary education fees.” *Economic Analysis and Policy* 18, no. 2 (1988): 149–170.

Chapman, B., and T. T Chia. “Financing higher education: Private rates of return and externalities in the context of the tertiary tax.” *Centre for Economic Policy Research Discussion Paper* 213 (1989).

Coleman, W. “Gauging Economic Performance Under Changing Terms of Trade: Real Gross Domestic Income Or Real Gross Domestic Product?.” *Economic Papers: A journal of applied economics and policy* 27, no. 4 (2008): 329–342.

Economic Modelling of Improved Funding and Reform Arrangements for Universities. Report to Universities Australia. KPMG Econtech, March 31, 2009.

Groot, W., and H. Maassen van den Brink. “The health effects of education.” *Economics of Education Review* 26, no. 2 (2007): 186–200.

Hall, J., and G. M Scobie. *The role of R&D in productivity growth: the case of agriculture in New Zealand: 1927 to 2001*. Working Paper. Wellington, New Zealand: New Zealand Treasury, 2006.

Horridge, Mark. *Using ORANI-G as an input-output model*. Centre of Policy Studies: Monash University, March 2008. http://www.monash.edu.au/policy/archivep/tpmh0082.zip.

Johnson, R., W. A Razzak, and S. Stillman. *Has New Zealand Benefited from its Investments in Research and Development?* Wellington, New Zealand: Department of Labour, 2005.

Lleras-Muney, A. “The relationship between education and adult mortality in the United States.” *The Review of Economic Studies* 72, no. 1 (2005): 189–221.

McMahon, W. W. “Externalities in education.” *Economics of Education: Research and Studies, Oxford: Pergamon* (1987): 133–37.

New Zealand's Research, Science and Technology Priorities: feedback document. Wellington, New Zealand: Ministry of Research, Science & Technology, November 2009.

Psacharopoulos, G., and H. A Patrinos. “Returns to investment in education: a further update.” *Education Economics* 12, no. 2 (2004): 111–134.

Rapoport, J. “The Autonomy of the Product-innovation Process: Cost and Time.” *Research and Innovation in the Modern Corporation, ed. E. Mansfield* 110035 (1971).

Scobie, G. M, and W. M Eveleens. “The return to investment in agricultural research in New Zealand: 1926-27 to 1983-84.” *MAF Economics Research Report* 1 (1987): 87.

Scott, David. “Retention, Completion and Progression in Tertiary Education in New Zealand.,” n.d. http://www.educationcounts.govt.nz/publications/tertiary_education/retention,_completion_and_progression_in_tertiary_education_in_new_zealand.

———. *What Do Students Earn After Their Tertiary Education?* Wellington, N.Z.: Statistics New Zealand and Ministry of Education, September 2009.

Spasojevic, J. “Effects of education on adult health in Sweden: results from a natural experiment.” *PhD diss., Graduate Center, City University of New York* (2003).

Tertiary Education Strategy 2010-2015. Wellington, New Zealand: Ministry of Education, 2010.

Thirtle, C., J. Piesse, D. Schimmelpfennig, and ERS USDA. “Modeling the length and shape of the R&D lag: an application to UK agricultural productivity.” (2008).

Wagner, L. U. “Problems in estimating research and development investments and stock.” In *1968 Proceedings of the Business and Economic Statistics Section*, 189–97, 1968.

Webb, L. D. “Savings to society by investing in adult education.” In *Economic and*

Social Perspectives on Adult Illiteracy. Florida: Department of Education, State of Florida, 1977.

Appendix B CGE modelling framework

B.1 MONASH

Our results were produced on a model of the New Zealand economy based on a tried and tested generic model (MONASH) that has been found effective for policy analysis in Australia and around the world. The model has been calibrated to the local setting and loaded with New Zealand data. The assumptions needed are based on consultation with industry specialists and reflect best practice.

The model has been developed with considerable assistance from CGE modelling experts at the Centre of Policy Studies at Monash University in Melbourne Australia.

B.2 Database structure

The model is based on a large database containing the value flows of the economy, as per Figure 23. The database defines the initial structure of the economy, which by definition is assumed to be in equilibrium in all markets. The structure of the database is broadly similar to traditional input-output tables; for example commodities may be used as intermediate input for further production, utilised in investment, exported or consumed by households and the government. Industry costs include the cost of intermediates, margins, taxes and primary factor costs for labour, land and capital. As per the accounting identities in input-output tables, the total value sum of producers' input costs (including margins, taxes, returns to factors and other costs) equates to the total value of output production (the 'MAKE' matrix in the database).

The condensed version of the MONASH-NZ model used here consists of:

- 26 industries
- 26 commodities
- 14 regions
- 1 household

The database has been sourced initially from Statistics New Zealand 1995/96 Inter-Industry tables, updated using the subsequently released 2003 Supply and Use tables, and finally 'up-scaled' to 2007 levels using latest Statistics New Zealand macroeconomic data.

Figure 23 The ORANI-NZ database

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Government	Change in Inventories
	Size	← I →	← I →	← 1 →	← 1 →	← 1 →	← 1 →
Basic Flows	↑ C×S ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Production Tax	↑ 1 ↓	V1PTX					
Other Costs	↑ 1 ↓	V1OCT					

C = 210 Commodities

I = 131 Industries

S = 2: Domestic, Imported

O = 24 Occupation Types

M = 5 Commodities used as Margins

Size	Joint Production Matrix
	← I →
↑ C ↓	MAKE

Size	Import Duty
	← 1 →
↑ C ↓	V0TAR

Source: Horridge (2008)[26]; NZIER

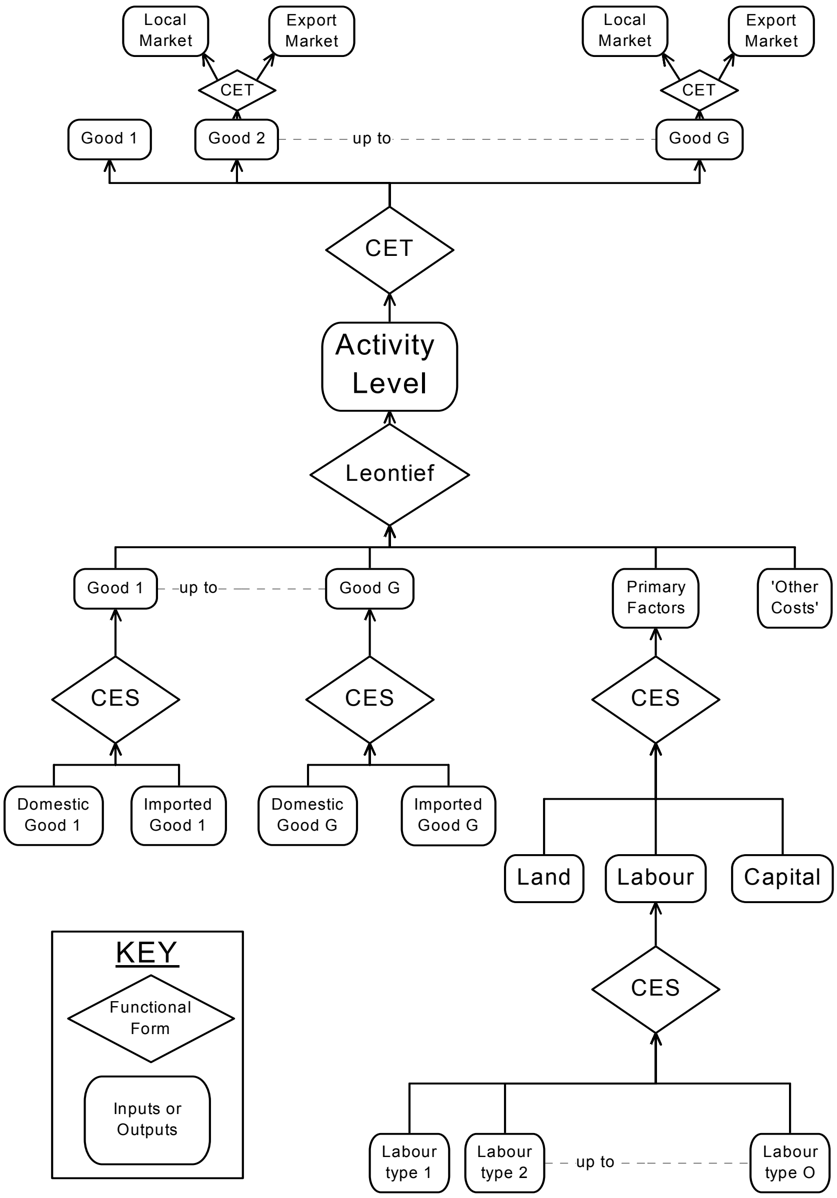
B.3 Production structure

The production structure of the model is presented in Figure 24. Each industry can produce a number of different commodities. Production inputs are intermediate commodities, both domestic and imported, and primary factors labour, land and capital. Working from bottom to top, we see constant elasticity of substitution (CES) production nests for occupations, primary factors and the choice between imported and domestic commodities. In this case, an increase in price moves sourcing

[26] Horridge, *Using ORANI-G as an input-output model*.

towards another input, for example, if the price of imports increases, more domestic commodities are demanded in the intermediate sourcing CES nest.

Figure 24 Production structure



Source: Horridge (2008)[27]

At the activity level, intermediate goods, primary factors and other costs are combined using a Leontief production function. This means the proportion of production inputs does not change. On the output side, there are two further constant elasticity of transformation (CET)[28] nests. The production mix of each

[27] Ibid.

[28] A CET function is identical to a CES function except that the transformation parameter has the opposite sign (i.e. increasing price increases output in a CET; in a CES, increasing price reduces demand)

industry is dependent on the relative prices of each commodity. Similarly, the export nest determines local and export market shares depending on relative prices.

Appendix C University productivity model

NZIER developed a systems dynamics model to estimate how changes to university numbers impacted the size of labour force and the average productivity of the labour force. The labour force is stratified by the highest level of attained education:

- L1-3
- Bachelor
- Master
- PhD
- Other

The model incorporates the duration of each education and transition rates (e.g. Bachelor to Master; quitting Bachelor etc) to accurately model student numbers within the education sector over time, after the initial change to student places. We then use parameters on the marginal productivity of education, and labour force participation rates by level of education attained, to compute labour force and average productivity metrics.

For this project, the model is constructed to be a 'marginal' model. We are focussed on the changes to the labour force and university sector, ceteris paribus.